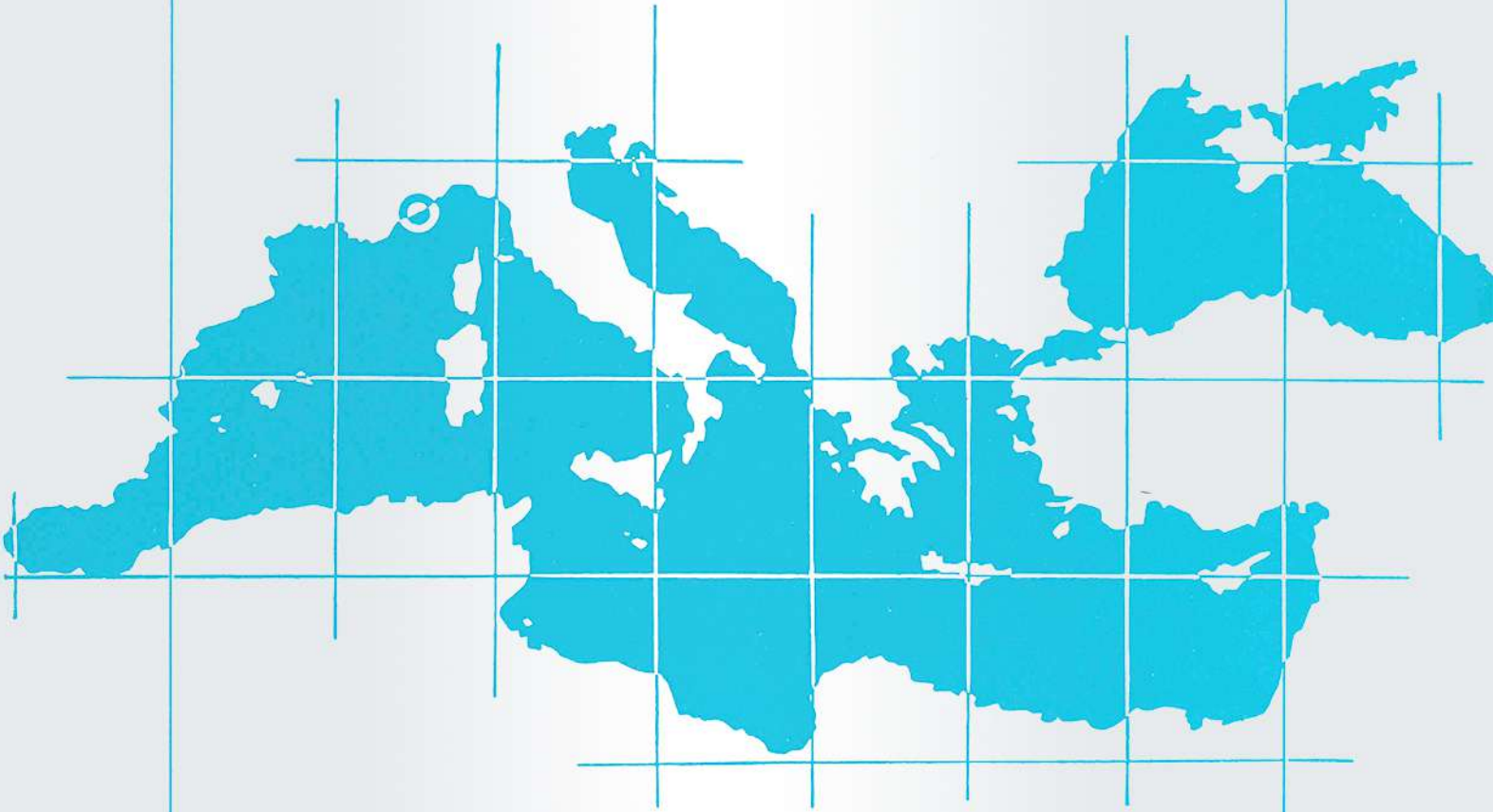COMMISSION INTERNATIONALE
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RAPPORT DU 43e CONGRES DE LA CIESM

43rd CIESM CONGRESS PROCEEDINGS

Palerme (Italie)   2024   Volume 43

Ce volume rassemble sous la forme d'articles synthétiques toutes les communications scientifiques présentées lors du 43ème Congrès de la CIESM. Cet ensemble qui regroupe les articles de centaines de chercheurs ainsi que les synthèses des modérateurs des diverses sessions tenues à Palerme en octobre 2024, offre un panorama représentatif des recherches marines menées actuellement en Méditerranée et dans les mers adjacentes.

Les articles présentés dans le cadre des six comités scientifiques sont édités sous la responsabilité du Président de comité concerné. Seules les communications physiquement présentées à Palerme par leur auteur ont été retenues pour cette publication.

Laura Giuliano
Directeur Général, CIESM

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SESSIONS CONJOINTES

Congress Joint Session : *Pinna nobilis* crisis
(C5 -C6)
Moderator : Gionata De Vico – Univ. of Naples Federico II, Italy

Session's Synthesis

The session was introduced by a short report by Prof. Gionata De Vico on the state of the art of the crisis involving *Pinna nobilis*, the largest bivalve in the Mediterranean, which has been in decline since 2016 due to repeated episodes of mass mortality: retracing the various stages of research on the topic, Prof. De Vico recalled how from the original idea of mortality due to a parasitic cause (*Haplosporidium pinnae*) we moved on to the hypothesis of a multifactorial disease also involving other pathogens (*Mycobacterium sherrisii*, *Vibrio mediterranei*, etc.), up to the most recent discovery of a picornavirus (PnPv) that multiplies in the bivalve's haemocytes, causing its death and therefore a state of acquired immunodeficiency responsible for the attachment of opportunistic pathogens with consequent mortality. Then, Prof. Cizmek described a new method to understand the historical population structure of an isolated population of *Pinna nobilis* in the Malo Jezero lagoon as a model for future population restoration efforts, using shell width as a proxy for height estimation. Dr Raul Gonzales reported the results of a recent study to identify optimal sites for the reintroduction of *Pinna nobilis* in the Balearic Islands. The study involved twenty-eight sites, among which Estany des Ponts within the Albufera of Mallorca was chosen as a reference site based on environmental analyses carried out. Dr Carmelo Iaria then reported in an interesting study, the first detection of PnPV in the declining population in Faro lake in Messina (Sicily, Italy), confirming the pathogenetic importance of this virus in determining the decline of populations in the Mediterranean. The report was followed by the speech of Dr. Elisabet Nebot Colomer, who reported the results of an interesting study on the genetics of a residual population of *Pinna nobilis* in the Mar Menor lagoon with that of a now extinct population located in Cabrera National Park. Using 19 microsatellites and comparing the genotypes of the two populations, it was concluded that the Mar Menor is a crucial area as a genetic reserve, retaining over 80% of the species genetic variation. Dr Marco Sigovini, then described the conservation status of *Pinna nobilis* in the Venice lagoon and finally Dr Domen Trkov reported an interesting study on the role of the shell of dead fan mussel for fish community conservation. The discussion that followed was very lively, testifying to the interest of the papers presented, in particular on population genetics, and the ecological impact of PnPV and the shells of dead subjects.

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THE TOTAL HEIGHT OF NOBLE PEN SHELL *PINNA NOBILIS* IN THE ISOLATED POPULATION OF MALO JEZERO LAGOON, MLJET MPA (ADRIATIC SEA): A NEW EQUATION

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Abstract

Pinna nobilis, an endemic species in the Mediterranean Sea, has recently faced mass mortality. Accurate measurement of its shell height is crucial for ecological studies and conservation efforts. Measuring partially buried shells presents challenges. Fieldwork in Malo jezero lagoon in 2018 yielded data on the shell dimensions of 47 deceased individuals to explore the possibility of using width as a proxy for height estimation. A simple linear regression model accurately predicts shell height and enables a better understanding of this unique population. Understanding the historical population structure can help in future efforts to restore the *P.nobilis* population in the Mediterranean Sea.

Keywords: Adriatic Sea, Bivalves, Biometrics

Introduction - *Pinna nobilis*, the Noble pen shell, is a species of bivalve endemic to the Mediterranean Sea and affected by mass mortality in the last eight years. Known for its large size and elongated shell, *P. nobilis* plays a crucial ecological role in coastal ecosystems. Accurately measuring shell height is essential for studying population dynamics [1], changes in the environment, conservation of species, and, in this case, monitoring the repopulation of the species. Measuring the height of the shell when partially buried presents a significant challenge for researchers. Indirect methods, such as using width as a proxy for height estimation, offer a promising solution to this issue, facilitating morphometric studies of *P. nobilis* populations [2].

Materials and Methods - To investigate the correlation between shell height and width, we conducted fieldwork in Malo jezero lagoon, Mljet MPA, in 2018, the year before the pandemic of Noble pen shell reached the Adriatic Sea. Using SCUBA diving, unbroken shells of 47 deceased individuals were measured using a ruler to validate maximum width and total height data. This rigorous methodology ensured accurate data collection, providing a robust foundation for subsequent analyses. Statistical analysis was done using R version 4.3.3.

Results and Discussion - The data on the maximum width (W) of the Noble pen shell population displays a narrow range of sizes (16 – 27 cm) and low interquartile range (IQR) (Fig. 1).
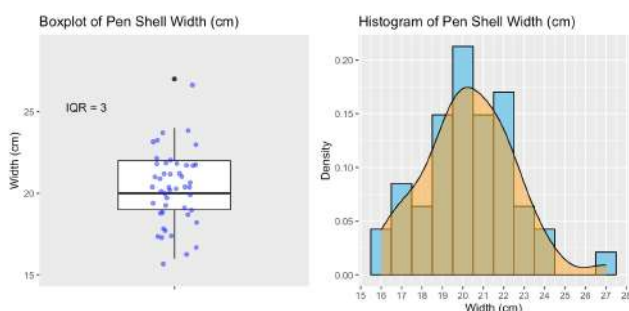

Fig. 1. Distribution of Nobel pen shell width (cm) observed in the dataset. The left panel shows a boxplot with jittered data points and the right panel presents a histogram with a density line for width measurements. The plots provide insights into the variability and central tendency of Nobel pen shell dimensions.

Subsequently, the data on total height (Ht) has a narrow range (54 – 71 cm + outlier 84 cm). For determining which method is the most appropriate for determining height based on width data for our population, five different predictive models [1,3,4,5,6] were evaluated, and an additional one was proposed. The population in Malo jezero lagoon best fits in correlation: Ht = 1.18W + 40.39. Compared to other models, our simple linear regression provides an accurate prediction of the overall height. Using Kruskal-Wallis and subsequent DSCF pairwise comparisons, we found no statistically significant difference between the measured data on Ht and our modeled data (p=0,999). Additionally, our proposed model had the lowest Mean Absolute Error (MAE), showing that the simplicity of the linear regression model indicates its effectiveness in describing the relationship between *P. nobilis* height and width for this population in Mljet MPA lagoon in 2018 (Table 1).

Tab. 1. Pairwise comparisons of Noble pen shell width (cm) across different models. The comparisons include W-statistics, p-values, and Mean Absolute Errors (MAE) for each comparison. The results provide insights into the differences between groups and the statistical significance of these differences.

Pairwise comparisons			W	p	MAE
Measured	-	Regression	-0,36	0,999	3,44
Measured	-	Ref [1]	-2,79	0,434	3,62
Measured	-	Ref [3]	-1,34	0,964	5,89
Measured	-	Ref [4]	-11,69	<.001	18,39
Measured	-	Ref [5]	-7,15	<.001	7,54
Measured	-	Ref [6]	-8,2	<.001	12,09

This finding has significant implications for the Noble pen shell population in Mljet MPA, offering a reliable method for estimating shell height when direct measurement is impractical. This research provides insight into the historical population structure. Understanding the population status of *P. nobilis* before the mass mortality event (MME) pushed the species to the brink of extinction could help predict future population structure.

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SUCCESSFUL REINTRODUCTION IN THE BRINK OF EXTINCTION?: LOOKING FOR OPTIMAL SITES FOR THE ENDEMIC AND CRITICALLY ENDANGERED SPECIES PINNA NOBILIS

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Abstract

The endemic bivalve *Pinna nobilis* from the Mediterranean Sea is on the brink of extinction since a Mortality Mass Event (MME) started in 2016, where *Haplosporidium pinnae* is one of the main agents involved in this MME. Thus, the identification of optimal sites to perform conservation actions has been carried out. In the Balearic Islands, twenty-eight locations have been proposed and analysed. The Cabrera National Park has been chosen based on *P. nobilis* populations information before the MME and preliminary results, based on environmental monitoring, have placed the focus on the Estany des Ponts, within the Albufera of Mallorca. This study, may suggest a new way to support and enhance the conservation status of the species.

Keywords: Mediterranean Sea, Bivalves, Endemism, Mollusca

The endemic Mediterranean filter-feeder *Pinna nobilis* (Linnaeus, 1758) is on the brink of extinction due to a Mortality Mass Event (MME) that began in Spanish waters in the fall of 2016 and has spread to the rest of the Mediterranean Sea [1]. The new endoparasite species *Haplosporidium pinnae* is one of the main agents involved in this MME although synergistic effects with other pathogens cannot be discarded [2]. Its populations have declined close to 100%, becoming locally extinct in some regions of the Mediterranean. Thus, is now protected as a critically endangered species [1,3].

In the frame of LIFE PINNARCA project, a consensus criterion has been achieved on the parameters for defining optimal sites for *P. nobilis* considering two different scenarios: optimal sites for *H. pinnae* resistant individuals (HPRI), and optimal sites for *H. pinnae* non resistant individuals (HPNRI), where the presence of a natural barrier against the pathogen allow the survival of HPNRI. Within the latter scenario, only two *P. nobilis* populations remain in spanish waters, the Ebro Delta and Mar Menor lagoon, which are considered "sanctuary areas". These "sanctuary areas" face many pressures and impacts affecting the resident *P. nobilis* populations (fishing, anchoring, water sports, agricultural discharges, etc.) [4].

Therefore, the general aim is to conserve the remaining natural sanctuary populations and find suitable places for breeding, thereby increasing the survival rates of *P. nobilis* individuals and improving the conservation status of the populations. Thus, the identification of new optimal sites to perform conservation actions plays a vital role to reach successful reintroductions / reinforcements / restoking in *P. nobilis* populations (fattening juveniles/breeding programmes).

In the Balearic Islands, twenty-eight locations were evaluated as possible optimal sites including both scenarios (23 for HPRI + 5 for HPNRI). Cabrera National Park has been chosen as an optimal site to host HPRI, based on previous information on *P. nobilis* populations before the MME.

Regarding HPNRI, five localities were proposed as possible new optimal sites based on environmental parameters: Estany des Peix and Estany Pudent (Formentera); Albufera des Grau (Menorca); Estany des Codols (Ibiza) and Albufera de Mallorca (Mallorca). Monthly environmental monitoring and measurement of other physicochemical parameters have been conducted and preliminary results have placed the focus on the Estany des Ponts, within the Albufera of Mallorca as a new pilot area to support pilot actions and enhance the conservation status of this species.

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FIRST REPORT OF THE PICORNAVIRUS OF *PINNA NOBILIS* (PNPV) AFFECTING THE POPULATION OF THE LAKE FARO (SOUTHERN ITALY*)*

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Abstract

Pinna nobilis L., 1758, is a unique bivalve species native of the Mediterranean Sea and it is currently facing threats to survival. Designated as a protected and endangered species since 1992 under the European Council Directive 92/43/EEC, *P. nobilis* has been increasingly at risk since 2016 due to mass mortality events (MMEs) causing local extinctions across the Mediterranean Sea. This research aims to assess the health state of *Pinna nobilis* population within the Capo Peloro natural reserve in Sicily (Southern Italy), by conducting seasonal health monitoring of local specimens during the 2023. This study reports for the first time the presence of PnPV (*Pinna nobilis* Picornavirus) in in the population of the Lake of Faro (Sicily, Italy).

Keywords: Biodiversity, Bivalves, Pathology, Mortality, Messina Strait

Since 2016, *P. nobilis* populations in the southwestern Mediterranean Sea have suffered mass mortality events (MME) due to several pathogens such as *Haplosporidium pinnae* and *Mycobacterium* sp. [1]. Recently, Carella et al. (2023b) identified the presence of a Picornavirus in animal population from Italy and Spain. The virus affects the Pen shell immune cells, leading to immunosuppression with consequent vulnerability to opportunistic infections. Over the last years, the *P. nobilis* population in the nature reserve from Capo Peloro Lagoon in Sicily (Southern Italy), has been extensively studied, and considered possibly resistant to the MME [3]. In the context of the LIFE PINNARCA (LIFE20 NAT/ES/001265) Project, the study aims to evaluate the health state of the natural population of *P. nobilis* in the marine reserve. The study was conducted in Lake Faro, located in in the Capo Peloro natural reserve (Southern Italy). Visual censuses were conducted from January 2023 over 9 sampling stations. Each station was monthly monitored by 3 operators, who identified, labelled, and sized *in situ* (outside the substrate) *P. nobilis* individuals. Haemolymph and biopsies of the mantle were taken with a non-destructive method as reported in the Italian Ministry Permission (Prot. MATTM 0016478 del 05/03/2020) and sent to the University of Naples Federico II for Transmission Electron Microscopy (TEM) and molecular analysis. The presence of PnPV, *Mycobacterium* sp. and *Haplosporidium pinnae* have been evaluated. During the visual census performed from January to June 2023, nine specimens of *P. nobilis* have been observed on a sandy or gravelly sediment rich in shell debris (**Fig.1**). Animal displayed different size with mean length of 40.5±8,54 cm and mean width of 16.88±4,03 cm, found at mean depth of 1.21±0,31 m.

Fig. 1. Health monitoring stations with position of *P. nobilis* specimens.

Animals were reactive, displaying promptness in closing the valves, appearing in good health state. During the following observations, *P. nobilis* specimens showed signs of illness represented by weakness in closing the valves. In October 2023 three specimens (labelled as n. 1, 2, 3) were found dead, while other 6 individuals (n. 4, 5, 6, 7, 8 and 9) died around the last census in January 2024. TEM and qPCR analysis revealed the presence of PnPV in the haemocytes of the Pen shell collected between January and June 2023 with Ct values

between 20-27. Melting curve analysis confirmed the presence of a single specific product (**Fig. 2**). Samples were sent to sequencing, giving 100% identity with the Picornavirus PnPV affecting species in Spain and Italy [2]. Other analysis about the presence of other pathogens is in progress. In 2021, 20 specimens of *P. nobilis* were reported in Lake Faro as in good health state [3].
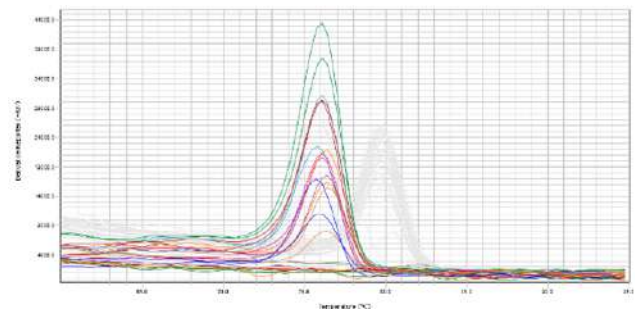
Fig. 2. Melting Curve confirming specificity of the amplicon obtained from the qPCR performed from the hemolymph samples of Sicily in 2023.

Although the local *P. nobilis* population was previously considered resistant to MME, the following year, in 2022 only few specimens remained alive, and mortality was attributed to the haplosporidian parasite *H. pinnae* following molecular investigations [3]. Our study conducted during the year 2023, report the death of the totality of the local individuals found, also recording the presence of a Picornavirus for the first time in the area. Animals affected by PnPV can maintain persistent infections until the disease becomes chronic, weakening them, and susceptible to opportunistic infections, as also reported in other immunosuppressive viruses (Carella et al., 2023b). This can explain the apparent resistance of the residual individuals during the years, that instead were slowly dying.

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IMPACT OF MASS MORTALITY EVENTS ON THE GENETIC DIVERSITY OF THE CRITICALLY ENDANGERED SPECIES *PINNA NOBILIS*

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Abstract

Pinna nobilis, an endemic Mediterranean species that has experienced recurrent mass mortality events (MMEs) since 2016, is now critically endangered. Assessing the impact of the MMEs on the genetic diversity levels of the species is crucial for its recovery. This study compares the genetic diversity of a remnant isolated population located in the Mar Menor coastal lagoon with the now, extinct population located in Cabrera National Park (CNP). Using 19 microsatellites, we analyzed the genetic structure and compared genotypic data of 284 Mar Menor and 771 CNP *P. nobilis* individuals. Results indicated the Mar Menor's crucial role as a genetic reservoir, retaining over 80% of the species' genetic variation.

Keywords: Conservation, Mediterranean Sea, Genetics, Bivalves

Understanding the genetic make-up and health of endangered populations is vital for their conservation. Maintaining high levels of genetic diversity is essential for species adaptation to environmental changes, resistance to diseases, and overall population resilience[1]. Therefore, knowledge of the level and the distribution of genetic diversity within and between populations of a given species is necessary in order to design conservation strategies. In the case of *P. nobilis*, the MMEs suffered by the species have highlighted the need to determine the impact of populations reductions, fragmentations and isolations on the genetic conservation status of the species. Here, we compare genotypic data from two unique populations, one located in the Mar Menor coastal lagoon, which currently acts as a potential reservoir for the species as one of the few populations remaining alive, and another that was located in the CNP and it is considered as a key extinct population. Specifically, we seek to (i) compare the genetic diversity levels between them, and (ii) to determine what was the genetic differentiation of the populations.

Different analytical methods were used to study the genetic diversity and population structure of *P. nobilis* in Mar Menor and Cabrera National Park. Results from Mar Menor showed genetic diversity values comparable to other populations. Moreover, contrary to expectations, and considering the magnitude of the MMEs and the great isolation of Mar Menor population, we did not find any significant genetic differentiation between these two populations (Fst = 0.0005, p.value > 00.5). In fact, the genetic variation observed in Mar Menor is encapsulated within the greater diversity observed in the CNP, indicating a subsample of the species' CNP genetic diversity (Figure 1).

In terms of genetic diversity level, the Mar Menor *P. nobilis* population displayed lower private allele diversity (20%) (Figure 2). This outcome aligns with expectations, as low-frequency alleles (freq. < 0.005), like most of those identified, are typically the first to be impacted and diminish following a substantial population reduction [4]. In any case, despite the severe decline suffered by the species [2-3], it still retains around 80% of CNP's species diversity and harbours 16 private alleles from unknown populations. This highlights Mar Menor's crucial role as a genetic reservoir, retaining over 80% of the species' genetic variation.
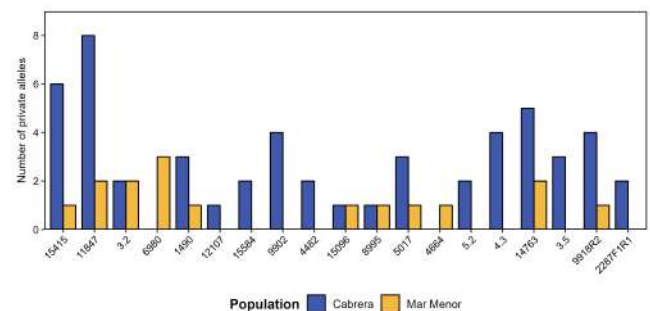
Fig. 2. Number of private alleles per locus in both sampled populations, Mar Menor (n = 16) and Cabrera National Park (n = 53).

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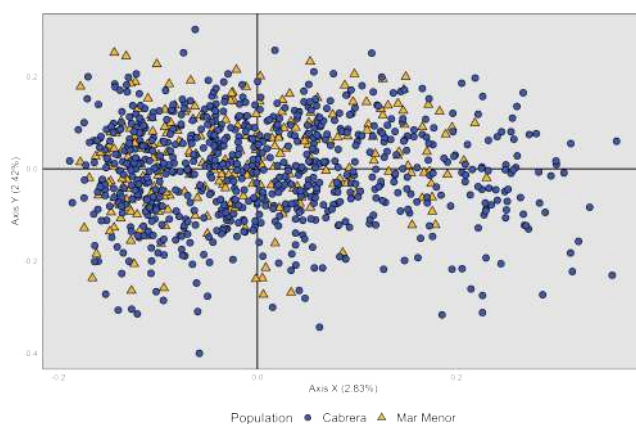
Fig. 1. Principal component analysis on the 1055 individuals from Mar Menor (n = 284) and Cabrera National Park (n = 771).

THE LAST STRONGHOLD IN THE ADRIATIC: DISTRIBUTION AND STATUS OF *PINNA NOBILIS* IN THE VENICE LAGOON

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Abstract

The present work describes the status of a significant surviving population of the endemic Mediterranean bivalve *Pinna nobilis* in the Lagoon of Venice in the wake of the ongoing epidemic. Results of monitoring activities in the period 2020-2024 are presented.

Keywords: North Adriatic Sea, Lagoons, Bivalves, Mortality, Monitoring

Since 2016 an epidemic has affected the Mediterranean endemic fan mussel *Pinna nobilis* (L. 1758), causing Mass Mortality Events (MMEs) with mortality rates up to 100% and a drastic decline of populations all over the species range [1]. The disease has been associated with the protozoan parasite *Haplosporidium pinnae* [2]. However, the underlying dynamics has not yet been fully clarified, and might also involve picornavirus infection causing immunosuppression [3]. The Lagoon of Venice (NW Adriatic, Italy) is one of the largest coastal transitional ecosystems (CTEs) in the Mediterranean, covering about 550 km^2, with a complex mosaic of intertidal and subtidal habitats. The overall distribution of *Pinna nobilis* in the Lagoon has been mapped through a citizen science initiative, called "Mappa La Pinna", based on a collaborative platform launched in 2020 by CNR-ISMAR, followed by on-field validation, as well as other exploratory surveys. The distribution was found to span about 60 km^2 of subtidal flats in the open lagoon, mostly overlapping with seagrass meadows distribution. Pre-epidemics density was very high, reaching in some areas values higher than 1•m^{-2}. In October 2020, the first signs of a MME were observed in the Venice lagoon. The mortality trend was thereafter monitored by monthly samplings at a study area on a subtidal flat (about 1.5 m below m.s.l.) located near Ottagono Alberoni island, in the Central Lagoon. Both alive and dead *Pinna nobilis* specimens were preliminarily mapped by underwater photogrammetric surveys on three replicates of about 120 m^2 each, with a total of 417 individuals counted (mean overall density 1.1•m^{-2}). The produced high-detailed maps allowed divers to check the status of each specimen monthly until February 2024, even in high turbidity conditions, without the need to mark them.

Results of monthly monitoring in the study area are sinthetically presented in fig. 1. The rise in mortality lasted for several months up to around 80%. After almost two years of stasis, a new wave of deaths was observed in summer 2023, which caused a significant further decline in the population. Although significant extreme values were recorded during the summer months, temperature alone does not seem to explain the observed trend. In the study area, density dropped roughly to 1.7% of the pre-epidemic's density. However, other areas of the Lagoon seem characterized by a slightly lower mortality, and consequently higher density of living specimens. Juveniles and young individuals seem to present a lower mortality rate. Spawning or recruitment has been recorded in all the years of activities. Due to pre-epidemics wide distribution and extremely high density, despite the low percentage of survival, the Venice lagoon still likely hosts one of the largest extant population of *Pinna nobilis*, which can be roughly estimated in the order of magnitude of 10^5. Moreover, the delayed dynamics of the infection in the lagoon have guaranteed a significant reproductive population for two years more than in the surrounding marine waters, which could have allowed recruitment in the northern Adriatic basin, due to larval dispersal by tides and marine currents. In addition to being a refugium to relic populations, CTEs may have a role as source of propagules, as well as potential donor sites for transplanting of adult individuals. At the same time, these ecosystems are very vulnerable to several threats, such as climate change, anoxic events, alien species, etc. It is therefore necessary to identify and monitor CTEs hosting relic *Pinna nobilis* populations, acknowledge their role, develop, and implement specific management policies and conservation strategies, within a larger framework and trans-boundary scale.
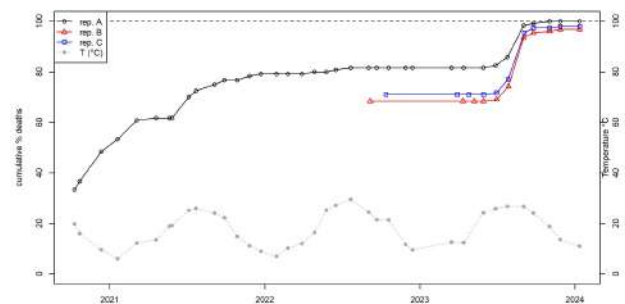
Fig. 1. Cumulative percentage of observed deaths in the study area, three replicates (monitoring of replicates B and C started in autumn 2022); water temperature recorded in the area during monitoring is also presented.

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IMPORTANCE OF DEAD FAN MUSSEL (*PINNA NOBILIS*) SHELLS FOR FISH COMMUNITY

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Abstract

The fan mussel (*Pinna nobilis*) is an important habitat builder whose shells are increasingly disappearing in the environment. In the present study, we investigated the fish fauna associated with fan mussel shells in the northern Adriatic Sea. The results showed that the presence of fan mussels in the environment has a positive effect on fish density and diversity. Fan mussels have proven to be an important element in the environment, as many fish species use their shells as cover, hiding and nesting places. The disappearance of the shells after the death of the specimens could have a negative impact on the fish species associated with these shells in the near future, which could lead to a change in the fish fauna in certain areas.

Keywords: Fishes, Bivalves, Adriatic Sea

Introduction - The fan mussel (*Pinna nobilis* Linnaeus, 1758) is the largest mussel in the Mediterranean Sea, whose shells can reach a length of up to 120 cm (1). It is found at depths between 0.5 and 60 m on sediment bottom, mostly in seagrass meadows (1, 2). The species is considered an important habitat builder, as its shells form a hard substrate in soft-bottom areas, which increases habitat variability and provides a surface that can be colonised by many benthic organisms (3). Nowadays, the fan mussel is critically endangered as specimens are dying out throughout the Mediterranean Sea (4). Consequently, the shells, which continue to fulfil an ecological function after the death of the animals, are slowly disappearing from the environment. The aim of this study is to investigate the importance of fan mussel shells for the fish fauna and to determine how the absence of these shells might affect the fish community of the sediment bottom.

Material and methods - The study was conducted in the Gulf of Trieste in the northern Adriatic Sea from August 2022 to October 2023. It was carried out at different sites from 1 to about 10 m depth in the habitat of *P. nobilis* on the sediment bottom (Fig. 1). A total of 142 quadrats (of which 43 quadrats contained *P. nobilis* shells) of 50 cm x 50 cm were sampled using a fish anaesthetic (Quinaldine).

Results - Fish specimens were found in 47.9 % of the quadrats, with a total of 106 fish specimens of 17 fish species recorded. The density of fish in the samples with shell was 3.5 individuals/m^2 and in the samples without shell 2.7 individuals/m^2. Four species (*Parablennius gattorugine, Serranus scriba, Gobius cruentatus, Seranus hepatus*) were only found in the quadrats with shell. There were statistical differences between quadrats with and without shells (Permanova, *p*-<0.05), with the most representative species in the quadrats without shells being *Pomatoschistus bathi* and *Callionymus risso*, while in the quadrats with shells the most representative species were *Gobius fallax, Millerigobius macrocephalus* and *Parablennius tentacularis* (SIMPER analysis). These 5 species explain 61 % of the dissimilarity between the quadrats with and without shells.

Discussion - Fan mussel shells, whose specimens have the highest densities in the Gulf of Trieste (5), have proven to be very important habitat providers for various fish species. Some species typical of sedimentary bottoms and seagrass beds, such as *Gobius niger* and *P. tentacularis*, nest in them during the breeding season or retreat into them in case of danger, while the nectobenthic *S. scriba* and *S. hepatus* linger and hide in the shelter of the standing shells. The shells of the fan mussels also provide shelter for species that mainly live on rocky bottoms (e.g. *G. fallax*), but can also be found on the sediment bottom and in seagrass meadows due to the presence of shells. Oysters, which are often found on the shells of fan mussels, provide additional nesting and hiding sites, especially for smaller species such as *Apletodon incognitus*, which only occur in these microhabitats (6). The fan mussel therefore has a positive effect on fish diversity and density in the environment. It is therefore important to understand and monitor the impact of fan mussel shells on fish communities, especially as fan mussels and their shells, are disappearing, which could have serious consequences, especially for species that depend on their shells.
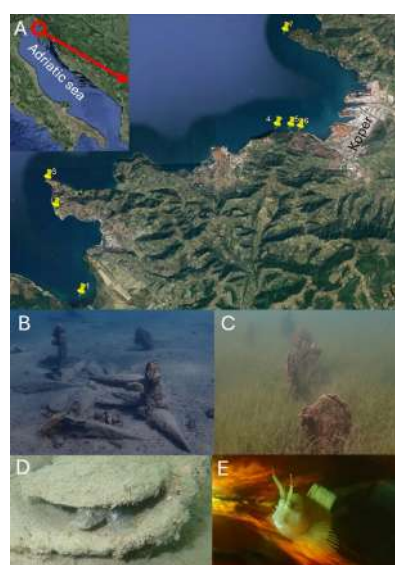
Fig. 1. Sampling sites in the Slovenian part of the Gulf of Trieste (A). Shells of *Pinna nobilis* increase habitat variability on the sediment bottom (B) and in seagrass meadows (C), where they provide hiding and nesting sites for various species such as *Gobius niger* (D) and *Parablennius tentacularis* (E).

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Congress Joint Session : Climate Change Impacts (all committees)

Moderator : Paolo Galli – Univ. of Milano-Bicocca, Italy

Session's Synthesis

The "Climate Change Impacts" session provided valuable insights into how climate change is affecting marine ecosystems and human activities such as fishing and port management.

One of the key topics was the integration of climate variability into fisheries management, particularly for Mediterranean albacore tuna. Researchers developed models that incorporate climate-driven habitat changes, improving fisheries advice and stock assessments.

Another significant discussion centered on the northward shift of *Parapenaeus longirostris* (red prawn) in the western Mediterranean, driven by rising sea temperatures. This highlights how climate change is altering species distribution and needs to be considered in fisheries management.

The interaction between marine heatwaves (MHWs) and Mediterranean cyclones (medicanes) also emerged as a critical area of study. The research showed that MHWs can intensify cyclones, while the strength of the cyclones can reduce or eliminate MHWs, emphasizing the complexity of climate events.

The vulnerability of marine species like *Lepas anatifera* to rising sea temperatures was another key finding. The study showed significant population declines linked to marine heatwaves, underscoring the need for proactive conservation measures.

Lastly, climate impacts on human infrastructure were addressed, with a study on Greek ports proposing a framework to assess and mitigate the effects of climate change on coastal areas.

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CLIMATE INFORMED FISHERIES ASSESSMENT, A STUDY CASE FOR THE MEDITERRANEAN ALBACORE IN THE FRAMEWORK OF THE MEDITERRANEAN TUNA HABITAT OBSERVATORY

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Abstract

The fisheries of the Mediterranean albacore tuna (*Thunnus alalunga*) are managed by ICCAT, which is seeking innovative ways to integrate climate variability into fisheries advice. We propose that integrating climate-driven habitat changes in catch standardization, and using population models adaptable to environmental data, provide paths for climate-informed fisheries assessment. To show the potential of this proposal we develop an albacore larval abundance index standardized to spatio-temporal changes of habitat distribution in the Western Mediterranean. Then, we integrate temperature variability into the stock recruitment of a population simulation using FLR. Results indicate improved fisheries advice with environmental indicators tailored for albacore

Keywords: Fisheries, Global change, Habitat, Balearic Islands, Population Dynamics

Introduction - The regional fisheries management organizations are currently confronted with a significant challenge: integrating climate variability into the process of fisheries scientific advice. One promising approach to progress in this regard is to incorporate climate variability indicators at various steps of the fisheries assessment process. Two potential strategies to achieve this objective include: i) Improving indices of abundance considering changes in the spatio-temporal distribution of fish stocks. ii) Providing fisheries models with the flexibility to adapt population parameters (such as stock-recruitment relationships) to time series of ecologically meaningful environmental variability indicators. By adopting these approaches, fisheries management organizations can better address the complex interplay between climate variability and fisheries dynamics, thus improving the accuracy and effectiveness of their scientific advice. This exercise responds to the objectives of the Mediterranean Tuna Habitat Observatory, an initiative to monitor climate effects on Mediterranean tunas and to propel climate informed fisheries assessment.

Methods - We studied the Mediterranean stock of Albacore tuna in the Western Mediterranean. First, we assess how the larval abundance index used in the fisheries assessments of the ICCAT scientific working group [1] is sensitive to climate-induced spatio-temporal changes in larval habitat distribution. Secondly, we explore the possibility of reducing the uncertainty of a fisheries population model by providing the model with flexibility to adjust the stock-recruitment relationships annually as a function of the temperature in the albacore spawning ground during the reproduction and larval developmental season. The larval abundance index, expressing captures per unit area (CPUA) [2], has been developed with time series of ichthyoplankton surveys in a recognized albacore tuna Western Mediterranean Spawning ground [3] using a delta-log normal general additive model, where the presence probability is informed by oceanographic information on salinity and temperature in the mixed layer depth (MLD). These two environmental variables are highly dynamic and dependent on climate forcing. The fisheries assessment model has been developed with the "Fisheries Library in R" (https://flr-project.org/). Input abundance indices of fisheries catches for the Mediterranean between years 2000 and 2016 were obtained from ICCAT albacore assessment reports [1]. Three models were compared by their AIC and BIC: M1) a model where temperatures were included as informative in the Ricker productivity parameter, M2) a model with a random time series of values (with the same ranges of SST) included as informative in the Ricker productivity parameter, and M3) a model with no temperature information included (the recruitment model is fitted as Factor (year)). Models M2 and M3 are computed as null models to provide a reference for the improvement of the M1 model.

Results - Standardization of larval CPUA: Salinity and temperature in the MLD are significant in the larval standardization model ($p<=0.001$). The response functions (Fig1) show that higher temperatures, associated with the day of sampling and lower salinities of the recent Atlantic waters determine higher catch probability. The non-consideration of these variables in the larval index model would cause interannual variability to be affected by changes in timing and habitat distribution of the sampling.
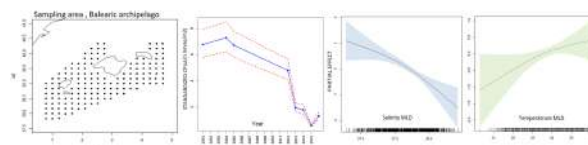
Fig. 1. Sampling area; Larval abundance index;response function of the salinity and temperature in the mixed layer depth(MLD)

Reducing uncertainty of the fisheries assessment model: The three models provided different levels of Spawning Stock Biomass (Fig 2). The performance indicators (the lower the better) for the three models were; **M1:**AIC=452,BIC=618; **M2:** AIC=472, BIC=638; **M3:**AIC=482,BIC=639.The model with informative temperatures (M1) performed better than the two reference models M2 and M3, providing a more robust assessment on population status
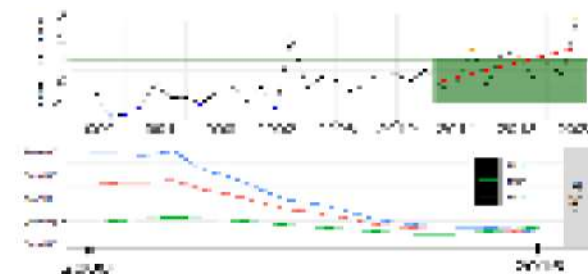
Fig. 2. Temperature anomalies in the study area (June:July) and Spawning stock Biomass from FLR models M1,M2 and M3

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WARMING PROMOTES EXPANSION OF A KEY DEMERSAL FISHING RESOURCE OF THE WESTERN MEDITERRANEAN

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Abstract

Information on the distribution and habitat preferences of species of ecological and commercial importance is essential for their assessment and management. This is especially relevant within the current context of climate change. We have developed Generalized Additive Models (GAM) to model the spatial distribution of *P. longirostris* (*Parapenaeus longirostris*) along the western Mediterranean during the period 2001-2020, in relation to topographic, environmental and temporal variables. The results showed that bathymetry and sea bottom temperature were the most relevant predictors of the distribution and abundance. Predictive maps suggest that during the last two decades the P. longirostris is increasing its distribution area northwards along the north-western Mediterranean, as response to global warming.

Keywords: Fisheries, Demersal, Habitat, Marine policy, Western Mediterranea

The climate change can modify the structure and function of the marine environment, habitats and ecosystems. The *P. longirostris* is a fast-growing demersal species, with a thermophilic preference [3]. In this study we analyze data on the density of this species combining them with oceanographic data for understand the habitat preferences and spatial ecology of *P. longirostris* and spatio-temporal changes in its distribution. Data from the of program MEDITS has been used. Data on standardized abundance of *P. longirostris* were compiled during the period 2001-2020 for GSA 1 (Northern Alboran Sea), GSA 2 (Alboran Island), GSA 5 (Balearic Islands) and GSA 6 (Northern Spain). Nine environmental variables considered as potential predictors were selected. GAM were used to construct a two-part model, consisting of a binomial model and an abundance model. The best model was selected based on AIC, UBRE and the explained deviance. The results showed that bathymetry and SBT were the main drivers of *P. longirostris* presence and abundance. Predictive maps indicate changes in the abundance and distribution of *P. longirostris*, with an increasing northward gradient along the northwestern Mediterranean (Fig. 1), mainly due to the increase in Sea Bottom Temperature (Fig. 2).
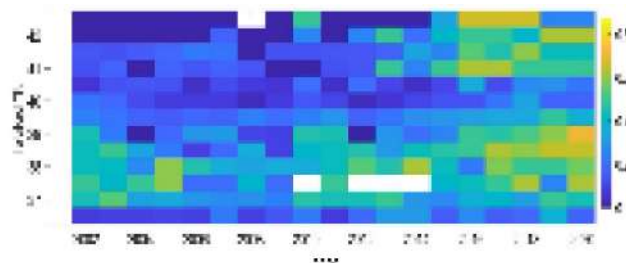
Fig. 2. Graph showing the increasing trend in the Sea Bottom Temperature (ºC) at 200 m depth during the last decade (>37ºN latitude).

These results are corroborated by other authors who point out the preference of this species for warmer waters increasing its abundance and distribution in Iberian Peninsula [2], Ionian Sea [3], Ligurian and Tyrrhenian seas [1].

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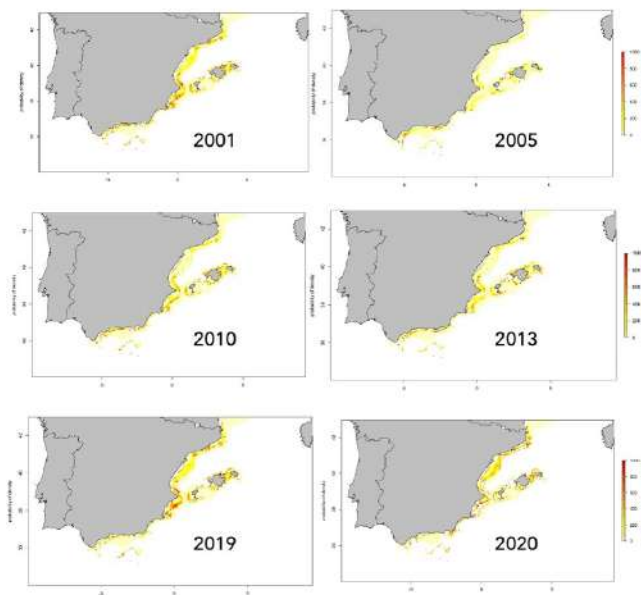
Fig. 1. Prediction map of the probability of density of the *P. longirostris* in period: 2001 and 2005, -2010 and 2013 and 2019 and 2020.

INVESTIGATING THE INTERACTION BETWEEN MEDITERRANEAN EXTREMES - A DEEP DIVE INTO MEDICANE ZORBAS 2018

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Abstract

In our study, we explore the interaction between marine heatwaves (MHWs) and tropical-like cyclones (medicanes) in the Mediterranean Sea. We have found that these events influence each other: warm sea surface temperatures (SSTs) during MHWs can enhance the intensification of cyclones, leading to higher wind speeds, lower mean sea level pressure (MSLP) and more precipitation. Conversely, depending on the strength of the medicane, it can weaken or completely eliminate MHWs. Although our findings are based on the analysis of 15 events from 2011 to 2023, they provide valuable insights into the interaction between these two extreme events.

Introduction

The Mediterranean Sea, a semi-enclosed basin, has experienced rapid warming in the recent decades that has resulted in both marine heatwaves (MHWs) and Mediterranean hurricanes (medicanes) [1,2]. MHWs are prolonged episodes of anomalously high temperatures that disrupt marine ecosystems and contribute to the intensification of storms [3,4]. Medicanes are rare cyclonic systems with tropical-like characteristics that bring heavy rainfall and strong winds, causing coastal flooding, infrastructure damage, economic disruption and threats to human safety [2]. In this work, we aim to investigate the interaction between MHWs and medicanes that occurred between 20211 and 2023.

Data and Methods

For this study, we used daily satellite-derived sea surface temperature (SST; OSTIA product) and modeled mixed layer depth (MLD) and potential temperature (NEMO model output), both from CMEMS. The atmospheric variables and heat flux components are from the ECMWF ERA5 reanalysis. Using the standard MHW definition from [1], we determined MHWs from 2011 to 2023 using a 30-year climatology from 1993 to 2022. We selected 15 Medicane events from the literature during the study period. The coincidence of a MHW and medicane was determined based on the proximity of the storm tracks to the MHW areas, as described in [5]. The medicane events were then categorized into two groups (with or without MHW) and the composite mean and standard error for the main atmospheric variables were calculated to compare these groups 5 days before to 4 days after the storm lifetime maximum intensity (LMI).

Results and discussion

Of the 15 selected events, 5 originated in the western Mediterranean (WMED), 8 formed over the central basin (CMED) and 2 in the eastern basin (EMED). This is agrees with other studies highlighting WMED and CMED basins as hotspots for Mediterranean cyclogenesis. Ten of these medicanes coincided with MHWs. During the intensification phase 2 days before the LMI, these had on average a lower MSLP and higher wind speeds and precipitation than the medicanes without MHWs (Fig. 1). Our results are consistent with those of [5].
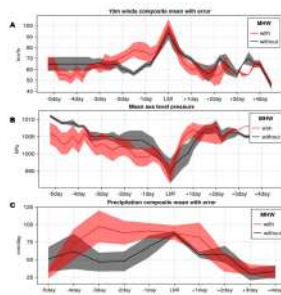
Fig. 1. Composite mean and standard error of wind speed (A), MSLP (B) and precipitation rete (C) for the medicanes with or without MHW for 5 days before and 4 days after the storm lifetime maximum intensity (LMI).

On the other hand, we found that the medicanes also affect the intensity and vertical extend of MHWs. We found three categories of impacts based on the storm intensity and the amount of latent heat flux (LHF) released from the ocean to the atmosphere. The first category is characterized by a slight reduction in MHW intensity and vertical extent with an average LHF < 50 W/m² (e.g. Xandra 2014 and Scott 2019), the second by a stronger and more extensive reduction in MHW intensity and vertical extent as in the case of Rolf 2011 and Trixie 2016, which were associated with an average LHF between 50 and 100 W/m², and the third category by the complete termination of the MHW event as in the case of Zorbas 2018 and Ianos 2020 with an average LHF > 150 W/m².
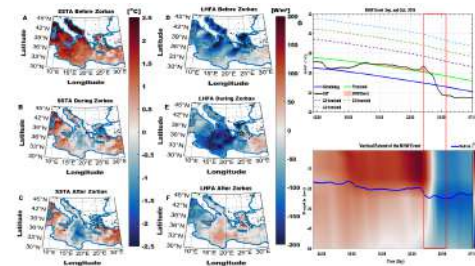
Fig. 2. The SSTA and LHFA before, during and after Zorbas (A-F), and (G) is the temporal (top) and vertical structure (bottom) of the MHW event that began before Zorbas.

During the passage of Zorbas, the SST anomaly decreased from +2.5°C one day before the storm to ~-2.0°C one day after, corresponding to a temperature cooling of ~4.5°C (Fig. 2). During Zorbas, the MLD deepened by about 7 meters, indicating mixing in the water column. In combination with the heat loss (> 200 W/m²) to the atmosphere, this mixing contributed to the cooling of water temperatures and the end of the MHW event (Fig. 2). These results are in well agreement with those of [6].

Conclusion

The interaction between exterme events can amplify their impacts. Our research reveals that although medicanes occur mainly in fall and winter, they often coincide with MHWs. Both MHWs and medicanes influence each other. Medicanes that occurred alongside MHWs exhibited higher wind speeds, lower MSLPs and higher precipitation rates. In addition, medicanes can weaken MHWs by reducing their intensity and vertical structure.

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UNDERSTANDING THE INFLUENCE OF MARINE HEAT WAVES ON THE ABUNDANCE OF *LEPAS ANATIFERA* IN THE BALEARIC SEA

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Abstract

Lepas anatifera, a widely distributed epipelagic cirriped crustacean with remarkable attachment abilities, experienced a notable population decline in the Balearic Sea between 2021 and 2022, coinciding with a marked increase in Sea Surface Temperature (SST) and marine heat waves (MHWs) episodes. Laboratory experiments, mirroring observed SSTs, revealed a concerning 50% mortality rate and significant oxidative stress damage in *L. anatifera*, underscoring its susceptibility to warming temperatures and MHWs compared to other environmental factors. Understanding these stressors is crucial for predicting and mitigating future declines in *L. anatifera* and similar species, urging proactive conservation efforts.

Keywords: Balearic Islands, Crustacea, Warming, Surface waters, Stressors

Introduction

Lepas anatifera (Linnaeus, 1758) is a marine pedunculate cirriped crustacean of the family *Lepadidae*. It is an epipelagic drifter with a wide oceanic distribution under different temperature ranges, although with some preferences and limitations [1]. Between 2021 and 2022, a marked decline in its population was observed in the Balearic Sea, prompting research into the determinants of this occurrence. In 2022, mean maximum SST values were notably higher compared to the previous year (+ 1.93 ºC in spring; + 1.55 ºC in summer), coupled with strong MHWs episodes. As a record average, the Balearic Sea reached 29 ºC on august (Fig. 1) [2,3].
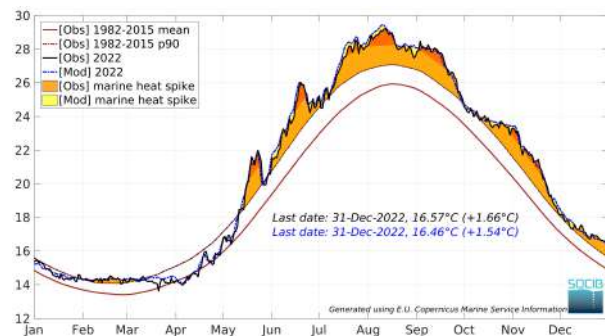

Fig. 1. Daily Sea Surface Temperature (ºC) in the Balearic Sea over 2022 and compared to the previous year and average historical records [2,3]

Material and Methods

To assess whether heat played a detrimental role for *L. anatifera*, a group of individuals collected in S'Estalella (south of Mallorca) was exposed to a water temperature of 32 ºC for 72 hours, while a control group was kept at 27 ºC (temperature of the Balearic Sea when collected). Oxidative stress markers, including catalase (CAT), superoxide dismutase (SOD), and malondialdehyde (MDA), were quantified using established procedures [4]. Finally, ANOVA and Tukey HSD tests were used to compare results between experimental groups.

Results and Discussion

At 32 ºC, only 50% of individuals survived, showing stress signs (barely moving and overextended cirri). High temperatures led to significant increases in SOD and CAT activities (Fig. 2) ($p < 0.05$) by 66% and 53% respectively. Enzyme activities contained significant lipid damage (MDA), although an increase of 48% was also recorded. This is a striking heat susceptibility of *L. anatifera* that contrasts with its remarkable resistance to other environmental variables demonstrated in previous tests. Such findings raise concerns about the warming trend and MHWs episodes in the Mediterranean Sea [5]. In addition to observed mortality and oxidative damage, temperatures above 28 °C can also reduce attachment abilities in other barnacles [6]. This places heat as a major stressor for *L. anatifera* and similar species, and may explain the population decline observed in 2022.
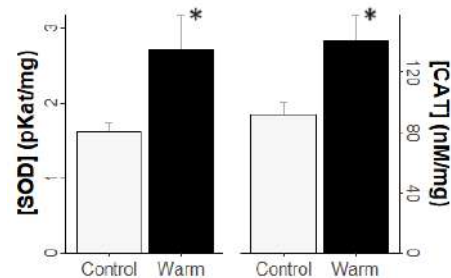
Fig. 2. Enzyme activities (SOD and CAT) in *L. anatifera* after 72h exposure to control temperature, 27ºC and to warm water, 32ºC. Significance: *<0.05.

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PILOT APPLICATION OF CLIMATE ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT IN GREEK PORT AREAS

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Abstract

Ports are crucial economic hubs developed in coastal zone, the presence of which both influence and is influenced by coastal physical forcings. Climate Change is expected to further intensify impacts on port itself as well as on the adjacent coastal areas. This study presents the application of a methodological framework for tackling and mitigating climatic forcing on Greek port coastal areas.

Keywords: Coastal management, Aegean Sea

Introduction

Ports are critical coastal infrastructures located in low coasts and/or deltaic areas the design of which has frequently resulted in erosional processes in the adjacent areas. Furthermore, their location constitutes port areas particularly exposed to the impacts of Climate Change which is expected to pose additional challenges in physical setting (eg. inundation) (Monioudi et al., 2018). As many port infrastructures have been constructed for a different climate regime and considering their essential character as a blue economy sector, addressing their climatic vulnerability becomes a major priority (ESPO, 2023) as part of sustainable development and a matter of strategic economic importance (UNCTAD, 2020).The scope of this study is to introduce an integrated environmental impact assessment framework and a coherent response plan to mitigate climate change impacts on coastal port areas.

Methodology

A research methodology for the climate Port Risk Assessment in Heraklion and Volos ports, located in the Aegean Sea, in Greece, is applied. The approach investigates the potential for climate Hazards and subsequent impacts to result in damages on ports' infrastructures (infrastructure risk) and their adjacent coastal area. Risk Assessment is expressed as a function of: (i) Hazard (H), (ii) Vulnerability (V) (sensitivity and adaptive capacity) and (iii) Exposure (E) (IPCC, 2022) and is, followingly, mitigated through Response (R) actions (Figure 1). Hazard refers to the projections of climatic factors i.e. mean sea level rise, winds, waves and associated increased frequency and intensity of ESLs, that pose serious threats to the selected case studies ports areas. Extreme coastal flooding is driven by Extreme Sea Levels (ESLs), estimated as the sum of the mean sea level (MSL), the astronomical tide, and the episodic coastal water level rise due to storm surges (SSL) and wave setups. Considering the lifetime of port infrastructure (~30 years) the extreme short term SSP 8.5 scenario for 2050 of the latest IPCC (2021) report is applied. The propensity or susceptibility of each port area to be adversely affected is considered at the Vulnerability Factor, via a series of indicators (natural or artificial). The assessment is based on both soft adaptation capacity or sensitivity assessment including geomorphological/ physical characteristics (bathymetry, terrestrial morphology), river presence in the vicinity, hydrodynamic conditions and hard adaptation capacity or artificial defenses (coastal defense structures) considering -also- the viability (age) of the infrastructures. Port exposure analysis identifies the extent that port assets (population, services, infrastructure, hinterland, transport facilities) are exposed and may be adversely affected by climate risk.

Results and Discussion

The application develops a comprehensive methodological framework for the identification of the climate change risks for ports infrastructures and surrounding coastal area. Based on the assessed risks and impacts, the study results in a set of proposed adaptation responses (regulation, management, and technical measures) for each port under investigation, considering their vulnerabilities and exposures toward each outlined potential hazard.

Acknowledgements
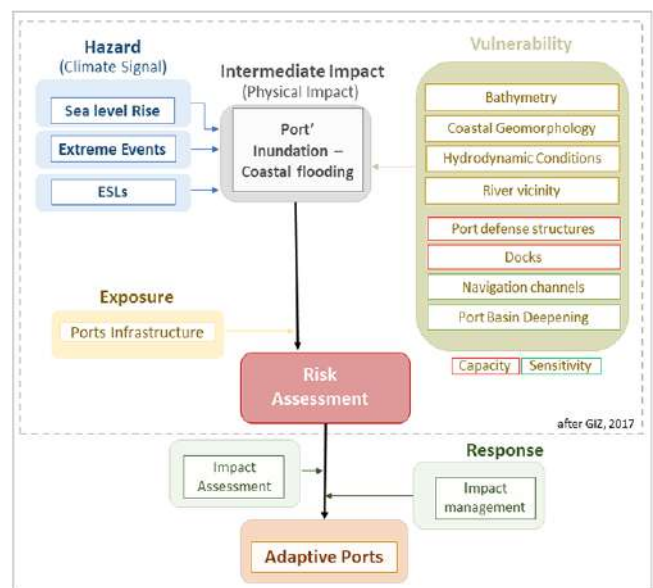
Fig. 1. Methodological framework

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THE IMPACT OF STORM MINERVA ON THE UPPER LAYER OF THE MEDITERRANEAN SEA

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Abstract

The low-pressure system named Minerva by the Italian weather service Meteo Aeronautica Militare, brought heavy rainfall and strong winds to Italy and neighbouring countries in May 2023, causing widespread damage and tragic loss of life. During the event, the Tyrrhenian Sea the Sicily Channel and the Ionian Sea was monitored by autonomous instruments (Argo floats; Figure 1), as well as satellite and model products. In this work we use these data to investigate the physical and biogeochemical responses of the oceans to the impact of Minerva storm.

Keywords: Air-sea interactions, Currents, Circulation, Eastern Mediterranean, Western Mediterranea

Severe weather systems are important components of the global atmospheric circulation and play a fundamental role in shaping the water budget, the location and the magnitude of extreme events [1]. The Mediterranean region is one of the areas where severe weather system activity is more frequent [2]. Nowadays, these systems are studied with increasing interest, as they can have potentially damaging natural and socioeconomic consequences. Recent simulations projected a decrease in their frequency in the future, but also an increase in their intensity and duration [2]. Weather systems intensification and predictability are strictly linked to the preexisting upper-ocean conditions [3]. Satellite data are an important source of information but have some limitations. Modelled data reconstruct the 3D physical and biogeochemical variables during the passage of severe weather systems, but they can be affected by large uncertainties. In this context, autonomous instruments allow us to study the effect of cyclones in real-time and provide critical in-situ measurements at and beneath the ocean surface useful to initialize numerical weather prediction models [3,4,5]. In this work, we combined autonomous oceanographic instruments with satellite and model products to describe the impacts of the extreme weather system Minerva on the upper layer of the Mediterranean Sea.
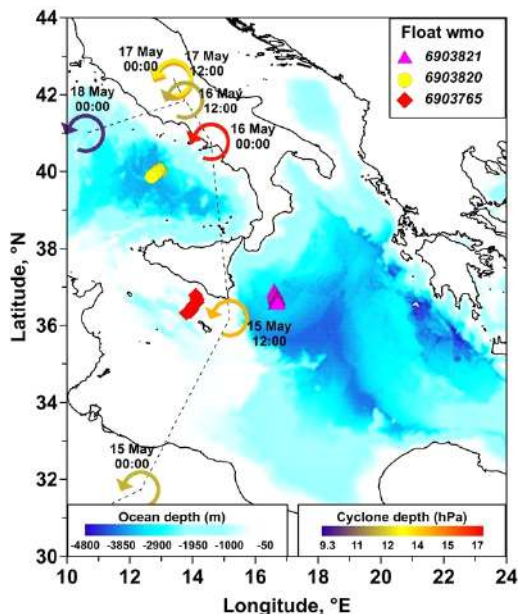

Fig. 1. Argo float positions (colored symbols) and track of the Minerva Storm (black dashed line) superimposed on the geography and bathymetry of the Mediterranean Sea (sea bottom depth in blue shade). Circular arrows indicate the daily position of the Minerva Storm from 15 May 2023 00:00 UTC to 18 May 2023 00.00 UTC; arrows are colored by cyclone depth.
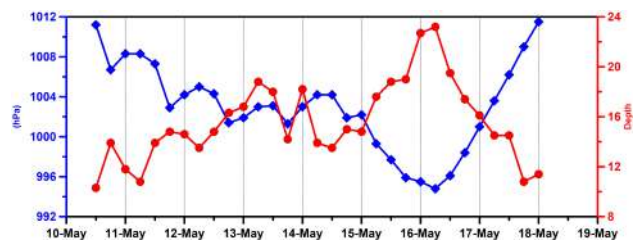
Fig. 2. MSLP (red) and cyclonic depth (blue) derived from ERA5.

The trajectory of the storm Minerva was reconstructed by applying an objective procedure [5] based on searching the minimum in the 6-hourly 0.25º ERA5 Mean Sea Level Pressure (MSLP) fields (Figure 2). Minerva storm showed its largest intensity on May 15th-16th, exhibiting the maximum cyclone depth (defined as a cyclone intensity metric that takes into account both the MSLP at the centre of the system and in the surrounding area) and the lowest MSLP (Figures 1 and 2). The low pressure centre is located on the Sicily Channel and Ionian Sea on May 15th and over the central Italy on May 16th. The upper ocean response typically consists of the sea surface cooling and subsurface warming ("heat pump" effect), driven by a combination of different physical processes. This effect can be more or less pronounced depending on the oceanic conditions that the storm encounters on its path. The Argo float which was located in an anticyclonic meander of the Ionian Sea (Figure 1; magenta square), was affected by a sharp drop in temperature in the upper layer and a warming of the subsurface that propagated to a depth of 150 m due to a combination of mixing and downwelling in its interior. The Argo float which was located in a cyclonic vortex of the Sicily Channel (Figure 1; red diamond), was characterised by mixing and upwelling in its interior. The subsurface warming was reduced in intensity and stored in a thin layer (between 30 m and 40 m depth) compared to the anticyclonic condition. The Argo float which was located in an anticyclonic vortex of the Tyrrhenian Sea (Figure 1; yellow dot), showed a stronger heating of the subsurface in the thermocline compared to the others.

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VARIABILITY AND RESPONSE OF SURFACE CHLOROPHYLL TO THE MARINE HEATWAVE IN THE SOUTHERN NORTH SEA

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Abstract
This study investigates the variability and response of surface chlorophyll (CHL) concentrations in the southern North Sea to marine heatwaves (MHWs) over 26 years (1998-2023). The analysis uses daily high-resolution cloud-free SST and CHL data obtained from CMEMS. The SST showed a significant positive temporal trend, while the CHL concentration showed a non-significant trend. Spatially, the CHL trend map showed high variability, with significant negative trends along the French coast and in certain regions west of the Dogger Bank and significant positive trends along the east coast of the United Kingdom, the Belgian and Dutch coasts, and the German Bight. The analysis of MHW and low chlorophyll (LCHL) events showed an increasing trend in the total number of MHW and LCHL days as well as compound MHW-LCHL days over the study period.

Keywords: Chlorophyll-A, North Atlantic, Temperature

Introduction

The SNS is a highly productive region characterized by dynamic physical and biological processes [1]. In recent years, the SNS has experienced the effects of marine heatwaves (MHWs) [2], which are prolonged periods of unusually warm SST [3]. These MHWs can have profound impacts on the marine environment, including alterations in CHL concentrations [4,5]. The CHL is a key indicator of the productivity of marine ecosystems. It serves as a proxy for phytoplankton biomass, which forms the base of the marine food web and plays a crucial role in global carbon cycling. However, the response of CHL to environmental changes, such as MHWs, can significantly impact ecosystem dynamics [5]. The aim of this study is to investigate the variability and trend of CHL concentrations in the SNS and their response to MHWs over the last 26 years (1998-2023).

Methods

To identify MHW metrics and their compound MHW-LCHL events, we follow [5,6], who defined the MHW (LCHL) as days when the SST (CHL) anomalies are above (below) their 90th (10th) percentile threshold for that time of year. For more details on the compound MHW and LCHL events, the reader is referred to [5]. Here we have used the daily high-resolution cloud-free SST and CHL concentrations at the surface downloaded from the CMEMS. Both data sets are available from 1998 to 2023 with a horizontal resolution of 2 km for SST and 1 km for CHL. The CHL data were re-mapped by cubic spatial interpolation to obtain the same resolution as the SST (i.e. 2 km).

Results

Fig1 shows the temporal evaluation of the SST and CHL concentration anomalies (SSTA, CCA) in the SNS during the period from 1998 to 2023. The highest SSTA was found in 2007, 2014, 2016, and 2022, while the highest CCA was observed in the spring of 2001 and 2003. Although there is no strong significant correlation between SSTA and CCA over the whole study period, there is a coincidence between the extremely positive SSTA and extremely negative CCA in some years during the study period (see the pink line in Fig.1). Excessive heat in these years can lead to thermal stress, which affects the growth, photosynthesis, and overall productivity of phytoplankton. Consequently, this can lead to a decrease in CHL concentrations. The SST showed a significant temporal trend of 0.28 °C/decade, while the CHL concentration showed a non-significant trend of 0.09 (mg/m^3)/decade (Fig. 1). The analysis of the seasonal chlorophyll cycle (not shown) usually peaks in April and May and describes the phytoplankton spring bloom in the SNS.
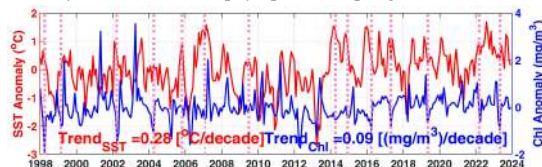
Fig. 1. Time series of SST anomaly and CHL concentration anomaly averaged in the southern North Sea. The pink lines show the coincidence of low CHL with high SST.

The CCA trend map shows high spatial variability, ranging from significant negative trends to positive trends (Fig. 2). The negative CCA trend is found along the French coast, in the Wadden Sea, and in the deep part west of the Dogger Bank. The strongest significant positive CCA trends are found along the east coast of the United Kingdom, in the central part of the study area, along the Belgian and Dutch coasts, and in the German Bight. The regions where higher CCA trends were recorded coincided with lower SSTA trends (see Fig. 4 in [2]), which is influenced by the inflow of freshwater. The spatial correlations revealed a non-significant relationship between CCA and SSTA for most of the study area. However, significant positive correlations (p<0.05) are found in the same regions that show positive CCA trends (i.e. along the Belgian and Dutch coasts and in the German Bight), while a patch of negative correlation is observed in the deep regions around the Dogger Bank.
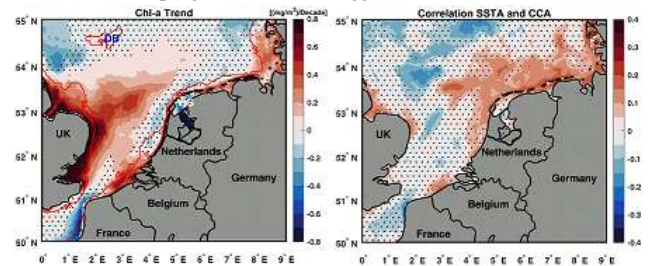
Fig. 2. Trend map of chlorophyll-a concentration anomaly (mg/m3)/decade and its correlation with sea surface temperature anomaly. The abbreviations stand for the Dogger Bank (DB) and the Wadden Sea (WS).

To investigate the temporal development of MHW and LCHL events or composite MHW-LCHL events, we calculate regional annual mean values of the total days in the entire study area from 1998 to 2023 (not shown). The highest total number of MHW days and MHW frequency were recorded in 2007, 2014, 2016, and 2022. The highest mean MHW-LCHL days were also recorded in the same years. The overall trend of MHW and LCHL days was 8.31 and 2.84 days/decade, respectively. The mean MHW-LCHL days also show an upward trend of around 0.87 days/decade over the entire study period.

Conclusions: This study highlights the complex relationship between MHWs and surface chlorophyll concentrations in the SNS, providing valuable insights into the dynamics of this productive marine region.

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ANALYSIS OF SEA SURFACE AND STRATIFICATION TRENDS THROUGH SUB-SURFACE MOORING AROUND MALTA

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Abstract

This study presents an analysis of water temperature data from the Maltese Islands in the southern Mediterranean, using moorings equipped with temperature loggers at various depths. This research aims to explore thermocline formation, shifts in peak temperatures, and the varying response times at different depths, which may provide insights into the effects of climate change. The data collected hourly from 2019 through mid-2022, and averaged into daily values, not only highlights short-term fluctuations but also reveals significant long-term trends in sea temperature. The findings underscore the importance of continuous and precise temperature monitoring to better understand and predict future climatic changes in marine environments.

Introduction - Over the past four decades, a consistent upward trajectory in sea surface temperatures around the Maltese islands has been documented, exhibiting an average annual increase of 0.05°C. This trend is particularly pronounced during summer months, with mean temperatures aligning closely with Mediterranean averages [1]. Recent findings from the Intergovernmental Panel on Climate Change (IPCC) underscore this phenomenon, indicating a general escalation in Mediterranean Sea surface temperatures over recent decades, varying regionally between +0.29°C and +0.44°C per decade across the entire upper mixed layer [2]. This is of high interest since these averages are above the global average of 0.01°C per year, highlighting the role of the Mediterranean region as a critical zone for future climatic changes [3]. This is especially pertinent given the heightened frequency and intensity of marine heatwaves [4]. Consequently, there is an urgent need for enhanced operational data collection, monitoring trends in the seasonal water temperature cycle. A set of temperature loggers was initially provided by the CIESM Tropical Signals Program to be installed at a single location in Malta in 2012; subsequently, the Oceanography Malta Research Group (OMRG) within the University of Malta installed additional loggers at multiple locations within Maltese coastal waters. This work presents an improved and extended implementation of these loggers.
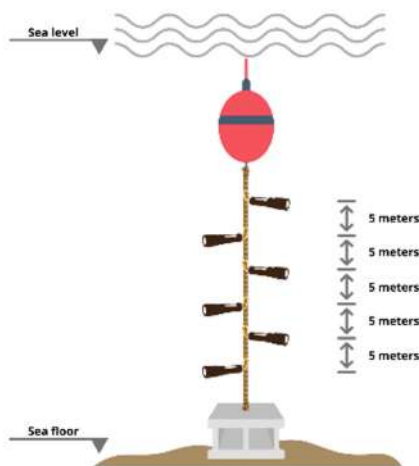
Fig. 1. Mooring setup designed for continuous monitoring, with temperature loggers attached at 5m intervals.

Method - A buoy, positioned five meters below the sea surface, and equipped with HOBO Water Temperature Pro v2 data loggers, was deployed in proximity to the Mgarr ix-Xini coast in Gozo, Malta, for continuous monitoring. The deployment strategy involved mounting loggers at regular intervals of five meters, starting at a depth of five meters and extending down to a depth of 45m (Figure 1).
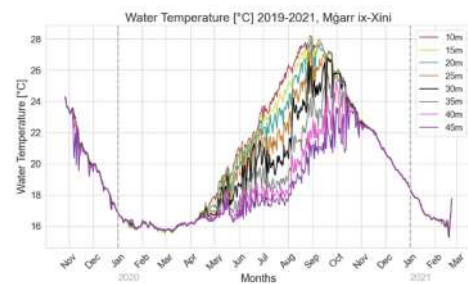
Fig. 2. Time series of water temperature measurements (in °C), obtained from the Mgarr ix-Xini location using the implemented mooring setup.

Results - Hourly temperature data was measured and subsequently averaged into daily values to mitigate short-term fluctuations and emphasize longer-term trends. This dataset spans from the beginning of 2019 to mid-2022 (subset shown in Figure 2). During 2020, the formation of the thermocline occurred in April, coinciding with the subsequent warming of water across all measured depths, a pattern consistent with other sampled years (2019-2022). Homogeneous temperatures were reestablished by mid-October. Throughout the sampling period, September remained the warmest month, with peak sea surface temperature values typically occurring at the end of August or the beginning of September. Besides the multiple deployment of water temperature loggers, the OMRG has also installed dissolved oxygen, pH and salinity loggers through permanent moorings within Maltese coastal waters as part of its operational monitoring mission.

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Congress Joint Session : Marine Data Analysis and Management I (all Committees)
Moderator : Katrin Schroeder – ISMAR-CNR, Venice, Italy

Session's Synthesis

Among the main issues debated, we can mention the interconnectedness of oceanographic processes. The EMSO-E2M3A South Adriatic Regional Facility presented high-frequency temperature and salinity data, highlighting the interconnectedness of oceanographic processes across various temporal scales. This data is crucial for understanding daily, seasonal, and climatic trends in the region. We also discussed about the evolution of data management. The National Oceanographic Data Centre (NODC) of OGS showcased its journey from floppy disks to modern databases. The emphasis was on the importance of Open Science and the FAIR data principles (Findable, Accessible, Interoperable, Reusable) in marine data management. We also address the topic of long-term oceanographic measurements and the associated challenges (especially in terms of sustained funding), with the example again of the EMSO ERIC marine observing system in the southern Adriatic Sea (13 years of uninterrupted oceanographic measurements). These long-term datasets are vital for studying deepwater dynamics and their implications for climate change. Finally, the use of Sentinel-2 satellite data for monitoring water quality in Vrana Lake, Croatia, was discussed. The study demonstrated the applicability of remote sensing technologies in assessing water quality dynamics and confirmed the suitability of Sentinel-2 data for such purposes. The discussions in this session underscored the importance of continuous innovation in marine data analysis and management. The transition from traditional data storage methods to modern, interoperable databases is a testament to the progress in this field. Additionally, the integration of remote sensing technologies and governance tools highlights the multidisciplinary approach needed to address complex marine and coastal challenges. The session provided a comprehensive overview of current advancements and future directions in marine data management.

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THE MULTIDISCIPLINARY SOUTH ADRIATIC FACILITY(EMSO E2M3A): INTERCONNECTEDNESS OF PROCESSES ON DIFFERENT SPATIAL AND TEMPORAL SCALES, INTERACTION AND RECURRENCE

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Abstract
The EMSO-E2M3A South Adriatic Regional Facility provides high-frequency (hourly) temperature and salinity data from 2006 on along the water column from the surface to the seafloor. Their study shows processes taking place in the area at different temporal scales, i.e. daily, seasonal, intra-annual and inter-annual, as well as their recurrence (seasonal or not) and climatic trends.

Keywords: Deep sea processes, Adriatic Sea, Open sea, Vertical migration, Time series

The southern Adriatic Pit where the EMSO-E2M3A is located, is characterized by a cyclonic circulation and deep convection processes involving both atmospheric and ocean dynamics, forming new, dense and oxygen-rich waters. There are intermittent inflows of water with high salinity from the Ionian Sea, which favor salt fingering [1], and dense overflows from the northern Adriatic Sea [2].

The data collected by the E2M3A observatory allow the monitoring of variability on short scales related to convection and submesoscale processes. ADCP data indicate that zooplankton migration at the surface/intermediate layer is enhanced by convection-induced mixing. Factors such as thermocline depth and stratification, the daily light cycle, the lunar cycle, physical ocean conditions and the deep clorophyll maximum could be responsible for the accumulation and movement of plankton and other planktivorous organisms such as fish (Fig. 1).
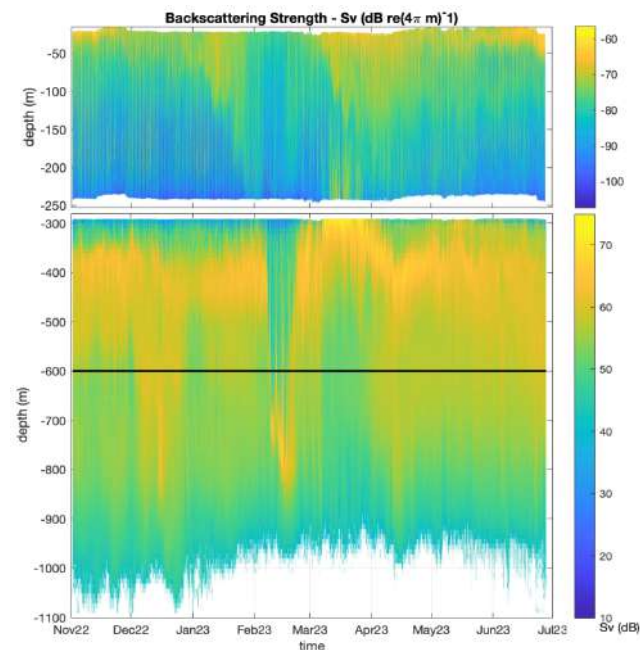
Fig. 1. Backscatter strength (Sv) shows the vertical migration from an upward looking 150kHz RDI ADCP and from a downward looking 55 kHz Nortek Signature ADCP between November 2022 and July 2023

On intermediate time scale, changes in the basin circulation are monitored, and on a larger time scale, climate variability in the area is observed. On the monthly scale, thermohaline variability increases significantly due to oscillations triggered by a combination of factors including salinity intrusion into the intermediate layer, strong heat loss at the surface and variability in vorticity during the winter months. The lower layer of the pit has been characterized by a slightly positive trend in temperature and salinity over the last decade, interrupted only by the inflow of dense water from the northern Adriatic Sea cascading through the Canyon of Bari.
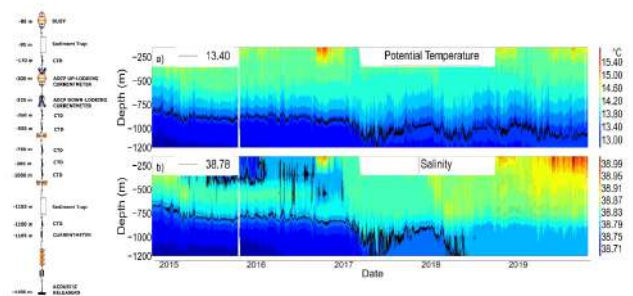
Fig. 2. Hovmüller diagram of potential temperature and salinity from the E2M3A mooring in the SAP. The isotherm of 13.4°C and the isohaline of 38.78 (black, solid line) show a strong oscillation after winter 2016/2017.

The Hovmöller diagrams, based on time series of potential temperature and salinity measured at SAP (Fig. 2), show a clear change in the characteristics before and after 2017. Looking at the 5-year dataset presented in this figure (November 2014–October 2019), the water column from the end of 2014 to the end of 2016 shows a clear signature of LIW occurrence restricted to the layer between 400 and 600 m, with a core value of 38.84.

The different processes interact in a non-linear way, which emphasizes the importance of high-frequency measurements of fast processes and their interaction with and correction of slowly varying properties on a longer time scale.

Measurements at the EMSO-E2M3A facility have demonstrated the Eulerian or fixed-point observatories' importance as an essential component of the global ocean observing system. They allow the detection of extreme events that occur rarely during the multi-year observation period, such as the strong convection events that homogenize the water column leading to long-term alterations of the density structure. They provide a unique opportunity for multidisciplinary and interdisciplinary work combining a variety of observations on a large range of timescales [3].

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FROM FLOPPY DISKS TO MODERN DATABASES: OGS REPORTS ON TWENTY YEARS OF THE NATIONAL OCEANOGRAPHIC DATA CENTRE

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Abstract
This year marks the twentieth anniversary of the National Oceanographic Data Centre (NODC), which is managed by the National Institute of Oceanography and Applied Geophysics - OGS. In 2004, the OGS formalised the infrastructure for the management of marine data under the name NODC to fulfil its obligations as the Italian representative in UNESCO's IODE/IOC: the International Oceanographic Data and Information Exchange (IODE) programme of the Intergovernmental Oceanographic Commission (IOC). Specifically, the NODC's mission is to pursue Open Science, fostering free access and use of data following the FAIR data principles, which require data to be easily Findable, Accessible, Interoperable and Reusable. After twenty years of activity, this article traces the main stages of the NODC, recent achievements and improvements in the pipeline.

Keywords: Management, Temperature, Salinity, Oxygen, Mediterranean Sea

The first step as marine data manager was taken by the OGS in 1979, when a relational database model, was implemented on the IBM 4341 system to collect, archive and analyse the temporal variability of marine data first in the Northern Adriatic and then in the whole Mediterranean [1, 2]. In 2004, the OGS established the National Oceanographic Data Centre to meet the obligations as the Italian representative in UNESCO's International Oceanographic Data and Information Exchange (IODE) programme of the Intergovernmental Oceanographic Commission (IOC). It aims at facilitating the exchange of oceanographic data and information while maintaining the research integrity. To this end, the Centre manages the assignment of identifiers as Digital Object Identifiers (https://nodc.ogs.it/catalogs/whattheyare) via the international DataCite consortium. The NODC infrastructure also pursues the principles of open science by using open softwares and tools to offer more and more efficient services (https://nodc.ogs.it/data/data-access), which can be found on its website (https://nodc.ogs.it). Some examples in Fig. 1 and Fig. 2. In 2024, the Centre was recognised as an accredited IODE NODC: the only one in Italy and the 11th of 101 data centres in the IODE network. In order to be certified, the NODC at OGS has ensured compliance with IODE standards and set up a quality management system in line with ISO 9001:2015 [3] . This enables an organisation to identify risks and opportunities and work towards improvements. The NODCs certified by IODE are also accredited as part of the World Data System (https://worlddatasystem.org).

Fig. 1. ERDDAP, the server to download subsets of NRT oceanographic datasets.
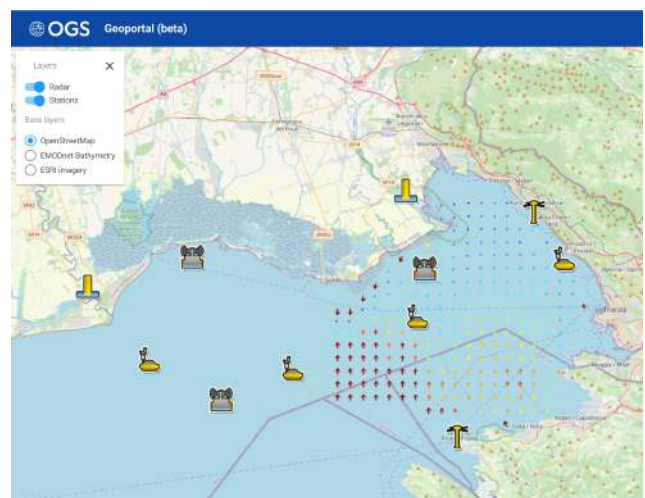
Fig. 2. The geoportal (https://nodc.ogs.it/geoportal) to view the OGS NRT data in the Adriatic Sea.

Currently, the NODC database with delayed mode data includes more than 460 million measurements from 1880 to 2024; 75.8 % of it is freely accessible to all users, 24.1 % by arrangement. All these data are made available through the European Blue Data infrastructures, such as SeaDataNet, the pan-European infrastructure for ocean and marine data management, EMODnet, the European Marine Observation and Data Network, and Copernicus. The NODC is improving its geoportal and ERDDAP server for near real-time data, its database and data access service for marine data in delayed mode.

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THE EMSO ERIC MARINE OBSERVING SYSTEM IN THE SOUTHERN ADRIATIC SEA: 13-YEARS OF UNINTERRUPTED OCEANOGRAPHIC MEASUREMENTS WITH MOORINGS BB AND FF

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Abstract
The observing activities started in 2004 along the western margin of the southern Adriatic Sea is developed with the establishment of the EMSO-ERIC regional facility operated by CNR-ISP and OGS. The observatory produces a high-quality and FAIR-compliant dataset, that provides information on the long-term changes in deepwater dynamics along the southern Adriatic continental margin.

Keywords: Continental slope, Adriatic Sea, Mediterranean Sea, Deep waters

Monitoring activities along the southern margin of the Adriatic Sea began with the objective of addressing several scientific questions related to sediment transport pathways along the Adriatic shelf and slope and the dynamics of Dense Shelf Water (DSW) cascading events exploring its role in particle transport. Since 2012, two moorings have been permanently deployed in the Bari Canyon (mooring BB) and in the open-slope (mooring FF). These moorings were strategically placed at sites where the passage of Dense Shelf Water (DSW) was most anticipated. Both moorings produce a high-quality open-access dataset that complies with FAIR principles (https://erddap.emso.eu/erddap/index.html). The development of standardised procedures and best practices ensure uninterrupted monitoring of several key ocean variables available from 2012 to the present [1]. The measured data have played a key role in understanding the dynamics of DSW masses along the shelf and slope [2], and demonstrate the primary role of the Bari Canyon as a conduit for sediment dispersal from the shelf to the deep basin [3] where DSW cascading events are primarily responsible for particle and organic matter fluxes across the western margin of the southern Adriatic [4].

Fig. 1. A) Study Area. Monthly mean T measured on FF (b) and BB (c). Dashed lines show the trend obtained by linear regression.

A long-term analysis of temperature and salinity in BB and FF in the last 100 m of the water column (500-600 m in BB and 637–737 m in FF) reveals a consistently positive trend at the various depths investigated. In particular, there has been a notable cumulative increase (p-val < 0.001) of +0.67°C and +0.23 PSU in the near-bottom level (-590 m) since 2010. The DSW passage typically occurs between late winter and spring, although its occurrence is not consistent between years. Moreover, the thickness of the water column exhibits vertical variability and shows site-specific behaviour. The characteristics of DSWs influence the buoyancy of water masses and determine their sinking along the slope and basin.
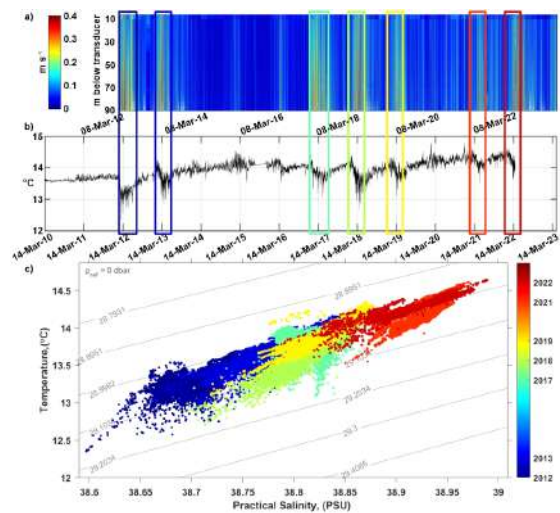
Fig. 2. a) Current speed measured by ADCP on the last 100m water column, rectangles refer to DW passage events; b) T at BB measured at 590m; c) TS diagram of selected DSW passage events. Different years are colour coded.

In BB, which is the shallowest mooring, DSWs were observed in 7 different years and the properties of the water masses revealed a change in density anomaly of about 0.105 kg m-3 with a reduction in the sinking capability of DSWs thus affecting the renewal of bottom waters with an impact on biogeochemical cycles. The long-term measurements shed light on the recent changes in the deep-water dynamics of the southern Adriatic continental margin, emphasizing the central role of the EMSO-ERIC observatory in understanding the climatological evolution of the Mediterranean basin.

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ADVANCING GOVERNANCE IN MARINE AND COASTAL SOCIO-ECOLOGICAL SYSTEMS

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Abstract

This study describes the main features of the OGMAR platform, an online tool designed to assess the governance of marine and coastal socio-ecological systems. OGMAR includes a novel GIS map viewer depicting the limits and essential characteristics of more than 800 Spanish Marine Protected Areas (MPAs). Our assessment methodology enables the effective evaluation of the MPAs governance based on a battery of 27 indicators and facilitate management proposals based on the gaps detected. The OGMAR tool will enhance decision-making and ensure sustainable ecosystem governance.

Keywords: Management, MPAs, Mediterranean Sea

The current socio-ecological crisis demands a profound re-evaluation of our approach to manage our oceans and coasts, compelling science to take a leading role. Researchers worldwide have shed light on key research priorities necessary to tackle this challenge [1]. These priorities encompass understanding socio-ecological systems, effective governance, and the pivotal role of institutions in ecosystems [2] [3] [4] (Fig. 1).

Fig. 1. Complexity of coastal and marine social ecological systems.

A main challenge lies on achieving good governance, i.e., discerning whether decision-making processes result in environmentally and socially sustainable outcomes [5]. Here we introduce a methodological framework for assessing the governance of socio-ecological systems, with emphasis on marine protected areas (MPA). This framework integrates various complementary approaches, including the MPAG f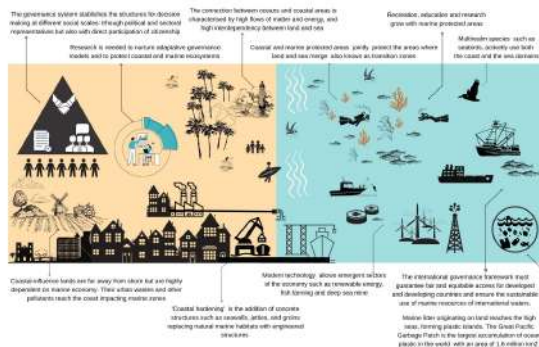ramework [6] and the social theory of incentives. Incentives, in this context, denote interventions shaping behaviour to align with biodiversity conservation goals [7].

Building upon these principles, we have developed an evaluation tool – OGMAR – comprising a survey featuring 27 indicators, with special emphasis on the assessment of the system of incentives, encompassing economic, interpretative, knowledge, legal and participative aspects. Consequently, OGMAR can propose interventions to enhance decision-making and problem-solving processes. Utilizing the OGMAR platform, we have successfully identified and mapped over 800 MPAs in Spain, spanning different protection categories such as Natural Parks, Natura 2000 marine sites, the OSPAR Network of MPAs, SPAMI, and Biosphere Reserves (Fig. 2). This Geographic Information System (GIS) tool aggregates essential data for each MPA, including their size and responsible administrations. Notably, we have also incorporated considered coastal protected areas lacking a marine component due to their significance in land-sea interactions.

This approach has facilitated the establishment of a comprehensive GIS-based registry of marine and coastal areas in Spain across international, national and local levels. The compiled data enables us to conduct an initial analysis of the geographical and administrative overlaps, posing significant challenges to effective management and governance. Stakeholder responses to the OGMAR survey provide detailed insights into individual and collective perceptions regarding MPA governance, culminating in an analysis of the marine-coastal governance efficiency of Spanish MPAs across various spatial and temporal scales.

Fig. 2. Observatory of Marine Governance map viewer.

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SPATIAL-TEMPORAL ASSESSMENT OF WATER QUALITY DYNAMICS USING SENTINEL-2 SATELLITE DATA: VRANA LAKE, CROATIA

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Abstract

The aim of this research is to investigate the applicability of Sentinel-2 imagery in monitoring the spatio-temporal dynamics of water quality using the example of Lake Vransko. The estimates of water constituents were generated using the C2RCC (Case 2 Regional Coast Colour) processor, in particular the C2RCC, C2X and C2X-COMPLEX versions. Model validation was performed using 20 samples collected by in situ measurements. The correlation results showed investigated parameter have an R^2 greater than 0.5. Due to the considerable variability of the water composition, the C2RCC algorithm showed the best results. The chlorophyll-a concentration (Chl-α) values show that the lake falls into the category of mesotrophic/eutrophic conditions. The study confirms the suitability of the Sentinel-2 data for water quality monitoring.

Keywords: Chlorophyll-A, Remote sensing, Mapping, Analytical methods, Adriatic Sea

Introduction

Spatio-temporal monitoring of water quality is important to protect lakes from various forms of pollution and to preserve aquatic ecosystems [1]. In this complex process, remote sensing methods offer numerous advantages over traditional field measurements, as they provide a cost-effective and less time-consuming way to obtain information for large areas [2]. In this study, two approaches were applied: (1) in situ field measurements and (2) remote sensing (Figure 1) to evaluate the utility of Sentinel-2 satellite imagery in predicting the spatio-temporal distribution of water quality in the case of Lake Vrana in the Republic of Croatia.
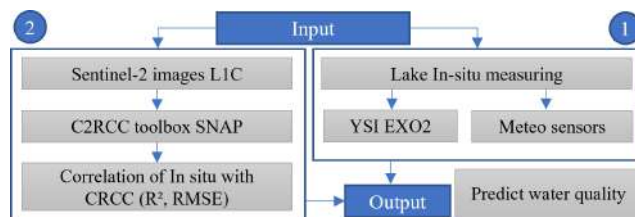

Fig. 1. Flowchart of research methodology

Lake Vrana is the largest natural lake (28.849 km²) in the country, exposed to various anthropogenic and natural influences. The estimates of water constituents were produced using the C2RCC (Case 2 Regional Coast Color) processor based on deep learning approaches, specifically C2RCC, C2X and C2X-COMPLEX versions, using the Sentinel Applications Platform (SNAP). The C2RCC atmospheric correction is a full spectrum version using a set of neural networks which are trained on simulated top-of-atmosphere reflectance [2]. The raditiave transfer simulations include the full ocean and atmosphere system. As a result of the methodological process, values of Chl-α concentration in [mg/m3] as well as their spatio-temporal distribution were determined for 4 months (Figure 2). The model validation was carried out using 20 samples collected with an YSI EXO2 multiparameter probe. As part of the study, a correlation was established between satellite images and samples collected on site. The results will provide valuable insights into the dynamics of water quality in Lake Vrana and can serve as a basis for the further management of this important protected ecosystem.

Result and discussion

The measured concentrations of Chl-α for all sampling events were plotted against reflectance values and algorithms. RMSE and R^2 values as calculated by field data against the values from the automatic products of each C2RCC version. The best atmospheric correction was C2RCC. The method is optimal for lakes with low levels of water pollution (higher water transparency and lower Chl-α and total suspended matter concentration values) where trophic activities are limited [2]. Chl-α values, based on a four-month average, are relatively low and vary between 0.207 to 13.981 mg/m³. The highest concentrations and area (3.243 % of total area) of Chl-α (in the class from 10 to 19.995 mg/m³) were recorded in September 2023. Generally, the distribution of Chl-α indicates higher concentrations in the northeast section of the lake, near the primary freshwater inflow from the Kotarka and Lateral channel (Figure 2). This elevation in Chl-α levels can generally be linked to the input from freshwater channels, which fosters the growth of local phytoplankton through the introduction of nutrients. Conversely, the eastern part of the lake consistently exhibits lower Chl-α concentrations. In this environment, where macrophytes are absent, phytoplankton predominantly account for the chlorophyll present in the lake. These phytoplankton populations are subject to distribution across the lake driven by various dynamics such as wind activity and variations in water density. These factors complicate the ability to accurately predict and model the fluctuations in phytoplankton levels. The study emphasized the importance of chl-α in the lake ecosystem and its relationship with another water quality parameters and meteorological data.
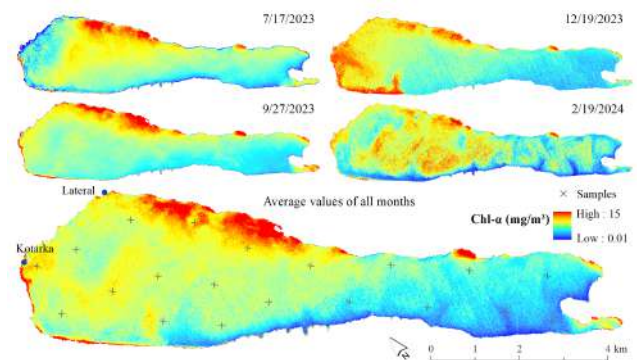
Fig. 2. Spatial-temporal distribution Chl-α of using the best atmospheric correction C2RCC version

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Congress Joint Session : Marine Data Analysis and Management II (all Committees)

Moderator : Antonio Terlizzi – Univ. of Trieste, Italy

Session's Synthesis

The "Marine data analysis & management II" session saw the presentation of interesting contributions concerning the monitoring of biodiversity, from microbes, to the planktonic component, to algae and invertebrates. A common thread of the session was the reconstruction of diversity data also and above all through museum collections and historical data. The session looked essentially at historical information without neglecting innovative approaches such as, for example, promising perspectives of metabarcoding analysis of historical zooplankton samples preserved in formalin. The communications, on the proposal of the coordinator, were followed by a single and broad discussion that ranged from the importance of taxonomy, to the need for data sharing, and the importance of historical data for the quantitative reconstruction of changes in the structural patterns of biodiversity in a context of increasing anthropic pressure on marine ecosystems.

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FROM PHYSICAL TO DIGITAL SPECIMENS: HOW TO MAKE THE SCIENTIFIC COLLECTIONS AVAILABLE FOR RESEARCHERS AND STAKEHOLDERS

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Abstract
The Natural Science Collections (NSCs) represent evidence of a territory's historical and present biodiversity and geodiversity, thus assuming the dual role of a vehicle of cultural information and study material. Digitalization of NSCs is a priority to obtain an irreplaceable database of information on species diversity and habitat changes at large areal and temporal scales. We present the NSCs workflow developed by the Institute of Marine Science (CNR-ISMAR), as part of a national repository for marine digital collections, shared according to the FAIR principles. The obtained data will contribute to detecting biodiversity changes and developing appropriate conservation measures. Furthermore, the available data will allow us to contribute to developing the European RI DiSSCo (Distributed System of Scientific Collections).

Keywords: Biodiversity, Mediterranean Sea, Instruments and tech, Worldwide

The Natural Science Collections (NSCs) have historically been pivotal in addressing fundamental questions in science, innovations, discoveries, and sustainability. The digitization of NSC plans the transition from Physical Specimens to Digital Specimens, providing data findable, accessible, interoperable, and reusable according to the FAIR principles. In this context, the DiSSCo Research Infrastructure (Distributed System of Scientific Collections), aim to virtually bring together NSCs and related information preserved in natural history museums, botanical gardens, research institutes and universities in a single portal at the European level [1]. The Institute of Marine Science (CNR-ISMAR) hosts a large heritage of naturalistic collections relating to different fields of study (botany, zoology, paleontology and geology) (Fig.1) and capable of making a significant contribution to the knowledge of marine biodiversity and geodiversity.

As part of the "Italian Integrated Environmental Research Infrastructures System" - ITINERIS project, a flowchart has been defined from cataloging to the release of the NSCs of the CNR-ISMAR (Fig.2). The actions needed to organize and make the scientific collections available for research are the following: curatorship of physical collections; specimen cataloguing and assignment of the permanent identifier; taxonomic revision; digitisation and metadating to create digital collections according to international standards [2,3]; data storage; release of the data and metadata in the open access Institute catalog and the Global Biodiversity Information Facility (GBIF) [4], to make the NSCs available from different stakeholders (researchers, teachers, museums, citizen, etc.). The creation of digital twins of NSC objects originating from research activities, together with maintaining the physical sample, will contribute to detecting biodiversity changes and developing appropriate conservation measures; furthermore, it will offer fast and efficient information sharing, encouraging collaboration, communication, and dissemination within and outside the scientific community.
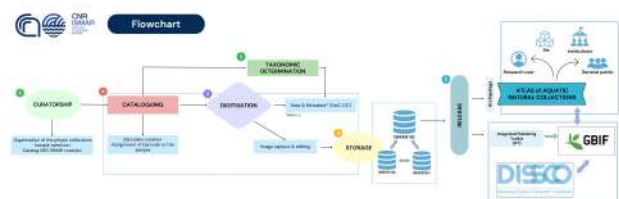
Fig. 2. Workflow for the cataloguing, metadating and digitisation of the NSCs hosted in CNR-ISMAR

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Fig. 1. Geographical origin of NSCs of CNR-ISMAR concerning the different fields of study

BLAST FROM THE PAST: METABARCODING ANALYSIS OF FORMALIN-PRESERVED MESOZOOPLANKTON ASSEMBLAGES

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Abstract

Historically, zooplankton samples preserved in formalin pose challenges for molecular analysis due to induced DNA alterations. This study aimed to develop an extraction method and amplification protocol for DNA metabarcoding of such samples. Pre-treated with an alkaline buffer, samples underwent amplification targeting two gene regions: nuclear 18S rRNA and mitochondrial COI, using four primer sets. Results suggest DNA metabarcoding as promising for studying historical collections, with successful amplification for both genes despite optimization needs. This method represents a significant advancement in the study of historical zooplankton communities.

Keywords: Zooplankton , Adriatic Sea

Formalin has long served as a preservation method for various biological samples, including zooplankton assemblages. However, formalin treatment induces DNA alterations, such as cross-links between DNA and proteins, resulting in significant fragmentation of the nucleic acids contained in the samples. This issue, known among researchers as the "formalin problem" [1] presents a challenge for molecular techniques. Nonetheless, scientific interest in resolving the latter has grown, recognizing the value of historical and museum collections for biodiversity research, especially in understanding potential shifts within mesozooplankton communities amid rapid climate change.

Samples from the "MAMBO Station" in the Gulf of Trieste were collected monthly in 2017 using vertical nets and taxonomically identified before preservation in formalin. The study aimed to evaluate if annual taxonomic changes in assemblages could be detected through metabarcoding after long-term formalin preservation.

In this study, seven years old samples underwent pretreatment with an alkaline buffer followed by thermal treatment. This method, commonly employed for FFPE samples, effectively breaks cross-links and has proven successful for formalin-preserved plankton samples [2], Extraction utilized the E.Z.N.A.® Mollusc DNA kit (Omega Biotek), following the manufacturer's instructions. Testing different thermal profiles, we were able to amplify four primer sets targeting 18S and COI DNA markers.

However, the number of PCR cycles required to obtain amplification was extremely high in all four cases. Despite being a common requirement in such studies [2], reducing the number of cycles is one of the necessary future developments for this type of analysis. Amplicons were sequenced in two test samples; figure 1 illustrates the first metabarcoding analysis with the COI DNA marker.

The results of the metabarcoding analyses were then compared with the results from classical taxonomic analysis to enable a potential comparison between the two methods. The main aspect we are now working on is related to increasing the yield of amplifiable DNA, thus reducing amplification cycles and increasing the biodiversity that can be captured by sequencing zooplankton preserved in formalin even for many years.

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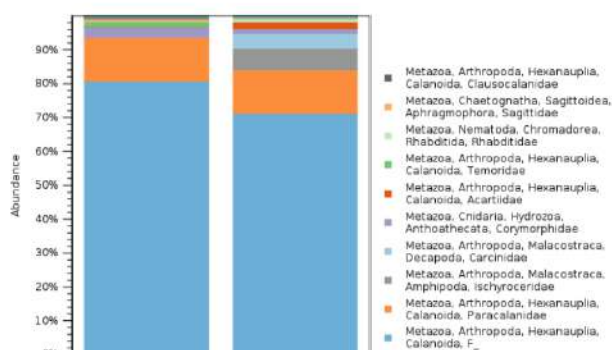
Fig. 1. Results of metabarcoding analysis with the COI DNA marker for Jan. 2017 and Feb. 2017

FROM ECOLOGICAL RESEARCH TO NATURAL SCIENCE COLLECTIONS: AN EXERCISE WITH MARINE BENTHIC INVERTEBRATES.

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Abstract

Biological samples produced by ecological research and biomonitoring can convey broader information than that for which they were collected. A test study to give wider access through the RI-DiSSCo to natural science collections composed of marine benthic invertebrates, stored in the CNR-ISMAR Institute, is here presented.

Keywords: Zoobenthos, Gulf of Venice, Biodiversity, Crustacea, Mollusca

Research and biomonitoring activities on benthic assemblages typically produce a big number of biodiversity samples with related (meta)data. Benthic biodiversity is characterized by high number of phyla and a wide range of body structure and size. When the original scientific questions are answered, the collected specimens can have different fates: they could be preserved for a long time, sometimes outliving those who collected them, or, in the other side of the spectrum, they can even be lost or destroyed once the original project is over. Unlike museal specimens, these samples are generally available only to experts in the sector, remaining inaccessible to a wider public.

The goal of the Research Infrastructure DiSSCo (Distributed System of Scientific Collections), is to virtually bring together all kinds of Natural Science Collections (NSCs) and related information in a single Findable, Accessible, Interoperable and Reusable (FAIR) portal at European level. The core is the Digital Object, a virtual representation of the physical sample stored in a collection, identified by MIDS (Minimal Information of Digital Specimen), such as name of the species, image, sampling date and location, to which further information can be associated (related literature, functional traits, molecular sequences, environmental parameters associated with sampling sites) [1].

The present test-study has been performed in the framework of the RI-DiSSCo and project ITINERIS. The aim is to create a digital twin in order to make virtually available the NSCs to any level of audience simplifying access and sharing information. Main steps include curatorship, cataloging, and digitization.

As a preliminary step, however, in order to optimize the effort, is crucial to select NSCs to be prioritized (e.g. participation to a larger scientific community effort, relevance for assessing global and local biodiversity changes, including the role of invasive alien species, access to primary biodiversity data, target the most urgent biodiversity and ecological imperatives). With these purposes, we selected 3 NSCs as starting point: "DC" Crustaceans of mobile bottom collected in the mud flat of the Dese estuary inside the Venice Lagoon, "Xi-LoVEU" wood borers collected in European seas and "NadEm" epimegabenthos organisms (>1 cm) collected in the Northern Adriatic (Fig. 1, 2) [2,3]. The heterogeneity of these collections serves as a stress test, which made it possible to identify the critical issues [e.g. 4] and define the criteria useful for digitization. This exercise was carried out in parallel with other research groups dealing with other taxa in different geographical areas but sharing the availability of physical samples and the goal to make them FAIR.

Fig. 2. Families and number of specimen ongoing cataloging of NSCs in CNR-ISMAR.

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Fig. 1. Location of the samplings. Xi-LoVEU (13 sites), DC (12 sites), NadEm (3 sites).

ZOOPLANKTON ABUNDANCE IN SEDIMENT TRAP SAMPLES AT THE LONG-TERM OBSERVATORY SYSTEM IN THE SOUTHERN ADRIATIC SEA.

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Abstract

The four oceanographic moorings: BB, EE, FF, and E2M3A constitute an observatory of the Southern Adriatic Sea, which also enables the monitoring of the seasonal cascading of dense waters originating from the Northern Adriatic Sea, and the tracking of the seasonal and inter-annual variability of the zooplankton over the long term, as a response to climate changes.

Keywords: Adriatic Sea, Zooplankton , Deep sea basins, Monitoring, Particle flux

The Bari Canyon plays a crucial role in the sinking of dense water and the transfer of sediment to the deep Southern Adriatic Pit. Indeed, the dense waters of North Adriatic origin flow southwards, mostly intermittently, along the Adriatic shelf and sink into the deeper basin, both along the open slope and through the Bari Canyon [1]. The North Adriatic Dense Water (NAdDW) cascading events transport organic matter from coastal regions to the depths of the sea, and hold significant importance in the biogeochemical cycles [2]. Consequently, the input of new nourishment sources resulting from cascading events profoundly influences deep-water communities, enriching deep-sea food availability and deep-sea fauna energy requirements. Thus, the basin due to its morphology is considered as a reservoir that collects these waters together with those formed in-situ by open sea convection, exiting the Adriatic as ADW that feeds the thermohaline circulation of the Eastern Mediterranean Sea [2]. Continuous measurements are essential to assess the inter-annual variability of the thermohaline circulation, water masses properties and transports, bio-geochemical fluxes and contents, and finally biomass composition and variability over times. Here a high-frequency sampling and long-sustained measurements of multiple interrelated variables from the sea surface to the seafloor are provided to resolve events and rapid processes on different time scale. The Southern Adriatic Observatory System (Fig.1) is formed by the E2M3A observatory in the Southern Adriatic Pit (Eastern Mediterranean), two oceanographic moorings (BB, FF) positioned along the Bari Canyon and the open-slope, and EE east of the Dauno seamount. E2M3A is a constituent of the European component of the Global Ocean Observing System of UNESCO (https://eurogoos.eu/), and, together with BB and FF, forms an integral part of the European Multidisciplinary Seafloor and water column Observatory European-Research Infrastructure Consortium (https://emso.eu/observatories-node/south-adriatic-sea). The zooplankton specimen collected by four moorings are part of the European National Biodiversity Future Centre (https://www.nbfc.it/en) aimed to monitor, conserve, restore, and valorise the Mediterranean biodiversity since 2022.

The four oceanographic moorings have been gathering year-round data of oceanographic parameters, and collected zooplankton and sinking particles by mean of automatic time-series sediment traps since 2013 to present. Trap-collected zooplankton samples (TCZs) have been checked following the World Register of Marine Species (WoRMS), ensuring accuracy and standardisation of species data linked to thermohaline measurements. TCZ data proves valuable for investigating biodiversity, revealing seasonal trends and dynamics. Copepoda and Polychaeta were found in each sample at both depths, suggesting that their entrapment activity was relatively constant throughout the year (Fig.2).
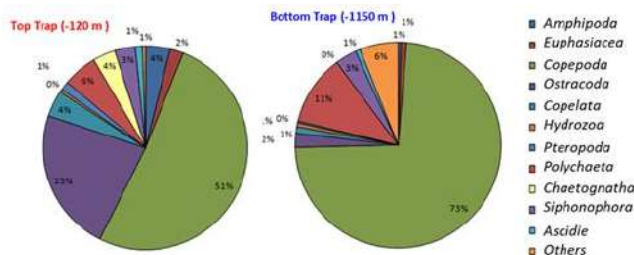
Fig. 2. Examples of Zooplankton taxonomic assemblages found at the two sediment traps (120 m and 1150 m water depths) in E2M3A in 2020.

Moreover, long-term TCZ data provide insights into deep-sea zooplankton distribution, diversity and ecology, and assess temporal dynamics and variability of zooplankton fluxes, composition and structure in relation to environmental changes. Specifically, we aimed to: (1) classified the zooplankton communities, analyse their long term and seasonal changes; (2) identify if the NAdDW cascading has a role in zooplankton abundance and variabilities; (3) harmonised long term zooplankton data with the adoption of standardised guidelines; and finally (4) sharing long-term series data as OPEN in the EMSO-ERIC and NBFC net. Signals of transport through the canyon to the deep pit layer are evident and the intrusion of dense waters of North Adriatic origin (cascading) is remarked from salinity homogenization at the 900 - 1000 m depth from the physical and biogeochemical data measured simultaneously at high frequency by the E2M3A, BB, and FF moorings.

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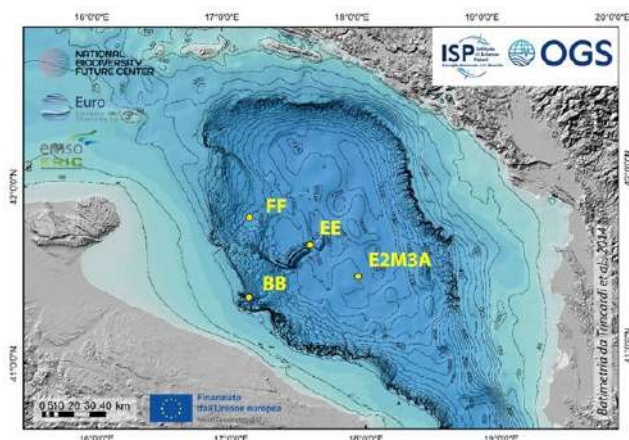
Fig. 1. Study Area. Bathymetry of the South-Adriatic Sea and the Bari Canyon System [3] where moorings E2M3A, BB, EE and FF are located.

BIODIVERSITY DATA MANAGEMENT FOR GOOD ENVIRONMENTAL STATUS ASSESSMENTS

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Abstract

Marine biodiversity data are fundamental for good environmental status (GES) assessments. Swift access to dependable and precise information plays a critical role in observational studies, shaping policies and legislation safeguarding coastal and oceanic regions. EMODnet Biology, one of seven thematic disciplines covered by EMODnet, specifically focuses on marine biodiversity data. The tasks within EMODNet Biology (EB) are covered by the National Oceanographic Data Center (NODCs), who are responsible for receival, storage, harmonization, data access, data products, and training. Using a macrozoobenthos time-series collection, this article provides an overview of the data flow, and underscores the significance of collecting and sharing marine biology data for GES assessments.

Keywords: Biodiversity, Worldwide, Coastal management, Mediterranean Sea

The OCE-OGS group conducted a study on the soft-bottom macrozoobenthos invertebrates at a coastal site within the buffer zone of a marine protected area in the Gulf of Trieste. The collection spanned from July 2014 to January 2018, forming a comprehensive time series. Sediments were gathered using a van Veen grab (0.1 m2; 18L), and species identification and counting were performed using a stereomicroscope. Totally, 235 distinct species were counted during 13 collection campaigns. The research was meant to shed light on the fluctuations and seasonal and yearly changes in species composition within the area.

The OGS-NODC performed the retrieval, storage, harmonization, and feeding of the data into the EB system. Data harmonization was done using the Darwin Core (DwC) approach, with standardized and controlled vocabularies used to define time frames, geospatial localization, species identification, and experimental methods, ensuring interoperability and reusability. The EB system is composed of several inter-related data platforms. The metadata and data was fed into the EB system using the Integrated Publishing Toolkit (IPT) software and subsequently to the Global Biodiversity Information Facility (GBIF) data system. Data was then harvested in a semi-automated process into the European Ocean Biodiversity Information System (EurOBIS) database, before being rendered on the EMODnet Central Portal Viewer and the EurOBIS Download toolbox. The EB system, by means of IPT/GBIF and EurOBIS, is designed to allow researchers and policy makers to access the data in a Findable, Accessible, Interoperable, and Reusable (FAIR) manner, and observe the geographical and temporal fluctuations in abundance of multiple species, to comprehend the evolving trends and predict future changes, and shape policies and legislation accordingly.

We performed a simple linear regression using the macrozoobenthos data. We calculated the t-statistic for the slope coefficient and its associated p-value using the t.cdf function from SciPy's stats module in python. The data showed a statistically significant increasing trend (T-statistic: 5.33; p-value: 0.001) for the species *Amphiura filiformis*. Commonly known as the mud brittle star, *Amphiura filiformis* plays several significant roles in marine ecosystems, such as bioturbation and nutrient cycling. As sensitive organisms, they respond to environmental stressors such as pollution, habitat degradation, and changes in water quality. Monitoring populations of *Amphiura filiformis* provide valuable insights into the health and resilience of marine ecosystems. The results of this campaign could indicate an improvement of the GES of the marine protected area in the Gulf of Trieste. Importantly, feeding the data into the EB system gives the possibility to compare the abundance of *Amphiura filiformis* (and many other species) in multiple geographical locations and time frames, thus using this indicator species to compare the GES of nearby marine areas.

This article showed the importance of sharing marine biodiversity data and how proper data management via an established international infrastructure can complement observational studies in multiple regions leading to better GES assessments.
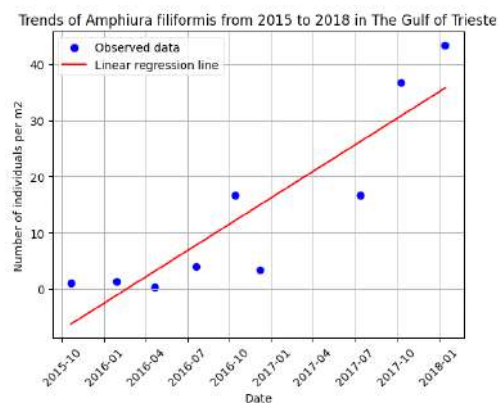

Fig. 1. Simple linear regression of *Amphiura filiformis* from 2015 to 2018 in the Gulf of Trieste

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DIGITIZATION OF ALGAL COLLECTIONS AT CNR-IRSA TARANTO: AN EXAMPLE OF LONG TERM DATA ENHANCEMENT

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Abstract

The digitization of natural science collections was started about twenty years ago, to make this cultural heritage usable by the scientific community. However, only recently the creation and implementation of scientific infrastructures, such as the Distributed System of Scientific Collections (DiSSCo) allowed to start a mass digitization process of biodiversity data, to make collections digital and available online. In this context, within the framework of the PNRR project "ITINERIS", the CNR-IRSA Taranto is involved in the digitization of two marine macroalgal herbaria: herbarium TAR, and the historical "Irma Pierpaoli" Herbarium.

Keywords: Ionian Sea, Gulf of Taranto, Algae

Natural historical collections, preserved in museums and research institutes around the world, represent an important source of long term data, which can help to integrate information from past and ongoing research. To this end, their digitization can allow to make this cultural heritage usable by the scientific community [1]. In order to digitize correctly any biological data, the minimum level of information of the Digital specimen (MIDS) has been established [2].

In addition, international standards have been developed to create datasets collecting metadata for each digital specimen, which can be managed according to FAIR principles. At CNR-IRSA Taranto (southern Italy), the TAR herbarium, preserving marine macrophytes mainly from the Taranto sea, is stored and continuously implemented since 1984. In addition, the "Irma Pierpapoli" herbarium, owned by the Marine Biological Station of Porto Cesareo (Lecce, Italy) and preserving seaweed samples from the Adriatic and the Ionian Sea dating back to the Twenties, is also stored for research purposes.

For this reason, CNR-IRSA Taranto is involved in the DiSSCo infrastrucure. Within the framework of the PNRR project "ITINERIS", aimed to enhance the Italian research infrastructures and create a national open repository for each of them, starting on February 2024, the digitization of herbarium sheets has been initiated, with the simultaneously acquisition of the metadata in a dataset defined according to the Darwin Core terms for biodiversity data [3].

Herbarium sheets are being scanned with a planetary scanner (BUCAP, Bookeye 5 V2, Monterotondo scalo, Italy) and photographed. High-resolution images are obtained and currently stored in a local repository. The digitized images include the color-check table, a paper ruler and two labels. The former label reports the institute name, the herbarium name, and the progressive number of the digital specimen. The latter reports the mandatory information, such as the species name, the collection place, the collection date, the collector name (*legit*), and the identifier name (*determinavit*) (Fig. 1).

To date, about 320 algal sheets belonging to Herbarium TAR have been digitized. When all the sheets from both the herbaria will be digitized, the two datasets, including images and metadata will be uploaded on an international biological data sharing platform, as agreed within the ITINERIS project.

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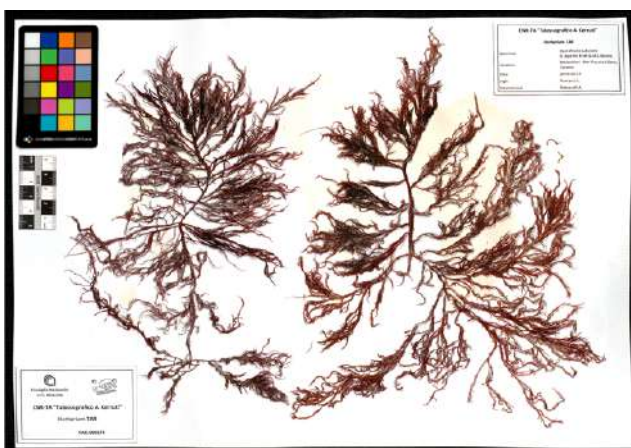3 - https://dwc.tdwg.org/list/

Fig. 1. An example of digitalized herbarium sheet.

MICROBIAL DIVERSITY IN THE CENTRAL ADRIATIC SEA

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Abstract

By combining qualitative and quantitative methods with neural gas analysis, different patterns of the microbial community were revealed at finer taxonomic levels in response to changing environmental conditions. We present the results of a one-year study carried out in an oligotrophic environment where increased salinity was recently observed. A general pattern of increasing diversity under harsh environmental conditions, particularly under the influence of increasing salinity at the expense of community abundance was observed. <\/div>

Keywords: Adriatic Sea, Bacteria

Introduction

Microbes play a key role in the marine environment. Through their different processes, they are involved in the functioning of the marine environment, especially in oligotrophic areas. Determining the patterns of bacterial communities provides a suitable approach to assessing their response to changes in the environment.

Material and methods

A samples were collected monthly in February 2021/January 2022 on vertical profiles in the central Adriatic. All members of the picoplankton community were determined using flow cytometry (Gasol and Morán, 2015.), infra-red microscopy (Mašín et al., 2006.) and for DNA extraction, a modified DNeasy PowerWater Kit (QIAGEN) was used. To extract characteristic distribution, an artificial neural network algorithm called neural gas (NG) (Vesanto and Alhoniemi, 2000.).

Results:

	PHBMU1	PHBMU2	PHBMU3	PHBMU4
Acidobacteriota	4	1	2	10
Actinobacteriota	1046	863	889	888
Bacteroidota	2375	3963	4675	2039
Bdellovibrionota	31	28	23	37
Chloroflexi	494	124	71	912
Crenarchaeota	2159	306	574	7809
Cyanobacteria	1833	3100	8013	868
Dadabacteria	179	157	93	161
Dependentiae	1	0	0	1
Desulfobacterota	24	19	16	23
Firmicutes	23	7	14	1
Gemmatimonadota	27	12	10	54
Halobacterota	0	0	1	5
Hydrogenedentes	1	1	1	4
Margulisbacteria	1	1	0	1
Marinimicrobia_(SAR406_clade)	669	362	210	865
Methylomirabilota	0	0	0	0
Myxococcota	28	15	12	22
Nanoarchaeota	1	1	0	3
NB1-j	26	14	15	19
Nitrospinota	16	11	10	125
PAUC34f	11	4	4	17
Planctomycetota	266	188	195	565
Proteobacteria	14670	17960	12590	11138
SAR324_clade(Marine_group_B)	169	145	77	462
Thermoplasmatota	2766	356	406	3919
Verrucomicrobiota	495	1018	836	593

Fig. 1. Bacterial phyllums in each BMU.

The 24 observed phyla were presented as the sum of the relative abundances of OTUs, which were classified into four distinct classes called phylum best match units (PHBMU1-PHBMU4) using NG and associated with other ecological factors (Figs. 1-2). Considering the classification of phyla patterns via NG analysis into four distinct BMUs described as specific environments, we analysed the diversity of the picoplankton community according to each BMU. The average values regarding the number of archaeal and bacterial OTU counts, Shannon diversity index, and bacterial Pielou's Pielou's evenness were the lowest in PHBMU3, which is described as the environment with the highest abundance of heterotrophic bacteria, AAPs, *Synechococcus*, picoeukaryotes, bacterial production and chlorophyll concentration. On the contrary, the environment with increased salinity, nitrates, nitrites and total nitrogen (PHBMU2) showed the highest bacterial diversity and evenness. The cold and ammonium- rich environment (PHBMU1) was represented by the highest percentage of high nucleic acid bacteria and the highest archaeal Shannon index. The highest archaeal Pielou's evenness was observed in PHBMU4.

	PHBMU1	PHBMU2	PHBMU3	PHBMU4
UHB	0.42	0.38	0.44	0.32
HIGH	26.21	26.34	28.09	27.40
SYN	17.44	14.11	26.62	6.12
PROCHL	52.75	1.67	3.97	1.82
PE	4.36	4.03	11.31	3.85
BP	0.16	0.12	0.13	0.13
HNF	0.38	0.80	1.10	0.20
AAP	1.08	1.82	1.96	1.03
Temp	14.58	18.69	15.62	15.64
Sal	38.32	38.17	37.73	38.85
NO_3^-	1.34	0.89	1.54	1.83
NO_2^-	0.25	0.15	0.09	0.34
NH_4^+	0.26	0.21	0.20	0.20
DIN	1.79	1.25	1.83	2.38
NTOT	12.25	15.74	13.94	14.49
SRP	0.04	0.04	0.03	0.05
PTOT	0.21	0.17	0.14	0.15
SiO_4^-	1.98	1.66	1.86	2.21
Chl a	0.32	0.20	0.44	0.25

Fig. 2. Ecological parameters in each BMU.

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Congress Joint Session : Deep Sea & Extreme Environments (all Committees)
Moderator : Mikhail Yakimov – ISP-CNR, Messina, Italy

Session's Synthesis

The deep sea is the largest ecosystem on our planet, and at the same time one of the least studied and unexplored. It is therefore no coincidence that even today the ocean depths hold a huge number of secrets and mysteries. The session "Deep Sea & Extreme Environment" featured eight contributions covering a wide range of topics and aspects. This was quite adequate, considering that this complex environment is home to a vast variety of all kinds of life forms, including some very bizarre creatures, such as carnivorous deep-sea sponges (presentation of Dorte Janussen), deep-water amphipods of the families *Ampeliscidaea* and *Carangoliopsidaea* (presentation of Sabrina Lo Brutto) and hydrothermal vents-associated bivalve molluscs of the genus *Bathymodiolus* (presentation of Karen Power). The latter organisms, in addition to containing intracellular chemoautotrophic bacterial symbionts, ultimately possess proterandrous hermaphroditic gonads.

The Mediterranean Sea is a unique hydrological formation of Earth that can be fully classified as a deep-sea habitat, since its average depth is approximately 1500 m with a maximum depth of 5267 m in the Calypso Deep (Hellenic Trench). Like deep ocean, the Mediterranean Sea still holds many secrets, such as not yet fully understood origin and stratification of abyssal water layers in Ionian Sea (presentation of Beatrice Giambenedetti), deep-sea mud volcanism and enormous flat-top methane-seeping structures on the Calabrian Accretionary Prism (presentation of Giulia Lisi), extreme heliothermal hydrological formations on the eastern Adriatic coast (presentation of Irena Ciglenecki-Jusic). Of particular note is the presence of huge hypersaline anoxic lakes on the seabed of the Mediterranean Ridge at depths of about 3000 - 3500m (presentation of Violetta La Cono), where living conditions are more reminiscent of extraterrestrial habitats, such as Mars, Europa and Enceladus than on Earth.

Another unique abyssal structure are deep-sea mountains, which rise from the sea floor without reaching the ocean surface. They are hot-spots of biodiversity in the vast ocean that swirls around them, and each one acts as a unique oasis in the desert. The deep Mediterranean is no exception, and is home to these fascinating formations in many places. One of these is the seamounts located in the Mallorca Channel. Their exposed rocks support a wide range of marine life and are colonized by sessile organisms including corals and sponges, which host numerous different species including shrimps, crabs, worms, brittlestars and fishes (presentation of Aida Frank). This dense benthic population is among our world's greatest biological treasures and supports the designation of the Mallorca Channel seamounts as a site of Community Interest for inclusion in the Natura 2000 network.

To sum up, the session was very intense and there were so many questions at the end of the presentations that the time allotted for the section was slightly exceeded.

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ROGOZNICA LAKE (DRAGON'S EYE), AN EXTREME, EUXINE ENVIRONMENT ON THE EASTERN ADRIATIC COAST

Irena Ciglenecki [1]*, Marija Marguš [1], Iva Dominovic-Novkovic [1], Niki Simonovic [1] and Sarah Mateša [1]
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Abstract

The integration of long-term data (30 years) on physico-chemical conditions and ecological status shows that the marine system of Rogoznica Lake (RL) - Dragon's Eye is an example of an extreme, euxinic environment on the eastern coast of the Adriatic Sea. The main characteristics of the RL water column are: i) warming with the highest ever measured temperature of 34 ºC in July 2023 at a depth of 4 m, ii) deoxygenation with the expansion of the anoxic layer towards the surface (0-5 m), iii) accumulation of organic carbon and toxic sulfides and ammonia in the anoxic layer. The large density difference between the surface and the middle layer leads to the development of an increasingly pronounced subsurface temperature (and oxygen) maximum, which makes this marine lake one of the so-called heliothermal systems.

Keywords: Anoxic basin, Stratification, Eutrophication, Warming, Adriatic Sea

Rogoznica Lake (RL, Dragon's Eye; Fig.1) is a small (ca. 1 ha, 14 m deep) karstified and highly eutrophic marine system on the eastern Adriatic coast of Croatia (43º32" N, 15º58" E). It is located close to the sea and has only limited water exchange with the surrounding coastal waters due to the porous limestone. The only supply of fresh water to this marine system is atmospheric precipitation and surface runoff, the frequency and intensity of which are directly influenced by climatic fluctuations.
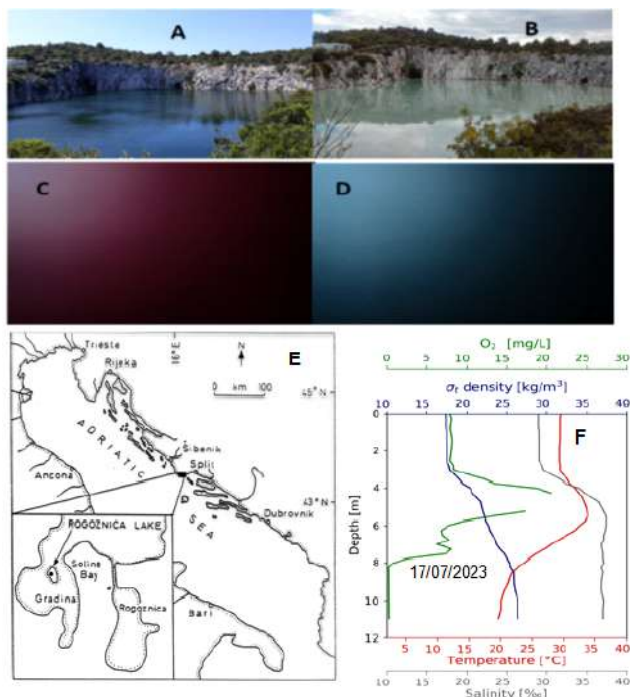

Fig. 1. A-B) Photos of Rogoznica Lake (RL) during spring stratification (A) and fall (2016) mixing (B), when the surface of the lake is greenish-milky white due to the presence of colloidal sulfur [1,3] in the water column; C-D) Photos taken by a submersible camera (D. Petricioli) in a purple water layer rich in PSB (C) and in an euxinic layer (D) where complete darkness and mixotrophic life exist [2,6]; E) Map of the Adriatic coast with reference to RL; F) RL water column profile in June 2023.

RL can be considered an extreme environment due to the strong stratification that separates the water column into a well oxygenated (up to 300% oxygen saturation) surface and a deep euxinic layer characterized by complete darkness (Fig. 1D) and a millimolar concentration of toxic sulfide (up to 5 mM) and ammonium (0.3 mM) [1-3].

Under certain (extreme) meteorological conditions, RL fluctuates between stratified and holomictic euxinic conditions, which strongly influences biodiversity [1].

At the oxia-anoxia boundary, a pink chemocline up to 50 cm wide forms seasonally (Fig. 1C), in which anoxygenic phototrophs, mainly represented by a dense population of purple sulfur bacteria (PSB) [2], contribute to a relatively high occurance of elemental sulfur (S0) in the chemocline and below [3]. The depth of the chemocline changes seasonally and migrates to the surface layer in the long term, accompanied by deoxygenation of the water column [4,5].
Organic matter (OM) with a high concentration of refractory dissolved organic carbon (DOC) of up to 6 mg accumulates in the dark euxinic water column [4].

The observed reduced exchange of seawater with the surrounding open sea [5] confirms that this marine system is increasingly developing into a lentic-lacustrine system, in which the influence of freshwater becomes more and more dominant and contributes to the strengthening of stratification. The large density difference between the surface and the middle layers leads to the occurrence of an increasingly pronounced subsurface temperature maximum (STM) [6] with the highest temperatures in the water column (up to 34°C) (Fig.1F). The STM usually occurs below the layer with high oxygen saturation (> 200%). Such extreme ecological conditions have a strong impact on the biological processes and changes in the communities of RL [1,6], mostly in an irreversible direction. All observed characteristics of the RL water column can be discussed as a consequence of pronounced natural and anthropogenic eutrophication due to climatic and environmental fluctuations.

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DISTRIBUTION OF BENTHIC HABITATS IN THE MALLORCA CHANNEL SEAMOUNTS (WESTERN MEDITERRANEAN)

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Abstract

Seamounts play a critical role in deep-sea biodiversity. The LIFE IP INTEMARES project aims to enhance knowledge of benthic communities of the seamounts in the Mallorca Channel: Ses Olives, Ausias March and Emile Baudot. We use presence data of habitat-forming species, obtained from several sampling methods, and environmental and fishing variables, to map 12 benthic habitats, using spatial distribution models. Additionally, the presence of 8 other benthic species of conservation interest was mapped. These results will support designating the Mallorca Channel seamounts as Site of Community Interest to be included within the Natura 2000 network.

Keywords: Habitat, Zoobenthos, Models, Mallorca Channel, Western Mediterranean

Seamounts are relevant seafloor hotspots of biodiversity [1]. The LIFE IP INTEMARES project aimed to enhance scientific knowledge on biodiversity and distribution of benthic species and habitats in the Mallorca Channel seamounts: Ses Olives (SO), Ausias March (AM) and Emile Baudot (EB). The aim is the inclusion of this area in the Natura 2000 network, aligning with prior proposal [2]. Preliminary results of the project [3] highlighted their biodiversity, identifying over 740 species or taxa, some protected by regulations, and others new to science or new records in the Mediterranean. Up to 31 benthic habitat types have been also identified [3], many of which are Habitats of Community Interest (HCI), including *1110 Sandbanks which are slightly covered by seawater all the time*, *1170 Reefs* and *1180 Submarine structures made by leaking gases*.

This work uses spatial distribution models (SDMs) to map habitat-forming species (HFS) and benthic species of conservation interest. To do so, we used presence/absence data of single species or assemblages of HFS collected from standard methodologies [3]: 532 ROV scenes, 48 photogrammetric sledge transects, 85 beam trawl samples, 46 rock dredge samples, along with 21 ROV transects provided by OCEANA. We analyzed up to 8 geomorphologic, 7 sedimentologic, 12 oceanographic and 3 fishing footprint variables, which were reduced to 14 after correlation analysis. We used them as explanatory variables in two types of SDMs: generalized additive models (GAMs) and maximum entropy modeling (Maxent). The models were used to predict probability of occurrence on a 100 m resolution grid. For each HFS, the presence of an habitat was only considered in a particular grid cell when both models predicted probability of occurrence above a threshold (determined by the kappa statistic). Twelve benthic habitats were modeled and mapped, while the presence of 8 species of conservation interest was only mapped due to data limitations (Fig. 1). The *Maërl/rodoliths* beds (HCI *1110*) were found in the summits of AM and EB, largely overlapping with sponges bottoms. Moreover, six habitats categorized as HCI *1170*, including sponge and gorgonian gardens on rocky substrates, and *Bathyal muds with Isidella elongate* were detected. Finally, *Pockmark fields* (HCI *1180*) were also identified. Considering the presence of these benthic species and habitats, their representativeness, singularity and sensitivity, we propose an area of 4498 km^2 to be proposed as Site of Community Interest for its inclusion in the marine Natura 2000 network.

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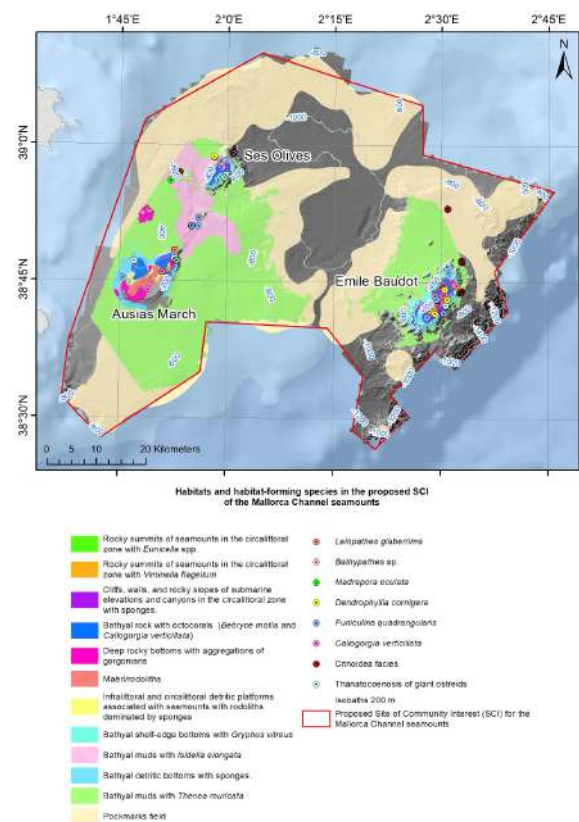
Fig. 1. Benthic habitats and habitat-forming species of conservation interest in the Mallorca Channel seamounts (Western Mediterranean).

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ROLE OF STRATIFICATION ON ABYSSAL PROPAGATION OF POTENTIAL VORTICITY IN THE IONIAN SEA WITH A STATIONARY QUASI-GEOSTROPHIC MODEL

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Abstract

The variation of the deep sea stratification, what generates it, and the impact it produces, are still under discussion. The mechanisms involved in such variability and the connection of the abyss with the above layers of the water column have yet to be fully understood. Starting from available observations of the deep Ionian Sea, we applied an idealized four-layer, non-linear, quasi-geostrophic model with a mathematical artifice to parametrize the observed decadal variability of the abyssal layer in the area. We found that even without considering a more realistic flow, the abyssal stratification influences the stability and rotation of vorticity among different density layers, linking deep-sea variability to the entire water column.

Keywords: Abyssal, Ionian Sea, Deep sea basins, Stratification, Models

Observations made in the Ionian Sea in the last decades, either from CTD (Conductivity, Temperature, and Depth) casts, moorings, or seafloor observatories, reveal the variability of the abyssal zones of the Mediterranean Sea at both interannual and decadal scales (Artale, et al., 2018). In particular, available observations in the Ionian Sea evidenced the presence of a dense and stable deep layer, whose thermohaline and dynamical properties changed drastically over a decade (Giambenedetti, et al, 2023; Favali, et al., 2013). These observations hinted at the stratification's role in deep sea variability, highlighting that the density profiles are not as linear in the deep as it has been considered so far (Smith, and Vallis, 2001). Hence, we numerically investigated the impact that deep stratification can have on the propagation of Potential Vorticity (PV). The theoretical framework and parameters used (i.e., primarily density profile) are based on hydrological observation of the Ionian Sea (Giambenedetti, et al, 2023). We applied a non-linear quasi-geostrophic model, with four layers. For the discretization of the layers, we used the z-coordinate instead of isopycnals since the observed density structure is not linear in z in the abyss, as commonly parametrized in models (Smith, and Vallis, 2001). To simplify as much as possible the model, no external forcing is applied, bathymetry effects are ignored, and only small-scale dissipation is retained. We fixed the first two layers' thicknesses and changed the relative thicknesses of the 3rd and 4th layers for each configuration, to parametrize the decadal variability observed in the abyssal layer in the Ionian Sea (Giambenedetti, et al, 2023; Artale, et al., 2018). Each stratification configuration is solved in time to reach stability, assumed as the state at which dissipation between consecutive iterations becomes negligible. The basic state considered is a cyclonic vortex only in the first layer, with no background flow.
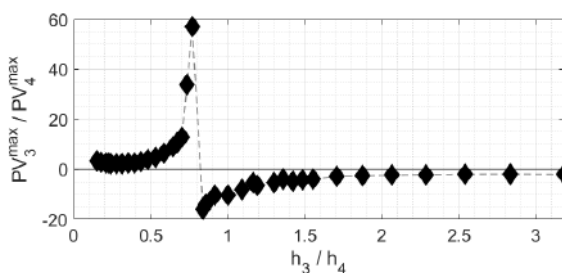

Fig. 1. Ratio of the sign-preserving max absolute values of 3rd and 4th layers PV versus thicknesses ratio.

The resulting ensemble of stationary state showed that as the relative thickness of the 3rd and 4th layers varies, there is a sort of phase transition for a critical ratio (Fig.1), where the rotation direction inverts, around a critical thickness ratio for the bottom layers of 0.8. Hence, the PV that propagates through the layers has a structure that differs significantly when altering the stratification configuration. From the spatial fields for configuration before and after the critical transition in Fig. 2, it can be seen how PV penetrates more in the 3rd layer when h3/h4=0.77 (before the transition) and more in the 4th when h3/h4 = 0.84 (after the transition). In particular, the 3rd layer vortices in Fig 2 show how the rotational direction inverts.
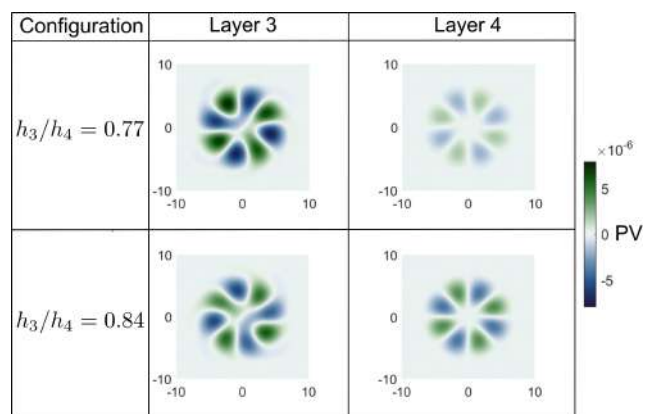
Fig. 2. Spatial fields of PV for two configurations of 3rd and 4th layers thickness.

Adding complexity to the vertical structure of the water column could give a more realistic picture without setting a priori conditions for stability, as is commonly done (Smith and Vallis, 2001). Moreover, the rotation direction inversion we found for some stratification configurations is consistent with the observed variability by the NEMO-SN1 observatory at the bottom of the Ionian Sea between 2003 and 2013 (Favali, et al., 2013). Therefore, stratification has a crucial role in directing the rotation of PV generated at the interface between layers of different densities depicting how the whole water column engages in the abyssal dynamics. This can have a role in stabilizing the propagation of Rossby waves, affecting the sub-surface circulation. Furthermore, it points out the impact of the bottom on the vertical propagation, which can have important implications on how the energy stored by the deep sea is redistributed, stressing the need for extended deep monitoring and investigation.

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NEW SPECIES OF CLADORHIZIDAE (SPONGES) AND INSIGHTS INTO THE DIVERSITY AND DISTRIBUTION OF CARNIVOROUS DEEP-SEA SPONGES

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Abstract

Three species of carnivorous deep-sea sponges of the the genera *Abyssocladia* and *Cladorhiza* from hydrothermal vent fields of Scotia Ridge (Antarctica) were discovered. They are new to science and show zoogeographic affinities to the Pacific and Central-North Atlantic, indicating high connectivety of Antarctic deep-sea sponges. As all our identified species were new to science, this underlines the need of further research effort in the deep oceans.

Keywords: Abyssal, Porifera, Deep sea ecology, Worldwide, Hydrothermal vents

Introduction

Cladorhizidae (carnivorous sponges) is one of the most common and diverse sponge families in the deep Oceans World-wide and it occurs also in shallow submarine caves, e. g. of the Mediterranean [1, 2]. Focus of our study is a small collection of deep-sea sponges from hydrothermal vent fields of the East Scotia Ridge, Antarctica, collected 2010 during the James Cook Cruise JC42 from two sites JC42-E2 (56°05'19.2" S, 30°19'07.7" W, depth ~2600 m) and JC42-E9 (60°02'35.6" S, 28°58'55.3" W, depth ~2400 m).

Results

The sponges were examined taxonomically by skeletal morphology and molecular methods and identified as two genera of the Cladorhizidae, this family is recorded here for the first time from the vicinity of hydrothermal vents within the Southern Ocean. We describe three species new to science: *Abyssocladia* sp. nov. 1, 2 and *Cladorhiza* sp. nov. 1. According to our morphological investigations combined with molecular phylogeny results by Georgieva et al. [3], close relationships can be established between *Cladorhiza* sp. nov. 1 and C. *corallophila* from the Sahelian Upwelling Zone [4], as well as with *C. abyssicola* and *C. gelida* from Central-North Atlantic, including Mediterranean. *Abyssocladia* sp. nov.1 and sp. nov. 2 show closest affinity to *A. oxeataand A. inflata* respectively *A. bruuni* and *A. dominalba*, all Pacific species of wide-spread occurrence.

Discussion & Conclusions

These findings confirm the assumed high connectivity between the Antarctic abyssal basins and other deep oceans [5]. Apparently high endemism within the Cladorhizidae may be due to fact that many species of this family reach only tiny individual sizes, e. g. *Abyssocladia* n. sp. 1 and 2 measure less than 5 mm. Therefore, they may tend not to be sampled by most trawling benthic gears (e.g. AGT), or to remain undiscovered within the samples. All the species found in our study turned out to be new to science. This emphasizes the high potential and urgent need of investigations into the abyss for the discovery of many, still unknown marine species.

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THE HABITABILITY OF MEDITERRANEAN DEEP SEA HYPERSALINE ANOXIC LAKES RICH IN MG^{2+} AS A MODEL FOR STUDYING BRINES ON MARS.

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Abstract

The recent discovery of magnesium-rich evaporite minerals and subglacial brines on Mars is sparking interest in exploring the potential habitability of terrestrial environments rich in Mg^{2+}. Among these environments are the deep-sea, magnesium-rich lakes Discovery, Hephaestus, and Kryos, situated at the bottom of the Mediterranean Ridge. They appear to be the only known terrestrial areas with ecological conditions such as high pressure, anoxia, athalassohaline hydrochemistry, magnesium richness, excessive chaotropicity, and extremely low water activity that closely resemble those of Martian subglacial lakes. Despite being inhospitable to most life forms, the interfaces between their brine and seawater layers are inhabited by highly stratified, diverse, and enigmatic prokaryotic communities adapted to thrive in such polyextreme conditions.

Keywords: Deep sea basins, Anoxic basin, Bacteria, Ionian Sea

Until now, nine such DHALs, L'Atalante, Bannock, Discovery, Hephaestus, Kryos, Medee, Thetis, Tyro, and Urania, have been discovered in the deep eastern Mediterranean and studied during last 40 years. The surfaces of these brine lakes lie between 3.0 and 3.5 km below sea level, and the salinity of their brines ranges from five to 13 times higher than that of seawater. DHALs of the Mediterranean Ridge represent some of the most hostile environments on our planet, as the saltiest, pressurized, highly reduced and H2S-rich habitats. Although these DHALs lie geographically close to each other, their hydrochemical diversity suggests that the processes leading to their formation were qualitatively different and can be unambiguously explained by the salt deposition dynamics during desiccation/re-flooding cycles occurred in the past. Notwithstanding harsh environmental conditions, both brine and seawater-interface of thalassohaline Bannock, l'Atalante, Medee, Thetis, Tyro, and Urania are populated by diverse and enigmatic extreme halophilic organisms that belong to all three domains of life, while brines of Discovery, Hephaestus and Kryos are sterile and only their interfaces act as refuges for Mg2+-adapted microbial communities [1-4]. The interface between the seawater column and the underlying MgCl2-dominated brines of Lakes Discovery, Hephaestus, and Kryos provides a unique biophysical environment for studying the limits of life at high magnesium levels. Using reconstructed 16S rRNA, investigations into phylogenetic diversity in Lake Hephaestus have unveiled a stratified native prokaryotic community at the seawater-Hephaestus brine interface down to 2.97 mM MgCl2, referred to as the low interface (LIF). Despite Lake Hephaestus's relative juvenility, it's evident that LIF layer-specific microbial communities are phylogenetically distinct from microbial populations in the overlying seawater. This community exhibits similarities in 16S rRNA phylogeny, and even more so in mRNA phylogeny, to those found in the seawater-brine interfaces of Discovery and Kryos. These findings suggest the presence of previously unidentified hyperhalophiles, adapted to withstand the chaotropic nature of MgCl2 and capable of metabolic activity under harsh athalassohaline conditions. This layer is predominantly composed of methylotrophic methanogenic organisms (*Methanohalophilus* group) from the phylum *Halobacteriota* and acetogenic representatives of the KB1 group, recently classified as *Acetothermia* (phylum *Bipolaricaulota*). Notably, the LIF community, like the aforementioned methylotrophic methanogens and acetogens, exhibits a significantly higher percentage of sequences belonging to known extremely halophilic archaeal groups (13% vs. 1%) such as *Halobacteriales* and Candidate Division *Nanohaloarchaeota*, compared to the overlying interface layers (Figure 1). These four groups of highly halophilic and chaotolerant prokaryotes warrant special attention, as their trophic interactions may provide insights into the adaptation mechanisms enabling them to thrive in polyextreme conditions within MgCl2-saturated environments, pushing the boundaries of life.
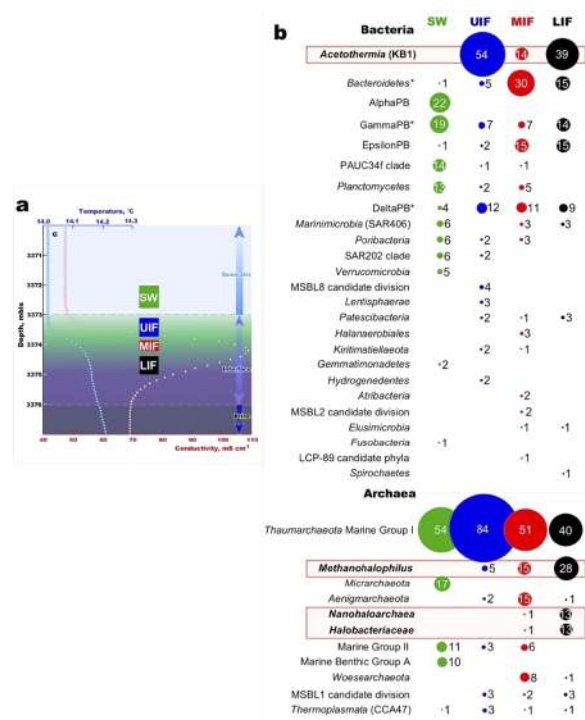
Fig. 1. Lake Hephaestus: Detailed CTD profile of the of conductivity and temperature data (**a**). Stratification of microbial community (**b**). Abbreviation used: LIF, the subsample of low interface; MIF, middle interface; UIF, upper interface; SW, seawater sample.

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NEW INSIGHTS INTO A SEEPAGE SYSTEM ON THE CALABRIAN ACCRETIONARY PRISM - IONIAN SEA: RESULTS OF THE PIONEER CRUISE (GAIA BLU R/V)

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Abstract

The occurrence of mud volcanism in an active tectonic scenario such as the Calabrian Accretionary Prism (CAP) has been intensively studied over the recent years in the Ionian Sea, with many interesting seepage systems revealed. This intriguing phenomenon involves geological, geochemical and microbial processes that sustain life in extreme environments. It was one of the primary research objectives of the PIONEER oceanographic cruise by CNR-ISMAR in the Ionian Sea. The acquisition of geophysical, geological and geochemical data allowed a multi-scale and multi-proxy investigation of a flat-top seepage structure located at 610 m water depth adjacent to an antiformal dome. The seepage structure exhibits active discharge of methane into the water column and is a result of multi-phase fluid migration across the Pliocene-Quaternary succession.

Keywords: Ionian Sea, Mud volcanoes, Deep sea processes, Seismics, Tectonics

PIONEER was the first scientific cruise on board of the CNR's research vessel Gaia Blu that took place from November 18th, 2023 to December 9th, 2023 in the Ionian Sea. The Ionian Sea is located in an active geodynamic region straddling the African-Eurasian plate boundary and the Thyrrhenian Calabrian subduction zone, where the Calabrian Accretionary Prism (CAP) was emplaced. The CAP is a thick accretionary complex that extends from the Calabrian onshore to the Ionian Abyssal Plain, where the subduction front is still active. The interplays between sedimentation, tectonics, oceanography and bio-geochemical processes have shaped the morphology of the seabed and sub-seabed. In the offshore CAP, the active deformation is evidenced by the occurrence of fluid seepage in the subsurface to the seabed giving rise to geological features such as: mud volcanoes (MV), mud diapirs, and pockmarks. In particular, MVs result from the upward migration of mobilized sediments, gas (e.g. CO_2, CH_4 and N) and water by an advective or diffusive fluid flow and the extrusion of a mixture of these components referred to as mud breccia. Until today approximately 70 MVs [1] have been discovered in the CAP, mainly concentrated in the inner morpho-tectonic (pre-Messinian, clastic) and in the Spartivento-Crotone forearc basins domains [2]. Here, we present geophysical, sedimentological, and geochemical data gained from the PIONEER cruise in the offshore Crotone Basin over a cold seep structure detected at 610 m water depth. The cold seep structure was previously identified with commercial 3D seismic data kindly provided by Eni S.p.A. Seismic reflection profiles reveal that the cold seep is rooted in the Miocene and acted as a preferential pathway for fluid mobilization during, at least, two main phases of activity in the Pliocene-Quaternary. Multibeam bathymetry and high-resolution sub-bottom profiles confirmed the nearly circular morphology of the structure with a flat top and a diameter of ~ 1250 m, for which reason was called Pool [3]. In general, the surface of the Pool is characterized by a high seafloor multibeam backscatter signal related to a rough morphology and it is confined by outer rims slightly emergent from the seafloor. Two gas flares detected by the water column backscatter, extend for a hundred of metres above the seabed and could indicate an active discharge of gas into the water column confined in the northern sector of the Pool. Two sediment gravity cores were collected in the central core (GC08; 1.85 m) and at the edge of the Pool (GC09; 3.8 m). An additional sediment piston core (PC12; 8.5 m) was collecetd slightly outside the Pool to serve as a reference and stratigraphic benchmark of the sorrounding area. Pore water was retrieved from sediment cores while on board. As soon as dispatched to the laboratories at ISMAR Bologna, sediment cores were analyzed with X-rays, magnetic susceptibility and core scanning X-ray fluorescence (XRF). Visual inspection and X-ray images highlight the presence of mud breccia especially in the lower part of the sediment core retrieved in the middle of the Pool, where the magnetic susceptibility signal is obliterated, possibly related to deformation caused by active diapirism. Breccias are made of mud clasts with calcite veins, over which thin sections have been prepared for SEM analysis. XRF data show high Zr/Rb ratios along the mud breccia, and peaks in the Ba/Ti ratio. These are important bio-geochemical proxies for deciphering the depth of the Sulphate-Methane Transition Zone (SMTZ) where the Anaerobic Oxidation of Methane takes place, which consumes methane by microbially-mediated reactions and release carbon and sulphates in the sedimentary environment. Geochemical analysis on pore waters show high content of SO_4^- (mmol). Further analysis are to be conducetd on sulphides and Dissolved Inorganic Carbon (DIC). $\delta^{13}C$ (‰) on foraminifera shells will be analysed to further reveal the presence and the inferred depth of the SMTZ [4] and reconstruct the seepage history of the Pool. Overall multi-scale and multi-proxy data have been integrated to investigate the bio-geochemical and diagenetic processes and highlight the multi-stage history of a mud/fluid Pool during the Pliocene to the recent.
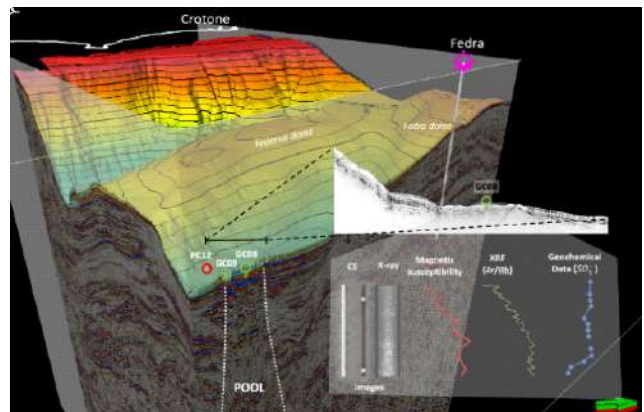
Fig. 1. Study area (Crotone basin) with the available data: from 3D seismic and wells to sub bottom profiles, sediment cores and geochemical data. Pool is highlighted with white dots lines.

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AMPHIPODA FAUNA BRINGS UP TO UPDATE THE KNOWLEDGE ON THE EASTERN MEDITERRANEAN DEEP-SEA BIODIVERSITY

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Abstract

An update on the amphipod fauna from the deep waters of the Levantine Basin is described. It is herein reported the first record in deep waters off the Israeli coast of the families *Ampeliscidae* Krøyer, 1842 and *Carangoliopsidae* Bousfield, 1977.

Keywords: Crustacea, Levantine Basin, Deep waters

Introduction

The Levantine basin has been considered for long time as an area with a low-diversity deep water fauna [1], though this hypothesis has always been treated as weak as efforts of sampling were limited by the inaccessible habitat [2]. Recently, new data integrated the previous knowledge, focusing on different taxa and shifting the vertical zonation range of deep sea to depths less than 200m. Knowledge of the amphipod peracarids is still scarce. Amphipod crustaceans inhabit all marine benthic habitats and show diverse feeding types, including scavengers, crucial in deep-sea food webs.

Material and Methods

In a previous investigation, performed in a period between 1993 and 1996 [3], 22 species of amphipods were identified from samples collected at depths ranging from 734 to 1558 m. After twenty years, 20 sites were sampled in 2013 at depths between 198 m and 1812 m along the Israeli coast. The samples were collected using a 0.062 m^2 and 0.025 m^2 box-corer with an effective penetration of 40 cm (Ocean Instruments model 700 AL) (see for details [4]). Each sample was preserved in 10% buffered formalin aboard the ship. In the laboratory, samples were washed and sieved through a 500 m mesh, preserved in 70% alcohol, and stained in Rose Bengal.

Results and Discussion

Amphipod bathymetric distribution was analysed to improve the knowledge about the distribution of this taxon. A total of 144 specimens belonging to 11 amphipod species were collected belonging to 7 families. It is herein reported the first record of two families in deep waters of the Israeli coast (*Ampeliscidae* Krøyer, 1842 and *Carangoliopsidae* Bousfield, 1977). Regarding three families, it was possible to extend their depth distribution: the family *Leucothoidae* Dana, 1852 was collected from 303 m to 601 m; the family *Oedicerotidae* Lilljeborg, 1865 from 994 m to 1301 m; the family *Phoxocephalidae* G.O. Sars, 1891 from 198 m to 1122 m (Figure 1).

The most relevant result was the discrepancy between the assemblage detected by [5] and the composition herein shown; some families found previously resulted absent (*Lepechinellidae* Schellenberg, 1926; *Liljeborgiidae* Stebbing, 1899; *Pardaliscidae* Boeck, 1871; *Stegocephalidae* Dana, 1852; *Tryphosida*e Lowry & Stoddart, 1997; *Uristidae* Hurley, 1963).

Conclusion

This study improves the knowledge of the bathymetric distribution of deep-sea amphipods including the addition of new records. Recently, studies have revealed that the deep-sea biodiversity of both the Eastern and the Western basins of the Mediterranean Sea is similar [6], however Amphipoda taxon still shows a low richness in the Levantine Basin compared with the Western basin.
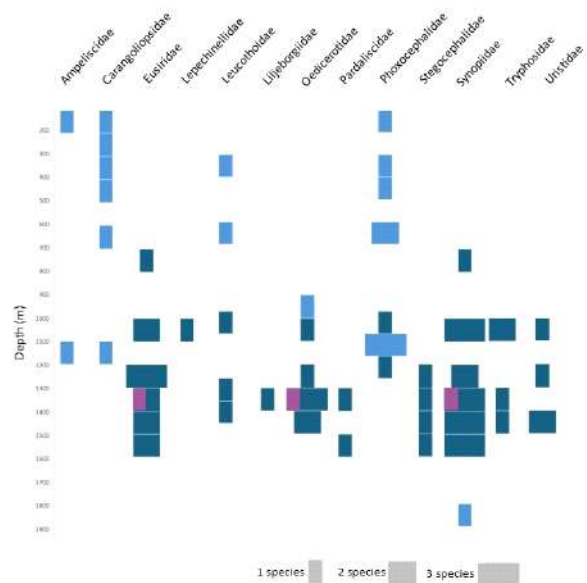
Fig. 1. Bathymetric distribution of species within the amphipod families. Dark blue indicates the number of species which were previously recorded by [3] and not found in our samples; light blue the new species recorded herein; violet indicates that the species recorded by [3] were herein confirmed.

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EARLY OBSERVATION ON *BATHYMODIOLUS SPP.* FROM THE EAST PACIFIC RISE 9.50 N SEGMENT HYDROTHERMAL VENT

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Abstract
Thirty specimens of *Bathymodiolus spp.* collected from the East Pacific Rise 9-13 N segment hydrothermal vents, were studied by histological and histochemical methods, and revealed some peculiar characteristics which distinguished them from *B. thermophilus* of which the most remarkable was the proterandry hermaphroditic gonads. This leads us suggest the examined area could accomodate more than one species of *Bathymodiolus*.

Introduction
Among symbiotic metazoans found at deep-sea hydrothermal vents and cold seeps, fourteen bivalve species pertaining to the family Mytilidae, genus *Bathymodiolus* (Kenk and Wilson, 1985), are currently recognized in the Pacific, Atlantic, and Indian oceans. *Bathymodilous thermophilus* (Kenk and Wilson 1985) is the type species of the genus (Duperron, S., 2010), and it is found living throughout the hydrothermal vents of the East Pacific Rise 9-13 N segment. At deep-sea hydrothermal vents, *B. thermophylus* constitutes the basis of the food web in lower temperature diffuse flow areas, playing a crucial ecological role in structuring vent communities.

Material and methods
Thirty specimens of *Bathymodiolus spp.* collected from the above area, were studied by routine histological methods, using H.E. and Masson Trichrome.

Results and discussion
microsopic examination (Fig. 1) revealed some peculiar characteristics which distinguished them from *B. thermophilus* of which the most remarkable was the proterandry hermaphroditic gonads (Fig. 2). Particularly, a detailed microscopic study of gonads anatomy revealed a type of male gonad emptying upon release of sperms, which involved all cellular components of the gonadal follicles, including the Sertoli cells, suggesting a characteristic adaptive behavior to deep sea. Detailed gross and microscopic description of the mussels leads us to suggest that the examined area could accommodate more than one species of the *Bathymodiolus* genus, as already occurring in other regions. Ongoing molecular investigations will be able to clarify whether the individuals studied belong to a species different from *B. thermophilus* or represent hybrids. our study testifies the great variability of the biology of organisms living in these extreme environments and the need for further investigations to clarify the biological mechanisms that regulate their adaptations.
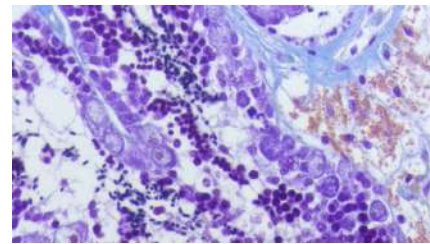
Fig. 2. Hermaphroditic gonad follicles in *Bathymodiolus spp.*

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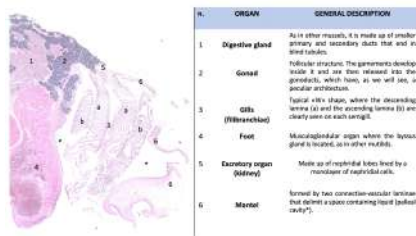
Fig. 1. General description of the microscopic anatomy of *Bathymodiolus spp.*

Congress Joint Session : Biodiversity changes & environmental crisis (C5 - C6)

Moderator : Bayram Öztürk – Univ. of Istanbul, Turkey

Session's Synthesis

During this session, presentations made by different scientists from the entire Mediterranean Sea on Thursday 17 October 2024, during the 43rd CIESM Congress in Palermo/Italy.

Effects of multi-stressors on phytoplankton and zooplankton communities were discussed.
Main discussion topic was how environmental crisis will impact on biodiversity in terms of species, habitat and ecosystem. Also how it can be responded by nature in short time. Besides, how we can monitor bioidversity changes related to environmental crisis.

It is expected that bioidversity change will continue as parallel to environmental crisis around the Mediterrnaean Sea. At a species level: Spawning period of fish can change, invasion of non- indigenous species number can increase in both the Mediterrarnean and Black Sea basins, and temperature anomalies can impact endemic soft and stony coral species in the Mediterranean Sea.

Temperature anomalies are often reported in recent years in the Mediterranean Sea and even mediterranization has also been reported in the Black Sea (see CIESM workshop monograph number 39). In that context, monitoring of marine environment of both the Black Sea and Mediterranean Sea is of crucial importance with regional cooperation, including the exchange of information in the entire basins. Finally, among presenters, the majority was young scientists, which is promising and presenting a hope for the monitoring of the Mediterranean and Black Seas.

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INVESTIGATION OF THE EFFECTS OF MULTI-STRESSORS ON BLACK SEA BY DIATOMS AND DINOFLAGELLATE CYSTS CHANGES AT BENTHIC ECOSYSTEMS IN THE CASE OF SINOP

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Abstract

The Black Sea faces environmental challenges like warming, eutrophication, and human activities. Benthic diatoms and dinoflagellate cysts are used as indicators due to their sensitivity. This study aims to assess their abundance and composition against multiple stressors, tracking biogeochemical changes using conventional and innovative methods. Core samples from 7 stations offshore Sinop were collected by the R/V Bilim-2 on June 2023. Measurements of porewater for dissolved inorganic nutrients and solid state Total Organic Carbon (TOC), and Total Nitrogen (TN) are performed for biogeochemical characterization. Results show spatial variations among stations. Diatom and dinoflagellate cysts analysis is ongoing. Integrating biological indicators with sediment biogeochemistry can enhance future studies and monitoring efforts significantly.

Keywords: Diatoms, Dinoflagellates, Biodiversity, Bio-indicators, Black Sea

Introduction - The Black Sea is a semi-enclosed basin fed by ten major rivers, forming a unique coastal-deep-sea system and recognized as the largest euxinic sea in the world. It receives Mediterranean seawater from the Marmara Sea via the Bosphorus, and the excess water is discharged through the straits [1]. Findings indicate that even at safe levels for individual stressors, eutrophication and climate change combination might reduce ecosystem resilience and cause unexpected collapses, like Harmful Algal Blooms [2]. Diatoms serve as a valuable tool for studying diversity-productivity relationships [3]. Also, dinoflagellate cysts in sediment offer knowledge due to their distribution, including diversity, abundance, and specific taxa against changing environmental factors influencing [4]. Benthic diatoms and dinoflagellate cysts are significant elements of the Black Sea seafloor ecosystem. Understanding how biodiversity change will influence the structure and the function of fragile ecosystems like the Black Sea and how the components can be implemented as early warning signs are critical to coping with the challenges faced. Furthermore, the assessment the ecological status of the Black Sea can be achieved by identifying and comprehending the responses of phytoplankton communities to various environmental factors, such as nutrient levels, water quality, and temperature. The primary objective of this study is to comprehend the ecological implications of changes within these communities.

Materials and Methods - Sediment samples are taken by the Multi-Corer (Oktupus) in 7 stations with depths ranging from 40 to 250 meters from oxic, suboxic and anoxic characteristics stations in two different regions the east and the west of Sinop at Black Sea in the cruise conducted by the R/V Bilim-2 on June 2023 as a part of Bridge-BS Project. The cores are sliced to a depth of 1 cm in the selected intervals. CTD System was conducted to measure oceanographic parameters. Physicochemical analysis which contains Dissolved Inorganic Nutrient Analysis in porewater, and Solid TC, TOC, and TN are applied. Also, pigment analysis in the surface sediment samples through the stations is conducted. Diatom analysis and dinoflagellate cysts analysis are under process.

Results and Discussion - It is observed spatial differences for the physicochemical parameters. Porewater nutrient analysis results show variations through the stations due to their different physicochemical characteristics. Values for each parameter are observed from 0,89 µM to 42,36 µM for PO4, from 2,4 µM to 520,78 µM for Si, and from 3,94 µM to 595,83 µM for DIN. The highest values are encountered in the anoxic station. TOC/TN values indicating the organic matter presence show differences in the samples through the stations with a range from 4,05 to 13,36. Pigment values demonstrate diverse patterns among the stations and several parameters such as Chl-a, Chl-b, C3, and C2 show elevated values in the same anoxic station.
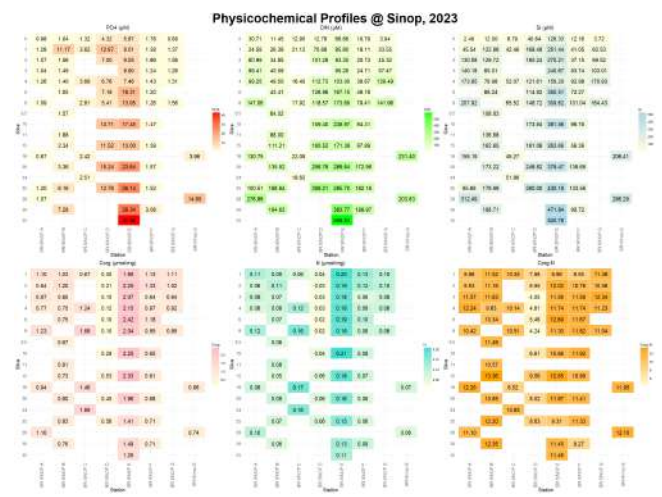
Fig. 1. Profiles in physicochemical parameters across different sediment depths at each sampling station.

Fig. 2. Diatoms species observed in the samples: _Diploneis_ sp. (left) and _Coscinodiscus_ sp. (right).

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PSEUDO-NITZSCHIA AND GLOBAL CHANGE FACTORS IN THE MEDITERRANEAN: IDENTIFYING KNOWLEDGE GAPS

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Abstract

Global change factors shape pelagic communities worldwide, and some of them, such as climate change and eutrophication, raise concerns about their effects on the proliferation of harmful algal blooms (HAB) such as *Pseudo-nitzschia*. Their consequences are expected to be most prominent in quasi/enclosed seas such as the Mediterranean, yet only a few studies address the issue of HAB. To this end, we performed a literature review to assess the current knowledge on the impacts of global change on *Pseudo-nitzschia* in the Mediterranean. A limited number of studies indicates a potential phytoplankton shift to *Pseudo-nitzschia* dominance under dfferent eutrophication scenarios, but effects are strain-specific. Importantly, we reveal a knowledge gap on the combined effects of global change factors on Mediterranean *Pseudo-nitzschia* populations.

Keywords: Phytoplankton, Mediterranean Sea, Warming, Eutrophication, Diatoms

Different global change factors and their interplay raise concerns about their effects on harmful algal bloom species (HABs) because those can profoundly alter ecosystem services and threaten human health [1]. Among them, diatoms from the genus *Pseudo-nitzchia* cause problems worldwide as some strains can produce domoic acid, which is toxic to humans and other vertebrates, and the number of toxic events has been steadily increasing since the 1980s [1]. In the Mediterranean, several strains were reported, among which are potential (i.e., *P. delicatissima, P. fraudulenta, P. multiseries, P. seriata*) and confirmed toxic producers (i.e., *P. galaxies, P. multistriata, P. calliantha, P. brasiliana* and *P. pseudodelicatissima*) [2]. Global change can have particularly pronounced effects in land-locked seas such as the Mediterranean. For instance, the most prominent climate change effects are intensified heat waves leading to 20% faster warming than the global average [3]. Moreover, reports on undesirable plankton blooms, often in coastal areas, are not isolated incidents [4]. It can be expected that the change in precipitation regime and aeolian processes as the major nutrient transport routes to oligotrophic waters will play progressively important roles. Yet, it is unclear what we know about the effects of global change factors on *Pseudo-nitzchia* in the Mediterranean. To learn about the experimental efforts on this genus in the Mediterranean, we performed a literature screening (March 2024) using the Scopus database and the TITLE-ABS-KEY search. The terms pseudo-nitzschia OR pseudonitzschia were used, firstly together with terms: climate OR "climate change" OR "global change factors" OR "temperature change" OR warming OR acidification OR greenhouse, which resulted in 132 articles. Most were *in situ* findings, 11 were community, and 18 were single-strain experiments, but only 4 were Mediterranean studies that did not include experiments testing for global change factors. Secondly, an extended search applied the terms nutrients OR eutrophication OR nitrogen OR silica OR phosphorus OR nitrate OR nitrite OR ammonia OR ammonium OR phosphate, resulting in 437 other articles, of which ~10% were Mediterranean studies. Among them, only 3 tested the response of the phytoplankton community, including *P. delicatissima* group [5] and non-harmful *P.* cf. *pungens* [6] and *P.* cf. *seriata* [7], while 2 reported on singe-strain experiments using *P. multistriata, P. calliantha* [7, 9] testing only single factor rather than combined effects. None of the studies tackled the effects on toxin production. Community experiments that simulated the riverine input showed increased numbers of *Pseudo-nitzschia* when nutrients were abundant and when the riverine inflow was low [5]. This might indicate that, regardless of the lowered overall inflow that the region has recently witnessed [8], *Pseudo-nitzschia* might still be able to bloom and thrive even on organic nitrogen supply [7]. The dominance of the genus was also noted when the community was exposed to pollutants such as PAHs and heavy metals [6], hinting at its resistance in the coastal areas exposed to extreme anthropogenic pressures. Because it was shown that domoic acid production requires a sufficient nitrogen supply and can be stimulated by urea [10], coastal areas might be especially prone to bloom development. Single-strain experiments were focused on growth rates for different treatments, including differenr temperatures, salinities, irradiances, as well as nutrient and silicate depletion [8], and different nitrogen sources [7]. Strains grew slower in suboptimal conditions but increased their RNA content as a rapic response to stress, possibly as resilience against diminished protein production, which sets them apart from other diatoms [8].Other studies also examined the effects of ocean acidification and an increase in pCO_2 and concentrations of metals (iron and copper). While increade/decrease of salinity and silicate-limitation consistently negatively affected the growth of Mediterranean strains, the growth discrepancy between species, e.g. *P. multiseries* exhibited about 3x slower growth rated under N/P/Si-limitation than *P. calliantha* [8], underlines the importance of testing various strains.

In conclusion, the literature gives a sufficient rationale for studying *Pseudo-nitzschia* in the Mediterranean but also identifies existing knowledge gaps, i.e., low variability of tested ii) strains, ii) factors, and iii) no tests on multiple-factor effects.

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SENTINEL OF THE SEABED INDICATOR APPLICATION TO THE BENTHIC HABITATS OF THE WESTERN MEDITERRANEAN

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Abstract

We have estimated the Sentinel of the Seabed indicator for the benthic habitats in the Levantine-Balearic (western Mediterranean), one of the five Spanish marine established for the implementation of the European Marine Strategy Framework. The assessment is summarised by Broad Habitat Types and depth stratum. The results show that the habitats most affected by bottom trawling are *Circalittoral mud*, *Offshore circalittoral mud* and *Circalittoral sand*. The greatest extent of surface adversely affected is found off Iberian Peninsula. In terms of bathymetric strata, the least affected depth is between 100 and 200 m.

Keywords: Western Mediterranea, Habitat, Trawl surveys, Zoobenthos

Bottom trawling is the most widespread anthropogenic disturbance to seabed habitats, affecting the structure and functioning of benthic communities by altering their species composition ([1], [3]). In the Marine Strategy Framework Directive, Sentinel of the Seabed (SoS) indicator has been used to assess Good Environmental Status of circalitoral and bathyal benthic habitats. SoS species are the most representative species sensitive to bottom trawling in non or low impacted areas.

We have calculated the SoS indicator ([3]) in the Levantine-Balearic demarcation (western Mediterranean), one of the five Spanish marine established for the implementation of the European Marine Strategy Framework, at two levels: (i) Broad Habitat Types (BHT), obtained from the Emodnet BHT layer; and (ii) depth strata sampled. This indicator combines three types of information: habitat distribution, trawling effort (in terms of Swept Area Ratio, SAR) and biological data.

The standardised biomass of epibenthic fauna (g/km^2) were obtained from MEDITS annual bottom trawl surveys carried out between 2014 and 2022. The sampling strategy applied consider five depth strata: A) <50 m; B) 51-100 m; C) 101-200 m; D) 201-500 m; and E) 501-800 m. Based on this data, the BESITO index ([2]) was calculated to estimate the sensitivity of each species to bottom trawling and to obtain SoS species.

The correlation between the proportion of SoS species and trawling effort has been analysed with General Additive Models. Based on the significant pressure-state curves obtained for each BHT or depth stratum and the SAR layer, the proportion of SoS species was predicted for the whole area. Finally, the extension of areas disturbed by bottom trawling was estimated applying quality thresholds obtained from those curves.

Lower fishing effort, and therefore higher proportion of SoS species, have been shown in the Balearic Islands compared to the Iberian Peninsula (Figure 1).
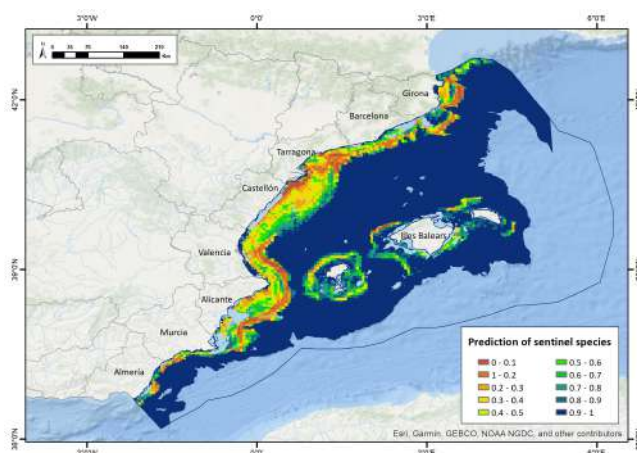
Fig. 1. Prediction of sentinel species based on the mean SAR value.

From the BHT, *Circalittoral mud*, *Offshore circalittoral mud* and *Circalittoral sand* showed the higher percentage of areas adversely affected by bottom trawling (85%, 63% and 52% of the area, respectively), while *Offshore circalittoral sand* and *Upper bathyal sediment or Lower bathyal sediment* showed the least ones (25 and 13% of the area, respectively). The most severely affected areas are off Iberian Peninsula (Figure 2).
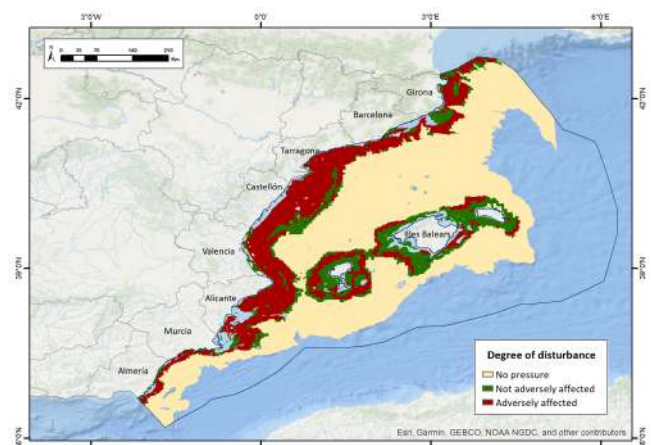
Fig. 2. Distribution of the degree of disturbance in relation to trawling.

Preliminary results of the second approach carried out, based on depth strata, showed significant pressure-state curves in three of the five strata analysed (B, C and D). Stratum C showed the smallest area adversely affected by bottom trawling, whereas B and D strata showed a larger area affected by fishing.

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IMPACT OF SEDIMENT DEPOSITIONAL EVENTS ON BENTHIC FORAMINIFERA: A MULTI-YEAR RECORD FROM THE NORTH ADRIATIC S1 AND E1 LONG-TERM ECOLOGICAL RESEARCH STATIONS

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Abstract

We investigate the impact of sediment depositional events on benthic foraminiferal (BF) assemblages in the North Adriatic focusing on two Italian Long-Term Ecosystem Research Network (LTER) stations, S1 and E1. Results show that BF assemblages at S1 are mainly influenced by the Po riverine discharges causing density and diversity decrease, and dominance of opportunistic taxa. In contrast, BF assemblages at E1 are dominated by taxa tolerant to moderate organic matter and are mostly affected by sediment reworking related to storm waves causing changes in environmental parameters and shifts in species composition. Specimens of this E1-S1 Foraminifera Collection are being digitised within the frame of DiSSCo (Distributed System of Scientific Collections) which will allow accessible information enhancing the role of foraminiferal records.

Keywords: Adriatic Sea, Biodiversity, Sediment transport, Foraminifera

Introduction

While many studies investigated the effects of changes in sedimentary supply on macrobenthos [1], the meiofaunal response remains largely unexplored [2]. Indeed, increase in rainfall patterns and severe storms, due to the ongoing climate change, is significantly affecting the sedimentary supply to coastal areas, with detrimental effects on aquatic ecosystem and biodiversity [3,4]. As meiofauna occupies lower trophic levels, has the potential to affect the ecosystem functioning through a bottom-up dynamic. Therefore, understanding their response to sedimentary supply fluctuations is crucial for predicting climate change impacts on marine ecosystems. Primary goal of this study is to document the relationship between changes in benthic foraminiferal (BF) assemblages of the North Adriatic Sea and sediment depositional events. The investigation is based on samples collected from 2016 to 2023 in two stations, S1 and E1, located south of the Po Delta River and in the Rimini offshore respectively, at the LTER-Italy research Site "Delta del Po and Costa Romagnola".

Material and Methods

Sediment samples were collected using a box corer during research cruises or during the ordinary maintenance activities of the S1 and E1 autonomous meteo-oceanographic systems. For foraminiferal analysis, the uppermost 0–1 cm interval was stored in buffered ethanol at 70% stained with rose Bengal (2 g per liter) for at least 14 days. In this work we report BF data collected on living (rose Bengal stained) assemblages from the >63 μm size fraction in order to obtain information on small-sized species. The used BF sample time-series is part of the Institute of Marine Science (CNR-ISMAR) Natural Science Collections which are currently involved in the DiSSCo (Distributed System of Scientific Collections) Research Infrastructure in the framework of the ITINERIS (Italian Integrated Environmental Research Infrastructure System) Project and are under the process of digitization (transition from physical to digital specimens). Related data and metadata will be shared on open institutional archive and GBIF (Global Biodiversity Information Facility) portal, fulfilling the FAIR (findable, accessible, interoperable, and reusable) principles. Making information accessible will contribute to detect potential biodiversity changes to distinguish major drivers, and to develop appropriate conservation measures thus enhancing the role of foraminiferal records for environmental and ecosystem sciences.

Results and Discussions

Our findings reveal that the primary driver influencing BF assemblages at S1 Station is the Po riverine discharge, while at Station E1, BF composition is mainly controlled by sediment reworking due to storm waves which lead to alterations in key environmental parameters for BF (Fig. 1). Following major flood episodes at S1 (Fig. 1 B3), closer to the delta, BF density and diversity markedly decrease, environmental quality deteriorate, and the BF population becomes dominated by highly opportunistic taxa tolerant to organic-rich sediments and oxygen deficiency, such as buliminids and *Nonionoides turgidus*, with subordinate *Stainforthia fusiformis* and *Hopkinsina pacifica* (Fig. 1 A5 and A8). Conversely, at Site E1, BF assemblages are typically dominated by taxa tolerant to moderate concentrations of organic matter. However, after major

storm wave episodes (Fig. 1 B2), lowest BF density and diversity values are recorded, accompanied by a significant increase in *Ammonia* species, *Aubignyna perlucida*, and a marked decrease in fragile agglutinant taxa (Fig. 1 A1 and A4). Notably, E1 environmental BF indices do not show any significant changes during these events.
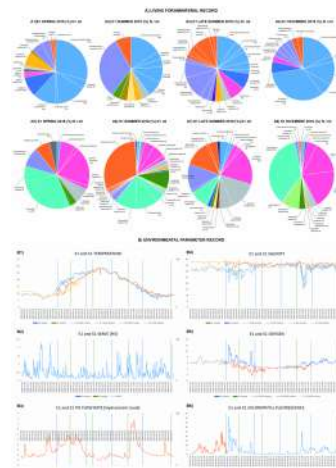
Fig. 1. A) Pie charts of living foraminiferal assemblages from stations S1 and E1 2018-2019 samples. Species illustrated with the same color belong to groups with similar ecological characters as following listed: Ammonia group (blu), Bolivina group (pink), Bulimina group (grey), Steinforthia group (green), Nonionella group (cyano), Miliolids group (purple), Agglutinants group (orange). B) Graphic showing environmental parameters fluctuations in 2018-2019 as recorded by the autonomous meteo-oceanographic stations S1 and E1.

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PPCI MED, A NEW PHYTOPLANKTON COMPOSITION INDEX RESPONDING TO ANTHROPOGENIC PRESSURE IN THE MEDITERRANEAN SEA

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Abstract

As phytoplankton reflect immediate effects of changes in nutrient inputs in ecosystems, they have been retained by several European legislations to assess the health status of marine ecosystems. Here, we present a new phytoplankton composition index, PPCI Med (**P**igment **P**ressure **C**omposition **I**ndex) adapted to the specificities of the Western Mediterranean coastal waters. It uses diagnostic pigments of total phytoplankton measured by HPLC. Only pigments responding positively to pressures (*i.e.* nutrient concentrations) are considered. The calculation protocol is described, and an evaluation grid is proposed. PPCI Med is designed to be scientifically robust yet easy to implement by stakeholders lacking expertise in phytoplankton biodiversity. PPCI is transferable in other coastal zones if pigments/ pressure relationships are established.

Keywords: Western Mediterranea, Phytoplankton, Pigments, Bio-indicators

Materials and methods

PPCI Med was developed in the French coastal waters of the Med Sea where a robust dataset of nutrients and phytopigments was collected in reference sites and impacted water masses (15 stations, 744 nutrients/ pigments samples; [1]).

Index elaboration and calculation protocol (Fig. 1)

1. Relationships between pigments and proxies for pressure

Only pigments responding positively to nutrient concentrations (as proxies for pressure) are integrated to PPCI (Spearman correlations, rho $\geq$ 0.45, p value < 0.0001). For phytoplankton groups identified by multiple diagnostic pigments, only the one that is most responsive to pressure is chosen. In our study, 4 diagnostic pigments, peridinin, fucoxanthin, prasinoxanthin and alloxanthin, were selected according to the criteria defined above. In the Med Sea, they act as biomass tracors for photosynthetic dinoflagellates, diatoms, prasinophytes, and cryptophytes, respectively. Consequently, PPCI Med is composed of 4 sub-indexes (S_i) : S_i Peridinin, S_i Fucoxanthin, S_i Prasinoxanthin and S_i Alloxanthin.

2. Construction of reference curves

Reference curves are established for reference stations identified by the Water Framework Directive monitoring and/or ongoing programs. For each selected pigment, a reference curve is constructed. It describes the seasonal evolution of this pigment. Ideally, the curves are constructed from bi-monthly data acquired over a sliding 6-year period. Each curve comprises 12 values (1 value per month) obtained by calculating the monthly P_{90} of pigment concentrations and adding a 50% safety margin to account for natural variability. For very low pigment concentrations, a minimum threshold of 5 ng L^{-1} is imposed. The principle of sliding reference curves contributes to incorporate long-term effects of climate change.

3. PPCI calculation

To assess phytoplankton composition quality at a site, a score and an ecological quality ratio (EQR) are calculated for each selected pigment :
3.1. Compare the pigment concentrations at the site to be assessed with the reference values, respecting the temporality,
3.2. Calculate the frequency (%) of overpassings from the reference, the relative magnitude (%) of each overpassing during the observation period (1-6 years) and the averaged overpassing (%),
3.3. Calculate a score for the considered pigment : score = (frequency of overpassings x averaged overpassing) / 1000,
3.4. Transform scores $\leq$ 20 into EQR by applying the formula : EQR = 1 - (0.050 x score). If the score is > 20, EQR = 0. The threshold of 20 was defined on the basis of our field expertise.

4. Repeat step 3 for all selected pigments and calculate the final EQR

The final EQR is the arithmetic mean of the sub-indexes EQRs. PPCI ranges from 0 (phytoplankton composition highly degraded) to 1 (phytoplankton composition in very good condition). Classification boundaries (Fig. 1) were established on the basis of our field knowledge, and what we consider to be very good and poor phytoplankton compositions in the study area. We then set the boundaries for the different states, checking the consistency of the classifications obtained with our expertise and other expert judgement.

Applications of PPCI

PPCI Med allows to detect the effects of anthropogenic disturbances on phytoplankton composition over different spatial and temporal scales. It can also be used to highlight the seasonality of disturbances, such as those caused by recreational boating, and to measure improvements in environmental quality following restoration efforts.
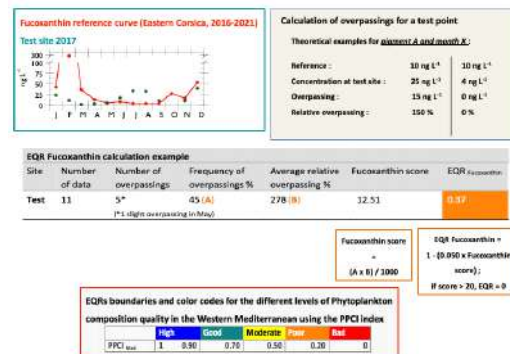

Fig. 1. Example of score and EQR calculation ; PPCI Med quality grid.

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MULTI-INDICES APPROACH OF ZOOPLANKTON LONG-TERM MONITORING SURVEY IN THE BAY OF MARSEILLE REVEALED THE EFFECTS OF INCREASING OLIGOTROPHY ON PLANKTIVOROUS FISH

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Abstract
Plankton constitutes the base of marine food webs. Temporal studies of zooplankton are allowing to understand the effects of global change on marine ecosystems. A study of quantitative and qualitative components of zooplankton related to environmental parameters was conducted in the Bay of Marseille from 2005 to 2020. Nutrient concentrations decreased and water temperature increased, leading to a decrease in phytoplankton size and a decrease in zooplankton quantity and quality. Changes in zooplankton were observed in 2008, concomitant with a decrease in size and weight of sardines. This study highlights the interest of a multi-indices approach (biomass, species, sizes, biochemical and energy content) of zooplankton to understand the link between environmental changes and zooplanktivorous fish populations.

Keywords: Zooplankton , Time series, Food webs, Chemical analysis, Gulf of Lyon

In recent decades, the coastal zones of the northwestern Mediterranean Sea have undergone major changes: nutrient concentrations have decreased and water temperatures increased. In parallel, the relative body condition and size of two small zooplanktivorous fish (sardine and anchovy) have decreased in the Gulf of Lion. This pattern was suggested as a bottom-up consequence of quantitative and qualitative changes of zooplankton.

This study presents a holistic multi-index analysis of a time series from bimonthly monitoring of zooplankton in the Bay of Marseille, in the eastern Gulf of Lion, over the last two decades (2005-2022). This study analyses the temporal variations in biomass, species composition, size structure, energy content, elemental composition and isotopic composition of the zooplankton community [1].

In the Bay of Marseille, zooplankton showed strong seasonal and interannual variations. This study evidenced the relationships between the quantitative and qualitative variations of zooplankton communities and the oligotrophisation of the environment, suggesting a strong bottom-up control at the base of the food webs.

During periods with high nutrients concentrations (winter-spring, and the beginning of the time series), the zooplankton community was largely dominated by copepods (herbivores, omnivores). At the community level, biomass and abundance were higher, while size and diversity were lower.
During periods with low nutrient concentrations (summer-autumn, and the end of the time series), the dominance of herbivorous and omnivorous copepods is reduced and large filter-feeding organisms (e.g., pteropods) and predators (e.g., chaetognaths and also large carnivorous copepods) are more abundant. At the community level, biomass and abundance were lower, while size and diversity are higher.

Analyses of the biochemical and isotope composition of the 300-500 µm zooplankton size-class, taken as the reference for zooplankton, have shown a decrease in lipids, an increase in proteins, and in nitrogen and carbon stable isotope ratios since 2009. These changes are in line with the increasing oligotrophy of the environment. Analyses of biochemical content and isotope ratios, carried out on all size classes of zooplankton (from 200 to >2000 µm) for a set of contrasted years, confirmed the decrease in lipid concentrations of all size classes.

The values of many indices drastically changed during the 2010s, in line with other observations of Mediterranean time series. However, the inter-annual variations in the biomass of the 1000-2000 µm size-class, lipid and protein concentrations, and isotope ratios were observed earlier (since 2008) concomitant with the crisis period for small zooplanktivorous pelagic fish.

These results provide insights into the potential effect of changes in zooplankton on the reduction in size and body condition of small planktivorous fish in the Gulf of Lion, linked to environmental changes [1].

This critical period in zooplankton community of the Bay of Marseille would have been missed without a combined analysis of the specific, quantitative and qualitative composition of the various size classes of zooplankton. The results of this study demonstrate the interest of a multi-indices approach during zooplankton long-term monitoring surveys.
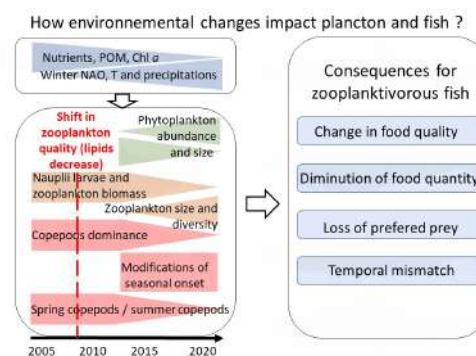

Fig. 1. Influence of environment on plankton and fish

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INFLUENCE OF EFFLUENT DISCHARGE ON MALTESE SHORE BIOTIC ASSEMBLAGES

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Abstract
Effluent discharges in coastal areas are a growing problem in a constantly developing world, with rocky shores being some of the most impacted by coastal development worldwide. The present study was aimed at establishing whether effluent discharge, having low nutrient levels, influences attributes of the associated biotic assemblages. Results indicated a significantly higher number and abundance of macroinvertebrate taxa, but lower diversity and evenness at effluent sites compared to reference sites. Therefore, even at low levels, nutrients in discharged effluent have a significant effect on shore biotic assemblages, but this impact is restricted to the vicinity of the effluent discharge point.

Keywords: Malta Channel, Pollution, Mediolittoral, Nutrients, Coastal waters

Introduction
Rocky shore habitats are an important component of coastal ecosystems, including those in the Mediterranean Sea [1]. Nutrient enrichment from effluent discharge can influence primary productivity on shores, which in turn may affect ecological attributes of shore macroinvertebrate assemblages, such as species diversity and abundance, ultimately reshaping the taxonomic and functional structure of the shore community [2]. Although numerous studies have assessed the influence of nutrient enrichment on shore algal communities, relatively few works have focused on the effects of nutrient-enriched discharge on shore macroinvertebrate assemblages. The available information indicates that nutrient enrichment can lead to reduced shore invertebrate diversity, while promoting dominance of certain species; thereby influencing the species composition and structure of shore invertebrate assemblages [3].

Method
Four study localities having effluent discharge with low levels of nutrients were identified for the study: Mellieha Bay, Bahar ic-Caghaq, Sliema, and Xghajra (Fig. 1.). A reference site without effluent was also assigned to each locality; this was located between 250 m and 1.8 km from the effluent site. Levels of nutrients were as follows: phosphates ranged from 0.051 µg-at P L^{-1} to 0.152 µg-at P L^{-1} at sites with effluent, and from 0.017 µg-at P L^{-1} to 0.102 µg-at P L^{-1} at sites without effluent. Ammonia ranged from 0.750 µg-at P L^{-1} to 3.179 µg-at N L^{-1} at sites with effluent, and from 0.667 µg-at P L^{-1} to 1.393 µg-at N L^{-1} at sites without effluent. Nitrate ranged from 1.030 µg-at P L^{-1} to 1.570 µg-at N L^{-1} at sites with effluent, and from 0.993 µg-at P L^{-1} to 1.356 µg-at N L^{-1} at sites without effluent. Using a 20 cm x 20 cm quadrat, three replicate samples were collected from the mediolittoral zone at both 'reference' and 'effluent' sites.

Fig. 1. Map of the Maltese Islands (excluding Gozo and Comino islands) showing the study localities, and effluent (filled circle) and reference (hollow circle) sites at each locality.

Results and Discussion
Results indicated that, when comparing the 'reference' (RS) and 'effluent' (ES) site at each study locality, total abundance and number of macroinvertebrate taxa were significantly higher but species diversity and evenness were significantly lower at the ES (Fig. 2.). Amphipods *Hyale* spp., polychaetes *Syllidae* spp. and *Neries rava* had significantly higher abundance at the ES compared to the RS. Abundance of algae, in particular of *Jania* sp. and *Palisada perforata*, was higher, but not significantly so, at the ES. It was concluded that effluent discharge influenced attributes of the rocky shore biotic assemblages; namely total abundance, number of taxa, taxon diversity, and taxon evenness and abundance. However, the magnitude of influence of the nutrient enrichment varied, such that some attributes increased and others decreased in value. In any case, the presence of effluent, even though having low levels of nutrients, resulted in changes to attributes of the shore biotic assemblages, but the changes were restricted to the vicinity of the effluent discharge point.
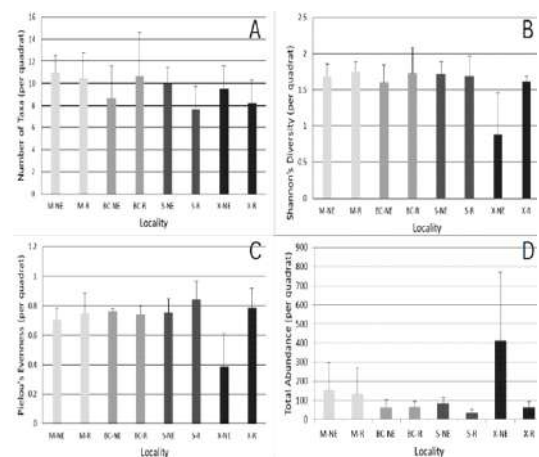
Fig. 2. Mean total number of taxa (A), Shanon's diversity (B), Pielou's evenness (C), and total abundance (D), recorded from the Mediolittoral Zone at Mellieha (M), Bahar ic-Caghaq (BC), Sliema (S), and Xghajra (X). ES = effluent site; RS = reference site.

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POTENTIAL ENVIRONMENTAL IMPACTS OF UNDERWATER POWER CABLES IN THE MEDITERRANEAN SEA

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Abstract

Underwater power cables connect territories and offshore renewable energy platforms to electrical grids all over the world. The submarine power cable industry is expected to boom in the coming years to help satisfying ever growing energy demands. Improving connectivity at basin, sub-basin and local scales and the need of evacuating future wind power produced offshore are pushing this industry in the Mediterranean Sea too. These developments require investigating the potential impacts of submarine power cables due to heating and electromagnetic radiations under the unique environmental conditions of the Mediterranean Sea. Infaunal communities appear as key indicators to assess such potential effects.

Keywords: Sediments, Bio-indicators, Thermal pollution, Polychaeta, Mediterranean Sea

State of the art There are almost 8,000 km of power cables running at the bottom of Earth's oceans. The era of submarine electrical connectivity begun in 1954 when the first commercial High Voltage Direct Current (HVDC) cable linked Sweden and Gotland Island in the Baltic Sea. Since then, major technology advances in terms of transporting capacity, material durability, cable length and installation techniques have led the network to spread around the planet[1]. Further growth is expected in the coming years as new offshore renewable energy platforms and higher connectivity between territories will play an essential role for transitioning to an electrified and carbon neutral world.

Such an exponential expansion has raised concerns about the environmental effects underwater power cables might have on organisms and habitats. These effects are classified as physical habitat disturbances, sediment resuspension, chemical pollution and underwater noise emission during installation, maintenance and decommissioning phases —which are beyond the scope of this contribution—; and changes in electromagnetic (EM) fields, heat emission, risk of entanglement, chemical pollution, and creation of artificial reef and reserve effects during the operational phase[2].

We focus on two of the least known and more controversial drivers of potential impacts of power cables while in operation, which are heat increase and EM fields, using as bioindicators small organisms inhabiting within the bottom sediments, such as polychaetes, crustacea and bivalves.

The Mediterranean Sea case More than 70% of the world's underwater power cables are in European waters, both in terms of number and cumulated length. These infrastructures are becoming more and more important in the Mediterranean Sea, with 5 international cables and multiple island-mainland and island-island links in operation[3]. In order to achieve the grid development objectives for 2030 the Association of the Mediterranean Transmission System Operators (Med-TSO) has published a Master Plan of Mediterranean Interconnections[4] where 11 new international underwater power cables are considered (Fig. 1).

Offshore renewable energy platforms, mainly wind energy, will also grow in Mediterranean waters, which implies more cables landing on its coasts. The most suitable areas are the Gulf of Lion, the North Adriatic Sea, the gulfs of Hammamet and Gabès, the Gulf of Sirte, and the Nile Delta[5]. At present, the only farm in operation is in Taranto, Italy, with several more in different stages of development.

Preliminary results First *in situ* measurements and sediment sampling for infaunal analysis were carried out by scuba in January 2024 along a newly laid double cable at water depths less than 10 m in between the islands of Eivissa and Formentera, in the Baleares. Methodological details are omitted for concision. An initial analysis of the *in situ* sediment temperature shows no correlation with the distance to the cable. Preliminary results on infauna in the sediment show a higher abundance and diversity in the upper 10-15 cm than in deeper layers (15-40 cm bsf), as is usually the case.

The view forward We advocate for more, systematic research on the effects of underwater power cables and, most importantly, it has to keep up with the pace of new installations. As for our work, after finishing the processing and analysis of all samples and measures, we will be able to draw firm conclusions about the effects of heat and EM fields on infauna. We are planning future field campaigns to study seasonal variations in the infaunal community and perform comparisons between different environments. A final goal of our work is drawing up a protocol to assess the environmental effects of temperature increase and EM fields caused by submarine power cables.
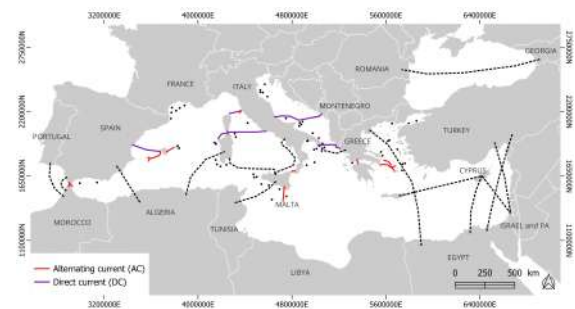
Fig. 1. Main underwater power cables in operation (solid lines) and planned (dashed lines) in the Mediterranean area. Main offshore wind power farms in operation (triangle in Italy) and under development including pilot phases (dots) are also shown. Based on data from various sources.

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PRESENT AND FUTURE DISTRIBUTION OF BROWN ALGAL FORESTS IN THE NORTHERN ADRIATIC

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Abstract

Canopy-forming species, particularly *Cystoseira s.l.*, provide essential ecosystem services in the Mediterranean coastal area. However, these species face significant regression due to anthropogenic stressors and climate change. This study aimed to assess the status and distribution of brown algal forests along the Slovenian coastline in the northern Adriatic, employing non-destructive, *in situ* methods and remote sensing techniques. A detailed distribution map was created, revealing signs of regression attributed to various anthropogenic pressures. Additionally, species distribution modelling and future scenario predictions were employed to understand spatial trends and potential future developments, providing valuable in formation for a better implementation of conservation measures, particularly in marine protected areas.

Keywords: Habitat, Adriatic Sea, Coastal models, Phytobenthos

Introduction - Canopy-forming species are widespread in the Mediterranean coastal area and represent the final stage of the succession of photophilic algal communities on hard substrata. Among them, *Cystoseira s.l.* spp. play an important role as habitat-building species, providing substrata for species settlement, protection from predators, and shelter from different disturbances. *Cystoseira s.l.* spp. contribute to numerous ecosystem services [1], such as high primary production, food sources and nutrient cycling. In recent decades it was observed that coastal ecosystems are subject to multiple anthropogenic local stressors, and *Cystoseira s.l.* species have been often replaced by persistent and less complex algae, defined as turf-forming taxa [2]. The regression of the most widespread *Cystoseira s.l.* algal belts was confirmed along the Slovenian coastline (northern Adriatic), with a consequent replacement by turf-forming taxa [3]. Moreover, anthropogenic climate change is causing unprecedented alterations to marine ecosystems and is known to induce species re-distributions. It is expected that under a warmer climate, species will move towards higher latitudes, higher altitudes, or to deeper waters [4], but in the semi enclosed and shallow northern Adriatic these migrations are not possible. The overall objective of the research was to assess the status and distribution of brown algal forests in Slovenian coastal waters, prepare a detailed cartography and identify the main causes for their regression.

Material and Methods - A non-destructive method was used, based on visual observation of sea-bottom segments occupied by brown algal forests (a modified CARLIT methodology [5] for the upper-infralittoral belt). Sedimentary bottoms were surveyed as well. Additionally, remote sensing techniques based on freely available satellite (Sentinel, Landsat) and ortho-photo multi-temporal imagery were applied to objectively develop a precise brown algal forests distribution map by combining fieldwork and multispectral geospatial data. Moreover, the current geographical distribution of brown algal forests was modelled by considering several species distribution modelling algorithms and environmental variables that co-crate their spatial pattern. Finally, the Bio-ORACLE 3.0 database [6, 7] was used to predict potential future spatial development of brown algal forest suitability in the Mediterranean and Adriatic Seas considering optimistic (SSP1-2.6, SSP2-4.5) and pessimistic (SSP4-6.0, SSP5-8.5) shared socioeconomic pathways scenarios.

Results and discussion - A brown algal forest distribution map in the Slovenian coastal sea was developed (Fig. 1). This product was then compared with existing (published) algal forest suitability products for the Mediterranean Sea [8]. The results of the study provide spatially accurate information on the distribution of different upper-infralittoral algal communities and signs of brown algal forests decline, which can be related to different anthropogenic pressures. Moreover, the identified and predicted geospatial trends in brown algal forests cover/ suitability can serve as a decision support system for a better implementation of conservation measures, especially in marine protected areas.
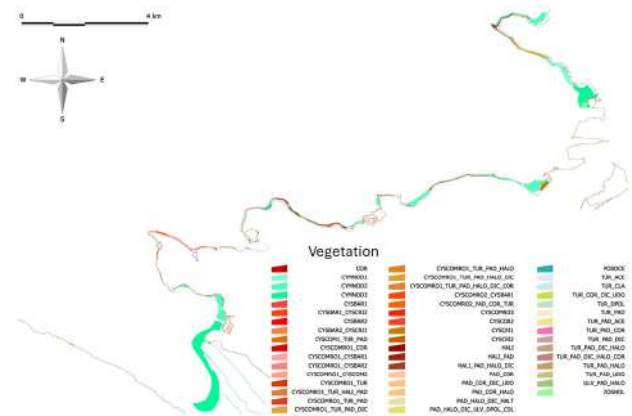
Fig. 1. The upper-infralittoral vegetation distribution according to the mapping along the Slovenian coastline. The green colours refer to seagrass meadows. The different red colours indicate the cover of canopy-forming species.

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Congress Joint Session : Technical advances for marine observations I (all Committees)

Moderator : Gian Luca Sarà – Univ. of Palermo, Italy

Session's Synthesis

The session "Technical Advances for Marine Observations I" reported on seven innovative approaches highlighting the potential of emerging technologies and collaborative methods for marine monitoring. The ANDROMEDA project demonstrated the use of artificial intelligence combined with citizen science to detect microplastics in coastal environments, providing a scalable and cost-effective method to tackle this pervasive pollution issue. In parallel, machine learning algorithms and satellite data were employed to model the bathymetry of the Maltese Islands with remarkable precision, representing a significant advancement in coastal management. The "LanderPick" was another significant innovation: a towed vehicle designed for the deployment and recovery of low-cost benthic landers, which has already proven successful in over 100 operations down to 1500 meters depth. Its potential for long-term benthic monitoring is substantial. Sustainable fisheries management was addressed through a methodology to calculate the "Swept Area Ratio" using GPRS/GMS data, applied to an artisanal fleet in the Gulf of Cadiz. This approach highlighted the value of real-time spatial data for assessing fishing effort and impacts.On the topic of chemical pollution, the RHE-MEDiation project demonstrated how microalgae-based technology can significantly reduce contaminants in urban wastewater, underscoring the potential of biotechnological solutions. The Fishing Vessel Ocean Observing Network presented a coastal observation system leveraging fishing vessels, capable of addressing gaps in oceanographic data collection. Finally, an ecotrophic model simulated radionuclide dispersion in the Gulf of Lion, providing insights into transfer and depuration mechanisms under various scenarios. These contributions underscore the critical role of advanced technologies and open science in addressing marine environmental challenges, fostering international collaboration, and enabling informed decision-making. The session attracted an average audience of about 30 attendees, reflecting a strong interest in these cutting-edge marine observation technologies.

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ENHANCING MICROPLASTIC DETECTION IN COASTAL AREAS THROUGH AI-ASSISTED CITIZEN SCIENCE

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Abstract

 The ANDROMEDA project, implemented in Malta by the University of Malta and funded through the JPI Oceans framework, introduced an innovative approach to parameterising microplastics in coastal environments. This study outlines the development of an algorithm, incorporating artificial intelligence (AI) techniques, to analyse microplastic pollution from images submitted by citizen scientists. The main aim of the app's development was to provide a cost-effective and scalable method for recording the distribution of microplastics along European coastlines, whilst engaging the public in simple sampling and microplastic recovery protocols, ultimately aiding in the mitigation of this pervasive type of pollution.

Keywords: Plastics, Malta Channel

Introduction Microplastics, small particles between 1mm and 5mm in size, are significant pollutants in marine environments due to their durable, flexible nature, and resistance to natural degradation processes. These particles originate from various sources, including industrial products and consumer waste, and pose substantial ecological risks, particularly in the Mediterranean region [1]. The Oceanography Malta Research Group (OMRG) of the University of Malta, through the ANDROMEDA project (funded over the 2020-2023 period, through the JPI Oceans 'Microplastics in the marine environment' Call), addressed these challenges by launching a citizen science campaign. As part of the project, a smart phone app that makes use of Artificial Intelligence (AI) for an *in-situ* and cost-effective analysis of microplastics, was developed.

Materials and Methods The public is being engaged in microplastic collection through the provision of extraction kits. A quadrat, 1mm and 5mm sieves, a shovel, and a ruler are provided to beachgoers who can participate by following the sampling protocol to extracting plastic fragments within a volume of 0.5 x 0.5 x 0.1m^3. These extracted LMPs can then be photographed on a scanning card (Figure 1) and uploaded to a computer server at the University of Malta through a dedicated mobile app ('ANDROMEDA microplastics', Figure 2), which is currently freely available to all iOS and Android mobile phone users. An in-house developed algorithm will process these images in batches. Plastic fragments within each photo are detected and the size, surface roughness, and colour, are estimated [2]. Before this parameterisation, the images undergo pre-processing to correct any distortions in the scanning area, remove skewness, balance colours, and determine each pixel's spatial dimensions using the QR code on the scanning card. This innovative process offers almost immediate feedback to participants and integrates the collected data into a European-wide database, significantly enhancing the scope of microplastic research. All submitted reports are plotted on a European continent map.

Results and Discussion Preliminary results from the ANDROMEDA project indicate that the AI algorithm successfully identifies, characterises (in terms of dimensions, surface roughness and colour) and quantifies microplastics from diverse beach environments. The algorithm's accuracy and efficiency in analysing microplastic characteristics have proven to be reliable, with considerable implications for assessing comparatively the degree of microplastic pollution of different sandy coastlines and for acquiring interesting microplastic-specific metrics. For instance, the characterisation of microplastics in terms of surface-roughness is a proxy for classifying the same particles as primary or as secondary microplastics and for shedding light on the putative length of time the same particles reside within the natural environment. The integration of citizen science has also fostered community engagement and increased awareness regarding marine pollution issues. Extracted and photographed microplastics are not discarded back into the environment but are retained for subsequent adequate disposal and, possibly, for further compositional analysis through, for example, hand-held NIR (near-infrared) scanners. Future developments aim to enhance algorithm accuracy and to expand the project's scope to include more diverse environmental conditions and microplastic types, with uptake of the ANDROMEDA microplastics app being promoted on other coastlines outside the Maltese archipelago.

Fig. 1. Scanning card for mobile phone photography purposes.

Fig. 2. Developed mobile phone application for photo submission.

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SATELLITE-DERIVED BATHYMETRY OF THE MALTESE ISLANDS

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Abstract
This study combines *in-situ* data, satellite data, and machine learning algorithms to accurately predicted the bathymetry in the coastal region around the Maltese archipelago. Using data collected from a single embayment, the Random Forest algorithm was used to predict the bathymetry of the entire Maltese Islands, resulting in highly precise outcomes. These predictions were validated and spatially visualised to provide a better understanding of the variation in depth.

Keywords: Bathymetry, Coastal waters, Mediterranean Sea, Remote sensing

Introduction
Bathymetry denotes the depth difference between the seabed and the sea surface [1]. Precise determination of bathymetric data plays a pivotal role in coastal modelling [2], underscoring the significance of having comprehensive depth data available at various temporal and spatial scales [3]. This objective can be realised through the integration of remote sensing and in-situ methodologies, alongside the application of machine learning (ML) frameworks, to generate precise and current bathymetric mappings.

Fig. 1. Graph showing the correlation between the *in-situ* and predicted depth data.

Fig. 2. Random Forest predicted bathymetry of the Maltese archipelago.

Materials and Methods
During a Multibeam Echosounder survey in 2023, in-situ bathymetric data was collected from Marsaxlokk Bay. Simultaneously, satellite data from the Sentinel-2 constellation for the same day, was acquired. The integration of these datasets was followed by a band ratio computation utilising the protocol outlined by [4]. Subsequently, they were processed by the Random Forest algorithm to develop a predictive model. The Pearson Correlation Coefficient was employed to quantify the linear correlation between the aforementioned data and the effectiveness of the algorithmic model. Finally, this model was validated through a comparison between the predicted depth data and a set of in-situ bathymetric data, which was originally excluded during the model's development phase.

Results and Discussion
A correlation coefficient of 0.99 was computed between the in-situ and the predicted depth values in the testing set over Marsaxlokk Bay (Figure 1). The ML model was then run on all the other data points and the results were visualised to illustrate the bathymetric variation around the entire Maltese Islands (Figure 2). Additionally, during the model's validation, a high association was obtained between the predicted depth data and the excluded in-situ dataset, demonstrating the efficacy of the methodology employed in this study in generating precise bathymetric predictions. This work was part of the BathMalta project funded by MCST (Malta Council of Science and Technology) through the Space Research fund call 2022.

This methodology was also implemented on a dataset from 2022 to investigate the temporal variations in the underwater topography surrounding the Maltese Islands by comparing the predicted depth data of 2022 and 2023. The aim was to establish an efficient method for comprehending the evolving bathymetric patterns and identifying regions more susceptible to fluctuations in depth.

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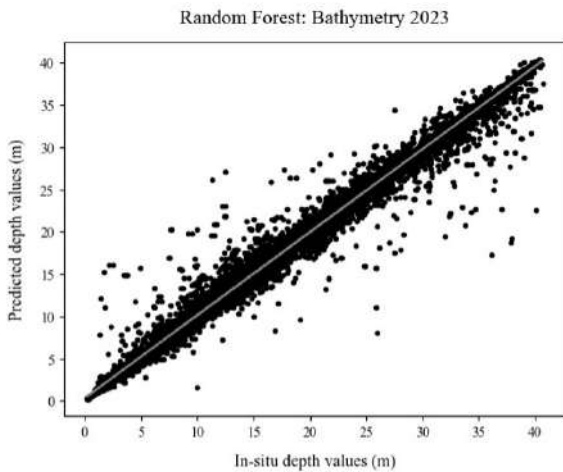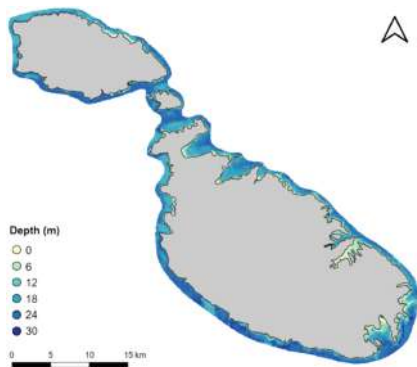
LOW-COST LANDER ARRAYS FOR OCEAN BOTTOM MONITORING: THE 'LANDERPICK' TOWED VEHICLE

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Abstract

Benthic landers are structures devised to be placed at the seabed, hosting sensors for autonomous sampling. Landers offer valuable insights into the physical, biochemical, and ecological conditions of the benthic layer, but a notable limitation lies in their costly recovery systems. The LanderPick development involves the design of a remotely operated towed vehicle to deploy and recover basic landers provided with a recapture mesh for hitching. Two LanderPick vehicles and a fleet of about 30 low-cost suited landers have conducted more than 100 successful operations of up to 1500 m around Spanish waters, including western Mediterranean, since 2021. Low-cost lander arrays have a strong potential to provide sustained seafloor monitoring in the long term.

Keywords: Circulation, Hydrography, MPAs, Monitoring, Western Mediterranea

The need for sustained observation of the Earth's climate system, including the ocean, is acknowledged by several international panels. Monitoring of the deep ocean has traditionally relied on regular intensive oceanographic cruises as well as eulerian systems (mooring lines) at strategic sites. The hydrochanges program [1] is a nice example of international coordination to track the changes of the deep Mediterranean Sea. Focusing on conditions right at the seabed, benthic landers are already identified as a robust eulerian approach for long-term deep-sea observations [2]. The high cost of the recovery systems, tipically based on buoyancy modules and expendable ballast uncoupled by an acoustic release, prevents the expansion of monitoring strategies based on lander arrays.

Fig. 1. a) Cylindrical lander, suited with a Lowell TCM-3 tilt-current meter, a Seabird-56 thermometer and a hydrophone, set as payload in the LanderPick vehicle ready to be deployed. b) Underwater image of a flat-type lander about to be hitched. c) Year-long (330 days) average currents as measured by a 5-lander array at the Mazarrón escarpment in 2022-2023.

Assisted by vessel dynamic positioning and the underwater positioning systems of modern oceanographic fleets, the 'LanderPick' concept [3,4] was conceived and developed by the Spanish Institute of Oceanography in partnership with the engineering company Envisad. LanderPick consists of a Remote Operated Towed Vehicle specifically designed to deploy and recover landers devoid of built-in recovery systems, but provided instead with a mesh for easy hitching (Fig. 1a). The LanderPick vehicle, controlled through the vessel electromechanical cable, is provided with a camera, spotlights and propellers to assist in the target approach manoeuvre. A mechanical mechanism allows for the precise placement of landers as a payload on deployment-mode, and their recovery using a triple hoist hook on pick-mode (Fig, 1b).

A first LanderPick vehicle prototype was built in 2020, followed soon by a second advanced vehicle along with an ambitious fleet of landers of various designs. To date, more than 100 successful operations, including deployments and recoveries, have been conducted at depths ranging from 50 to 1500 meters. Missions encompass short-term deployments for time-lapse image monitoring of endangered habitats, mid to long-term lander arrays at complex topography locations and a large fleet covering the north-western Iberian continental shelf/slope. A first mission in the Mediterranean consisted of an array of 5 landers deployed in 2022 in a Marine Protected Area canyon complex system known as 'Mazarrón escarpments' (southern Spain) to explore near bottom dynamics along the shelf-break in such an intricate site (Fig.1c). The nearly year-long record challenges our established understanding of regional circulation. After recovery of the array, a sentinel lander is set in place to operate on a permanent basis.

Our primary aim for developing the LanderPick concept was establishing a cost-efficient system to sustain the near-seafloor monitoring required for (i) the management of the Spanish Marine Protected Areas network and (ii) tracking prevailing conditions to comply with the Marine Strategy Directive implementation. Once the technology has matured, our goal is to facilitate its transfer to a broader oceanography community.

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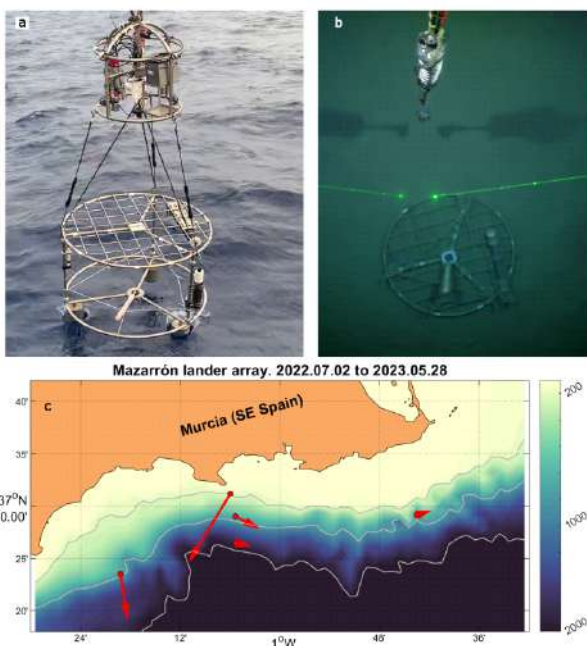https://www.youtube.com/watch?v=OI15wGSR2fE

DEVELOPMENT OF A REPRODUCIBLE METHOD TO ASSESS THE IMPACT OF HYDRAULIC DREDGE FLEET IN THE GULF OF CADIZ TROUGH SWEPT AREA RATIO (SAR)

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Abstract

This research presents a method to calculate the SAR (Swept Area Ratio) using General Pack Radio Service/Global Mobile System (GPRS/GMS) technology data from a fleet of nearly 100 vessels in the artisanal fishery of striped venus clam in the Gulf of Cadiz. Artisanal fisheries often lack comprehensive data, hampering, among other things, know impacts on exploited populations and their ecosystem, and consequently, carry out an effective management. GPRS/GMS data offers a unique advantage by providing real-time spatial information on fishing activity. We can identify the fleet effort trough SAR in both spatial and temporal terms. The main objective is to develop a methodological protocol based on reproducible science with accessible codes and open data applicable to other fishing contexts similar to this type of artisanal fishery

Keywords: Management, Artisanal fishery, Gulf of Cadiz

The intertidal and subtidal biological communities have a special ecological value due to their biodiversity and their productive role. Bivalves mollusks and other sedentary and sessile species had traditionally been caught by artisanal vessels using towed dredges. The introduction in the early 90`s of the hydraulic dredges radically changed this type of fishery. These vessels had much more power and were much more efficient, which resulted in an increase in catches of this benthic species [1]. As a result, a series of measures had to be taken, since 2004 the Andalusian Regional Government started installing its own monitoring system, called SLSEPA ("*Sistema de Localización y Seguimiento de Embarcaciones Pesqueras Andaluzas*"). Boats carry a device, regionally called "green boxes" on board hydraulic dredges and towed dredges. With this system it is possible to continuously monitor the activity of these vessels, to know the exact time of fishing (fishing effort) as well as the spatial distribution of this fishing effort [2]. Knowing the pression and intensity of a fishing gear on a habitat or community of organisms is essential when implementing management measures, for this it is necessary to implement a methodology which can be used and adapted to all types of gears. A way to describe the intensity of "areas fished with some type of fishing gear" is based on the Swept-Area-Ratio (SAR) value. The Swept-Area is estimated as hours of fished x average fishing speed x gear width [3]. We propose a methodological protocol for the trawl fleet in the Gulf of Cadiz, which includes the minimum steps for calculating the SAR.

We have designed a step-by-step protocol for processing GPRS/GSM data in this context [3].The database underwent the following sequence: 1- Removing duplicate records, 2- Removing records in ports, 3- Calculating the time interval between successive records, 4- Distinguishing between fishing and non-fishing records based on speed, 5- Calculating the distance between effective hauls (Fig 1), 6- Computing effort indicators, 7- Spatially gridding (0.5 x 0.5 mn) the data, 8- Presenting estimates using spatial objects.

objects, and spatial analysis, respectively. In this sense, we consider the foundations of reproducible science, standard methods, open data, and transparency [4]. This approach is necessary to unify criteria and develop common concepts for this type of fishing gear, given the complexities of each fishing reality. This research explores three key elements in fisheries data management. Firstly, it investigates the challenges and opportunities of small-scale fisheries with monitoring systems to estimate intensity fishery on ecosystem calculating SAR in Cádiz Gulf. Secondly, it focuses on developing specialized algorithms for estimating fishing effort in trawl fisheries, crucial to know the impact in the ecosystems and effective management. Lastly, the paper advocates for a reproducible science methodology, emphasizing transparency, open data, and open-source software usage.
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Fig. 1. Routine to calculate distance (mts) between trawl register in dataframe

The methodology employs R-CRAN and libraries including *tidyverse, lubridate,* and *sf*. These libraries facilitate data wrangling, handling of date-time

INNOVATIVE APPROACHES TO MITIGATE CHEMICAL POLLUTION IN THE MEDITERRANEAN SEA: A CASE STUDY AT THE THRIASIO WASTEWATER TREATMENT PLANT IN THE GULF OF ELEFSIS

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Abstract

The RHE-MEDiation project aims at establishing a responsive hub deploying long-term governance to destress the Mediterranean Sea from chemical pollution. The focus is on removing pollutants from wastewater before they enter the sea. RHE-MEDiation optimizes the Wastewater Treatment Plant by treating wastewater using microalgae technology, namely the GREEN DUNE® Photobioreactor since microalgae have demonstrated the ability to remove a wide range of environmental inorganic and organic contaminants including nutrients, metals, PCBs, PAHs, pesticides, pharmaceuticals and forever chemicals.

Keywords: Mediterranean Sea, Pollution, Chemical analysis, Coastal management, Stressors

Addressing the urgent challenge of chemical pollution in the Mediterranean Sea is of utmost importance, as decades of land-based toxic pollutants have significantly degraded its marine ecosystems [1]. 'Restore our Ocean and Waters by 2030' is an EU Mission launched to develop and demonstrate innovative technological, social, business and governance solutions, and promote new forms of co-operation to destress the Mediterranean from chemical pollution. The RHE-MEDiation project intends to remove heavy metals, PCBs, PAHs, pesticides and 'forever chemicals', namely PFAS, from wastewater before they reach the marine environment [2].

The RHE-MEDiation demo site in Greece is the Thriasio Waste Water Treatment Plant (TWWTP) by the Gulf of Elefsis [3], where the RHE-MEDiation GREEN DUNE® Photobioreactor using microalgae is to be applied after the secondary treatment (Figure 1).

Fig. 1. The microalgae bioreactors system at Thriasio WWTP.

The water will pass through microfiltration and sensors on its way to the mixing tank. Membrane filtration equipment based on industrial micro and ultra-filtration solutions collect microalgal biomass, while the monitoring system deployed consists of appropriate continuous and periodical sampling points: (i) at the WWTP outlet and the RHE-MEDiation pilot system (ii) in the Gulf of Elefsis, using a multi-sensor microsystem platform with mobile, autonomous drifters. The sensors include measurements for Redox Potential, pH, temperature, turbidity, conductivity, ammonia and chlorophyll-A.

The experiment duration is one year while maintenance periods with reduced sampling frequency are designated, emphasizing reliance on microalgae for water bioremediation. Emerging contaminants (e.g. PFAS, pharmaceuticals) analyses are performed to detect dominant substances in the WWTP effluent, using wide-scope screening analytical techniques, which provide better understanding of the chemical imprint of related anthropogenic activities. The annual average of TWWTP wastewater inflow is 6,089 m^3/d, whereas approximately 1,500 kg BOD$_5$/d enter the marine environment. TWWTP is already very efficient, since chemical analyses of COD, BOD$_5$, NO$_3$-N, NH$_4$-N, TN, TP and TSS (mg/l) do not exceed national legislation thresholds. The prismatic shape of the photobioreactor, which is placed after secondary treatment, ensure increased microalgae productivity, wastewater treatment capabilities and enhanced water quality. Achieving ammonium removal rates >80% meets stringent environmental standards, while pollutant sampling aims to balance data comprehensiveness with resource efficiency.

The deployment of RHE-MEDiation in Greece demonstrates a tailored approach to remove undesired chemicals that conventional WWT technologies do not treat. The innovative GREEN DUNE® Photobioreactor, now positioned as a financially viable solution for large-scale applications, aligns with Blue Growth. Hence, RHE-MEDiation emerges as a promising and sustainable solution in the ongoing mission to mitigate chemical pollution in the Mediterranean Sea.

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FROM CANOES TO INDUSTRIAL TRAWLERS: THE FISHING VESSELS OCEAN OBSERVING NETWORK

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Abstract

The Fishing Vessel Ocean Observing Network (FVON) is a collaborative, innovative approach involving cost-effective coastal observations with the aim of supporting climate-informed advice, reducing risks. Here, we showcase examples of FVON projects from deploying oceanographic sensors in canoes to industrial trawlers. The FVON network as it evolves has the potential to complement existing ocean observing systems in areas where oceanographic data is lacking and needed most for long-term coastal and ocean monitoring.

Keywords: Coastal systems, Fisheries, Monitoring, Instruments and tech, Worldwide

The Fishing Vessel Ocean Observing Network (FVON) [1,2] aims to foster collaborative, cost-effective ocean data collection, democratize ocean observations, establish community standards, and best practices, and facilitate observation uptake to enhance ocean predictions while promoting sustainable fishing practices. Fishing vessels offer potential as platforms for hosting and deploying a variety of oceanographic instrumentation (Fig.1 upper left panel). Many fishing gear types already profile through the water column, presenting a unique opportunity for subsurface data collection (Fig. 1 upper right panel). This approach demonstrated to be valuable to provide data to feed oceanographic models, advance knowledge on climate change and improve ecosystem approach to fishery management, as in the case of the Adriatic Fishery and Oceanography Observing System (AdriFOOS) [3].Integrating ocean data collection into fishing vessel operations complements existing ocean observing networks, enabling cost-effective collection of subsurface ocean data to significantly enhance coverage in data-sparse regions. These data represent a win-win scenario, enabling the fishing industry, fisheries scientists, and managers to adopt innovative solutions to enhance fisheries sustainability, profitability, and community resilience.
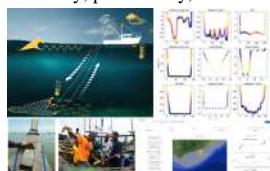

Fig. 1. The Fishing Vessel Ocean Observing Network (FVON) (upper left panel) concept and a selection of depth over time series showing the diversity of data which can be produced by fishing (upper right panel). Ghana's fishing canoes (lower panel): solar deck unit; fixing a sensor to a net; and portal displaying data acquired by the Obeye Yie canoe.

An innovative coastal observing system in Ghana's fisheries involved the attachment of temperature depth profiling sensors to fishing nets on two local fishing canoes (Fig. 1 lower panel) [4]. The Moana project in New Zealand instrumented approximately 250 fishing vessels. The Argo program provides sustained observation in the open ocean but there are important gaps in subsurface ocean observation coverage in shelf and coastal regions (Fig. 2 upper panel). These latter regions have complex bathymetry, coastlines and frontal mixing zones that complicate autonomous observations but concentrate fish and therefore fishing. Beyond being productive biodiversity hotspots, the coastal seas are also the regions most directly relevant to coastal communities and the blue economy. Comparing today's operational subsurface observation networks with the distribution of fishing activities suitable for sensor integration shows that fishing occurs precisely where observations today are lacking in shelf and coastal regions. This pattern is repeated, with few exceptions, around the world [5]. These data can be used for a wide range of purposes. For example, data collected through the eMOLT program in the northeast U.S are used both to improve the forecast used by the US Coast Guard for search and rescue operations, and in the American lobster (_Homarus americanus_) stock assessment [1,5].
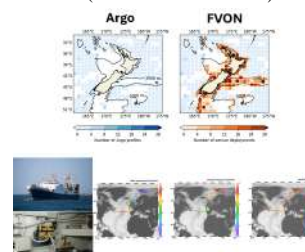
Fig. 2. New Zealand's Moana project (upper panel): the coverage of the Argo program (left map); and the coverage of the NZ fishing vessel observing network (right map). The Portuguese ferrybox programme (lower panel): MV COIMBRA cod-trawler and the Undersee's ferrybox (left); and data (SST, DO and pH) from a transcontinental transect to the fishing grounds of the Grand Banks of Newfoundland and a meridional transect to the fishing grounds of the Barents Sea (right).

An Undersee ferrybox is installed under the Portuguese ferrybox programme in a cod trawler vessel sailing from Portugal Mainland to the Grand Banks of Newfoundland and to the Barents Sea. The ferrybox measured continuously temperature, salinity, chlorophyll, dissolved oxygen, pH, ORP and turbidity from water pumped from the surface (Fig. 2 lower panel).

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MODELLING RADIONUCLIDE TROPHIC TRANSFER IN THE GULF OF LION ECOSYSTEM (NW MEDITERRANEAN SEA)

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Abstract
The nuclear authorities aim to be in capacity to model radionuclide dispersion in ecosystems likely to be exposed to accidental or controlled emissions. Being under the influence of Rhone River, one of the most nuclearized European river, the Gulf of Lion is one of those ecosystem. In this work, a detailed Ecopath with Ecosim ecotrophic model was build (called GOLEM), including the Ecotracer module parametrized for cesium-137. The simulation of 4 accidental scenarios revealed that both season and duration of the emission influence the spatial dispersion and transfer intensity of radionuclides. The model also allowed the understanding of smaller scale mechanisms, such as a higher concentration in microzooplankton during winter and a slower depuration in rays.

Keywords: Models, Radionuclides, Food webs, Gulf of Lyon

The Chernobyl and Fukushima accidents led to renewed interest in radioecology from the international scientific community, and a desire of nuclear authorities to be able to model the dispersion of radionuclides in ecosystems likely to be exposed to accidental or controlled emissions.

The ecosystem approach is particularly well-suited for addressing this issue thanks to its ability to represent both the environment and the organisms of the ecosystem of interest. Despite its increased need for species data and computing power, this method is becoming increasingly popular, favored by advances in computing and sampling capabilities.

The aim of this study was to simulate the fate of cesium-137 in the marine ecosystem of the Gulf of Lion (northwestern Mediterranean) in the context of accidental scenarios along the Rhône River.
Ecopath software with Ecosim was used to develop an ecotrophic model, called GOLEM (Gulf of Lion Ecopath Model) parameterized and calibrated for the period 2010-2014 and covering the 0-200 m depth range of the continental shelf.

Particularly detailed, especially for invertebrates, GOLEM is made up of 68 groups representing 99% of the biomass in the study area. The Ecosim dynamic and Ecospace spatialized modules have been implemented, and Ecotracer has been parameterized for cesium-137.

Each module, designed to increase the model's ability to achieve its radioecological objective, also brought interesting intermediate results. In particular, the study of the effect of a cessation of fishing activities, expected in the event of a nuclear accident, showed that around 10 groups showed variations larger than 10%, with *Dicentrarchus labrax* and *Lophius* spp. being the most impacted fishes. The effects were long-lasting, even after the resumption of catches.

Four accident scenarios were simulated, differing in terms of release period (summer or winter) and release duration (6 days or 1.5 month). The simulations showed that the time during which 137Cs concentrations in groups of organisms remained at high thresholds was longer in winter. In winter, trophic inputs were responsible for particularly high 137Cs concentrations in microzooplankton. Increasing the duration of the discharge increased peak 137Cs concentrations in high trophic level species and slowly depurating organisms, such as rays.

The GOLEM model was able to simulate the fate of cesium-137 in a detailed and credible manner. Nevertheless, some further improvements can be made: some of these are relatively straightforward through the acquisition of new data, while others are more complex and would require a partnership with the developers, notably for the implementation of the vertical dimension. Other uses for GOLEM are also envisaged, either with new contaminants, or for different issues such as fisheries or marine ecosystems management.

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Congress Joint Session : Technical advances for marine observations II (all Committees)

Moderator : Gioele Capillo – Univ. of Messina, Italy

Session's Synthesis

The session on "Technical advances for marine observations II" hosted seven presentations (one was not present at the conference) that focused on different topics related to marine observation, ranging from "classical" marine data collection to innovative ones, with a total of 26 authors contributing to the session. Contributions covered observations on both faunistic and floristic assemblages within the Mediterranean Sea, and particularly from French Catalonia, north-western Med, Southern Black Sea and other nearby areas, Levantine Sea, Central and Southern Tyrrhenian Sea, and Adriatic Sea. The most covered aspect was related to marine biodiversity, explored in the different studies with the application of various methods: DNA-based methods have been used in most of the studies for marine species present in the water column via eDNA and DNA metabarcoding approaches, also for detection of non-indigenous species; Two studies covered topics related to seagrass monitoring, one focused on monitoring methods of *Cymodocea nodosa*, and the other one, more related to the observation of faunal assemblages associated with *Posidonia oceanica* meadows; Comparison of the efficiency of two different bottom trawl methods for epibenthic and nectobenthic species monitoring has been also presented pushing out the necessity to integrate information derived from both the methods; the use of artisanal fishing of fauna species monitoring highlighted the importance of the fisherman communities in marine biodiversity observations. Despite the wide topic coverage of the contributions, the importance of standardization among different marine observation methods has been highlighted, especially for the DNA-based, as well as the importance of update, also following the technological advances, the data collection methods. The session 38 had an open and active discussion with several interactions which posed the attention on the need of multi- and cross- disciplinary approaches to reach as more as possible completeness of data collected.

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INNOVATIVE AND EASY TO IMPLEMENT METHODS TO MONITOR THE MEDITERRANEAN THERMOPHILIC FAST GROWING *CYMODOCEA NODOSA*

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Abstract

Cymodocea nodosa is a thermophilic seagrass found in the Mediterranean Sea and the eastern Atlantic, likely to benefit from climate warming. The *C. nodosa* seagrass meadow, located off Le Barcarès (French Catalonia, northwestern Mediterranean) was monitored in April and July 2023. Meadow cover and mean leaf length differed significantly between the two periods, whereas shoot density did not. The meadow constitutes a functioning ecosystem, hosting a remarquable fish nursery. The mean horizontal rhizome growth, measured by the underwater photomosaic method, was about 6.4 mm.day^{-1}. We propose here easy-to-implement tools for assessing the dynamic and the health of this fast growing species. Monitoring the capabilities of thermophilic species is essential for understanding the trends related to the long-term effects of climate warming.

Keywords: Sampling methods, Gulf of Lyon, Warming, Infralittoral

The seagrass *Cymodocea nodosa* (Ucria) Ascherson is a marine plant which grows in shallow soft substrate along the Mediterranean and Eastearn Atlantic coasts [1]. Despite its importance, *C. nodosa* meadows undergo significant local regressions linked to both natural and human-induced phenomena [2]. As a thermophilic species, *C.nodosa* is favoured by the current climate change [3]. The dynamic and the health status of the *C. nodosa* meadow at Le Barcarès (French Catalonia, western Mediterranean) were assessed in April and July 2023. Meadow cover, leaf length, shoot density and growth rate were measured in four sites within the meadow, and a non-exhaustive inventory of visible epibenthic macrofauna (e.g. fish teleosts) and macrophytes was carried out.

Meadow cover ranged between 1% and 2% in April and between 19% and 42% in July. Mean leaf length was significantly higher in July (38 ± 7 cm) than in April (14 ± 2 cm). Shoot density was not significantly different between seasons, with 125-205 shoots.m^{-2} in April and 165-198 shoots.m^{-2} in July. The mean horizontal rhizome growth was measured on thirty rhizomes per site at two sites after 100 days using the underwater photomosaic technique (Fig. 1).
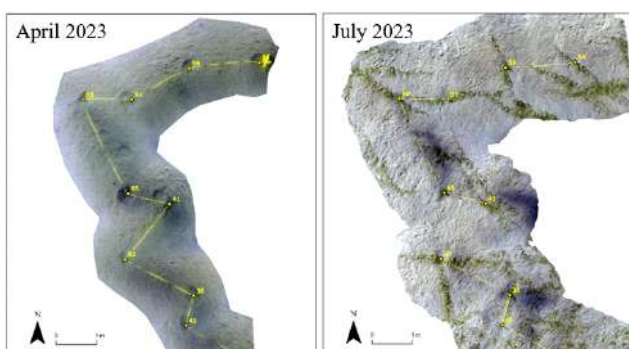

Fig. 1. Zoom of the rhizome marking (yellow dots) photomosaic in April 2023 on the left and in July 2023 on the right to measure horizontal growth

The results showed a mean daily growth of 6.4 mm.day^{-1} (between 0.2 and 12.2 mm.day^{-1}, Fig. 2). The fauna and flora inventory of the *C. nodosa* meadow at Le Barcarès allowed the identification of 55 taxa including the threatened long-snouted seahorse *Hippocampus guttulatus*. Furthermore, it was also found to be a remarkable fish nursery for the common seabream (*Pagrus pagrus*) and the red mullet (*Mullus surmuletus*).

The results show a relatively sparse seagrass meadow, with low shoot densities (125-198 shoots.m^{-2}), whereas *C. nodosa* can exceed 1 000 shoots.m^{-2} [4]. These densities can be explained by the depth of the sites (9-13 m), while very high densities are typically found in shallower meadows (less than 5 m). The hydro-sedimentary dynamic in the area is likely to limit the meadow density. The seasonal dynamic of the meadow showed a very sparsely populated meadow with very low cover during the April campaign. Monitoring in July showed a much higher cover, which is consistent with the literature [4]. Our work highlights the importance of this meadow as a refuge and food supply for juveniles of the common seabream and red mullet, species of interest for the local artisanal fishery. The growth values measured in this study are much higher than those reported in the literature (i.e, 2 mm.day^{-1}) [4]. We propose here easy-to-implement tools (*in situ* sampling, photomosaics) to assess the rapid dynamic of *C. nodosa*. Furthermore, increasing underwater temperatures and dryer periods will lead to an increase in *C. nodosa* plant production [3;5].

Fig. 2. Horizontal rhizome growth after 100 days.

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EDNA METABARCODING FOR SPATIOTEMPORAL MONITORING OF BLACK SEA MARINE BIODIVERSITY

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Abstract

Biodiversity assessment and monitoring via environmental DNA (eDNA) metabarcoding has a highly ascending interest due to its non-invasive, labor-efficient and cost-effective nature for complex marine ecosystems. To evaluate overall biodiversity, the Southern Black Sea was sampled in December 2022 and June 2023. Sampling was performed in line with whole Turkish coast of the Black Sea and from different depths representing the unique oxygenic conditions of the Black Sea. Preliminary results show that the technique is able to catch marine biodiversity widely, and indicate difference in species composition across 3D spatial variations.

Keywords: Black Sea, Biodiversity, Monitoring, Metagenomics, Genetics

eDNA metabarcoding is a revolutionary tool to be a non-invasive and highly sensitive method used for assessing biodiversity and understanding spatial and temporal community patterns and processes. It involves analyzing DNA sequences released by organisms into their surroundings, directly from environmental samples such as air, water, and sediments. Utilizing eDNA with genetic markers enables the simultaneous identification of multiple species, providing valuable insights into species presence and distribution [1,2].

The Black Sea is a unique marine environment characterized by distinct layers of water with varying physical and chemical properties. The strong stratification of water imparts special oxygenic characteristics to the layers, such as oxic, suboxic, and anoxic conditions. These stratified layers influence species distribution, nutrient cycling, and ecological processes [3]. Thus, understanding and monitoring the changes in this complex marine ecosystem is very important. This study aims to assess overall pelagic biodiversity of the Black Sea and monitor it for spatial and temporal variations using eDNA metabarcoding.

eDNA samples were obtained by collecting water from 16 stations during the cruise expeditions in December 2022 and June 2023. Different depths of water column were employed to represent biodiversity in oxic, suboxic and anoxic conditions of Black Sea. The water samples were filtered through 0.45 µm and 0.2 µm pore sized filters. A total of 104 filters underwent eDNA extraction using the Phenol-Chloroform method, all of which met the quality and quantity requirements for library preparation. Libraries were prepared by amplifying specific gene regions to identify prokaryotic, eukaryotic, and fish biodiversity with 16S, 18S, and 12S genetic markers, respectively. Overall, 146 libraries were selected for Next-Generation Sequencing (NGS), which is currently underway. Following NGS, raw sequence data are expected to be obtained May 2024, and several bioinformatic tools and pipelines will be utilized for biodiversity assignments.

Previously, two samples from the December 2022 underwent library preparation and NGS for 18S and 12S markers to validate the method's capability to capture biodiversity. Samples were chosen from two different stations and depths, representing oxic (B31) and suboxic (B19) conditions. The raw sequences of these samples were subjected to the bioinformatic analyses using Qiime2 software [4]. The biodiversity assessment results via the 18S marker confirmed the eDNA metabarcoding technique's accuracy in capturing the eukaryotic diversity of the Black Sea (Fig. 1.a) [5]. Additionally, the taxa assigned to these two samples varied according to locality and depth, indicating the efficacy of the eDNA metabarcoding approach (Fig. 1.b). The 12S marker identified one fish species per sample: _Engraulis encrasicolus_ in the surface sample and _Trachurus mediterraneus_ in the suboxic sample, validating the method's usefulness for fish diversity monitoring.

Monitoring through eDNA metabarcoding offers a rapid, realistic, and non-invasive method for detecting changes in biodiversity, as well as ecosystem health and dynamics, which reflect the impacts of anthropogenic stressors and climate change. The application of this technique in the Black Sea represents a transformative approach to the comprehensive monitoring and management of marine biodiversity, enabling quick and informed decision-making for the conservation and sustainable utilization of this unique ecosystem.
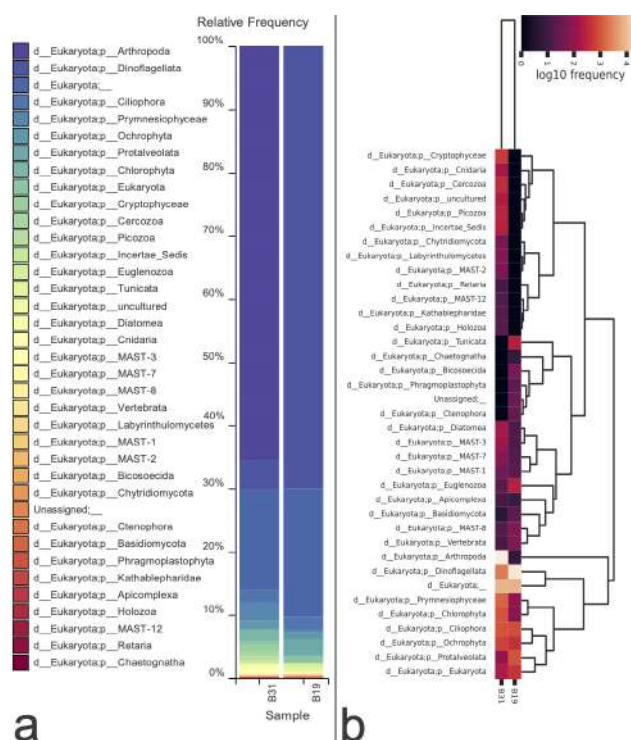
Fig. 1. (a) 18S Eukaryotic Biodiversity Assessments in Phylum Level Taxonomy. (b) Comparative Heatmap of All Eukaryotic Phyla Frequencies.

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IMPROVING THE EFFICIENCY OF BENTHIC SPECIES AND COMMUNITIES SAMPLING

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Abstract

In this work we have compared the efficiency of the Jennings Beam Trawl (BT) and the experimental bottom trawl GOC-73 to sample epibenthic and nectobentic species. The results have shown better estimations of abundance and biomass of epibenthic species with BT than GOC-73. Although the higher area covered by GOC-73, Jennings BT is more accurate to study the spatial distribution of benthic habitats. The high number of species captured exclusively with one of both samplers make them complementary to sample benthic species and communities.

Keywords: Sampling methods, Western Mediterranea, Habitat, Demersal, Trawl surveys

Benthic species and habitats are receiving increasing attention in the framework of European regulations such as the Marine Strategy Framework Directive (MSFD) and the implementation of Ecosystem Approach to Fisheries Management by the current European Union Common Fishery Policy (CFP). As a consequence, scientific surveys initially designed to assess demersal resources, like MEDITS [1], have broadened over the years from demersal species and their communities to benthic ones. At the same time, in the framework of the MSFD, new scientific surveys have also appeared to properly identify and characterize benthic communities.

The aim of this work is to compare the efficiency of Jennings Beam Trawl (BT; [2]) and experimental bottom trawl GOC-73, to sample epibenthic and nectobentic species and communities. To do that, data from 144 stations sampled during MSFD surveys conducted in 2021 and 2022 were compared to their corresponding 144 stations conducted in the same period from MEDITS surveys in the Levantine-Balearic demarcation (western Mediterranean; Figure 1). Mean values of abundance and species richness of epibenthic and nectobentic species between gears were compared with the paired Mann-Whitney-Wilcoxon (WMW) test. From the mean abundance, the list of the 10 most abundant species by taxonomic group and depth stratum for each gear were obtained. Instead of abundance, biomass was used for algae and sponges in all the analyses. Species accumulation curves were also performed.
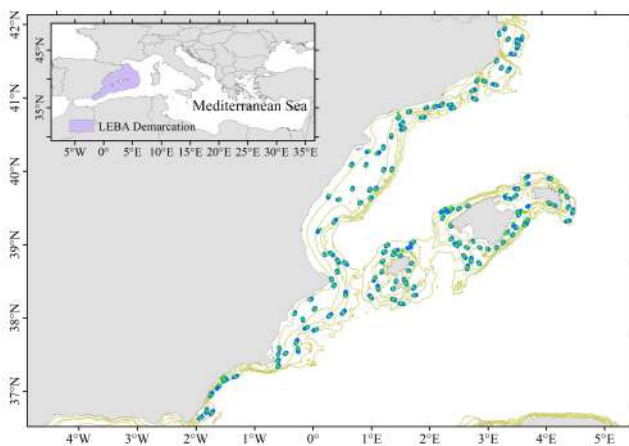
Fig. 1. Map of the study area showing the stations sampled with Jennings beam trawl (green) and bottom trawl GOC-73 (blue) in the Levantine-Balearic (LEBA) demarcation, during CIRCA-LEBA and MEDITS surveys respectively. The isobaths represent 50, 100, 200, 500 and 800 m depth.

The results showed that catch composition for each taxonomic group varied across depth strata and showed relevant differences between gears, based on size and behaviour of species. BT provides better estimations of density and species richness for small species closely associated to the seabed and GOC-73 of the occurrence of some macroepibenthic species presenting low abundances. Whereas GOC-73 permits a higher spatial coverage, BT gives more precise information on the location of benthic species and the patchiness distribution of benthic habitats. Although sampling the same habitats, an important fraction of the species is collected exclusively using one or another gear (Figure 2).
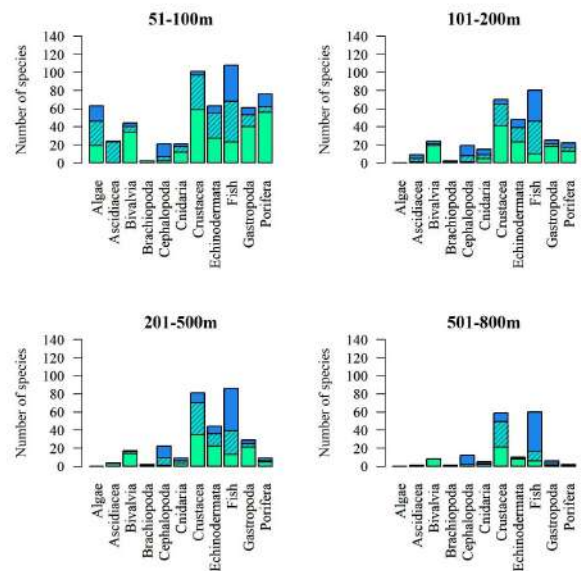
Fig. 2. Total number of species or taxons by taxonomic group and depth stratum. Number of species obtained exclusively from Jennings beam trawl and experimental bottom trawl GOC-73 are in green and blue, respectively. Number of species detected using both gears is represented as green and blue stripes.

Both sampling methods provide complementary information that improves biodiversity estimations and the description of benthic habitats This sampling combination allows a better assessment of the fishing and other anthropogenic impacts on them, hence improving the objectives required in the MSFD and CFP.

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USING DNA METABARCODING OF ZOOPLANKTON AS AN EARLY DETECTION TOOL FOR NON-INDIGENOUS SPECIES IN THE LEVANTINE SEA

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Abstract

 DNA metabarcoding of zooplankton is a potent tool for an early detection of non-indigenous species (NIS), with implications for managing biological invasions and environmental risks. Zooplankton communities in the Israeli Mediterranean Sea were monitored monthly in a coastal LTER station from 2019 to 2024. NGS of COI and 18S v9 markers classified using five different databases revealed 635 OTUs, including new validated records. Metabarcoding proved effective in early NIS detection, aiding in understanding larval dispersal and native/non-indigenous species recruitment. It is further recommended to augment the existing reference barcoding libraries and standardize analysis protocols for effective regional management of NIS in the Mediterranean Sea.

Keywords: Zooplankton , Invasive species, NIS, Monitoring, Levantine Basin

Introduction

Early detection of non-indigenous species (NIS) has been advocated as an important management measure for dealing with biological invasions and limiting the environmental risks associated with their establishment. For this purpose, many countries have adopted regulations to prevent, minimize and mitigate the adverse impact on biodiversity of the introduction and spread of invasive NIS. To accomplish that, powerful early warning tools were developed to identify species at all developmental stages and detect NIS at even very low concentrations in the introduced geographical range. These systems are required to be highly efficient in order to detect invasive species at low densities and in all their life stages. The use of DNA metabarcoding, i.e. the identification of multi-species samples in high throughput using all the genomic DNA extracted from a bulk sample, enables efficient identification of species in plankton communities. Although this method is generally qualitative, or semi-quantitative, and strongly limited by the existing reference libraries (e.g., NCBI GenBank, BOLD), it allows a rapid and relatively inexpensive detection of NIS. Furthermore, metabarcoding overcomes the need to isolate or identify individual specimens and thus avoids morphology-based identification problems, e.g., morphological complexities, cryptic, different life stages, sexual dimorphism, and dependence on taxonomic expertise. The zooplankton communities of the Israeli Mediterranean Sea are especially prone to biological invasions due to the migration of species through the Suez Canal in combination with the acceleration of climate change, facilitating the establishment of Indo-Pacific thermophilic species. In shallow coastal area, meroplankton—early life stages of benthic or nekton species—make up nearly a third of the zooplankton community. Their survival is an essential step in the establishment of NIS.

Materials and methods

In the framework of the National Monitoring Program of the Israeli Mediterranean Sea, zooplankton samples were collected monthly from the LTER station in Hadera between 2019 and 2024, using vertical net hauls. COI and 18S (v9) markers were amplified and sequenced using Next Generation Sequencing. Demultiplexed paired-end reads were processed in a QIIME2. Reads were edited, merged and grouped into amplicon sequence variants (ASVs) with DADA2. Multiple databases (NCBI GenBank, BOLD, MetaZooGene, Silva and PR2) were used to classify the ASVs to species or higher taxonomic level.

Results

Overall 18S and COI metabarcoding results yielded 2405 ASVs, of them, 635 classified to species level. Numerous molluscs, crustaceans, algae, hydrozoans and other taxonomic groups were identified for the first time in the Levantine Basin. Among these species, several records were validated by morphological identification (Velasquez et al. 2021, Guy-Haim et al. 2022), or by finding adult specimens in the benthos (Belkin et al. 2022, Rabi et al. 2020).

Discussion

Using zooplankton metabarcoding in the monthly biological monitoring proves as an efficient early detection system for NIS. Furthermore, it enables the identification of seasonal patterns in the larval dispersal and assessments of larval pelagic duration, and contributes to the understanding of the recruitment processes of native and non-indigenous species. Expanding the reference libraries and unifying zooplankton monitoring and analysis protocols will promote our ability to detect, minimize and mitigate NIS and their impacts in the Mediterranean Sea.

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FROM ARTISANAL FISHING TO SCIENTIFIC DATA: CHARACTERIZING MARINE BIODIVERSITY OVER TIME AND SPACE.

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Abstract

The study for the conservation of marine biodiversity is increasingly important and data from fishing can contribute to this aim. In this study we propose to use two trammel nets as a tool for monitoring marine biodiversity. Data collection involved the use of two similar fishing methods, the conventional trammel net and its modified version, employed in different locations: the island of Favignana (Aegadian Islands, Sicily) and the southern region of Sardinia. Analysis of the data collected showed a total of 93 species, showing a higher average number of species in southern Sardinia, while a greater species richness with the conventional trammel net than its modified version in Favignana island.

Keywords: Biodiversity, Mediterranean Sea, Fisheries

Fishing represents a serious threat to marine biodiversity, but at the same time it can be used as a valuable tool to monitor it over time and space, drawing conclusions on population structure and marine community dynamics [1]. Artisanal fishing remains a longstanding tradition in countries bordering the Mediterranean Sea and, as such, represents an important socio-economic sector. The main fishing gears used in artisanal fishing are longlines or fixed nets (trammel nets and gillnets) [2]. In this study we propose to use two trammel nets as a tool for monitoring marine biodiversity present in the areas of Favignana island and southern Sardinia. Catches, in two different locations, were collected using two similar fishing gears, the classic trammel net (TN) and its modified version, the guarding net (GN), designed to reduce fishing discard; this allowed comparison of catch data in two separate time periods. Eighteen experimental fisheries were conducted in June (period 1) and October 2023 (period 2) in Favignana, and sixteen in July (period 1) and September 2023 (period 2) in southern Sardinia to test the two types of gillnets. For each fishing trial, individuals found in the gears were identified to the lowest possible taxonomic level. To examine differences between the factors locations, periods and fishing gears, we applied univariate and multivariate PERMANOVA on species richness (S), Margalef's index (d), Shannon-Wiener index (H') and on the assembly matrix.

Tab. 1. Mean values and standard deviation on biodiversity indices (S= species richness; d= Margalef's index and H'= Shannon-Wiener index) on the factors: fishing gears (TN= trammel net; GN= guarding net), locations and periods and results of pairwise comparison.

	Period 1 Favignana		Period 2 Favignana		Period 1 south. Sardinia		Period 2 south. Sardinia		Pairwise
	TN	GN	TN	GN	TN	GN	TN	GN	
S	10,67 (2,18)	8,89 (2,42)	10,44 (3,09)	9,78 (3,27)	10,56 (4,64)	12,56 (4,69)	14,29 (3,99)	12,57 (3,55)	south. sardinia > Favignana
d	3,31 (0,79)	2,45 (0,69)	3,35 (1,08)	2,9 (0,74)	2,79 (1,01)	3,32 (1,01)	3,33 (0,76)	3,38 (0,78)	Favignana: TN > GN
H'	2,09 (0,18)	1,78 (0,37)	2,09 (0,28)	1,84 (0,50)	1,75 (0,58)	2,11 (0,29)	2,14 (0,30)	2,17 (0,31)	Favignana: TN > GN

In order to understand the factors influencing community structure we used SIMPER (Similarity Percentage analysis).

Tab. 2. SIMPER (Similarity Percentage analysis) performed for species on the localities.

Species	Av.Abund group Favignana	Av.Abund group south. Sardinia	Av.Diss	Cum.%
Scorpaena porcus	1,02	2,04	4,5	6,17
Scorpaena scrofa	1,45	2,07	3,86	11,46
Uranoscopus scaber	0,39	1,33	3,8	16,68
Sepia officinalis	1,36	1,46	3,7	21,76
Posidonia oceanica	0,22	0,97	3,18	26,12
Diplodus vulgaris	0,87	0,75	3,1	30,37
Mullus surmuletus	0,54	0,8	2,49	33,78
Sciaena umbra	0,03	0,72	2,34	37
Diplodus annularis	0,3	0,7	2,23	40,06
Symphodus tinca	0,4	0,59	2,17	43,04
Pagellus acarne	0,74	0	2,14	45,97

The results showed a total of 93 species, including 8 species listed on the IUCN Red List of Threatened Species, such as *Mustelus mustelus*, *Myliobatis aquila* and *Sciaena umbra* [3]. The analyses highlighted a significantly higher average S in southern Sardinia, while in Favignana TN showed significantly higher d and H' than GN. PERMANOVA conducted on the assemblage showed significant differences between the two locations in periods and between TN and GN in Favignana locality. SIMPER analysis found that the genera *Scorpaena* and *Sepia* characterized both localities, but with different relative abundances. The research results highlighted the potential of trammel nets in assessing the biodiversity of necto-benthic and nektonic assemblages, along with their spatial and temporal variations.

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ENVIRONMENTAL DNA ANALYSIS FOR COMPREHENSIVE MARINE BIODIVERSITY ASSESSMENT: INSIGHTS FROM TWO CAMPAIGNS IN THE MEDITERRANEAN SEA

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Abstract
Environmental DNA (eDNA) analysis offers a game-changing approach to marine biodiversity assessment, providing a non-invasive and comprehensive method for species detection. Here we present the outcome of two Mediterranean campaigns where eDNA was utilized to assess biodiversity in coastal and offshore waters at varying depths. By targeting three key markers, these campaigns revealed a rich taxonomic diversity across different marine habitats. eDNA analysis shows high sensitivity and specificity, making it ideal for time-constrained oceanographic expeditions with limited resources. This study underscores the importance of eDNA as a crucial tool for monitoring and managing marine biodiversity, particularly in contexts where the entire spectrum of biodiversity, ranging from micro- to macroorganisms, needs to be taken into account.

Keywords: Biodiversity, Metagenomics, Monitoring, Adriatic Sea, Western Mediterranea

The exploration of marine biodiversity is crucial for understanding ecosystem dynamics and informing conservation efforts. Traditional methods for biodiversity assessment often involve time-consuming sampling techniques and regardless of the rising necessity for taxonomic information across trophic levels to support ecological research and ecosystem-based management, morphological taxonomic expertise is in decline. Environmental DNA (eDNA), which refers to genetic material shed by organisms into their environment, offers insights into the species composition present in a given habitat and has revolutionized biodiversity studies by providing a non-invasive, efficient, and highly sensitive monitoring tool.

Within two projects, SNAPSHOT [1] and the Med-Ship campaign TAlPro22 [2; financed by the Eurofleets+ project and by CIESM], eDNA analysis on water samples was utilized to explore marine biodiversity. The SNAPSHOT surface water samples were taken in two coastal ecosystems within the Northern Adriatic Sea, the Venice Lagoon and the Po Delta, representing two very productive transitional environments subjected to high anthropogenic pressure, while the TAlPro22 campaign was focused on two north-south transects through the Western Mediterranean Sea crossing the Tyrrhenian and the Algero-Provencal basins and involved the sample collection at the surface, 75 meters, and seabed with more than 3000 m depth.

Fig. 1. Map of the two investigated areas in the Mediterranean Sea.

After DNA extraction, the samples were subjected to eDNA analysis targeting three key markers: 18S V4 for eukaryotes [3], COI for metazoans [4], and MiFish U for fish diversity [5]. Subsequently to amplification, the samples were sequenced on Illumina NGS platform and taxonomy was bioinformatically assigned. The results revealed the vast potential of eDNA in elucidating marine biodiversity patterns and the utilization of multiple markers enabled a thorough examination of taxonomic diversity across different marine habitats, maximizing the taxonomic coverage. The three investigated depths of the offshore samples exhibited distinct community compositions. In the surface layer and at 75 meters depth, the communities were characterized by Dinophyceae, Bacillariophyceae, Arthropoda, Chaetognatha, and Ciliata. In contrast, the bottom samples displayed an increased presence of cnidarians and radiolarians. Within the Northern

Adriatic samples, the Venice Lagoon showed for fishes a typical lagoon community dominated by *Chelon saliens*, *Atherina boyeri* as well as Gobiidae and Blennidae, while *Engraulis*, *Sardinia* and *Solea* dominated the Po Delta samples. These coastal samples were also characterized, among others, by the presence of the rotifer *Synchaeta*, the calanoids *Paracalanus parvus-complex*, *Acartia clausi* and *A. tonsa*, as well as the Pacific oyster *Magallana gigas* and the clam *Chamelea gallina*. However, the percentage of the taxonomically assigned sequences decreased in the offshore bottom samples, probably due the presence of unknown taxa, therefore missing in the reference database. Moreover, especially for the COI marker, eDNA samples showed a particularly high amplification rate of non-target DNA with more than 95% of taxonomically unassigned sequences, highlighting the need of increased sequencing depth when using this marker gene. Despite the challenges posed by diverse environmental conditions and spatial scales, eDNA analysis consistently demonstrated its ability to detect a wide range of taxa with high sensitivity and specificity. Moreover, the limited requests of eDNA sampling in terms of water volumes and time, as it can be samples just like any other environmental parameter, makes it particularly suitable for use in oceanographic cruises, where time constraints and water budget limitations are significant.

Overall, the findings of this study, which was supported by iNEST [6] and NBFC [7], highlight the promising role of eDNA analysis in marine biodiversity research and conservation, facilitating informed decision-making and sustainable management of marine ecosystems.

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A DEVELOPMENT OF THE METHOD FOR A PRECISE ASSESSMENT OF FISH ASSEMBLAGES INHABITING *POSIDONIA OCEANICA* MEADOWS

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Abstract
The *Posidonia oceanica* meadows has been widely recognized as the richest habitat for fish in the Mediterranean. However, there is a significant disproportion in species richness reported for the *Posidonia* meadows between studies using using fishing gear that report relatively high species richness, and those using underwater methods that report considerably lower number. The underwater methods focus solely on *Posidonia* beds, while fishing gear inevitably samples other habitats neighboring *Posidonia*, which results in reporting species that are not essentially associated with it. Thus, the aim of this paper is to describe the method for a better assessment of fish species inside the *Posidonia* meadows.

Keywords: Posidonia, Habitat, Monitoring, Adriatic Sea

The importance of *Posidonia oceanica* seagrass meadows for various fish communities has been widely recognized, which consequently resulted in opinion that these seagrass meadows are the richest habitats for fish in the Mediterranean [1]. However, there is a significant disproportion in fish species richness reported for the *Posidonia* habitats between studies using different sampling methods. While some studies using fishing gear report relatively high species richness, those using underwater research methods report considerably lower number. This can be explained by the fact that underwater methods allow researchers to focus on *Posidonia* beds, while fishing gear always and inevitably samples also other habitats neighboring *Posidonia*, thus reporting even species that are not essentially associated with seagrass meadows. Therefore, biases induced by sampling techniques resulted in different interpretation of data and, consequently, different conclusions. However, while fishing gears probably collected fish inside *Posidonia*, above it and nearby it and visual census recorded only fishes above the *Posidonia*, there is no quantitative research up to date to describe the fish assemblage inside *Posidonia*. Recent studies showed that some other habitats, such as coralligenous reefs, are probably the most important habitats in terms of species richness in the Mediterranean [2]. However, even Soldo et al. [2] used the underwater research methods in their study they combined different methods (DVT-Deep Vertical Transect and square with anesthetics method) for assessing fish assemblages which resulted in high number of observed cryptobenthic species that are usually not reported by other sampling methods. Thus, the aim of this paper is to describe the method for a better assessment of fish species inside the *Posidonia* seagrass meadows. This underwater method uses divers who apply the protocols of Kovacic et al. [3] which were modified to fit the *Posidonia* habitat (and *non-Posidonia* habitat for a comparison) by the application of cube and the suction sampler. It matches Hofrichter's [4] cube and the suction sampler method for *Posidonia* habitats, except for the 4x increased size of the cube bottom surface, matching the size of squares (1 m²) studied by Kovacic et al. [3], based on the pretesting *Posidonia* fieldwork results. The first diver sprayed anaesthetic, collected and stored fish from the manual check and from the suction sampler, while the second diver fixed cube, took cube photographs, recorded habitat characteristics and handled suction sampler. A stratified systematic sampling approach was applied to achieve equal representation of cubes from *Posidonia* and *non-Posidonia* habitats at different depths (5, 10 and 15 m). The bulky equipment requested the diving immediately below the boat, so the diving boat on every dive was anchored on the randomly chosen edge of *Posidonia* meadows. The sampling cubes were performed in blocks of three in a row at each position: at edge of *Posidonia* distribution, up to five meters inside *Posidonia* meadows and up to five meters from the edge of *Posidonia* distribution on other type of bottoms. Each cube was sampled and documented according to the following protocol: 1) fixing a cube (1 x 1 x 0.4 m) onto the bottom, 2) photographing the surface inside the cube, 3) recording habitat characteristics of 1m², 4) spraying the anaesthetic Quinaldine into the cube, 5) catching eventual escaping fishes with a handnet and manual check with handnets for anaesthetised fish inside the cube, 6) extracting the anaesthetised fish from the cube by the application of the suction sampler. The anaesthetic used was Quinaldine diluted 1:15 with 96% ethanol and then mixed with sea water 1:5 in 750-mL bottles. The total volume of Quinaldine deployed was 3 750-mL bottles/m². The following habitat characteristics were recorded: "Depth" ranging from 5 to 15 meters. "Distance"

as outside or inside distance from the edge of *Posidonia* meadow, ranging up to 5 meters. "Inclination" as three estimated classes: gentle (<20º), medium (20º – 60º) and steep (>60º). "Bottom substrate" as five types of different estimated particle size (sand <2 mm, gravel <60 mm, cobbles <200 mm, boulders >200 mm, bedrock) expressed as estimated percentages (10 %, 20 % …100 %) of the total surface in each box (1 x 1 m). "Number of bottom layers", i.e. no layers, single layer, multiple layers. "Biocover" as seven types (no biocover, dense *Posidonia*, sparse *Posidonia*, long thallus algae, short thallus algae, calcareous algae, zoocover). The standard length of each fish was measured thereafter. Initial field species identifications of cryptobenthic specimens were later rechecked in the lab on preserved specimens. Preliminary results showed a significant difference in species composition compared to the previous studies by other methods and much less fish abundance inside *Posidonia*, compared to other types of tested bottoms.

Fig. 1. Divers performing a new method for assessment of fish in *Posidonia*.

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Congress Joint Session : Ocean Literacy (all Committees)
Moderator : Teresa Romeo – Stazione Zoologica Anton Dohrn, Naples, Italy

Session's Synthesis

The session on "Ocean Literacy" brought together a diverse team of experts, including marine biologists, engineers, sociologists, architects, illustrators, and philosophers. Their presentations explored various methodologies for promoting ocean literacy, particularly those engaging children, families, and the broader public. A key focus was on societal perceptions of marine environmental issues, from deep-sea ecosystems, to marine biodiversity, climate change, marine spatial planning. The session also discussed strategies for making complex research accessible to diverse audiences, including the use of iconography and design. Citizen and community engagement emerged as a priority for communicating scientific findings and fostering a sense of ownership in ocean conservation. The session was highly interactive, with participants enthusiastically sharing ideas for sustainable ocean management. Experts emphasized the need for a dedicated session on ocean literacy at future conferences to integrate the results of various research areas. They underscored the importance of ongoing efforts to communicate marine research and data effectively, acknowledging the challenges posed by traditional conference formats. To address these challenges, the session highlighted the value of cross-disciplinary collaboration and the collective responsibility of all stakeholders in protecting our oceans and planet. Finally, we've agreed on the need for a more holistic approach to ocean management, one that incorporates scientific knowledge, traditional ecological knowledge, and societal values.

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REVISITING PERSPECTIVES ON BIODIVERSITY AND RESILIENCE: ENDANGERED BIODIVERSITY IN THE MEDITERRANEAN SEA AS A MODEL AND METAPHOR

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Abstract

I examine how marine biodiversity research in the Mediterranean is contributing to redefining ideas of biodiversity and how to manage it. The Med is a biodiversity hotspot, containing many more species than other marine regions with respect to size. It is also warming much more rapidly than other regions, leading to a growing frequency and intensity of mass mortality events, with several species being corralled toward cooler areas in the North and creating risks for Mediterranean marine protected areas. I review recent work on Mediterranean marine biodiversity loss and its impact on regional resilience, highlighting the hotspot nature of the Mediterranean and the importance of protecting its biodiversity. I also examine how these findings can inform broader societal discussions about biodiversity and socio-ecological resilience.

Keywords: Biodiversity, Mediterranean Sea

Like many other scientific concepts, ideas of biodiversity have evolved with time. Here, based on recent work in the Mediterranean Sea, I revisit the recent evolution of the biodiversity concept and its role within public debates about conservationist and socio-environmental policy. Although discussions on biological diversity somewhat precede the coinage of the concept, *biodiversity* first emerged in 1980s [1]. Initially, it was framed as the absolute number of species on Earth, or species richness, which probably remains the most important measure and/or way of understanding the concept. However, with time, biodiversity was reconceptualized in several other ways [2] and in connection to different scientific and conservationist aims. For example, species richness has been challenged as an insufficient account of biodiversity for changing environments. Also, within an ecosystem focus, certain keystone and 'engineer' species are more critical than others, for example due to their greater role in the ecosystem's functional or response diversity and hence in its resilience [3,4]. Further, from an Earth systems science perspective, not all Earth subsystems play an equivalent role in forecasting Earth's futures. For example, an acidified ocean may, among other things, disrupt phytoplankton communities, which hold a key role in the biological carbon pump, one the Earth's most critical mechanisms and an indispensable agent in carbon capture [5,6]. This example illustrates that some understandings of biodiversity somewhat return to the traditional conservationist emphasis on some species over others - although the reasons for this shift have, indeed, little in common with traditional conservationism.

In my contribution, I address how Earth-scientific and environmental research on the oceans and on marine biodiversity are further redefining prevailing ideas of biodiversity and how to manage it. I focus specifically on the Mediterranean sea. The Mediterranean is a critical biodiversity hotspot, containing disproportionately more species than other marine regions with respect to size [4]. It is also warming substantially more rapidly than other regions [7,8], leading to a growing frequency and intensity of mass mortality events [9], corralling many species toward cooler areas in the North [4] and thus posing exceptional challenges for the management of Mediterranean marine protected areas, most of which locate in these cooler pockets [10]. In my presentation I review recent research about the loss of Mediterranean marine biodiversity and its influence on regional resilience, highlighting the multi-hotspot nature of the Mediterranean and the importance of protecting its biodiversity. I also examine how the lessons obtained from this stream of work can inform broader societal discussions about biodiversity and socioecological resilience, at regional and at higher scales.

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YOUTH THINKS (OF) BLUE – FIRST RESULTS OF HANDS-ON OCEAN LITERACY FOR YOUTH IN CROATIA

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Abstract
The study explores the effectiveness of the "Youth thinks (of) blue" Program in enhancing ocean literacy (OL) among high school students in Croatia. The three-day interdisciplinary program integrates STEAM and OL principles to foster understanding of the ocean influence and human impact on it. Pre-post assessments revealed a significant increase in participants' knowledge, with notable improvements in understanding the principles of One Ocean. While there were no siginificant differences in results between participants' gender and age, variances were observed between town of origin. Attitudinal shifts reflect heightened awareness of personal connections, while behavioural changes indicate a shift towards more conscientious actions. The program will further support integration of OL and STEAM principles into partcipants' daily lives.

Keywords: Adriatic Sea, Behaviour, Marine policy

Introduction - Ocean Literacy (OL) is defined by two questions: "How does the Ocean influence you?" and "How do you influence the Ocean?" [1]. In Croatia, students' scientific literacy achievements have shown a considerable decline [2]. While STEAM (Science, Technology, Engineering, Arts, and Math) is becoming more and more popular, Ocean Literacy (OL) remains a relatively new idea in Croatia. OL education can integrate all areas of STEAM and is the basis of scientific literacy [1]. There are gaps in formal education, but the agility of civil society organisations can be used to fill those gaps by implementing high-quality, non-formal education initiatives. Youth Thinks (of) Blue is the first interdisciplinary hands-on Program that combines STEAM with OL principles. Its concept, design, and efficiency were tested. The study objectives were to: 1) quantify participants' understanding of ocean literacy; 2) evaluate participants' perspectives; and 3) identify potential behavioural changes with respect to OL issues.

Materials and methods - Youth thinks (of) blue is a three-day Program divided into six platforms that follow the seven OL principles, encouraging critical thinking and providing simple tangible examples for complex science postulates about how the sea supports life on Earth through fieldwork, sample collection, games, and group work. Participants in the Program used a pre-post questionnaire setup [3] to assess changes in their knowledge (multiple choice responses), attitude, and behaviour (5-point Likert scale). The 41 questions mostly focussed on the level of concern about overexploitation of marine resources, on the willingness to participate in local actions or share knowledge among peers. Questionnaire data were gathered from two groups of 15 participants in the Programme, who were all high school students, aged 14 to 18 years old, with similar gender ratios but from two different non-coastal towns in Middle Adriatic. Data analysis was performed by using non-parametric Wilcoxon signed rank test for paired up data and Kruskal-Wallis test to assess differences of participants response based on gender, age, or town.
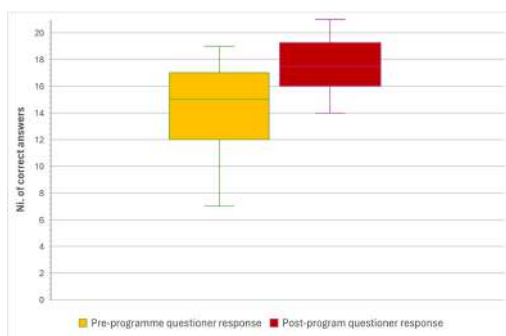

Fig. 1. Bar plot illustrating the correct responses in pre-post Program questionnaires.

Results and Discussion - The Program demonstrated a significant increase in participants knowledge, with the mean relative frequency (MRF) of correct answers rising from 15 to 17.5 out of 21 (Fig.1). Notably, understanding of One Ocean and ocean connectivity principles showed the highest increase, while links to climate regulation remained problematic. Gender and age were not significant in questionnaire results, but variations were observed beween towns (Fig. 2). The pre- and post- questionnaires between the participants from the two towns showed significant difference in their knowledge, while there was no significant difference in their rate of knowledge learning. This leads to the presumption that the scale of change in their knowledge is similar, but students from one town had the better starting position. Attitudinal shifts reflected heightened awareness of personal connections to the ocean. Significant improvements were seen in three out of ten attitude questions. The rest of the questions had a highest rank in pre-questionnaire so no significant change could have been expected. Behavioural changes towards more conscientious actions were noted in four out of ten scenarios. The remaining situations remained close to pre-questionnaire. Future Program revisions aim to inspire greater change in participants attitudes and behaviour to integrate OL and STEAM principles into daily life.

Fig. 2. Participants in a dynamic session, blending role-play and social network analysis to discuss options for enhancing MPAs effectiveness.

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DEEP SEA: DEVELOPING HUMAN CONNECTIONS BY HIGHLIGHTING A FUNDAMENTAL INVISIBILITY. WHAT DO PEOPLE THINK ABOUT THE DEEP SEA?

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Abstract

We live on a deep blue planet whose vast depths remain in a distant darkness. Given today's environmental, political and economic challenges, how do people perceive the ocean? What do they think of the deep sea? How does society deal with ocean matters? This study aims at integrating knowledge from social psychology and oceanography to answer these questions. People's beliefs, emotions, and attitudes, as well as their understanding of the deep sea are explored. This initiative should help develop scientific mediation and educational content, improve deep-sea knowledge and foster interdisciplinary collaborations related to the ocean.

Keywords: Deep waters, Worldwide

Beneath its surface, our blue planet harbours an immense dark territory of depths - unlighted even in our minds. Yet, the deep sea (below 200 meters depth) is the world's largest ecosystem, accounting for over 90% of the ocean's volume and regulating atmospheric temperature, storing carbon, and serving as a nutritional reservoir necessary for the survival of our species. In a context of climate change and ever-growing economic appetite, the ocean is receiving increasing attention. We are in the midst of shedding light on the large gap between scientific knowledge and public understanding of the deep sea [1]. We can also observe that in the eyes of people living on land, the ocean most commonly seems to represent coastlines, reefs, waves and a number of ocean related activities. Whereas the open sea and the deep sea seem to hold less space in the community's mind [2]. This distance may be explained by the fact that we, as humans, have evolved being physically and emotionally disconnected from the deep sea [3]. **Yet in this environmental, political and economic context, how do people perceive the ocean? What do they think of the deep sea? How does society deal with ocean-related challenges?** This study integrates expertise from social psychology and deep-sea oceanography to answer these questions by exploring the existing beliefs, the related emotions and imaginary universes of individuals, and the materials that people use to perceive and comprehend the deep sea. The methodology consists of a descriptive approach to study social representations, based on individual semi-directive interviews prior to collective interviews (the results of these interviews will serve as the basis for a questionnaire survey). As a first step in exploring the field, one-to-one interviews started shedding light on people's perceptions of the deep sea. They revealed a variety of beliefs about the concept of the depth of the ocean, a differing imagination of its biodiversity, and a mixed knowledge of human activity on the deep seabed. Thoughts seem to be shared on the desire to preserve the deep sea, the belief that all animals without distinction deserve our protection, and on a sinister future for the ocean. This new approach toward the Ocean in France provides insights that allow us to understand the relationship people have with the deep sea, and what society expects in terms of political action.
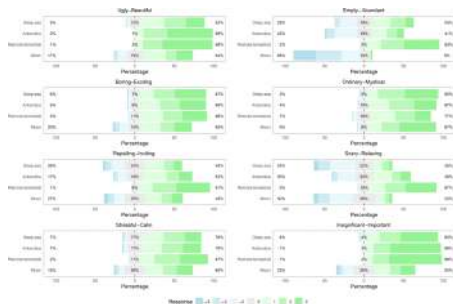

Fig. 1. Symbolic values attributed to four different remote environments including the deep sea [4].
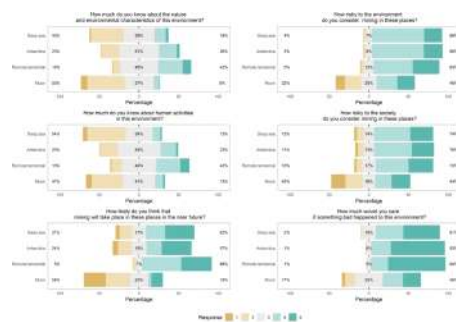

Fig. 2. Perceived environmental and social risk of mining in the deep sea (and the three other remote environments) [4].

Symbolic values (Fig 1) - emotions, moods, and meanings associated with environments -significantly shape people's environmental care (Fig 2). Despite perceiving deep-sea mining as both likely and risky, people tend to feel less well-informed about the deep sea. This emphasizes the critical importance of enhancing public understanding and emotional connection to the deep sea to foster stewardship and informed decision-making regarding deep-sea mining activities [4]. There have been social sciences studies that have focused on the ocean [5], and we noticed how relevant it could be to compare the difference in results between the "ocean" and the "deep sea". Regarding the public discourse and the media coverage of the ocean, we focused our attention on an exceptional French television program, broadcasted at prime time and bringing together ocean scientists, users, politicians and activists for ocean conservation. This media coverage allowed us to carry out a case study to explore the value given to the ocean (instrumental VS intrinsic) and the motivations of individuals to protect or appreciate marine ecosystems (aesthetics, recreational, survival, etc.). All of our observations help us create scientific mediation and educational content to develop the ocean literacy of the deep sea and increase collaborations between disciplines around the ocean (legal sciences, ocean sciences, social sciences, arts, and others).

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THE EASTERN MEDITERRANEAN: THE BRAINCHILD OF 'BIG OCEANOGRAPHY' (1970-2000)

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Abstract

The exploration of Mediterranean deep waters and currents has been long embedded in a network of geopolitical, strategic and epistemic constraints that play a crucial role in the integration of knowledge of the multiple scales of ocean dynamics, from the meso-scale up to basin and global scales. This paper aims to delve into this set of constraints in order to critically assess the historical split between global and regional oceanography, tracing the missing connections between the actors and practitioners involved in the 'big oceanography' experiments of the second half of the 20th century and research conducted in the so-called 'marginal' seas like the Mediterranean.

Keywords: Currents, Deep waters, Circulation, Eastern Mediterranean

In the past two decades, historians of science and technology and environmental historians have pushed forward a global history of oceanography focused on the interplay of scientific, territorial and colonialist aims of imperial powers over the past two centuries [1,2,3]. Against this historical scholarship, some remarkable contributions have engaged with a 'regional' or 'mediterranean' turn that bridges the missing links between histories of Mediterranean and global oceanography, providing a historiographic breadth to the several scientific literature reviews that physical oceanographers have written of their own field from both a global [4,5,6] and a Mediterranean perspective [7]. The objective of this paper is precisely to foster this 'mediterranean' turn and to give an outline of how the contributions of the Physical Oceanography of the Eastern Mediterranean (POEM) experiment to the understanding of some unresolved issues of the large-scale global ocean circulation in the period 1970-2000 are a clear example of this embedding of local and global histories of science. In fact, the planning, execution and success of POEM gave the Mediterranean Sea central stage in the discussion of fundamental oceanographic questions, like the mechanisms of deep water formation, mixing and spreading, the causes of open ocean deep convection, the role of meso-scale eddies in the large-scale circulation and the contribution of the Gibraltar outflow to the Atlantic deep water budget [8]. However, delving into these open problems in the specific setting of the Mediterranean basin was only possible thanks to the linkages of POEM with previous collective efforts in deciphering the functioning of a time-dependent unsteady ocean, like the International Decade of Ocean Exploration (1971-1980), within whose framework the Mid-Ocean Dynamics Experiment (MODE, 1973) and its siblings POLYGON and POLYMODE were devised [9]. Both projects informed the design and research questions of POEM [10] under the auspice of UNESCO and the CIESM and the world-leading expertise of oceanographer Allan R. Robinson in air-sea interaction and meso-scale dynamics [11;12], who held the co-chairmanship of the program. These 'big oceanography' research programs of the 1970s casted evidence about the importance of meso-scale features, such as eddies and jets, that were later discovered in the Mediterranean basin during POEM [13]. Secondly, in combination with the current knowledge on the Mediterranean embodied by the other co-chairman of POEM, italian oceanographer Paola Malanotte-Rizzoli [14], both supervisors of the program pointed at the largely underexplored Eastern Mediterranean basin as a easily manageable, surveyable and perfectly suitable spot to conduct a basin-scale research program on the poorly known phenomena of deep water formation and convection [15]. The 'regional' approach in history of science, of which this paper is a follow-up, claims that the scientific concept of the global environment [16;17] and associated notions, like the global ocean and the global climate, are not self-evident wholes, but their emergence is rather a piecemeal and contingent process that builds on the reciprocal shaping of local and worldwide scientific practices [18;19]. The origins, contribution and outreach of the Physical Oceanography of the Eastern Mediterranean Experiment (POEM) to the exploration and understanding of ocean dynamics serves as a clear example of this reciprocal relationship. Ongoing research on conference proceedings, workshop reports, peer journal articles and personal papers communications will continue to draw historical connections between 'big oceanography' in the 1970s, Mediterranean oceanography in the 1980s and beyond. The subsequent reproduction, dissemination and globalization of POEM outcome, which enabled the discovery of the Eastern Mediterranean Transient in the 1990s, was instrumental in fixing the goals and focus of physical oceanography [20], a legacy that is yet to be historicized.

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PLANET TUNA: DIVING DEEP INTO THE WORLD OF TUNA

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Abstract
The Planet Tuna ocean education project combines multidisciplinary and accessible scientific knowledge in a unique and creative way through tunas, reflecting a very particular vision of scientific outreach based on processes, multidisciplinarity, the quality of information and scientific dissemination to a diverse audience in terms of interests, backgrounds, ages, and languages, to promote fascination with the sciences and their cultural, economic, and technological values. And to do so, we rely on the combination of art and science.

Keywords: Open sea, Mediterranean Sea, Tuna

For centuries tunas have been a symbol of the Mediterranean Sea. Although they possess great ecological, social, cultural and economic value, these species remain largely unknown to science and society, despite the fact that the Mediterranean Sea represents one of the most crucial areas in the world for the reproduction of species such as the Atlantic bluefin tuna. Tunas, and large oceanic migrators in general, allow us to address various topics, such as biology, history, critical thinking, art, consumption, environment among others. In Planet Tuna, they constitute a platform that, through ocean education, impacts various fields of knowledge (Science, Arts, Humanities and Society). Complex scientific discoveries are communicated in Planet Tuna in an accessible and inspiring way through articles, infographics, interviews, videos, illustrations, reviews of current research from IEO-CSIC and other national and international research groups related to the theme, and photography, as the main communication tools. To improve the availability and acceptance of scientific research, Planet Tuna draws on the connection between art, humanities, society, and science.
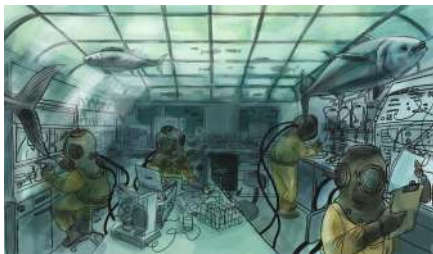

Fig. 1. Planet tuna combines art and science. Illustration by Flavia Gargiulo. Our work can be consulted at Planettuna.com; FB, X @planettunaIEO; IG @planettuna_IEO ; YT youtube.com/youtuna.

Some examples of our content are: Informative **articles** and photographies, for example in the area of ecology https://planettuna.com/en/when-the-hunter-becomes-a-prey-who-eats-who-in-the-world-of-the-tuna/ , as well as **illustrated articles** in ecology, Mediterranean history https://planettuna.com/en/from-the-strait-of-gibraltar-to-greece-the-tuna-trade-in-phoenician-times/consumption and sustainability https://planettuna.com/en/canned-tuna-i-whats-in-the-can/.
Infographics covering topics related to ecology and the importance of the Mediterranean Sea https://planettuna.com/en/bluefin-tuna-migtation-routes-infographics/ , archeology and the Phoenician amphora https://planettuna.com/en/phoenician-tuna-anphorae-infographics/, fact sheets of key species of marine migrators https://planettuna.com/en/tuna-that-breed-in-the-mediterranean-infographics/ and Figure 2 (https://planettuna.com/en/why-tuna-breed-in-the-balearic-islands-and-how-we-know/). On our platform, we've placed special emphasis on the intersection between art and science. Through **illustrated videos**, we explore the discipline of scientific illustration: what it is, its practical utility,

and how it can become an exciting career path https://planettuna.com/en/scientific-illustration-i-a-guided-tour/, and examples of how international illustrators work https://planettuna.com/en/scientific-illustration-iii-illustrating-a-bluefin-tuna-with-pedro-salgado-part-2/.
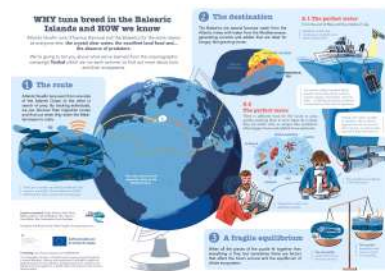

Fig. 2. Example of inphographics based on the work developed during the oceanographic survey TUNIBAL. Illustration Flavia Gargiulo

Additionally, we offer explanatory videos on marine ecology, providing a unique window to understand and appreciate marine ecosystems and processes as for example https://planettuna.com/en/who-eats-who-baby-tuna-vs-baby-jellyfish/, https://planettuna.com/en/marine-heatwaves/. We also publicly answer some of the questions to the scientist that we receive in our section "Ask a scientist".
This outreach platform receives funding through national and regional competitive calls aimed at promoting dissemination, as well as research projects that allocate part of their funds to the dissemination of scientific results. As an impact indicator, Planet Tuna´s activity data in 2022 are Twitter 312451 reach; Instagram 13841 reach; Facebook 46975 reach; Youtube 56300 reach; Web page 197991 visits. We can summarize it had an impact of over 50.000 views. Hence, the importance of combining channels and formats to achieve a greater impact. We are seeking to interact with offline content that includes educational activities and exhibitions. Many scientific partners collaborate in the development and help with the scientific content created in the platform. We believe we should reflect on responsibility and accessibility in scientific dissemination, flexible communication models, information and science times and the limits in science communication. Scientific literacy is an essential tool to understand the processes of science.

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1 - All cited work can be found in www.planettuna.com. Figure 2 has been co-funded by the European Union through the European Maritime Fisheries and Aquaculture Fund (EMFAF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy

VISUAL TOOLS FOR MARITIME SPATIAL PLANNING: AN INFOGRAPHICS SCREENING

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Abstract

Ocean Literacy implies not only educational but also cultural and outreach actions related to marine sciences and processes. The present research investigates the visual communication effort put in place by some countries in and for their Maritime Spatial Plans using the EU MSP Platform. The screening takes into account the presence of infographics in MSP plans or in linked official communication materials. The overall quantitative results and key examples are discussed. This study opens a path of study on the visual communication of MSP.

Keywords: Marine policy, Western Mediterranea, Eastern Mediterranea

Introduction

Ocean literacy is nowadays considered a framework to promote the sociocultural aspects of Marine Spatial Planning [1]. In its broadening scope we wish to consider the visual communication that can be retraced in Maritime Spatial Planning (MSP) processes at European level. The study aimed at identifying and quantifying the presence of infographic in MSP plans, as approved by EU Member States and publicly available. The plans from the United Kingdom were also included in the analysis since they were mostly approved before Brexit. This exercise helps understanding the role of visual communication as an enabler of MSP processes according to the MSP Directive [2].

Methodology

The study screened the countries' official web pages and documents accessible *via* the MSP Platform. "Plans", i.e. policy documents, and related communication materials approved by the government were considered. The choice was motivated by the fact that plans are heterogeneous in their nature and outcomes. Other forms of visual communication (diagrams, illustrations, layouts) and maps, inherently present in MSP documents were not included in the study. We only considered the use of infographics (as defined by [3] and [4]), and motion graphics, a form of infographics in which written text is mainly replaced by an oral description and a narrative is presented in a sequence. We specified when motion graphics have been employed not only as a promotional tool but as a way to present specific visions within the plan. We also specified the type of infographic according to the classification proposed by [5].

Results

Only 7 out of 23 plans employed infographics, none in the Mediterranean Sea. Only the English and Finnish infographics are included in legally binding documents. The Finnish infographics, as a digital format, were used structurally, i.e. as a tool to convey information that is expected to trigger intellectual and emotional engagement. This is also the only case in which a limited level of interactivity can be retraced, thanks to the slider. Diagrams are used more often (12 cases) but generally to organize more simple information.

Conclusions

The study shows that, in general, the infographics were not extensively used. This can be linked to several reasons, often limited access to time and financial resources. It must be said that maps are a priority in this type of management tool, hence, the possibility that more importance was given to those types of visualization rather than in developing infographics. However, this can also show a lack of effort and willingness to engage citizens and stakeholders and it may also imply a low level of transparency if a plan remains in a technical language.

Tab. 1. Infographics presence in MSP plans by country.

	Country	Infographic presence
1	BE	Motion graphics, a short animation presenting the plan.
2	BG	No
3	CY	No
4	DK	No
5	EE	Infographics are used in a video presentation hosted in the official webpage.
6	FI	Yes (Process and Geographical Based). Interactive infographics to show sector-specific roadmaps. Motion Graphics for Area-specific development visions.
7	FR	No
8	DE	No
9	IT	Yes, planning areas and units sintesis.
10	LV	No
11	LT	No
12	MT	No
13	NL	No
14	PL	No
15	PT	no
16	IE	Yes (Timeline/Process Based) to present roadmap to national MSP framework.
17	SI	No
18	ES	No
19	SE	No
20	GB-EN	Yes (Statistical Based), summary infographic. Explanatory motion graphic for promotion of the general process.
21	GB-NI	No
22	GB-SCO	No. Use of motion graphics in a video promoting the 2020 assessment of the plan.
23	GB-WE	Yes (Process Based) regarding terrestrial planning permission. Use of motion graphics to present the general process of MSP.

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Congress Joint Session : Non-Indigenous species
(C5 - C6)
Moderator : Ernesto Azzurro– IRBIM-CNR, Ancona, Italy

Session's Synthesis

The session on "Non-Indigenous Species" hosted nine contributions that shed light on the complex and varied realm of marine bioinvasions, addressing a diversity of topics wich ranged from Lessepsian foraminifera and small ciliates to invasive fishes. Presentations covered taxonomic, monitoring and management aspects, and a particular attention was given to the blue crab (*Callinectes sapidus*) due to its recent spread across several Mediterranean countries. Key environmental factors, notably temperature and salinity, were discussed as critical influences on the success of non-native species and rapid assessment methods for benthic species were presented. Sicily's strategic location in the Mediterranean was highlighted as a crucial crossroads for species dispersal and a valuable observatory for tracking biodiversity changes across the region. Community engagement emerged as a central theme, exemplified by successful participatory initiatives in the Strait of Sicily and other Mediterranean regions. Citizen involvement in species detection has significantly enhanced the monitoring capabilities of traditional methods, particularly for conspicuous species that are easily identified taxonomically. Constructive discussions addressed challenges related to data validation, management, and international collaboration, underscoring the importance of stakeholder participation in monitoring and management processes, which may consider certification schemes to foster sustainable practices. The session also underscored the significance of comprehensive data collection, processing, and application throughout the entire data lifecycle, in line with Open and FAIR science principles. This approach received broad support as vital for advancing bioinvasion science in the Mediterranean. Reflecting the enthusiastic spirit of invasive species research, the session was highly interactive, fostering cross-disciplinary dialogue and underscoring the need for active and broad cooperation among the increasing number of Mediterranean scientists working on the fascinating subject of Non-Indigenous Species.

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EFFECTS OF TEMPERATURE AND SALINITY ON THE MOVEMENT AND BLEACHING OF
AMPHISTEGINA LOBIFERA LARSEN, 1976

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Abstract
Amphistegina lobifera Larsen, 1976 is a Lessepsian immigrant foraminiferan which has invaded many areas of the Eastern and Central Mediterranean Sea. Movement and bleaching of individuals from the Central Mediterranean (Malta) were tested at different salinities and temperatures. The test individuals became stressed at temperatures lower than 14°C and higher than 30°C. The optimum salinity range was 36 - 37gL^{-1}, but individuals survived at all salinities tested (25 - 48gL^{-1}). Temperature, but not salinity, may limit expansion of the range in the northwestern Mediterranean.

Keywords: Behaviour, Erythrean species, Foraminifera, Invasive species, Mediterranean Sea

Introduction:
The Lessepsian immigrant foraminiferan *Amphistegina lobifera* Larsen, 1976 has been recorded from the Central and Eastern Mediterranean Sea, including Albania, Egypt, Greece, Israel, Italy (including Sicily), Lebanon, Libya, Malta and Turkey [1 and references therein]. This species hosts diatom photosymbionts but when stressed, such as due to extremes in temperature, salinity and light intensity, shedding of the photosymbionts ('bleaching') can occur, which reduces the energy production of the foraminiferan, increases the chances of reproductive failure and weakens the test, making the foraminiferan more susceptible to predators and parasites [2]. The aim of this study was to determine the effects of different temperatures and salinitiees on the movement and bleaching of *Amphistegina lobifera* sourced from the Central Mediterranean (Malta).

Methods:
Temperature: Fifteen *A. lobifera* individuals picked at random from a stock tank were placed in aquaria maintained at different fixed temperatures (10, 12, 14, 16, 18, 20, 25, 30, 32, 34 and 36°C). The aquaria were placed over gridded paper (5x5mm) and any movement of the foraminiferans from one square to another was recorded for seven days, after which the amphisteginids were examined under a stereomicroscope for signs of bleaching. *Salinity:* Six salinity concentrations were prepared using distilled water and "Aquaforest reef salt": 25gL^{-1}, 36gL^{-1} (cf. Western Mediterranean), 37gL^{-1} (cf. Central Mediterranean), 39gL^{-1} (cf. Eastern Mediterranean), 41gL^{-1} (cf. Northern Red Sea) and 48gL^{-1}. Fifteen individuals of *A. lobifera* from a stock aquarium were placed in each and daily readings of movement were taken for seven days, after which the foraminiferans were inspected for signs of bleaching. All experiments were conducted in an aquarium room with lights set to mimic the intensities and day/night cycles of the natural environment at 25°C.

Results and Discussion:
Temperature: Movement in *A. lobifera* was noted at temperatures between 14°C and 32°C, peaking at 20°C (Tab. 1). Similarly, bleaching was observed to peak at the extremes of the temperatures tested, with minimal bleaching observed at temperatures close to 20°C (Tab. 1). This suggests that *A.lobifera* are least stressed at temperatures between 20-30°C. These findings extend those of Schmidt et al. [3] who found that this temperature range is ideal for the species in the area around Israel. The present results suggest that *A. lobifera* may be less stressed during the spring and summer months, compared to the winter months, in the Central and Eastern Mediterranean Sea, and that under present temperature conditions, the expansion of this species to colder waters such as those in Liguria, France, and Spain is unlikely. While *A. lobifera* would be viable in these waters, it would be under high stress in winter months. A southwesterly expansion to countries such as Algeria and Morocco is more likely. However, the warming trend of Mediterranean waters can change the situation, allowing this species to thrive in new, warmer waters [4]. *Salinity:* Highest movement was observed at salinities of 36gL^{-1} and 37gL^{-1}, although movement was noted even at the extremes of 25gL^{-1} and 48gL^{-1} (Tab. 2). Bleaching in these experiments was not as evident as in the temperature experiments but whitening at the edge of the test was noted. The highest degree of bleaching was observed at 48gL^{-1} and 41gL^{-1} whilst no bleaching was observed at 36gL^{-1} and 37gL^{-1} (Tab. 2). These results suggest that *A. lobifera*

is able to thrive in salinities characteristic of different areas of the Mediterranean Sea, including the Western basin, and can possibly survive also relatively brackish waters of salinity *ca* 25gL^{-1}. Salinity, therefore, does not seem to impede *A. lobifera* from colonising the Northwestern parts of the Mediterranean Sea.

Tab. 1. Number of *A.lobifera* individuals which moved in each day of the experiment and the number of bleached individuals at the different temperatures tested.

		Temperature									
		10°C	12°C	14°C	16°C	20°C	25°C	30°C	32°C	34°C	36°C
Day Number	1	0	0	0	1	7	1	1	1	0	0
	2	0	0	1	2	7	3	2	1	0	0
	3	0	0	1	4	7	5	2	1	0	0
	4	0	0	2	6	8	6	3	1	0	0
	5	0	0	3	6	9	7	4	2	0	0
	6	0	0	3	7	11	9	7	4	0	0
	7	0	0	3	8	11	10	7	4	0	0

Temperature	10°C	12°C	14°C	16°C	20°C	25°C	30°C	32°C	34°C	36°C
Bleached individuals	4	3	2	1	0	2	6	10	13	14

Tab. 2. Number of *A.lobifera* individuals which moved in each day of the experiment and the number of bleached individuals at the different salinities tested.

		Salinity concentration					
		25gL^{-1}	36gL^{-1}	37gL^{-1}	39gL^{-1}	41gL^{-1}	48gL^{-1}
Day Number	1	0	12	10	2	3	0
	2	1	14	11	3	5	0
	3	2	15	14	4	6	0
	4	3	15	15	7	8	0
	5	5	15	15	9	10	1
	6	5	15	15	12	10	1
	7	5	15	15	12	11	1

Salinity	25gL^{-1}	36gL^{-1}	37gL^{-1}	39gL^{-1}	41gL^{-1}	48gL^{-1}
Bleached individuals	3	0	0	2	4	7

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NAVIGATING FISH INVASIONS WITH THE ORMEF INTERACTIVE WEB PLATFORM

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Abstract

ORMEF https://www.ormef.eu, is a new interactive Web platform that consolidates a vast historical repository of georeferenced records of exotic fish species extracted from scientific literature. Covering observations spanning over a century, from 1896 to the present day we incorporated 12,553 georeferenced occurrences distributed across 221 fish taxa. As an authoritative yet user-friendly reference, ORMEF offers promising applications not only for marine bioinvasion research but also for informed decision-making at both the Mediterranean and EU levels.

Keywords: Alien species, Fishes, NIS, Mapping, Mediterranean Sea

Introduction

Dedicated information systems are becoming increasingly essential in tackling the mounting challenges presented by invasive species. This need is particularly apparent in European and Mediterranean seas, due to the current introduction rates and to the growing importance of georeferenced data for predictive models [1]. Recent efforts by the CIESM exotic task force, have documented in the new atlas of exotic fishes [2] the occurrence and distribution of 188 exotic fish species, adding 107 species to the initial 2002 edition. In light of this situation, there is a pressing need for new information systems. These systems would facilitate regular updates on new species and validated occurrences, ensuring the accessibility and ease of access to this crucial information.

Materials and methods

The ORMEF web platform is based on a three-level architecture consisting of 1. the user interface, which includes a GIS-based user graphical user interface plus a number of user functional tools; 2. the application layer, which consists of the various web services such as map rendering, feature streaming, data projection, geographic and attribute-based queries, metadata query and management, and data extraction and 3. the data layer, where the application data is stored and managed. Each record in the ORMEF database has undergone a meticulous validation process, cross-checked against original sources, and subjected to multiple peer reviews according to the publication procedures of the aforementioned papers. The ORMEF database has played a pivotal role in supporting various basin-scale scientific research projects. ORMEF datasets follow the FAIR principle of Findability, Accessibility, Interoperability, and Reusability of data (Wilkinson et al, 2016), and its vocabulary follows the Darwin Core Standard (DwC, https://dwctdwgorg/).

Fig. 1. The homepage of the ORMEF web platform, freely consultable at the address https://www.ormef.eu (https://www.ormef.eu – accessed January 30th 2024).

Results and discussion

As of April 2024, the ORMEF web platform enables users to visualize 12,553 georeferenced occurrences across 221 accepted species and 88 families, including Abudefduf cfr. saxatilis/vaigiensis/troschelii. Map-based searches enable users to visualize species records on the map and filter the data set based on various fields. Each point record provides interactive information on the data source, bibliographic reference, and the details of each capture or observation. The Web platform system also allows for the production of animations of point records according to the selected filters and along the chosen temporal frame. These data can be used to reconstruct the invasion history at different spatial and temporal scales [3].

Conclusions

The ORMEF web platform serves as a dynamic and interactive resource for exploring historical occurrences of exotic fish in the Mediterranean and neighboring seas. It consolidates and updates information relevant to European and Mediterranean policies, serving researchers, scholars, Marine Protected Areas, and the general public. Aligned with international and regional legislation, it supports biodiversity strategies such as the EU 2020 Biodiversity Strategy and the Convention on Biological Diversity's Strategic Plan.

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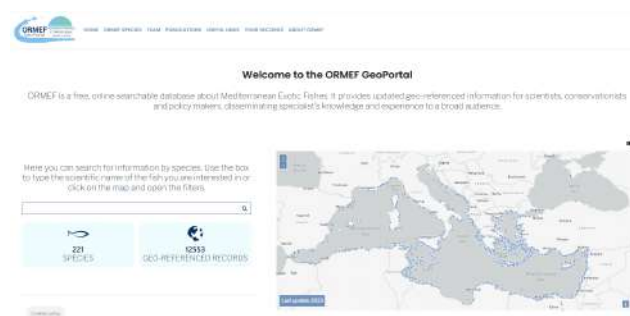
THE SICILY ISLAND: AN OBSERVATORY TO DETECT NON-INDIGENOUS, VAGRANT AND NEGLECTED SPECIES IN THE MEDITERRANEAN SEA

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Abstract
Sicily's central position in the Mediterranean Sea makes it a crossroad for marine species dispersal routes. This study, through data collected along the coast (sampling sites: Trapani, Palermo, Catania, Siracusa, Marzamemi, and Portopalo di Capo Passero), confirms its strategic role in connecting sub-basins, for both native species and NIS, also favoursing the detection of rare or neglected species. Surveys in this area could improve understanding of biodiversity changes, biological invasions, and rare and neglected marine species distribution.

Keywords: NIS, Mediterranean Sea

Sicily is the largest island of the Mediterranean Sea and is located in a strategic and central position within the basin making it a crossroad for dispersal routes of marine species. In fact, along its coasts, three main sub-geographic areas are interconnected, namely the Tyrrhenian Sea on the north, the Ionian Sea on the east, and the Strait of Sicily on the south. Recent studies (e.g. [2]; [3]) showed that Sicily is a suitable area for monitoring the spread of non-indigenous (NIS) or vagrant species from the eastern Mediterranean or the Atlantic Ocean. Moreover, the Island can be also of interest to carry out general studies assessing the Mediterranean biodiversity [1]. The present work further supports the idea that Sicily is a point of connectivity between the Mediterranean sub-basins, employing some study cases of detection of NIS, rare, or neglected species.

We present herein new occurrence data of invertebrate species collected in 2023–2024 at the following localities: Trapani, Palermo, Catania, Siracusa, Marzamemi, and Portopalo di Capo Passero (Fig. 1).
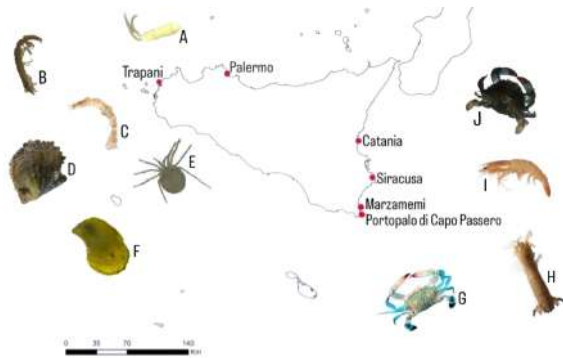

Fig. 1. Map of Sicily with the four sampling localities (Trapani; Palermo; Catania; Siracusa; Marzamemi; Portopalo di Capo Passero). Collected NIS and neglected taxa were: A) Botryllophilidae Sars G.O.,1921; B) *Paranthura japonica* Richardson 1909; C) *Mesanthura* cf. *romulea* Poore & Lew Ton, 1986; D) *Pinctada imbricata radiata* (Leach, 1814); E) Pontarachnidae Koenike, 1910; F) *Isognomon* sp. [Lightfoot], 1786; G) *Portunus segnis* (Forsskål, 1775); H) *Erugosquilla massavensis* (Kossmann, 1880); I) *Penaeus aztecus* Ives, 1891; J) *Callinectes sapidus* Rathbun, 1896.

Data from Catania, Siracusa, Marzamemi and Portopalo di Capo Passero were obtained through a participatory approach (Citizen Science) — i.e. from professional fishermen and fishmongers operating along the Ionian coast of Sicily. Four NIS crustaceans of commercial interest were detected, namely *Callinectes sapidus* Rathbun, 1896, *Erugosquilla massavensis* (Kossmann, 1880), *Penaeus aztecus* Ives, 1891, and *Portunus segnis* (Forsskål, 1775). The observations indicated a significant increase in abundance compared to recent years. Their presence was also linked to an increase in local markets, highlighting the economic and social impact of such species. On the contrary, data from the

western coast of Sicily (Palermo and Trapani) were collected by direct scraping of fouling communities grown on nautical ropes immersed at about 2 m depth. The invertebrate taxa identified were both NIS and neglectedspecies. The Lessepsian bivalve *Brachidontes pharaonis* (P. Fischer, 1870) was found in the Trapani harbour and the Palermo marina with an unexpectedly high number of individuals (more than 500 specimens), byssed on a rope fragment of about 50 cm. The records of the bivalve *Pinctada imbricata radiata* (Leach, 1814) and of the isopod *Mesanthura* cf. *romulea* Poore & Lew Ton, 1986 confirmed their presence in the Trapani harbour and the Palermo marina, suggesting the presence of established populations. The isopod *Paranthura japonica* Richardson 1909 and the bivalve *Isognomon* sp. [Lightfoot], 1786 were first recorded in Trapani. Further taxa found during the present field work are generally considered rare or neglected species. Copepods parasitic of tunicates of the family Botryllophilidae Sars G.O.,1921 were recorded for the first time in the central Mediterranean at Palermo, while marine mites of the family Pontarachnidae Koenike, 1910 were first recorded from Sicily at Trapani. The results of this work highlight the role of Sicily as a territory of connectivity between different Mediterranean sub-geographic areas, both for native and non-indigenous species. Its strategic position in the centre of the basin and its variability of habitats also favour the establishment of species that request peculiar conditions. Thus, changes in marine biodiversity could be easily monitored to better understand biological invasions and to improve the knowledge about rare species that often tend to be neglected.

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CERTIFYING FISHERIES OF AQUATIC INVASIVE SPECIES: CHALLENGES AND OPPORTUNITIES IN THE MEDITERRANEAN

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Abstract

The Mediterranean Sea is considered the world's most invaded marine region but many invasive species have economic potential to be exploited as new fishery resources. Fishers harvesting Aquatic Invasive Species (AIS) could receive support to adopt selective fishing methods and to develop specific labeling requirements for edible species. In the present study, we attempt to include the invasive blue crab (*Callinectes sapidus*) as a new fishery resource for a responsible exploitation within the framework of a local Italian certification scheme. We mention the challenges that the blue crab poses and how it could be a new opportunity for local artisanal fishing communities, who can be actively involved to mitigate the expansion of the species and yield economic advantages.

Keywords: Mediterranean Sea, Management, Fisheries, Invasive species, Ecosystem services

The Mediterranean Sea has experienced a dramatic increase of Aquatic Invasive Species (AIS) over the last few decades [1, 2]. It currently stands as one of most invaded seas in the world [3] in terms of number of taxa recorded with high reproductive rate and high dispersal ability [2, 4]. With such biological traits, AIS can have negative ecological and economic consequences on native communities and their associated ecosystem services. Thus, there is an urgent need to develop an adaptive management strategy to cope with potential impacts of increasing AIS expansion. One way to mitigate this harmful spreading would be to support fishers on adopting selective fishing methods and to develop specific labeling requirements for edible AIS. For instance, the ongoing expansion of the Atlantic blue crab (*Callinectes sapidus*) is posing significant challenges to local ecosystem and artisanal small-scale fishing community in the Mediterranean [5-7]. In this contest, the use of *C. sapidus* as a target species fishery resource would be a potential case for a responsible exploitation in the framework of the regional certification scheme. Here, we outline a potential adaptive management strategy (**Fig.1**) to mitigate the expansion of the *C. sapidus* in invaded coastal habitats in the Adriatic Sea and assess quantitatively trade-offs between ecosystem impacts of the AIS and ecosystem impacts of its exploitation.
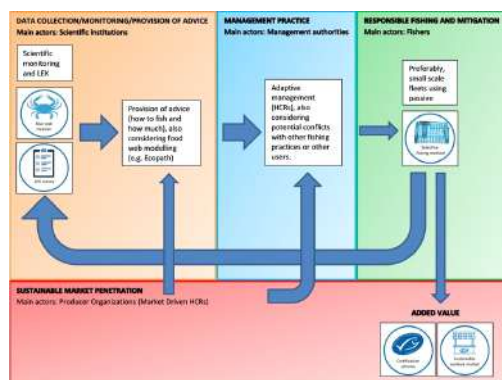

Fig. 1. Conceptual framework of a potential adaptive harvest strategy to contain the expansion of *C. sapidus* in invaded coastal habitats. The collection of key information will be carried out through consolidated participatory approaches for AIS monitoring applied to small-scale fisheries. Active monitoring on the abundance and distribution of *C. sapidus* will be carried out according to standard protocols.

Identifying and implementing a certified fisheries to mitigate the expansion of an edible AIS such as *C. sapidus* would yield ecological benefits and economic advantages for local fishing community. This will make value chains more efficient and responsive to market demand, while ensuring food security and ready access to local products. However, there are still gaps to be addressed to better understand and monitor local knowledge and perception regarding *C. sapidus*. Thus, awareness initiatives and responsible fishing practices should be promoted through effective communication and training tools by engaging the public. Finally, this strategy may serve to promote certification as a sustainability driver through capacity building, appropriate regulatory frameworks and awareness activities of other edible AIS, heightening consumer awareness.

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DATA MINING ON INVASIVE SPECIES: THE CASE OF *ANADARA* SPP., BY-CATCH BIVALVE IN THE NORTH ADRIATIC FISHERY

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Abstract

A dataset with abundance and distribution records of invasive arkshells, *Anadara kagoshimensis* and *A. tranvsersa*, was gathered and published as a result of the collaboration between two national projects, SoleMon and USEit. The dataset includes about 2,000 records of *Anadara* spp. in the Northern-Central Adriatic Sea collected between 2008 and 2023. The entire data lifecycle, including collection, harmonisation, sharing, and archiving, was meticulously managed to ensure the integrity and reusability of data and metadata according to the principles of Open and FAIR science. This endeavour exemplifies the potential for (re)using by-catch invasive species data to inform conservation efforts and effectively manage biological invasions.

Keywords: Alien species, Invasive species, Bivalves, Management, Adriatic Sea

Introduction

The scientific community has increasingly acknowledged the importance of Open Science and FAIR practices to share Findable, Accessible, Interoperable and Reusable research products [1]. Scientists can also take advantage of data management practices and digital tools provided by environmental Research Infrastructures. For example, LifeWatch Italy, the national node of LifeWatch ERIC [2], offers a set of digital services to support scientific research in the domain of biodiversity and ecosystems. Exploiting such digital services for data management can be beneficial for Invasive Alien Species (IAS) data, which often remain obscured, widely dispersed and unavailable for long-term reuse. The collaboration between LifeWatch Italy and two national projects, SoleMon and UseIT, enabled the FAIR publication of existing data on IAS. This joint effort allows to overcome the current fragmentation of scientific information on IAS, facilitating their reuse and integration with other evidence to find efficient solutions for managing biological invasions.

Methods

This case study presents a dataset of *Anadara kagoshimensis* and *A. transversa*, two invasive bivalves widespread in the Adriatic Sea. Their "by-catch" sampling occurred within the framework of the SoleMon project, an experimental beam trawl survey designed to collect data on commercial marine species. The harmonisation of (meta)data was performed through the curation of the structure, syntax and semantics in alignment with international (meta)data standards. Specifically, the data schema adheres to the Darwin Core standard [3] and other controlled vocabularies [4,5], whereas the metadata schema to the Ecological Metadata Language (EML) version 2.2.0 [6].

Results and Discussion

The final dataset consists of 20 attributes describing sampling events, locations, taxonomy and abundance of *Anadara* species. Overall, the dataset includes 1,998 records distributed over 66 sampling sites in the Northern-Central Adriatic Sea and collected between 2008 and 2023. This dataset, and other IAS data, are available within the LifeWatch Italy Data Portal. The dataset is designed to perform spatial analyses on the abundance of *Anadara* spp. in the Adriatic Sea. Moreover, additional information on *Anadara* spp., i.e. nutraceutical and elemental composition data, are published using the same approach and standards, enabling a seamless integration of scientific evidence and ensuring a more effective reuse of these data. This approach is expected to offer significant advantages for IAS management, including their potential use as an economic resource under the principles of a sustainable circular economy.

Fig. 1. This composite image symbolises the harmonious integration of three distinct projects dedicated to the study of *Anadara* spp.. Central to this union is the adherence to the FAIR principles, ensuring that data are Findable, Accessible, Interoperable, and Reusable.

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MONITORING NON-INDIGENOUS SPECIES WITH RAPID ASSESMENT METHODS IN THE NORTHERN ADRIATIC

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Abstract

The number of non-indigenous species in the Mediterranean Sea is on the rise annually, highlighting the urgent need for comprehensive monitoring. From January 2022 to July 2023, rapid assessments were conducted at 10 locations in the northern Adriatic, revealing 46 species, bringing the total number of marine introduced species in Slovenia to 70. The fouling community dominated, with bryozoans, mollusks and crustaceans prominent. Maritime transport, particularly hull fouling and ballast waters, emerged as the predominant pathway for introductions. The results of the study have significant implications for marine conservation and the implementation of the Marine Strategy Framework Directive.

Keywords: North Adriatic Sea, NIS, Fouling

Introduction: Non-indigenous species (NIS) pose significant threats to biodiversity, inflicting adverse impacts on both the environment and the economy [1]. Each year, the Mediterranean Sea witnesses a rising influx of NIS [1]. Although efforts have been made to monitor marine NIS in Slovenia [2,3], the last scientific paper with a comprehensive list of marine NIS was published in 2012 [4]. The aim of the present study was to assess the most current number of introduced (including cryptogenic and questionable) species, improve the methodology for screening introduced marine species and identify hotspots of introduced species in Slovenian coastal sea.

Materials and methods: The study was conducted in the Slovenian coastal area, located in the southeastern part of the Gulf of Trieste (northern Adriatic). During January 2022 to July 2023, a total of 59 rapid assessments were performed targeting introduced and common species. They were carried out in 10 locations, comprising two types of donor locations – ports and marinas, and mariculture facilities, as well as coastal wetlands serving as special recipient areas. Sampling was conducted at least three times at each location: in winter (November–February), in spring (March–June), and in the summer-autumn period (July–October). Conspicuous species were identified on-site (*e.g., Styela plicata, Bugula neritina*), while other species were identified in the laboratory using a stereomicroscope or Scanning Electron Microscope.
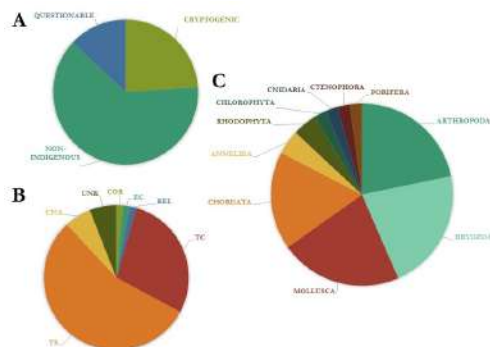

Fig. 1. Introduced species in Slovenian coastal waters by A) status, B) introduction pathway and C) taxonomic composition. TS = Transport-stowaway, TC = Transport-contaminant on animals, REL = Release in nature, EC = Escape from confinement, COR = Corridor, UNA = Unaided, UNK = Unknown.

Results and discussion: The fouling community emerged as the most prevalent community in the surveyed areas. A total of 46 introduced species were identified, comprising 29 NIS and 11 cryptogenic species, as well as 6 species with questionable status (unresolved status or uncertain identification) (Fig. 1). Notably, this study revealed 10 new introduced species, bringing the total number of introduced marine species in Slovenia to 70 when combined with data from previous screening activities [4]. Of significance was the presence of three introduced species belonging to the genus *Watersipora* (Fig.2), previously misidentified in the Mediterranean Sea [5]. The most represented phyla were

bryozoans, mollusks, and crustaceans. Among the NIS, the three most common were *Styela plicata* (Fig.2), *Magallana gigas*, and *Tricellaria inopinata*. The primary pathways for introduced species in Slovenia were attributed to maritime transport, including stowaways (hull fouling and ballast waters – TS), as well as contaminants on animals (TC), aligning with NIS pathways across the entire Adriatic subregion [6]. Most species were recorded in ports and marinas. The findings of the study represent the most up-to-date status of marine introduced species in Slovenia, serving as a vital knowledge base for future assessments under the EU Marine Strategy Framework Directive and to inform policymakers and stakeholders.

Fig. 2. Two important species found in this study: A) *Styela plicata* – the most frequent species, B) *Watersipora subatra* complex – a first record for Slovenia.

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REPORTING MARINE ALIEN AND RANGE EXPANDING SPECIES FROM MALTA THROUGH CITIZEN SCIENCE CAMPAIGNS

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Abstract
Citizen Science emerges as a crucial strategy for documenting and monitoring the occurrence of Non-Indigenous Species (NIS) and range expanding species within heavily-invaded seas. This study presents findings from two Citizen Science campaigns, the 'Spot the Alien' and 'Spot the Alien Fish' ones, implemented for Maltese coastal waters over the 2019-2023 timeframe. A total of 310 reports were collected, documenting 659 NIS individuals, with their occurrence varying across years and seasons. The results highlights the importance of Citizen Science in providing valuable data for monitoring and management strategies. However, the study also underscores the need for revised engagement techniques involving a broader range of stakeholders, particularly professionals, within NIS monitoring and managing protocols.

Keywords: Invasive species, Mediterranean Sea, LEK, Global change, NIS

Introduction
The phenomenon of the spread of non-indigenous species (NIS) in the Mediterranean Sea is one of the major concerns in terms of ecological and socio-economic impacts [1]. The Maltese archipelago has witnessed the occurrence of these species for decades [2], due to active migration, larval dispersion and human facilitation. One of most insidious challenges is the monitoring of the spread of the NIS, hindering the formulation of effective managing protocols. Targeted monitoring actions are expensive and scientists have focused their attention on Citizen Science (CS) as an effective tool for providing reports on the occurrence of NIS in coastal waters [3]. For these reasons, CS campaigns have represented so far the most cost-effective method for monitoring NIS populations and range expanding species, providing the dual benefit of observational data collection while also increasing the commitment of local communities to understand the threats these species may pose [4].

Materials and Methods
In the present work, we retrieved records submitted to the ongoing CS "Spot the Alien" and "Spot the Alien Fish" campaigns, implemented by the Oceanography Malta Research Group (OMRG) at the University of Malta, with the support of the International Ocean Institute (IOI). Public engagement was carried out amongst stakeholders (e.g. diving centers and fishing clubs) through social media channels, workshops and outreach events. Despite the availability of the campaigns website (www.aliensmalta.eu), social media platforms (Facebook, Instagram) were preferred. Reporters provided details on the location, depth, date and habitat where the specimen was encountered and paired with photographic evidence for validation. The dataset was analyzed with PRIMER 7 statistical software using a SIMPER routine to identify which species contributed the most in terms of abundance across years and seasons [5] and, graphically represented through boxplot and bar chart.

Results and Discussion
A total of 310 reports were collected between 2019 and 2023, documenting a total of 659 individuals. An increasing number of NIS records were recorded over the 2019 (31) to 2022 (82) period with a slight decrement in the number of reports registered in 2023 (69). Concerning the NIS reports received, the 26 NIS recorded belonged mostly to Actinopterygii (73%), followed by Crustacea (22%), Mollusca (2%), Cnidaria (2%) and Platyhelminthes (1%). From the SIMPER analysis, seven species were identified as the most relevant (80% of the dataset). The most abundant species reported were _Aplysia dactylomela_, _Fistularia commersonii_, _Lobotes surinamensis_, _Portunus segnis_, _Seriola fasciata_, _Siganus luridus_ and _Stephanolepis diaspros_. However, the individual abundance of these species varied significantly over different years and seasons (Fig. 1). In 2019, _A. dactylomela_, _P. segnis_ and _S. fasciata_ were the main species reported, while, in 2020, _S. luridus_ was by far the most commonly observed species. In 2021, _P. segnis_ and _S. diaspros_ alone contributed up to the 78% of the NIS sightings. 2022 was dominated by _S. diaspros_ followed by _L. surinamensis_ and _P. segni_s. Finally, in 2023 there was a dominance by _S. luridus_ (42% of the submitted reports). Looking at the differences in terms of seasons: winter was the season with the least number of records, with _S. diaspros_ accounting for 50% of the sightings. In spring, mostly young individuals of

P. segnis were sighted. As expected, most records were obtained in summer (39%) with evenly distributed sightings of _P. segnis_, _L. surinamensis_, _S. diaspros_ and _S. luridus_. In autumn, _S. luridus_ and _S. diaspros_ together accounted for 71% of the records. From our results, CS confirmed once again its value as a tool in monitoring the spread and the occurrence of NIS, as well as an important predictor of potential outbreaks. The effectiveness of CS campaigns relies on the commitment of researchers to engage the public through adequate educational materials and _ad hoc_ workshops for target groups [4] whitnessed by the increading number of reports aquired every year. We observed how most of these categories belonged to recreational users rather than professionals, highlighting the importance of involving professional fishers as they represent daily sea-users [3-6]. For these reasons, we suggest to revise some of the most commonly used engagement techniques.
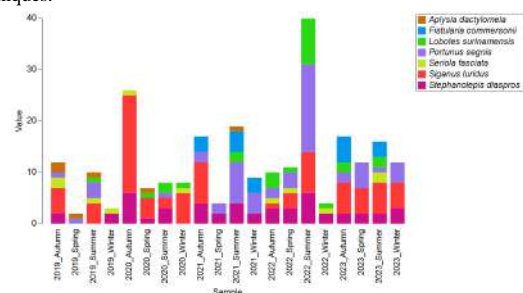

Fig. 1. Results of the SIMPER analysis showing differences in terms of year and season for the seven NIS contributing up to 80% of the dataset.

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FIRST RECORD OF HIGH OCCURRENCE OF THE NON-INDIGENOUS TINTINNIDS *EUTINTINNUS MACILENTUS* (KOFOID & CAMPBELL) IN THE OPEN WATERS OF THE SOUTH ADRIATIC SEA

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Abstract

This study presents the first occurrence of the non-indigenous tintinnids *Eutintinnus macilentus* in the open waters of the South Adriatic Sea. Presence of high abundances in December 2021 and September 2023 indicates that the mechanism, named Bimodal Oscillating System (BiOS) strongly influences on the biodiversity of the Adriatic Sea. The impact newcomers make a significant contribution to the zooplankton community in the southern Adriatic and have replaced native species.

Keywords: Adriatic Sea, Invasive species, Zooplankton

Tintinnid ciliates are a common component of planktonic communities and they are present in all of the world's oceans. These pelagic ciliates are generally significant consumers of pico- and nano-plankton and their distribution is related to hydrographical conditions. They have been often used as indicators for the effects of physical forcing on zooplankton communities. The first investigation of composition and distribution of tintinnids in the open South Adriatic was started at the end of the last century and it has continued until the present time, with shorter or longer interruptions. The recent research indicates changes in the zooplankton composition are connected with mechanism, named Adriatic-Ionian Bimodal Oscillating System (BiOS), ([1],[2],[3]). Besides hydrology, BiOS also affects the biological diversity of the Adriatic; it modulates the connectivity patterns between different Mediterranean ecosystems, in its cyclonic mode, favouring Lessepsian migrations in the Adriatic ([4]). In this paper, we present this phenomenon, i.e. the high occurrence of non-indigenous tintinnids *Eutintinnus macilentus* at station P1200 (in the central part of the South Adriatic Sea) (Fig. 1).

Fig. 2. Tintinnid *Eutintinnus macilentus*

The following mass occurrence was in September 2023. Even more numerous then December, tintinnids again inhabited upper layers (474 ind. m^{-3} in the layer 0-50m and 179 ind. m^{-3} in the layer 50-100m). This remarkable presence of non-indigenous tintinnids *E. macilentus* indicates two events: first the influence of Levantine Intermediate Water in late autumn and winter and second, probably an intensive late-winter phytoplankton bloom in the central area of the south Adriatic. It's evident that the impact newcomers now make a significant contribution to the zooplankton community in the southern Adriatic and, in certain cases, have replaced native species. Further studies will be important in confirming the maintenance of natural populations of tintinnids under the influence of winter physical conditions, as well as the emergence and effects of new non-native species.
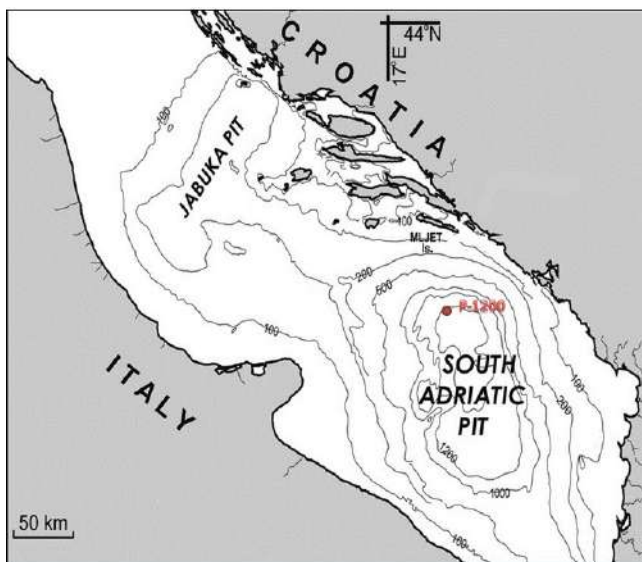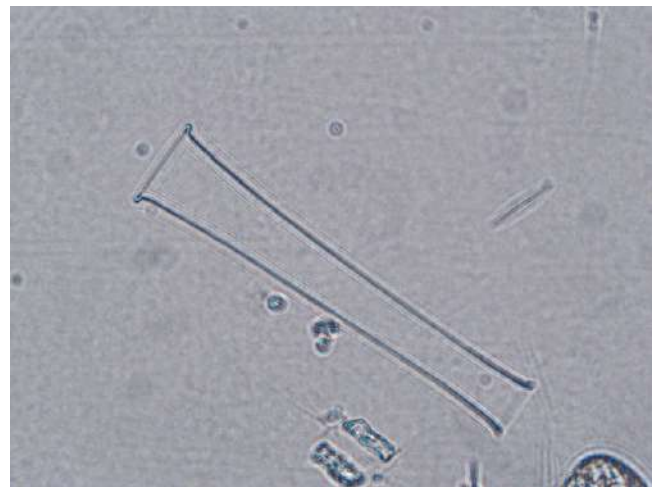

Fig. 1. Sampling station P-1200 in the South Adriatic Sea.

These investigations were conducted in the framework of a research DiVMAd and the first mass occurrence was noted in December 2021. The main bulk of the tintinnid population was in the upper 100 m layer. Tintinnids *E. macilentus* prevailed in layer 0-50m with high value of 384 ind.m^{-3}. Lower abundance (115 ind.m^{-3}) was recorded in the subsurface layer (50-100m). In deeper layers, only a few individuals were found. Measurements were made for total length (average 223,2 μm), oral diameter (average 45,9 μm) and aboral diameter (average 30,9 μm) (Fig 2.).

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SEASONAL VARIABILITY OF *CALLINECTES SAPIDUS* YIELDS IN NUMBER IN THE CANET SAINT-NAZAIRE LAGOON (FRANCE) ACCORDING TO SOME ENVIRONMENTAL FACTORS

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Abstract

The American blue crab, *Callinectes sapidus*, is one of the worst invasive alien species in the Mediterranean. The Canet Saint-Nazaire Lagoon Complex (CSNLC) is among the most affected and it is imperative to control its expansion because its presence hampers traditional eel fishing and threats endemic crab species. The aim of this study was to understand the spatio-temporal distribution of *C. sapidus* yields within this lagoon, and to make relations to certain environmental factors and its life cycle, with a view to implement the most appropriate management measures. The yield was the catch per unit effort in number (using fyke nets) considered as a proxi of an abundance index. The yields of both sexes were significantly lower in Spring.

Keywords: Invasive species, Conservation, Fisheries, Crustacea, Western Mediterranea

Introduction

This study focuses on the Canet Saint-Nazaire Lagoon Complex (CSNLC), which is one of the lagoons the most affected by *Callinectes sapidus* [1], one of the worst invasive alien species in this area [2]. This invasion threatens native and endemic species and the traditional eel fishing activity. Moreover, it amplifies the threats that the CLCSN is already facing, notably that of climate change [3]. Hence, it is necessary to better understand blue crab spatio-temporal distribution on this site. The objectives were to understand the seasonal variability of blue crab yields in the CSNLC, by sex and season, in relation to its life cycle and certain environmental factors.

Material and methods

The study site, the CSNLC, is located on the coast of the Gulf of Lion (France). With an area of nearly 600 ha for a depth not exceeding 1 m, the lagoon is connected to the sea by a single artificial channel (*Fig. 1*)
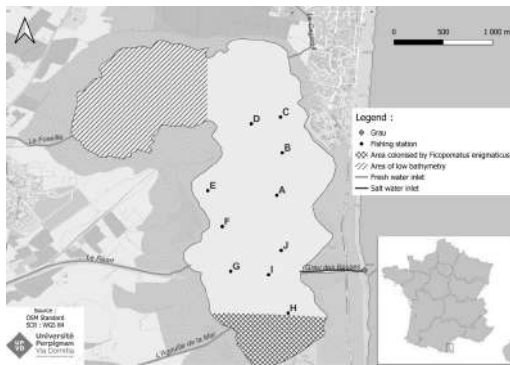.

Fig. 1. *Map of the study area, its general characteristics and the sampling stations (created with QGIS ©Latinis C.).*

The pond receives a supply of fresh water from several streams and is subject to two main regular winds. A total of 10 fishing stations with 3 replicates were set in the pond per trip and fyke nets were deployed by 4 to 5 financially compensated fishermen. Catch per unit effort in number of individuals per fishing effort, considered as an abundance index, was computed as : $CpueN_i = n_i / TpPose_i$; with i, line index for a given number, n the number of blue crabs, $TpPose$, the fishing time corresponding to the number of days of installation time of the nets that varied between 1 and 8 days (mean of 2.81 +/- 1.18 days). For each individual, the number and sex were identified such as other biological measures. Data analyses were performed for dates between December 18, 2022 and December 20, 2023, corresponding to 75 field trips. During this period, the number of monthly field trips was respectively: 5,4,5,7 and 6 for the last months.

Results

A total number of 570 blue crabs were caught in the lagoon during the considered period (mean of 43.83 ind/month) with a total average yield of 0.1+/-0.18 individual/fishing day. Among them, 351 individuals (61.58%) were males (with an average *CpueNm* 0.4+/-0.11 individual/fishing day), 207 (36.32%) were females (with an average *CpueNf* of 0.4+/-0.12 individual/fishing day), and 12 (2%) were not identified, due to forgetfulness (2.11%). No ovigerous females were captured. The *CpueN* for each sexes varied significantly between seasons (One-way nonparametric analyses of variance with Kruskal-Wallis rank sum test : *CPUENm* ~*Season*, p-value = 4.85×10^{-7}; *CPUENf* ~*Season*, p-value = 2.19×10^{-5}) and were significantly lower in Spring than in Summer and Autumn (*Fig.2*), this last season being the one with the highest total *CpueN*.
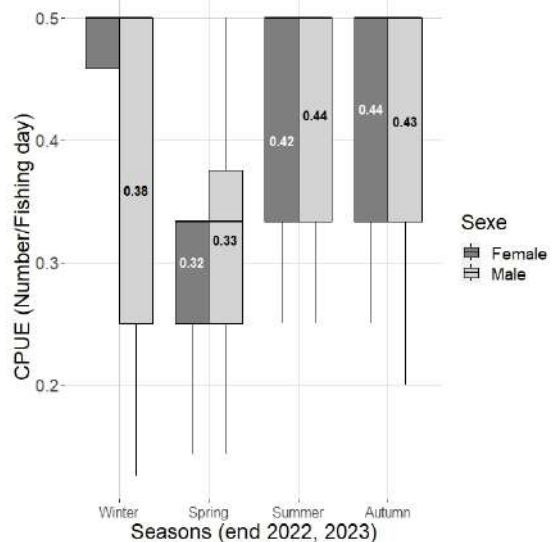

Fig. 2. *Boxplots of catches per unit of effort in number of individuals/fishing day (CpueN) according to sex and seasons.*

Conclusion

In a next step the spatial variation will be explored in link with environmntal factors. A similar study of CPUEs is renewed in 2024 which will make it possible to monitor its evolution from one year to the next.

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COMITÉ 1
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Géosciences marines

Président : Luis Pinheiro

CIESM Congress Session : Geodynamics and marine geological hazards
Moderator : Maria Conceição Neves – Univ. of Algarve, Portugal

Session's Synthesis

This session featured four presentations on submarine landslides and their associated geological hazards, with a focus on the Tyrrhenian continental margins and the Levant Fracture system. The talks explored the distribution and morphology of mass-wasting features, the neotectonic reactivation of fault systems, and the factors contributing to submarine landslides.

Key findings highlighted the spatial distribution and morphometric analysis of landslide scars and submarine canyons, emphasizing the risks associated with mass-wasting processes along southern Italy's coastlines. The RETURN project investigates the preconditioning, preparatory, and triggering factors of submarine landslides at canyon heads. By examining multiple case studies, the project aims to deepen our understanding of slope instability and contribute to a time-based classification of landslide factors in the Mediterranean.

Research on the Aeolian-Tindari Letojanni Fault System (ATLFS)—a seismically active strike-slip fault system at the southwestern edge of the Ionian Slab—revealed the complex interplay of slab dynamics, crustal block movements, volcanism, and seismic activity. Additionally, studies of the Levant Fracture System offshore Northern Lebanon, utilizing 2D and 3D seismic data, showed ongoing neotectonic activity throughout the Quaternary period. This activity reactivated deep structures, creating features on the seafloor that pose seismic hazards to the Levantine basin.

The session concluded with a discussion on the challenges of effectively communicating the risks of submarine landslides and geological hazards to the public and policymakers. While Italy has made signficant progress in identifying landslide precursors and triggering factors, other countries need further research to systematically address the characteristics and areas at risk. A critical challenge is bridging the gap between scientific knowledge and policy action, as decision-makers often prioritize immediate concerns over less visible but potentially catastrophic threats. Building trust and fostering ongoing dialogue between scientists and policymakers is essential to promote a proactive approach to managing these hazards.

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DISTRIBUTION AND MORPHOMETRY OF MASS-WASTING FEATURES ALONG THE TYRRHENIAN CONTINENTAL MARGINS, WITH PARTICULAR REFERENCE TO THE SOUTHERN ITALY

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Abstract
The Italian continental margins are generally affected by mass-wasting processes, mainly including landslide scars and submarine canyons, often largely indenting the continental shelf. In this paper, we present the spatial distribution of such processes as well as a preliminary morphometric analysis of these features, mainly focusing on geologically-active margins in the Southern Tyrrhenian Sea. The potential hazard associated with these events is very high, considering their proximity to the coast and the retrogressive evolution that commonly characterizes such features, as also demonstrated by historical damages to coastal and offshore infrastructures along the Italian coastlines.

Keywords: Continental margin, Tyrrhenian Sea, Geohazards, Bathymetry

The bathy-morphological setting of Italian continental is complex and largely variable mainly in relation to the interplay between sediment supply, sea-level fluctuations, tectonic evolution, volcanic (along insular margins) and erosive-depositional processes [1]. These margins are affected by a large suite of mass-wasting features (i.e., erosive scarps, landslide scars and associated deposits, canyons and so on) ranging at different and temporal spatial scales. More than 8,000 landslide scars and some hundreds of submarine canyons, sometimes deeply indenting the continental shelf, were mapped along most of the Italian Continental Margins through the multibeam data collected in the framework of the MaGIC Project (2007-2013). Mass-wasting processes are largely concentrated in geologically-active margins, such as the Ligurian, Eastern Sardinian, Calabrian and Sicilian margins (e.g., [2; 3; 4]), and along the submarine flank of insular volcanoes [5]. In such areas, mass-wasting features are recognized from coast to over 2500 m water depth, affecting large percentage of the continental slope, up to 97% off the W Pontine islands in the Central Tyrrhenian Sea [6]. Our analysis shows that small-scale (e.g., diameters of tens or hundreds of meters) landslides scars are mainly recognizable along the flanks and headwall of submarine canyons as well as along tectonically-controlled scarps present on the margins. Landslide deposits associated with these scars are rarely recognizable on the bathymetry. Differently, open-slope failures tend to have larger size (a few kms in diameters) and it is often possible to recognize the associated deposits on bathymetry. The number and density of landslide scars largely varies between open-slope and canyons as well as between different margins. For instance, we counted over 400 landslide scars along the Calabrian Continental Margin encompassed between Capo Vaticano and Scilla or 450 submarine landslide scars affecting the submarine flanks of the active Vulcano volcano. We measured the main morphometric parameters of these landslide scars and roughly computed their tsunamigenic potential through semi-empirical equations available in literature [7]. The results shows that several shallow-water landslide scars have potentially generated local tsunami waves that affected the facing coastlines. Because of the proximity of landslide scars and canyon heads to the coasts and the common retrogressive evolution of these slope failures and the concomitant occurrence of multiple predisposing, preparatory and triggering mechanisms, the morphological evolution of these areas should be carefully monitored in the next future, mainly in consideration of the strong anthropization and touristic exploitation of these coastlines. The high hazard associated with retrogressive slope failures is demonstrated by historical examples along the Italian and French coastlines, such as the 1977, 1979 and 2005 landslides at the head of the Gioia, Var and Punta Alice Canyons, respectively [8; 9; 10] or the Stromboli 2002 landslide [9] and reference therein).

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NEO-TECTONIC RE ACTIVATION OF THE LEVANT FRACTURE SYSTEM. (OUTER SHELF, OFFSHORE NORTHERN LEBANON)

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Abstract
By using high quality deep 2D and 3D seismic dataset) and grounding our observations on a detailed seismic mapping of the Messinian to quaternary units we produce evidence and a detailed 3D mapping of the Levantine Fracture System across the shelf edge along the offshore Northern Lebanon. We do provide and discuss examples for those Neogene-Quaternary structures pointing that the main regional tectonic activities re activated deep structures and persisted across the Quaternary producing active structures affecting the seafloor which represent potentially a seismic hazard for the Levantine basin.

Keywords: Tectonics, Levantine Basin, Sediments, Seismics

Introduction

The eastern Mediterranean Levant Basin is an area where the effect of an adjacent major strike-slip fault in a complex geodynamical context can be tested. Recent fieldwork has shown crustal shortening and mountain building in Lebanon to be initiating only around 10–15 Ma ago [1]. Strong evidence for recent and ongoing shoreline uplift along the coast, happened most prominently between Beirut and Tripoli [1]. Moreover, the identification of active thrust faults in the Tripoli region [1; 2] proposed the existence of a large thrust fault system (MLT, Mount Lebanon Thrust) underlying the Lebanese flexure, which would reach the surface in the offshore area between the cities of Saida and Tripoli. Despite the presence for structures taking up the convergent component of motion within the bend has since then been acknowledged none had been adequately mapped the 3D structures affecting the Messinian salt and the post Messinian deep water deposits.

Dataset

The dataset consist of around 3067 km² of merged Post-Stack Time Migrated 3D seismic cubes and several deep 2D seismic lines from Petroleum Geo-Services (PGS) acquired and processed between 2006 and 2013 were used in this work across the northern Levant Basin. All data were acquired and reprocessed through time with the same acquisition parameters as a part of the Lebanon MC 3D project. The final stack data are represented as zero-phased data and displayed with SEG reversed polarity . As in the Lebanon offshore basin, there are no publicly released well data-to-date, stratigraphic correlations (including their nomenclatures) of the different units based on previous studies. Average P-wave velocities for these intervals (2000, 4200 and 3000 m/s, respectively) are derived using information from exploration wells in the southern Levant Basin and data-processing reports by PGS Geophysical AS. Using the end-member velocities and frequencies, we estimate a vertical resolution (defined as tuning thickness, $\lambda/4 = v/4F$, being) of 10, 42 and 44 m, respectively. [3] suggest a velocity of 3600–4000 m/s for the top salt units in our paper showing a dominant frequency of 45 Hz.

Results

We did explore the offshore expression of the recent shortening in Northen Lebanon linked to Levant Fracture System (LFS) which are flanking transform fault related to the Dead Sea fault system . Grounding our observations on a detailed seismic mapping of the Messinian to quaternary units we produce evidence of thrust linked to the LFS across the shelf edge along the offshore Northern Lebanon. Neogene active shortening in the offshore Lebanon were already in part observed and mapped by the Shalimar cruise [1] but here we did focus on a detail mapping of the 3D structures including the Aabde-Rankine oblique thrust fault architecture and the surrounding fold structures affecting the Messinian units and the post Messinian deposits. The structures in part re-activate well known Mesozoic structures and are represented by both anticline and oblique ramp thrust structures affecting the seafloor and producing mini thrust top basin (Figure 1).
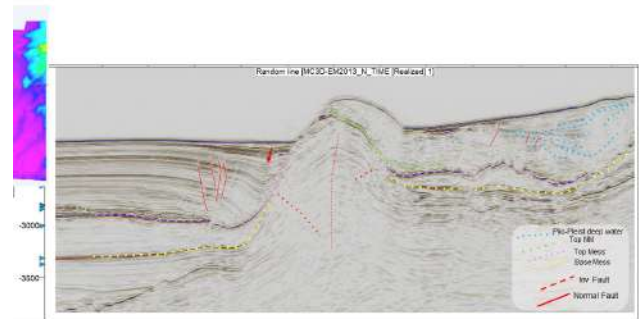

Fig. 1. E-W seismic section across the Northern offshore Lebanon. The main structure represent a fold and thrust ramp affecting the Messinian units and deforming the Plio Pleistocene Units.

The Mini basin provides the opportunity to study the geometry characteristics of the basin-filling deposits and their timing respect to the neo tectonic activity. In other case they deform both the Messinian Units (laterally pinching out toward the shelf) through both soft linkages affecting the post Messinian deep-water and deep water units mapped across the shelf edge. The structures are partly coeval with but un-related to the salt tectonic activity observed in the slope basin offshore Lebanon. We then do provide and discuss examples for those Neogene-Quaternary structures pointing that the main regional tectonic activities persisted across the Quaternary and produce structure which represent potentially a seismic hazard for the Levantine offshore basin.

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NEOTECTONIC ACTIVITY OF THE NORTHERN SECTOR OF AEOLIAN TINDARI LETOJANNI FAULT SYSTEM (ATLFS)

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Abstract

The Aeolian-Tindari Letojanni Fault System (ATLFS) is a seismically active dextral strike-slip fault system representing the superficial expression of the Subduction-Transform Edge Propagator (STEP) fault at the southwestern edge of the Ionian Slab. We combined morphostructural and seismological analysis to describe the tectonic setting of the sector of the upper plate insisting above the northernmost portion of the STEP fault. This is a region where slab dynamics determine a complex tectonic and geodynamic framework that influence relative movement of crustal blocks, volcanism and seismic activity.

Keywords: Tyrrhenian Sea, Tectonics, Seismics, Aeolian Arc

Introduction

The Gulf of Patti extends from Capo Calavà to Capo Milazzo and separates the island of Vulcano from the northeastern coast of Sicily. It is a seismically active tectonic depression controlled by the ATLFS, an important structural boundary that separates crustal domains featured by different rheology and styles of deformation [e.g. 1, 2]. Near the Sicilian coast, the transfer zone broads in a set of strike-slip tectonic features that control the formation of basins and ridges onshore and offshore [3]. The gulf, which is one of these basins (Fig. 1), could be the expression of a step-over formed between two sectors of the ATLFS [4]. In this work we study the active deformation induced by the ATLFS, trying to understand how it can relate to the deeper deformation induced by slab tearing.
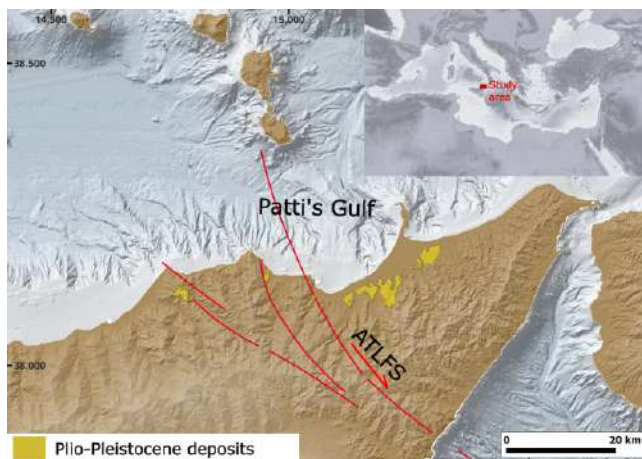

Fig. 1. Location of study area. Schematic model of the ATLFS from [2].

Methods

The tectonic setting described in this study is the result of a morphostructural analysis based on a detailed bathymetry map and a dense grid of seismic profiles acquired with different seismic sources. A seismological analysis was conducted to identify relationships between tectonic features and seismic activity.

Results

We map N-S to NW-SE oriented tectonic features that show an extensional dip-slip component. The major faults are on the lateral margin of the tectonic depression, where the seafloor is shaped by two canyons. The Gulf of Patti is one of the most seismically active areas of Sicily. Earthquakes concentrate on the two sides of the Gulf, near the Sicilian coast and onshore. Their focal mechanisms confirm the presence of an extensional domain inside the gulf and the strike-slip component of the mapped faults.

Discussion and Conclusions

The gulf is featured by the overstepping of large-scale strike-slip faults. This tectonic setting is compatible with transcurrent motion expected in the shear zone insisting on the southwestern termination of the Calabrian slab, where a STEP fault induces significant deformations of the upper plate

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DEFINITION OF PRECONDITIONING, PREPARATORY AND TRIGGERING FACTORS OF SUBMARINE LANDSLIDES AT CANYON HEADS – FIRST OUTCOMES FROM THE RETURN PROJECT

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Abstract

Submarine landslides are hazardous geological events due to the threat posed to coastal infrastructures and their tendency to generate tsunamis. Canyons are one the most prone areas for submarine landslides and the retrogressive failures affecting canyon heads, reducing their distance from the coast, increase their hazardous potential. In general, stability at canyon heads is less known compared to deep water landslides and the assessment of their hazard is crucial. Our analysis, focused on landslides occurring at the canyon heads in the Mediterranean Sea, aims to highlight which processes and to what extent affect slope instability processes. Analyzing different case studies, a time-based classification of controlling factors (i.e. predisposing, preparatory, and triggering) leading to landslides at the canyon heads has been constrained.

Keywords: Geohazards, Mediterranean Sea, Canyons, Continental slope

Introduction

Shallow-water instabilities, as those occurring at the head of shelf-indenting canyons, are as hazardous for coastal infrastructures and settlements as very difficult to study due to: 1) the poor penetration of seismic sources, 2) the usual disintegration of failed sediment mass, and 3) the frequent overprinting of multiple events. To reduce the knowledge gap due to the lack of monitoring when instabilities at canyon heads occur, a revision of published case studies was performed. The scale of the landslides and the potential factors conditioning the slope instability process have been defined through reiterative discussions among experts and detailed analysis of case studies. A time-based classification of landslides controlling factors, such as preconditioning (long scale), preparatory (short scale), and triggering processes has been applied following the approach used for subaerial mass-wasting in the RETURN project.

Results and Discussion

The predisposing factors are those considered invariable at the observational scale; with this perspective, from our analysis emerged that a high sedimentation rate (>1 mm/yr) and slope morphology (> 20°) are the most important factors predisposing small-scale landslides (<1 Mm^3) as those occurring on the Calabrian, Sicilian and Ligurian slopes [1,2]. In addition to these factors, medium-scale (>1 Mm^3) and tsunamigenic landslides are also influenced by the stratigraphy and especially by the presence of weak layers [3]. The preparatory factors are those changes considered time-variable or cyclical at the observational scale. Therefore preparatory are the processes that increase the sedimentation rate as the seasonal occurrence of flash floods [1], submarine depositional terrace formation [4], littoral drift [1], and other processes like groundwater level variation [3].

The triggering events are processes that act in a short and well-defined time. Triggering factors for small-scale landslides are earthquakes [2], storms [1], and extreme flash-floods [1]; medium-scale landslides, according to the case studies analyzed, are principally triggered by anthropic activity [3,4]. The mass-wasting process is therefore fully constrained in a chain of processes and states with different temporal durations of influence controlling the failure occurrence. Our analysis highlights that without real monitoring of pre-, sin and post-failure conditions, the same factor can be considered either preconditioning, preparatory or triggering such as the sedimentation rate that can be predisposing (as it produces a general proneness to instability not allowing overpressure to dissipate), but it may also be preparatory (when it increases in a relatively short time change in littoral regime or river inputs) and trigger the failure (in case of extreme load due to flash flood or sediment dumping). Of course, the usual lack of very important information such as the geotechnical (often even lithological) character of the failed mass makes the identification but especially the quantification of these factors very difficult for the submarine landslide. However, the elaboration of a landslide predictive model according to a time-based approach may be crucial, providing a conceptual framework for sea hazard mitigation and identifying the knowledge gaps that need to be detailed.

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CIESM Congress Session : Coastal and shelf-to-basin processes
Moderator : Ahmed Elshazly – Heliopolis Univ. for Sustainable Develop., Egypt

Session's Synthesis

The session on "Coastal and shelf-to-basin processes" hosted four contributions that shed light on the importance of using the past as a key to understand the future. The presentations covered different spots in the Mediterranean; from Sardinia and Sicily in Italy to the Nile Delta subsurface in Egypt, as well as, different geological periods including: post Last Glacial Maximum, Plio-Quaternary and late Neogene to mid Pleistocene. A land-sea stratigraphic continuum of the aeolian architecture of the western coast of Sardinia has been used to reconstruct the transgressive post-LGM episodes, and related coastal dynamics, this has been done by coupling geomorphological and stratigraphic information of the modern and ancient deposits outcropping along the coasts with geophysical and HR bathymetric data from the facing continental shelf. Still in the north-western part offshore Sicily, where the use of different seismic sources allowed developing a detailed seismostratigraphic characterization of the Transgressive Systems Tract and the Highstand Systems Tract and the reconstruction of their sedimentary and morphological evolution. The dataset consisted of high-resolution seismic profiles, integrated with cores and grab samples. Moving southward, The stratigraphic succession of the Plio-Quaternary megasequence in north-central Nile Delta in Egypt has been studied employing seismic stratigraphy, 3D geomorphology, and detailed cyclostratigraphic and electrofacies analysis lead to a detailed depositional dynamics across a transitioning open-marine to deltaic environment, marked by evolving sedimentation from hemipelagic conditions to mass-transport deposits and channel-levee systems, in addition to refining the age model for the sequence, offering insights into sedimentary processes, paleocurrent dynamics, and the potential for hydrocarbon accumulation within high-quality reservoir facies. Land-Sea exchange was present in the session as well through a study detailed the input of continental water to sea along the Arda and Stirone Rivers, northern Apennines in late Neogene to mid Pleistocene. The behavior and temporal changes in the Sr isotope system were studied by analyzing the radiogenic 87Sr/86Sr and stable 88Sr/86Sr ratios in skeletons of fossil shells and recent organisms. The 87Sr/86Sr ratios display a pronounced excursion (~0.7090 to ~0.7088) at ~5Ma indicating an enhanced input of continental waters to the sea. The 88Sr/86Sr ratio (expressed as d88/86Sr ~0.39‰) is constant and similar to the modern value. The isotope balance of the two Sr isotopic systems suggests that the discharge of brackish submarine groundwater from the continents to the sea is an important but generally neglected pathway in the marine Sr budget. Regarding the importance of the session's topic, the session was highly interactive, fostering a rich dialogue recommending the importance of having more research work on coastal and shelf-to-basin processes in the Mediterranean.

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POST LGM TRANSGRESSIVE MORPHODYNAMICS RECORDED IN THE LAND-SEA CONTINUUM OF THE WESTERN SARDINIA, ITALY

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Abstract

The sole examples of currently stabilized and active transgressive dune fields in Italy are on Sardinia's west coast, due to conditions of strong unimodal wind from the north-west. In the context of a MUR-PRIN 2022 Project we present a series of preliminary results regarding the coast of Piscinas (Sardinia, Italy), where an active dunefield develops, covering 132 ha. Geomorphological and stratigraphic information of the modern and ancient deposits outcropping along the coasts is coupled with geophysical and HR bathymetric data from the facing continental shelf. The main aim is to obtain a land-sea stratigraphic continuum of the aeolian architecture in order to reconstruct the transgressive post-LGM episodes, and related coastal dynamics.

Keywords: Coastal processes, Continental shelf, Stratigraphy, Sea level, Tyrrhenian Sea

Coastal transgressive dune systems are large-scale, mobile, partially vegetated dune complexes that can de-couple from the backshore and migrate inland. Coastal transgressive dunes are found worldwide, but require abundant sediment and wind energy to develop the complicated cut-and fill sequences seen in mature systems. The only examples of stabilized and active transgressive dunefields in Italy are found along the west coast of Sardinia, where they are exposed to strong winds with a unimodal wind regime from the north-west (Mistral). Today, there are no significant or extensive sedimentary sources, and active aeolian systems tend to migrate inland. As evidenced by Andreucci et al. (2010), several phases of active wind transport to the hinterland with the deposition of aeolianites have already been documented in the past, probably when a lower sea level exposed large areas of the shelf and therefore offered a greater contribution of sediment to onshore winds. The studies carried out in the geographical area concern the stratigraphy of Middle and Upper Pleistocene aeolianites that outcrop along the west coast of Sardinia. Information on the active dynamics and morphology of the dunefields, as well as on the superimposition (and/or cannibalisation) of the transgressive aeolian bodies linked to the sea level rise-and-fall history is still poorly understood. Due to the tectonic stability of Sardinia, the stratigraphic sequence records an almost uninterrupted succession of paleoclimatic events (MIS) that governed wide sea-level fluctuations during the late Quaternary, resulting in a succession of transgressive-regressive domains and subsequent coastal adaptation. After the Thyrrenian highstand (MIS 5e) sea level dropped progressively, allowing for the development of dunefields on more wind-exposed areas along the west coast of Sardinia (Pascucci et al., 2018). Similar conditions and subsequent sea level fall exposed the shelf up to at a depth of -125 m (Deiana et al., 2021) during the LGM. The subsequent Holocene transgression induced a rapid flooding of the shelf, and a consequent overstepping of the submerged landforms, as the transverse barrier-dune systems discovered off the coast of Oristano (De Falco et al., 2015). Here there is no evidence of transgressive aeolian bodies inland. Conversely, there is no evidence of transverse barrier-foredunes on the inner shelf facing the large transgressive dunefield of Piscinas. This opposite information can be associated to the possible evolutionary trajectory for coastal transgressive dunefields suggested in literature: in the lack of foredune, transgressive dune sheets can freely migrate inland from the backshore. In this context, two major questions regarding the occurrence of the aeolian activity remain unanswered: (i) what are the specific conditions triggering historic and older pulses of aeolian activity (i.e. transverse vs. parabolic) along the Sardinia coast? (ii) what is the significance of the dune building phases within the broader regional or even global context? In the framework of a project funded by the Italian Ministry of University and Research (MUR-PRIN 2022), here we present the preliminary results regarding the land-sea continuum of the coast of Piscinas (Sardinia, Italy), where an active dunefield develops over 132 ha. The main aim is to investigate the role of transgressive aeolian episodes as potential environmental indicators as part of a larger understanding of their significance on a local and global scale.

The first results are based on a detailed geomorphological description obtained by UAV and GPR surveys in Piscinas dunefield, as well as a stratigraphic survey of the Pleistocene aeolianites outcropping along the coasts. The main parabolic dune, aligned with the prevailing Mistral wind (from the northwest), extends from the coast for about 2 km inland to a maximum altitude of 113 m. Topographic sections and GPR profiles show the presence of a geological control due to the gradually sloping Paleozoic rocky basement over which the dune accommodated while climbing. The transgressive climbing dune is characterised by typical foreset beds dipping in the landward direction, with a series of well-marked bounding surfaces separating possible erosional/cannibalisation phases, as reported in the figure. Buried post-LGM (Late Glacial Maximum) aeolian deposits of partially consolidated sands were also recognized. These sands represent the sediment layer of the established transgressive dunefield and serve as the sediment source of the current active dune lobes, migrating downwind. Extensive outcrops of Middle and Upper Pleistocene aeolianites throughout the coasts attested to extensive aeolian activity in the context of sea level rise variation and tectonic stability in the past. On the continental shelf facing the study area, geophysical data have been acquired in the last 15 years, including high-resolution morpho-bathymetric surveys, acoustic backscatter maps, and high- and very-high-resolution seismic profiles.

A preliminary examination of the marine landforms on the inner shelf reveals the presence of parabolic bodies at a depth range of 31-40 m. These relict coastal landforms, which may have been subjected to early cementation (as previously explored at neighboring sites), attest to an aeolian pulse affecting the exposed continental shelf during the LGM, as a continuum to connect with the analogous signature on land.

The comparative stratigraphic and morphological analysis of present-day active dune fields and the transgressive deposits resting along the shelf will allow to reconstruct the unconformity surface related to the last sea level fall, the stratigraphy of the barriers and dune systems formed during the transgressive phases, partially preserved along the shelf, as well as the stratigraphy of the modern dune systems. The integrated analysis using direct and indirect stratigraphic information collected in the coastal area will permit to reconstruct the depositional palimpsest and order of accommodation of several aeolian transgressive bodies during the transgression, thus highlighting possible differences or analogies between the present regime and the climatic phases that drove the aeolian activity during the late Quaternary.

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CLIMATIC CONTROLS ON THE EVOLUTION OF THE PLIO-QUATERNARY SEDIMENTARY COVER IN THE NILE DELTA SUBSURFACE (EGYPT)

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Abstract
The stratigraphic succession of the Plio-Quaternary megasequence in north-central Nile Delta includes the Kafr El-Sheikh, El-Wastani, Mit-Ghamr, and Bilqas formations. Employing seismic stratigraphy, 3D geomorphology, and detailed cyclostratigraphic and electrofacies analysis, we accurately define their high-resolution stratigraphic architecture and associated depositional systems. Our results detail depositional dynamics across a transitioning open-marine to deltaic environment, marked by evolving sedimentation from hemipelagic conditions to mass-transport deposits and channel-levee systems. This study also refines the age model for the sequence, offering insights into sedimentary processes, paleocurrent dynamics, and the potential for hydrocarbon accumulation within high-quality reservoir facies.

The stratigraphic succession of the Plio-Quaternary megasequence in the north-central part of the Nile Delta comprises four main rock units: 1) the Kafr El-Sheikh Formation (Early-Middle Pliocene), 2) El-Wastani Formation (Late Pliocene), and the Quaternary, 3) Mit-Ghamr, and 4) Bilqas formations. The analysis of stratigraphic succession of the Plio-Quaternary megasequence in the north-central part of the Nile Delta stratigraphic units according to the principles of seismic stratigraphy and 3D geomorphology, combined with detailed cyclostratigraphic and electrofacies analysis (wireline logs), results in a high-resolution definition for their stratigraphic architecture and the associated depositional systems. Our results confirm the depositional dynamics of the overall prograding Plio-Quaternary megasequence from the Kafr El-Sheikh to El-Wastani succession [1] characterized by sedimentation in an open-marine domain initially transitioning from hemipelagic sedimentation to rapidly evolving mass-transport deposits (MTDs) and channel-levee systems (CLS) typical of an active prograding prodelta subaqueous deltaic subenvironments. The configuration of CLS reveals a SW-NE trending flow, with some lateral crevasse splays, suggesting a complex interaction between paleocurrent dynamics and sedimentary processes in the basin. The upper part of the Kafr El-Sheikh Formation is characterized by a transition to a more proximal environment of submarine fans at the base of clinoforms affected by characteristic mega sediment waves associated with hyperpycnal currents at the base of sub-marine canyons. El-Wastani Formation (Late Pliocene) were deposited as a constructive delta front pushing its way northward, characterized by a coastal environment of deltaic bars and distributary channels. The Pleistocene Mit-Ghamr Formation evolved as a direct result of significant fluvial input, organized as laterally extensive sand-rich bars, typical of the establishment of sandy deltaic plain environments. This study thus demonstrates the progressive infilling of the post-Messinian available space by a prograding Plio-Quaternary sequence. The cyclo-stratigraphic study has permit us to propose a more precise age model from the base of the Pliocene (5.33 million years) to the top Kafr El sheikh Formation (ca. 2.5 million years). The Nile plio-quaternary mega sequence is subdivided into seven 400,000-year sub-sequences. The base of each sequence is characterized by a submarine erosional truncation surface potentially linked to significant changes in climate events. Both Mass-Transport Deposits (MTDs) and Channel-Levee Systems (CLS) are capped by hemipelagic sediments, creating favorable conditions for the accumulation of hydrocarbons within high-quality reservoir facies.
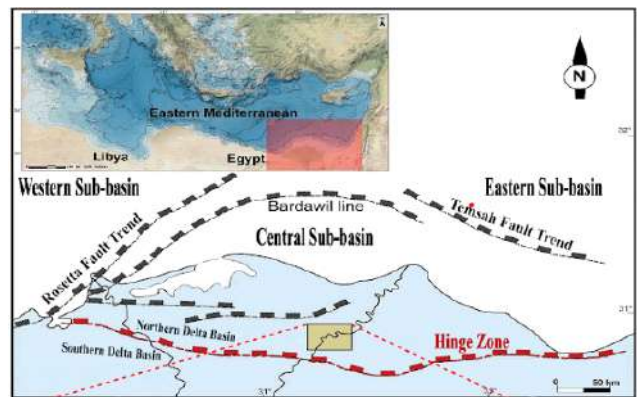

Fig. 1. The 3D seismic block used for the 3D geomorphological and seismic stratigraphic study is located above the Damietta branch of the Nile Delta, near the hinge line corresponding to the edge of the Tethys carbonate platform [2].

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LATE PLEISTOCENE TO HOLOCENE RELATIVE SEA-LEVEL RISE IN THE NORTH-WESTERN SICILY OFFSHORE: THE CASTELLAMMARE BASIN EXAMPLE

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Abstract

The post Last Glacial Maximum (about 30-19 cal. kyr b.P.) transgression of the continental shelves testifies how coastal environments dramatically migrated landward, in a brief span of time, and how their sedimentary architectures reveal the interplay between depositional and erosional processes. We discuss the sedimentary evolution of the Transgressive Systems Tract and the Highstand Systems Tract of the Castellammare Basin, NW Sicily offshore, during the Holocene to Present by the application of Sequence Stratigraphy concepts. The dataset consists of high-resolution seismic profiles, integrated with cores and grab samples. The use of different seismic sources allows us a detailed seismostratigraphic characterization of the TST and HST and the reconstruction of their sedimentary and morphological evolution.

Keywords: Sea level, Mediterranean Sea, Continental shelf, Seismics, Stratigraphy

Relative sea-level curves, established for the Central Mediterranean region, taking into account glacio-hydro-isostatic effects, assess small variations in the rate of the relative sea level rise since the Last Glacial Maximum [1]. However, morpho-bathymetric and seismic stratigraphic studies have depicted drowned coastal features (cliffs, terraces, barrier beaches and infralittoral wedges), which occurred at specific water depth intervals (between -100 m and -70 m; between -65 and -40 m) and have been attributed to phases of decreasing rate or relative sea level stillstands, preceded and followed by phases of rapid sea level rise likely the Melt Water pulses [2]. Analysis of high-resolution seismic profiles, integrated with cores and grabs from the north-western Sicily offshore enable the reconstruction of the stratigraphic variability of the post-glacial transgression and highstand, and the understanding of the interactions of different controls (hydrodynamics, sedimentary supply, moderate regional uplift) on the accommodation space during each sedimentary stage.

occurred only in areas with a consistent supply of sediment, while laterally shoreface erosion prevailed. The HST (up to 30 m of thickness) is made up of two parasequences with an aggradational to progradational stacking pattern. The main depocenters are located along a stretch of coast supplied by several small seasonal streams, and sedimentological analysis suggests a great efficiency of sedimentary supply and longshore transport. In the highstand evolution, fluid migration played a decisive role in triggering slides and slumps.

Fig. 2. Sliding structures affecting the Holocene Highstand Systems Tracts.

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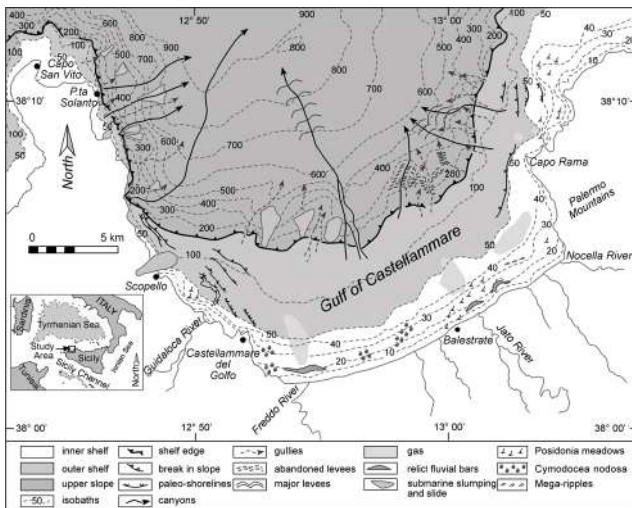
Fig. 1. Morphobathymetric scheme of the Castellammare Basin, showing the main geomorphological and sedimentary features of the continental shelf and upper slope. In the box, regional location of the study area is shown.

Marine areas of north-western Sicily belong to the Sicilian-Maghrebian thrust belt, which was generated by Africa-Europe plate convergence [3]. Above the unconformable type 1 sequence boundary, the Last Depositional Sequence Q.5.e. [4] consists of four late Pleistocene to Holocene sedimentary units, comprising Falling Stage Systems Tract (FSST, MIS 3 and MIS 2), Lowstand Systems Tract (Last Glacial Maximum, upper MIS 2 about 20 ka b.P.), Transgressive (TST, 18 ka – 6.0 ka b.P.) and Highstand (HST, 6 ka – 0 ka b.P.) Systems Tracts. The TST is particularly well developed and is composed of up three parasequences, with a retrogradational stacking pattern; accumulation
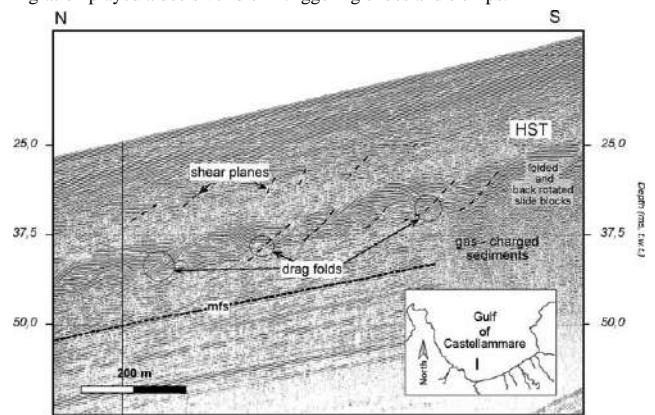
RADIOGENIC ^{87}SR/^{86}SR AND STABLE ^{88}SR/^{86}SR RATIOS IN LATE NEOGENE TO MID PLEISTOCENE MEDITERRANEAN WATERS- THE ROLE OF BRACKISH SUBMARINE GROUNDWATER DISCHARGE

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Abstract

The behavior and temporal changes in the Sr isotope system in Mediterranean seawater between ~5.3 to ~0.8 Ma were studied by analyzing the radiogenic ^{87}Sr/^{86}Sr and stable ^{88}Sr/^{86}Sr ratios in skeletons of fossil shells and recent organisms. The fossils were collected in marine sedimentary rocks exposed along the Arda and Stirone Rivers, northern Apennines. The ^{87}Sr/^{86}Sr ratios display a pronounced excursion (~0.7090 to ~0.7088) at ~5Ma indicating an enhanced input of continental waters to the sea. The ^{88}Sr/^{86}Sr ratio (expressed as d$^{88/86}$Sr ~0.39‰) is constant and similar to the modern value. The isotope balance of the two Sr isotopic systems suggests that the discharge of brackish submarine groundwater from the continents to the sea is an important but generally neglected pathway in the marine Sr budget.

Keywords: Geochemistry, Sediments, Time series, Adriatic Sea

The temporal changes in the Sr isotopes: the ^{87}Sr/^{86}Sr (the radiogenic Sr isotope ratio) and the ^{88}Sr/^{86}Sr (the stable Sr isotope ratio) comprise a powerful tool to evaluate and quantify the sources, sinks, and input fluxes of Sr and Ca to the oceans. It appears that the input fluxes of Sr and Ca from rivers and hydrothermal sources (at the mid-ocean ridges) are not in balance with the output fluxes. Previous studies suggested that this imbalance reflects a delay in the Sr input stemming from the difference in the weathering regime of continental material during glacial and interglacial periods. This study is an attempt to deal with this topic by analyzing the Sr-isotopic ratios and chemical compositions of the fossils collected from the sedimentary marine sequences of the late Neogene – Pleistocene Mediterranean Sea (spanning the time interval of ~ 5.3 to 0.8 Ma) [1]. These marine sequences were deposited in the ancient "Po Bay" and are exposed at the banks of the Stirone and Arda rivers that currently flow from the northern slopes of the Apennines to the Po Valley. The Sr isotope and chemical data were used to construct a simple box model that helped to evaluate the question of the Sr balance in the oceans. The marine sedimentary sequence contains various fossils: brachiopods, mollusks (e.g., Pectinids), and foraminifers that were collected from the exposures and identified, observed petrographically under the binocular microscope, and analyzed chemically and isotopically. First, we established the fractionation factors between gastropods and pectinid skeletons and seawater, which are needed for assessing the effect of the bio-mineralization mechanisms in brachiopods and mollusks and consequently the successful reconstruction of Pliocene-Pleistocene seawater. The isotope analyses indicate that during the studied time interval of ~5.3 to 0.8 Ma the ^{87}Sr/^{86}Sr ratios follow the global array with a significant excursion to lower values around ~5 Ma that is attributed to the contribution of continental groundwater whose enhanced flow is related to the hydroclimate conditions in the early Pliocene (Fig. 1). We think that the contribution of continental brackish groundwaters to the sea, a generally neglected pathway, is an important component in the global budget of marine Sr (Fig. 1). The importance of this water source is reflected by the calculated δ$^{88/86}$Sr ratios and the measured modern ratios, which are largely constant. This means that the amount of Sr that was deposited in the oceans versus the amount that was removed remained roughly the same during the past 5 Ma. We conclude that the Sr budget cannot have been balanced only during the ice ages. Modeling of all known inputs to the marine water indicates a missing Sr source [1], which we attribute to the inflow of brackish submarine groundwater discharge from the continents.
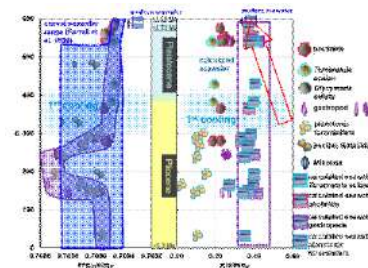

Fig. 1. The ^{87}Sr/^{86}Sr (left) and δ$^{88/86}$Sr (right) ratios of the seawater of the Plio-Pleistocene Po Bay presented on the columnar section of Stirone River (according to [1]). The middle shows the ^{87}Sr/^{86}Sr ratios measured on the different groups of marine organisms. From them, the ^{87}Sr/^{86}Sr seawater values were calculated. Time anchor points, Pliocene and Pleistocene Epochs, and the time span of the first cooling event [2] are marked. The purple area in the ^{87}Sr/^{86}Sr section shows the results of this study and the blue area represents the generally accepted coeval range for seawater [3]. The red arrow shows the evolution of the seawater δ$^{88/86}$Sr ratios according to the model of [4].

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COMITÉ 2

Physique et climat de l'océan

Président : Katrin Schroeder

CIESM Congress Session : Open Ocean Processes
Moderator : Bayoumy Mohamed – Liège Univ., Belgium / Alexandria Univ., Egypt

Session's Synthesis

The session covered various topics based on experimental, observational, and modeling studies of open ocean processes, focusing on the Mediterranean Sea and its sub-basins. Several important issues were discussed, including deep water warming, carbonate system dynamics, dense water supply mechanisms, light climate characterization, and ocean dynamics modeling.

These studies concluded that the observed warming of deep water in the western Mediterranean was closely related to the history of deep convection and the interactions between deep and intermediate water masses, emphasizing the role of turbulent mixing in heat transfer. The significant changes in the western Mediterranean during the transition event, including warmer, saltier, and denser water properties, indicate ongoing climatic shifts. The dynamics of the carbonate system were investigated in the southern Adriatic indicating that physical processes such as the increased vertical mixing have a decisive influence on the variability of the carbonate system in this region. The mixing of the deep water off Menorca shows that there is considerable diapycnal mixing due to boundary effects, especially in times of increased dynamics. This has an impact on regional mixing processes and nutrient distribution. A climate modeling study on the dynamics of dense water in the Adriatic successfully reproduced historical ocean data and provided insights into the properties of dense water in the Adriatic over three decades. Large-scale laboratory experiments modeling the Strait of Gibraltar and adjacent waters revealed the complexity of turbulent mixing and internal solitary wave formation and provided insights into the hydrodynamics of this critical region.

In conclusion, the session provided a comprehensive overview of the evolving dynamics of the Mediterranean Sea, emphasizing the interplay between ocean processes and climate change. The discussions indicated the importance of continued research and monitoring to understand these complex systems and their implications for marine ecosystems and regional climate.

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WARMING OF WESTERN MEDITERRANEAN DEEP WATER IN THE CONTEXT OF HALTED DEEP CONVECTION

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Abstract

Winter 2013 saw the last major open-ocean deep convection in the Northwestern Mediterranean Sea. Since then, Western Mediterranean Deep Waters have evolved under the action of slow turbulent mixing processes. Warming rates of bottom waters were close to zero between 2013 and 2018, and have increased to 0.002°C/year since then. Warming of bottom WMDW are tighly linked to the the history of deep convection and vertical gradients between deep and intermediate water masses. The evolution is compatible with turbulent vertical diffusivity transfering heat down from intermediate depths.

Since 1950, Western Mediterranean Deep Waters have warmed by about 0.3°C [1]. This warming trend has been linked to the warming of surface and intermediate waters propagating verticaly during intense deep convection events in the Gulf of Lions (Northwestern Mediterranean Sea). In particular, WMDW have undergone major abrupt shifts in their properties caused by intense deep convection events occuring after a period of reduced convection intensity (e.g., the Western Mediterranean Transient in 2005, [2]).

The MOOSE network is a multi-disciplinary ocean observatory of the Northwestern Mediterranean Sea runing since 2010 to monitor the physical, biogeochemical and biological evolution of the NW Mediterranean Sea [3]. It combines different platforms in order to resolve spatial and temporal gradients using moored time series, autonomous platforms (gliders and Argo floats), monthly CTD stations, and a yearly basin-scale cruise (MOOSE-GE, [4]).

After a period of intense mixing from 2009 to 2013 characterised by bottom reached mixing at 2500m, the typical maximum mixed layer depth observed in winter during the last decade (2014-2024) has only been of about 200-500m, with the exception of winters 2015 and 2018 with mixing observed down to respectively about 1500m and 1800m [5].

(thick line represent the mean profile). Each individual profile is represented by a thin line in the background, and the thick line is the mean profile. All profile are colored according to the year of the MOOSE-GE cruise.

Until 2018, bottom WMDW were located below a slighty colder (and fresher) WMDW, and no warming below 2000m observed since 2013. However, the 2018 deep convection event disrupted the temperature structure of WMDW. The temperature minmum found at around 2000m disappeared and vertical gradients of temperature of O(0.01/200 °C/m) started to prevail directly above the homogenoeous bottom layer of WMDW (Figure 1).

This had further important consequences for the evolution of the bottom WMDW, which are warming at a rate of 0.002°C/year since 2018. As vertical temperature gradients became more intense above the bottom layer, these gradients could convey heat fluxes all the way down to 2000m from warm and salty Estern Intermediate Waters (EIW) found at around 500m. EIW's temperature and salinity have also increased significantly during the study period [5].

Considering typical vertical diffivity coefficient of $K_z = 10^{-4}$ m^2 s^{-1} estimated from microstructure profiles in the region [6], the slow turbulent diffusion of heat between warm EIW and colder WMDW would typically flux O(10) mW m^{-2} to the bottom layer. This downward heat flux converges at the top of the homogeneous bottom layer where fluxes drop to zero (due to temperature gradients close to zero), hence contributing to the warming. A simple heat budget for a 200m thick bottom layer would give a warming rate of O(0.001° C/year) associated with this typical heat flux. The intensity of vertical diffusion due to turbulence, as well as the role of geothermal heating for the heat budget of WMDW requires further assessments.

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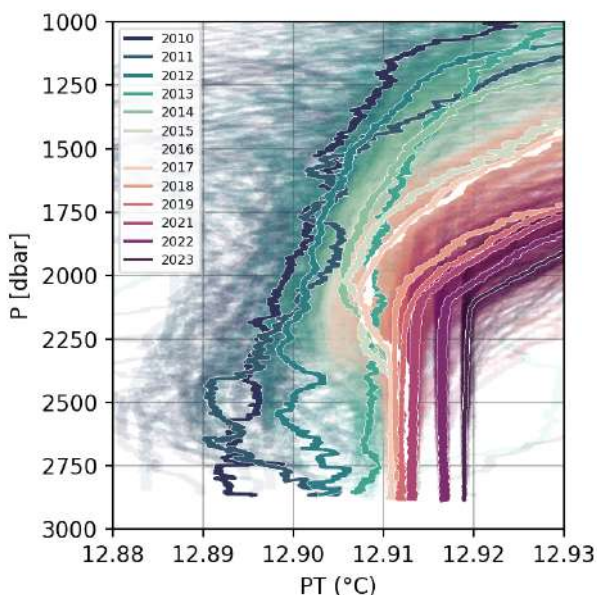
Fig. 1. Vertical structure of WMDW observed during the MOOSE-GE cruises

EXPLORING CARBONATE SYSTEM DYNAMICS IN THE SOUTHERN ADRIATIC

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Abstract

The analysis of the time series of temperature, salinity, density, and of the carbonate system measured in the Southern Adriatic Sea between 2008 and 2023 allowed to identify some relevant changes in the region. Since 2017 higher salinity and temperature have led to increased vertical mixing suggesting that physical processes play an important role in the variability of the carbonate system.

Keywords: Carbon, Ph, Open sea, South Adriatic Sea, Eastern Mediterranea

The Southern Adriatic Pit (SAP) is the deepest part of the Adriatic Sea (Fig. 1). This area is characterized by the presence of a basin-scale cyclonic circulation, and dense water forms in the center of the gyre through open-ocean winter convection. This area is also characterized by the interaction of different water masses: Atlantic water, Levantine surface and intermediate water and the dense water of the northern Adriatic. The final characteristics of the carbonate system are therefore the result of complex interactions between the different oceanographic processes in this basin and the transit and accumulation of different water masses.
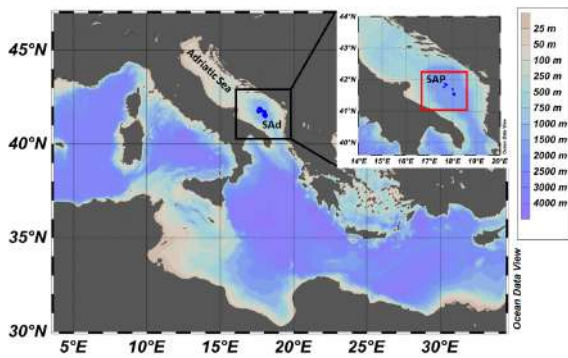

Fig. 1. Map of the study region. The black box identifies the Southern Adriatic (SAd) and the red box represents the Southern Adriatic Pit (SAP).

The aim of the research is to investigate the temporal variability of the carbonate system through the influence of physical and biological processes. We used data from oceanographic cruises between 2008 and 2023 in the SAP as well as $p\text{CO}_2$ data from the surface (2 m depth) acquired by an automated high-frequency system at the EMSO E2M3A regional facility moored at the center of the SAP. Samples for total alkalinity (A_T), $\text{pH}_{T25°C}$, dissolved oxygen (DO) and inorganic nutrients (NO_3, NO_2, PO_4 and Si(OH)_4) were collected. pH at in situ temperature (pH_T) and $p\text{CO}_2$ were calculated based on $\text{pH}_{T25°C}$, A_T, phosphate and silicate concentrations, pressure, in situ temperature and salinity using CO2Sys software [1]. Apparent oxygen utilization (AOU) was calculated as the difference between the oxygen saturation and the measured DO concentration. Argo float profiles collected in this area (2010 – 2023; doi:10.13120/bxf7-pb83) were also analysed. From 2017, the entire water column was characterized by warmer and exceptionally salty waters. The changes in the thermohaline properties in the SAP have led to increased vertical mixing, resulting in a significant homogenization of the water column. The concentration of A_T showed an increase particularly evident from 2017 onwards. This increase could be attributed to the reported increase in salinity of the SAP [2]. Similarly, a progressive decrease in both $\text{pH}_{T25°C}$ and pH_T was observed in the subsurface and intermediate layers (Fig. 2a). The decrease in pH_T is probably more related to the increase in temperature and CO_2 exchange with the atmosphere. Biological processes and the increase in $p\text{CO}_2$ contributed to the decrease in $\text{pH}_{T25°C}$ in the intermediate layers. A pronounced seasonal variability of $p\text{CO}_2$ was also observed, as shown by the high-frequency data collected on the E2M3A. From 2019 onwards, higher $p\text{CO}_2$ concentrations were observed in the intermediate layers, possibly due to the accumulation of CO_2 in

the subsurface layers, which is then redistributed along the water column during vertical mixing events (Fig. 2b). Analysis of AOU and inorganic nutrients has revealed seasonal and depth-dependent variations with higher concentrations in bottom waters. The effects of biological processes on the variability of the carbonate system are likely to be less important compared to the changes associated with thermohaline and physical processes.
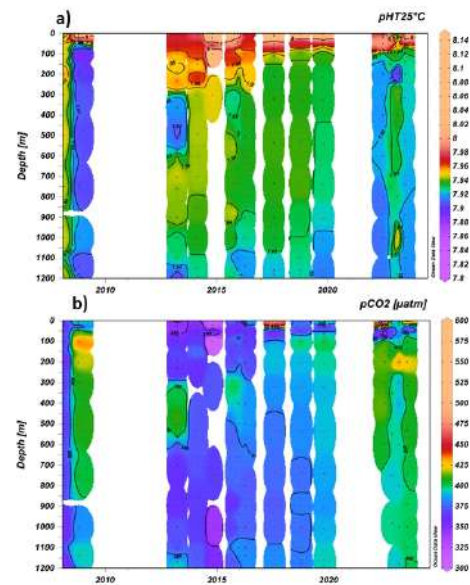

Fig. 2. Hovmöller diagram showing a decrease in (a) $\text{pH}_{T25°C}$ and an increase in (b) $p\text{CO}_2$ in the SAP.

This study highlighted that the warming and salinification of the SAd has led to relevant changes in the properties of the carbonate system, such as a decrease in pH and an increase in $p\text{CO}_2$ throughout the water column. Continuous monitoring of the area through an integrated oceanographic approach is essential for understanding the response of the carbonate system in the Adriatic to climate change.

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INTERMITTENT SUPPLY OF DENSE WATER TO THE DEEP SOUTH ADRIATIC PIT: AN OBSERVATIONAL STUDY

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Abstract
Using 15 years of high-frequency data from the European Multidisciplinary Seafloor and water column Observatory (EMSO) South Adriatic Regional Facility (moorings E2M3A, BB and FF), the occurrence of gravity currents in the deep South Adriatic Pit (SAP) is investigated. Six different criteria were used for the investigation of gravity currents. Four gravity current events were reported at the bottom of the SAP, in 2012, 2017, 2018 and 2022 (bottom mixing years). These events took place from mid-February to June and are followed by a relaxation phase that lasts a few months. While the 2012 gravity current event was driven by temperature, salinity played a governing role in the other years.

Keywords: Deep sea processes, Adriatic Sea, Instruments and tech, Gravity, Time series

Introduction
The Adriatic water masses that fill the deep SAP, are subject to the influence of various physical processes that occur on different spatial and temporal scales such as deep convection, double diffusive mixing (Amorim et al., 2024, Cardin et al. 2020) and gravity currents. Deep convection rarely occurs in the SAP (Cardin et al., 2011). Indeed, bottom water masses in the pit are renewed by gravity currents of high-density water, the North Adriatic Dense Water (NAdDW), which originates in the northern Adriatic where shelf convection occurs (Vilibic et al., 2023). These gravity currents flow along the western flank of the Adriatic and reach the SAP as intermittent pulses through the Canyon of Bari.

Results
To determine the arrival of gravity currents in the deepest layer of the southern Adriatic we applied six different criteria to different parameter time series. The first two criteria consist of deriving the normalized local-temporal variance ($\tilde{\eta}_X$) (1).

$$\tilde{\eta}_X = \frac{\eta_X - \langle \eta_X \rangle}{\sigma(\eta_X)} \text{ with } \eta_X = \langle (X(t) - \langle X(t) \rangle_{\Delta t})^2 \rangle_{\Delta t} \text{ (1)}$$

for density (rho), potential temperature (theta), salinity (S) and oxygen (O) at E2M3A and density at BB and FF. It results that, for X=rho, $\tilde{\eta}_X > 1$ (first criteria) are observed at E2M3A, in the Bari canyon (BB) and in the open slope area north of it (FF) only in the years occurring bottom mixing 2012, 2017, 2018 and 2022 (Fig. 1a). Moreover, there is a consistency for $\tilde{\eta}_X$ between the different variables at E2M3A: strong $\tilde{\eta}_X$ (X=rho, theta, S) occur only in the years with a strong increase in $\tilde{\eta}_X$ (X=O) (second criteria) associated with the ventilation of the bottom layer of the SAP (Fig. 1b).
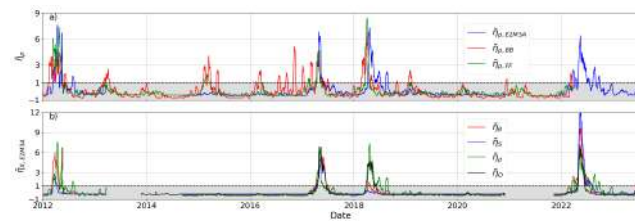

Fig. 1. Normalised local-temporal variance for density (a) at the three moorings and (b) for all variables at E2M3A

Comparisons were made between the density at the three moorings. It was assumed that the density of the water masses at BB and FF during gravity current events should be close to each other (third criteria):

$$\Delta \tilde{\rho} < 1 \text{ with } \Delta \rho = |\langle \rho_{FF} \rangle_{\Delta t} - \langle \rho_{BB} \rangle_{\Delta t}| \text{ (2)}$$

and greater than the density at the bottom of the SAP (fourth criteria):

$$\rho_{BB} \text{ or } \rho_{FF} > \rho_{E2M3A} \text{ (3)}$$

Years that fulfill these criteria correspond to the years of bottom mixing which are determined by equation (1).

The high-density waters produced in the northern Adriatic were analysed during the winter months using the equation (4 - fifth criteria). This criteria is only verified for the years of bottom mixing.

$$\langle \text{Max}(\rho_N) \rangle_{\Delta t} > 29.75 \text{ kg.m}^{-3} \text{ (4)}$$

The analysis of the mixing ratio of water masses (sixth criteria) at the three moorings, complemented by the analysis of heat fluxes and integrated salinity in the northern and middle Adriatic, shows that the gravity current formed in 2012 was driven by temperature, while after 2017 salinity played a governing role. Indeed, in 2017 (Fig. 2), the mixing ratio of these water masses confirms that salinity is the main driver as potential temperature increases.
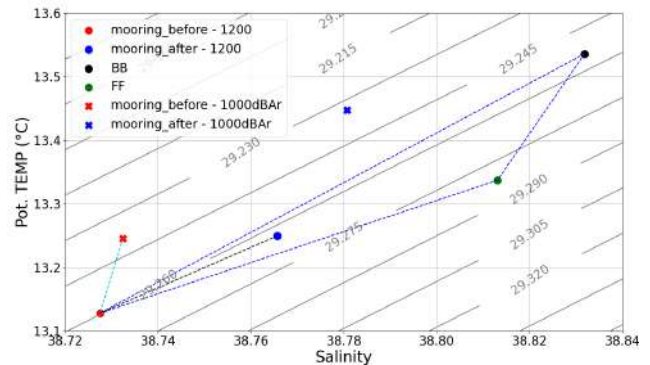

Fig. 2. Theta-S diagram of the different water masses involved in the mixing process at the deep SAP in 2017.

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SPATIOTEMPORAL CHARACTERIZATION OF LIGHT CLIMATE IN THE WESTERN MEDITERRANEAN BASIN

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Abstract

The euphotic layer depth is a deterministic factor of phytoplankton productivity within the water column. In this study, we explore a large spatiotemporal dataset of Secchi disk depths and subsurface PAR sensors to determine the long-term light climate trends in an extensive region of the Western Mediterranean basin. Differences between two different ecoregions within the basin are also explored.

Keywords: Instruments and tech, Global change, Mediterranean Sea

Introduction

The euphotic zone is the uppermost layer of the water column which receives sunlight and therefore, where photosynthetic rates are higher than respiration by the phytoplankton community. Water transparency, euphotic layer depth and the light attenuation coefficient, can be easily determined using the Secchi disk depth (SSD)[1]. Variation in maximum euphotic depth may depend on environmental conditions such as wind regimes or temperature. However, in contrast with the open ocean, coastal waters are generally less transparent due to the input of particulate matter and nutrients from land [2]. These variations determine the phytoplankton biomass and productivity. The main goal of this study is to explore the light climate, defined as the variations in subsurface natural light conditions [3], on the euphotic layer depth in the Western Mediterranean.

Data and methods

To analyze the temporal trends of light climate we use the comprehensive database of the RADMED project, which is a long-term monitoring program of the Spanish Oceanographic Institute Observing System (IEOOS) [4,5]. This project has been seasonally monitoring hydrographic and biogeochemistry parameters since 2007, including SSD, phytoplankton, and zooplankton biomass samplings. From 2015 onwards, both surface and subsurface PAR sensors were incorporated in the sampling strategy.

Results and discussion

The incorporation of PAR subsurface sensors has allowed calibrating the Secchi empirical coefficient for the Western Mediterranean region, and to infer the euphotic layer maximum depth (Fig. 1). Subsequent analysis of the long-term evolution of light climate in the euphotic layer let us to identify differences between the Alboran Sea and the Levantine Basin, two differentiated ecoregions within the Western Mediterranean[6,7]. The constructed dataset also sets the basis to infer the extent of the euphotic layer using other technologies such as satellite imagery or artificial intelligence-based methods[8,9].

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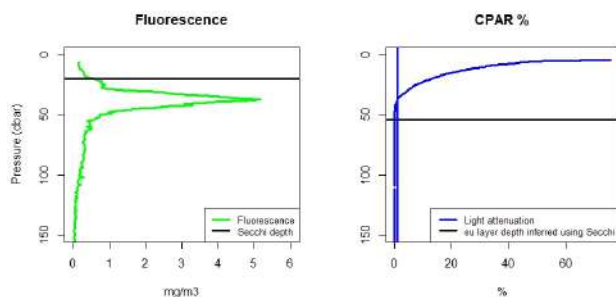
Fig. 1. Left panel: Fluorescence profile (mg/m3, green line) with the measured Secchi disk depth (black line). Right panel: Light attenuation (PAR/SPAR, blue line) and the estimated euphotic layer depth inferred using the Secchi disk depth (black line). The vertical blue line indicates the 1% CPAR.

LARGE-SCALE LABORATORY EXPERIMENTS OF THE GIBRALTAR EXCHANGE FLOW, INCLUDING GULF OF CADIZ AND ALBORAN SEA

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Abstract

Results from large scale laboratory experiments of a realistic physical model of the Gibraltar Strait and adjacent Gulf of Cadiz and Alboran Sea are presented. The physical model includes all forcings: the baroclinic exchange flow, the barotropic tide, the realistic bathymetry and the Earth's rotation. Results show that experiments are able to model and correctly reproduce such a large area of 250km x 150km with different dynamics, including turbulent mixing at the hydraulic control areas, the Mediterranean outflow propagation in the Gulf of Cadiz and the formation of internal solitary waves propagating in the Alboran Sea, revealing intriguing insights in the reach dynamics of the area.

Keywords: Gibraltar Strait, Straits and channels

Results from large scale laboratory experiments of a realistic physical model of the Gibraltar Strait and adjacent Gulf of Cadiz and Alboran Sea are presented, including all forcings: the baroclinic exchange flow, the barotropic tide, the realistic bathymetry and the Earth's rotation. The experiments were conducted at the Coriolis platform at LEGI, Grenoble (France), the largest rotating tank in the world. The baroclinic exchange flow was realized using a lock-exchange configuration with two different salinities at each side. Scaled semi-diurnal (M2) tides for both spring tide (ST) and neap tide (NT) regimes were generated, including the transient with the superposition of the M2+S2 tide. The experimental duration was of 13 rotational days. Similarity has been achieved for the Froude, Rossby, Burger numbers, and the Reynolds number is 5,000. Variation parameters in the experiments were the density difference and the different barotropic flows. The results show that experiments are able to model such a large area of 250km x 150km with different dynamics, including turbulent mixing at the hydraulic control areas, the Mediterranean outflow propagation in the Gulf of Cadiz and the formation of internal solitary waves propagating in the Alboran Sea.
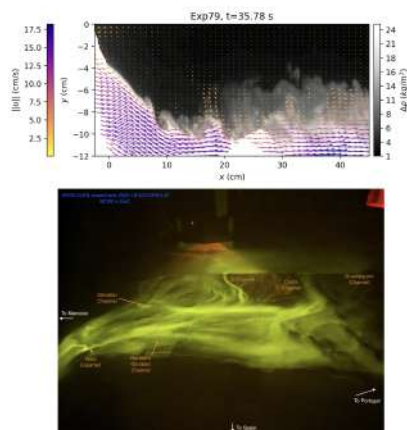

Fig. 1. Instantaneous PIV/PLIF image downstream CS (0,-3). Vertical scale 1/2,500, horizontal scale 1/25,000, velocity scale 1/20, density scale 6.25. Bottom - Fluorescent dye highlighting the propagation of the MOW in the different channels of the Gulf of Cadiz.

Measurements techniques were based on PIV in all regions at different horizontal and vertical sections, including combined PIV/PLIF in high mixing regions (Camarinal/Espartell Sills) which deliver the full turbulent fluxes crucial for parametrization of small-scale turbulent processes (see Figure 1). They appear to be very different during the different phase of the tide. Intrusive devices (ADV, ADV profilers, SSH, CTD) have been used as well, especially to track the Mediterranean outflow in the Gulf of Cadiz. The dense water transport reveals to be crucially determined by the bathymetric features (see Figure 1).
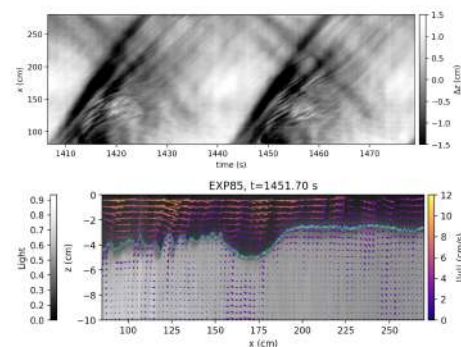

Fig. 2. Hovmöller diagram of the Mediterranean interface during two tidal cycles highlighting the internal tide, the soliton and small-scale instabilities propagating in the Alboran Sea. (Bottom) Dye image with the evident soliton with superposed characteristic velocity field. Speed: 8cm/s, amplitude: 2cm, wavelength 20cm. Scales as in Fig.1.

Solitons are produced during spring tide (ST) at CS and propagate toward the Alboran Sea (see figure 2), at each tidal inversion (West-Est). Preliminary results suggest hence that they are not related to the relaxation of the internal hydraulic jump downstream of Camarinal Sill, but rather from an internal bore generated by the internal tide at CS at the tidal inversion (West-Est).

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DEEP-WATER BOUNDARY MIXING OFF MENORCA

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Abstract

The continental slope of Menorca has been suggested to be a site where persistent, depth-intensified diapycnal mixing may occur in the deep layers due to strong boundary mixing. Here, from hydrographic and current observations gathered across the northeastern continental slope of Menorca between 2017 and 2020, we explore the occurrence of turbulent mixing enhancement over the sloping boundary. Our results indicate that regional deep mixing intensification can occur in the Menorca continental slope during periods of enhanced dynamics.

Keywords: Deep waters, Currents, Turbulence, Continental slope, Balearic Islands

Introduction

Deep waters, intermittently renewed in the Western Mediterranean, can eventually be incorporated into the Mediterranean Outflow leaving the basin through the Strait of Gibraltar. To be able to do so, deep waters must be uplifted to a certain level [1] either by the production of new denser deep waters [2] or by diabatic upwelling [3]. In the Western Mediterranean interior, contribution of turbulent diapycnal mixing to this process is known to be generally small [3]. However, deep mixing intensification is expected during transient highly dynamic periods and near topography.

Strong, depth-intensified mixing has been suggested to occur in the deep layers off Menorca during post-convective stages following major deep-water formation events [4]. Near-boundary mixing intensification over the deep continental slope and lateral export of well-mixed waters are hypothesized by these authors. They show evidence of near-boundary turbulent mixing intensification in observations during post-convective stages of winter 2017-2018, and stress the similarities with a deep boundary mixing mechanism thoroughly documented by [5] in the Southern Ocean. This mixing mechanism is associated with topographical stress induced by an abyssal along-slope flow that promotes large diapycnal mixing levels and lateral exchange between near-boundary, well-mixed waters and stratified ocean interior waters.

Dataset and methodology

To explore the evidence of deep boundary mixing intensification shown in [4], we analyze current and hydrographic data from an oceanographic section repeated four times between summer 2018 and winter 2020 across the northeastern continental slope of Menorca. We characterize the local deep boundary circulation and the development of conditions prone to small-scale turbulence production over the topographic boundary. We also further analyze the hydrographic cross-slope observations during the convective winter of 2017-2018 presented in [4], and expand the observational record with a deep mooring deployed in the outer continental slope.

Results

The analysis of the local deep hydrographic structure and currents in the cross-slope oceanographic section between summer 2018 and winter 2020 enable us to characterize the variability of the deep boundary circulation and the stability of the boundary flow off Menorca (Figure 1). From our results, evidence of the development of the boundary mixing mechanism observed by [5] will be presented. Additional evidence compatible with deep boundary mixing intensification and lateral exchange between near-boundary and interior waters is found in the observations of the convective winter of 2017-2018, and will be discussed.
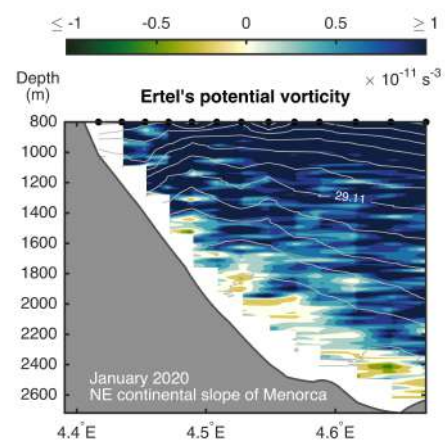

Fig. 1. Ertel's potential vorticity field beneath 800 meters in January 2020, during the RADMED0120 cruise. Solid lines indicate isopycnal levels every 0.001 kg m^{-3} (the 29.11 kg m^{-3} isopycnal is labelled for reference).

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CLIMATE MODELLING OF THE ADRIATIC DENSE WATER DYNAMICS AT KILOMETRE SCALE

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Abstract
An historical simulation of the kilometre-scale atmosphere-ocean climate model Adriatic Sea and Coast (AdriSC) was evaluated against a collection of ocean observational data in the 1987–2017 period. A comparison of the AdriSC simulation, the newest reanalysis product for the Mediterranean Sea and the Adriatic atmosphere-ocean forecast model was performed in terms of their reproduction of Adriatic dense water dynamics for the 2014–2015 period. The results of the AdriSC ocean simulation were then used to obtain a first kilometre-scale assessment of the Adriatic dense water dynamical properties during the 31-year period.

Keywords: Adriatic Sea, Deep waters, Salinity, Temperature, Water transport

Introduction
One of the main processes driving the circulation of the Adriatic Sea is the formation of the North Adriatic Dense Water (NAddW). This water mass forms on the open northern Adriatic shelf and in the Kvarner Bay during winter bora events, subsequently spreading and ventilating the deep layers of the Adriatic. Due to the complex geomorphology of the Adriatic region, processes at coastal scale are very challenging to simulate, requiring sufficient model resolution. In order to accurately reproduce the Adriatic dynamics at the climate scale, the atmosphere–ocean climate model Adriatic Sea and Coast (AdriSC) has been developed [1], with a horizontal resolution of 3 km and 1 km in the ocean, and up to 3 km in the atmosphere. This research aims to perform a skill assessment of the AdriSC ocean climate simulation and quantify the dense water dynamics in the Adriatic Sea.

Material and methods
The results of the ocean component of the 31-year (1987–2017) AdriSC climate simulation are compared to remotely sensed and in situ observations [2]. The variables analysed include sea surface temperature and height for the 3-km model, daily temperature and salinity, as well as hourly current speed and direction for the 3-km and 1-km models. The results of four different simulations during the 2014–2015 period, were compared in the reproduction of Adriatic dense water dynamics. These are: the AdriSC historical climate simulation, the most recent physical reanalysis for the Mediterranean Sea, and a modelling system used in both hindcast and data assimilation modes [3]. The 1-km AdriSC results were used to quantify the main phases of dense water dynamics – generation, spreading and accumulation, by analysing the thermohaline parameters during the 1987–2017 period.

Results and discussion
The skill assessment of the AdriSC ocean simulation showed that the AdriSC 1-km model is capable of reproducing the observed thermohaline and dynamical parameters with good accuracy. The comparison of the different simulations of Adriatic dense water dynamics highlighted that kilometre- or finer-resolution atmosphere-ocean models and non-hydrostatic atmospheric models, fine vertical resolutions in atmosphere and ocean, proper forcing of the open boundaries of the models and an appropriate representation of the air-sea interaction, are crucial prerequisites for modelling this process. The 31-year dense-water analysis revealed that winter differences in NAddW density between the two generation sites are primarily influenced by bottom temperature difference, while the Kvarner Bay generation site contributes 25–35% of the overall NAddW (Fig. 1). Further, the bottom of the deep Kvarner Bay accumulation site is renewed annually, whereas the renewal of the bottom of the Jabuka Pit and Southern Adriatic Pit occurs every 1–3 and 5–10 years, respectively.
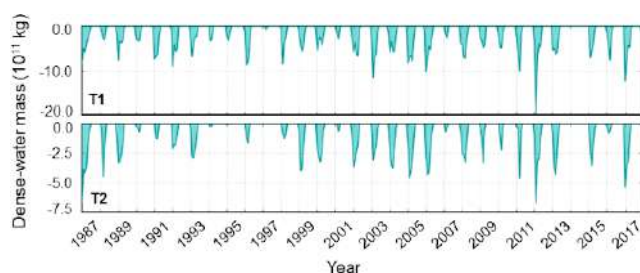

Fig. 1. Time series of monthly bottom dense water mass transported outward at transects T1 (northern Adriatic; *top*) and T2 (Kvarner Bay; *bottom)* in the 1987–2017 period.

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RECENT WATER MASS PROPERTIES IN THE WESTERN MEDITERRANEAN: THE TALPRO22 CRUISE

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Abstract

Recent water mass properties in the Western Mediterranean are investigated using data from the TAlPro22 cruise, as part of the Med-SHIP Programme. The study focuses on changes in the Eastern Intermediate Water (EIW), and Western Mediterranean Deep Water (WMDW). The Western Mediterranean Transition (WMT) event has led to significant modifications in deep water characteristics, with warmer, saltier, and denser water spreading throughout the region. Recent oceanographic campaigns, including the TAlPro22 cruise, provide insight into water mass properties, showing a progressive increase in salinity in the intermediate layer. Comparison with historical CTD data over repeated stations further highlights climatic changes over a 20-year period.

The circulation in the Western Mediterranean Sea (WMED) is an open thermohaline cell with three major water masses: the Atlantic Water (AW) entering at the surface the Strait of Gibraltar to the west, the Eastern Intermediate water (EIW) of eastern Mediterranean origin entering from the Sicily Channel and the locally produced Western Mediterranean Deep Water (WMDW). All these water masses are nowadays undergoing significant changes in their properties (Chiggiato et al., 2023).

The Western Mediterranean Transition (WMT) generated warmer, saltier and denser deep water and the timeline of spreading of this new water mass has been reviewed in Schroeder et al. (2016), occupying eventually large part of the deep layer, overflowing into the Tyrrhenian Sea and outside the Strait of Gibraltar. EIW entering from the Sicily Channel is routinely monitored and showed positive trends both in temperature (θ) and salinity (S) as well (Ben Ismail et al., 2021). This progressive signal of warming and salinification has been detected also downstream in the North-Western Mediterranean (e.g., Vargas-Yanez et al., 2021). The lack of significant open ocean convection in the Gulf of Lion after 2013 (e.g., Josey and Schroeder, 2023) prevented this signal to be further transferred to deep waters, with only limited diffusive mixing along the way to Gibraltar.
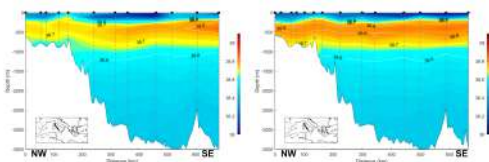

Fig. 1. NW - SE transect of salinity in the Tyrrhenian Sea from TAlPro16 (left panel) and TAlPro22 (right panel) cruises

Recent oceanographic campaigns in the Western Mediterranean have been conducted with fundings from CIESM, and the EU Projects Eurofleets2 and Eurofleets+, under the umbrella of the repeat hydrography programme Med-SHIP (Schroeder et al., 2024), which has been endorsed as an UN Ocean Decade Project. These cruises allow us (i) to evaluate the major differences in water mass properties in selected repeated CTD stations over time, (ii) to understand the final fate of the water masses generated during the WMT climatic event, (iii) to characterize at basin sub-level the EIW properties during this period of increased $\theta - S$ values and reduced convection, possibly implying very high salinity Mediterranean Overflow Water (MOW) to appear soon outside Gibraltar.

In particular, two large scale cruises were carried out in the WMED in 2016 (TAlPro16, Schroeder et al., 2024) and in 2022 (TAlPro22, Schroeder et al., 2022), allowing a large-scale comparison of tracers, clearly indicating the progressive increase of salinity in the intermediate layer all over the Tyrrhenian (figure 1), in agreement with up-current data from the Sicily Channel and corroborating the recent literature on these changes.

In order to increase the spatial domain, many recent regional cruises have been included in the dataset as well (RADMED, Lòpez-Jurado et al., 2015; MOOSE, Testor et al., 2010), so as to have a larger picture of the WMED

changes over the last years. Including also historical CTD data, over repeated stations, allowed to detect climatic changes over a 20 years period. Figure 2 shows CTD data over a repeated station located in the southern Tyrrhenian. The shift toward a higher salinity and warmer intermediate layer is evidenced.
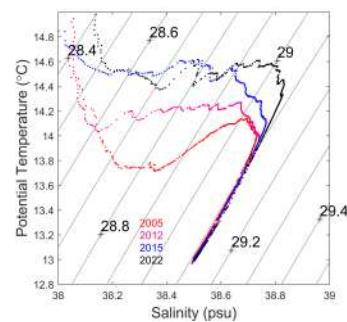

Fig. 2. CTD data from the station 051 (39.7 N, 11.9 E, see Durante et al., 2019)

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CIESM Congress Session : Sea Level Variability and Coastal Hydrodynamics

Moderator : Luis Pinheiro – Univ. of Aveiro, Portugal

Session's Synthesis

The session on "Sea Level Variability and Coastal Hydrodynamics" consisted of six presentations covering a wide spectrum of aspects on this topic. These included: the hydrodynamic modelling of seasonal variation of microplastic distribution and accumulation taking into account forcing by the Atlantic Current; the conditions that govern moderate to strong high-frequency sea level oscillations during extreme sea level events; the influence of wind stress and river outflow on modulating surface currents; the changes in water circulation patterns under different meteorological conditions, including seasonal variations; the atmospheric state during high frequency sea level extremes; and the apparent simultaneity of Mediterranean meteotsunami events under specific synoptic conditions. During the discussion, it was also recognized the need to better understand and monitor the combined mechanisms responsible for storm surges, meteotsunamis and other extreme events, with high impact on populations. There was a general agreement that his requires sustained high resolution monitoring and improved modeling, forecasting and early warning systems, taking into account present atmospheric, climatic and hydrodynamic variations, as well as their future trends under different climate change scenarios. Another recognized aspect was the need to remediate the present asymmetry in observation networks in the N and S Mediterranean and the need to encourage open data access, sharing of best practices, and a collective effort on capacity development for less developed countries. The use of emerging technologies, such as SMART cables (e.g. Medusa), were identified as an excellent opportunity for high resolution and long term sustained observations. These aspects were considered fundamental to build resilient coastal cities throughout the Mediterranean region, to better understand and forecast pollution dispersal and to protect costal populations from marine extreme events, in a climate change scenario.

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COUPLED HYDRODYNAMIC-LAGRANGIAN TRANSPORT MODELING OF MICROPLASTIC DISTRIBUTION AND ACCUMULATION IN THE GULF OF TUNIS

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Abstract

Identifying distribution and accumulation patterns of Microplastics (Mps) in the Gulf of Tunis were assessed using coupled numerical models. Surface water circulation forced by the Atlantic current (AC) develops seasonally changing patterns of Mps accumulation. Indeed, the AC circulates cyclonically during autumn and winter within the inner part of the gulf, facilitating the movement of surface waters and ensuring rapid exchange of water masses. However, in spring and summer, the AC branch fails to penetrate the inner part, leading to the emergence of mesoscale features and MPs beaching.

Introduction

The Gulf of Tunis, much like the Mediterranean Sea, suffers from considerable pollution, particularly plastic debris. Although the Gulf naturally accumulates floating particles such as microplastics, comprehensive studies are lacking, with only a few sampling stations in place. This study seeks to examine how hydrodynamics affect the dispersion and accumulation of floating debris in the Gulf of Tunis, as well as to map its residence time.

Modeling approach

The analysis is based on the hydrodynamic model ROMS [1] and the mass conserving TRACMASS trajectory model [2] . The modeled area including the Gulf of Tunis extends from 10°E to 11.2°E and from 36.5°N to 37.5°N. A high spatial resolution of 1/240° (~370m) was adopted. Grid spacing in sigma coordinates was used in the vertical with 24 vertical levels. The ROMS model was initialized by MEDATLAS monthly climatology for temperature and salinity [3]. The open boundaries are prescribed from monthly output (temperature, salinity, elevation and velocities) of MED12. Forcing included wind, atmospheric pressure, heat fluxes, and tides. The integration ran from 1995 to 2007, with focus on the last 4 years (2004 to 2007) after a 9-year spin-up period. ROMS velocity and mass transport fields were then utilized to compute Lagrangian trajectories in TRACMASS [4] starting from all grid cell walls at the northern boundary in surface layers up to 1m depth, once daily during one month and for each month, and tracked until exiting the Gulf at the same latitude at the open boundary (Figure 1).
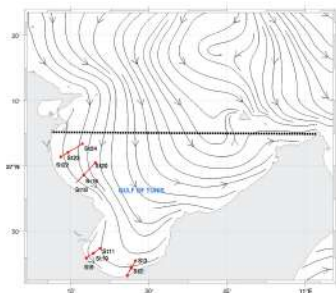

Fig. 1. Current streamlines on the currents magnitude (cm/s) at 1 m depth predicted by ROMS model in winter. Stations of Mps sampling are denoted by stars. The dashed line indicates the northern boundary from which trajectories were initialized in the Tracmass model.

Main results

The salinity evolution of trajectories in autumn and winter falls within the range of Atlantic water masses. The cyclonic circulation of water masses advected by the Atlantic currents strongly influences the spatial distribution of Mps in the Gulf during winter and autumn. Notably, stations 23, 10, and 2 (Figure 1), situated roughly at the same isobaths, exhibit similar polymer compositions and trends in bacterial concentrations on Mps, suggesting a common origin. Additionally, the positive volume transport through the northern boundary leads to the outflow of surface waters from the gulf, resulting in fluctuations that affect the residence time variability of surface water masses (Figure 2). This variability is particularly evident when volume transport is low, with spring and summer showing an increased residence time of water masses, typically ranging over 30 days compared to an average of 10 days in winter.
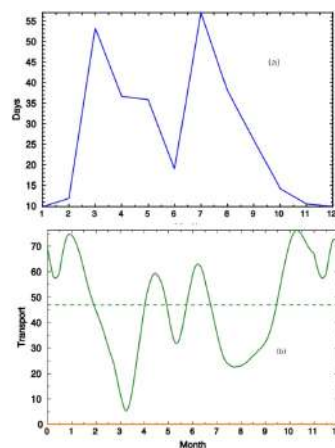

Fig. 2. Residence time of surface waters in the gulf (in days) as a function of time (a). Volume transport through the Gulf of Tunis (in 100 m^3/s) as a function of time for an average year (b). Dashed lines represent the yearly mean. The x-axis denotes the months.

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QUALITATIVE ANALYSIS OF SYNOPTIC CONDITIONS GOVERNING MODERATE TO STRONG HIGH-FREQUENCY SEA LEVEL OSCILLATIONS DURING EXTREME SEA LEVEL EVENTS

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Abstract
Recent research has shown that storm surges can happen jointly with shorter period sea level oscillations, such as meteorological tsunamis and infragravity waves, potentially leading to extreme sea level events. In this work we classify synoptic conditions under which two types of sea level extremes occur: (1) compound extremes, i.e., extremes for which long period and short period sea level oscillations act jointly to form the total sea level maximum; (2) high-frequency extremes, i.e., extremes in which short period oscillations play a dominant role. The analysis of relevant meteorological observables at the time of each event, such as mean sea level pressure field, shows that there is a clear distinction between synoptic images corresponding to the two types of extremes.

Keywords: Mediterranean Sea, Sea level

Extreme sea level events are, due to flooding, well-known for causing significant infrastructural damage and potential loss of human lives [1,2]. The most common cause of the sea-related floodings are storm surges which manifest at periods of a few hours to a few days, followed by seismic and meteorological tsunamis, which manifest on periods from minutes to tens of minutes. Recent research reveals, however, that storm surges can happen jointly with shorter period oscillations, such as meteorological tsunamis and infragravity waves [3]. In this work we classify synoptic conditions under which two types of sea level extremes occur: (1) compound extremes, i.e. extremes for which long period and short period sea level oscillations act jointly to form the total sea level maximum; (2) high-frequency extremes, i.e. extremes in which short period oscillations play a dominant role.

We analyze sea level time series measured with a 1-15 min time step at 5 tide gauge stations spread along the Mediterranean Sea, and mostly available through the UNESCO IOC Sea Level Station Monitoring Facility. We focus our analysis on the following stations: Lampedusa (LA23), Carloforte (CF06), Formentera (FORM), Otranto (OT15), Peiraias (PEIR). For each station, we extract six strongest episodes of compound extremes, and six strongest episodes of high-frequency (HF) extremes. To determine governing synoptic conditions, we use the following ERA5 reanalysis variables: mean sea level pressure, 10-m u and v wind components, 850 hPa temperature fields, 700 hPa humidity field, 500 hPa geopotential height and wind.

Our analysis showed that, in the context of gauge stations across the Mediterranean Sea, it is possible to see clear distinction between synoptics related to strong HF events versus synoptics related to compound events. While compound events appear to be strongly related to the existence of cyclones above the gauge station of interest, this is not the case for HF events, for which the sea level pressure above the gauge station at the time of event is closer to monthly mean value. However, strong HF events seem to be strongly related to the temperature at 850 hPa pressure surface above the gauge station. Namely, these HF events appear to be followed by the inflow of warm air at this pressure surface, coming generally from south (from Africa) or east-south (from Middle East) directions. In addition, wind at 500 hPa pressure surface, which is another commonly discussed observable in the context of HF sea level oscillations [2,4], exhibits speeds of about 30 m/s during both HF events and compound events, coming generally from western and south-western directions.

Mean sea level pressure fields and total wind at the height of 10 m above the sea level are shown in Figure 1 for typical compound event (left panel) and typical HF event (right panel) at Peiraias gauge station (marked with red dot in the map). The dark blue area above the gauge station in the left panel indicates the presence of cyclone, leading to the mean pressure at the sea level exhibiting values which are about 20 hPa lower than average value. However, during the typical HF event (right panel), mean sea level pressure at the gauge station does not deviate significantly from the average, indicating that the presence of strong cyclones is more characteristic for compound events, rather than HF events.
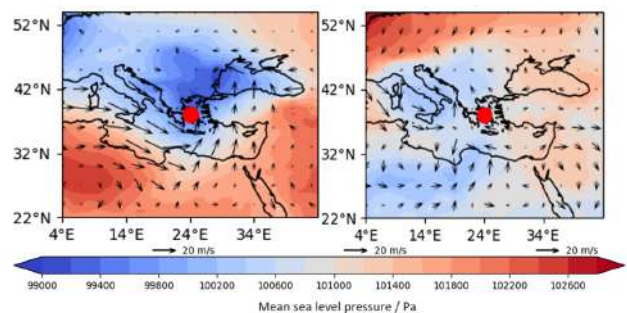

Fig. 1. Mean sea level pressure field (see the color bar for the reference values) and total wind at the height of 10 m above the sea level for typical compound event (left panel) and typical HF event (right panel) at Peiraias gauge station.

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INFLUENCE OF WIND STRESS AND THE ISONZO/SOCA RIVER OUTFLOW ON SURFACE CURRENTS IN THE GULF OF TRIESTE

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Abstract

Between October and November 2023, heavy rainfall in the Isonzo/Soca River catchment area led to two major runoff peaks with significant discharges into the Gulf of Trieste (GoT, northern Adriatic Sea). These events are an ideal case-study to investigate how the Isonzo/Soca outflow and associated winds affect ocean currents. Through an integrated multi-platform analysis of hydrometric, meteorological and oceanographic data, the mechanisms governing the interaction between river runoff and ocean currents in the GoT were analyzed and the importance of prevailing winds such as Bora and Sirocco in modulating current dynamics was addressed. It was also observed that intense Isonzo/Soca runoff, triggered by heavy rainfall, can prevail over wind effects, leading to a dominance of river-induced circulation patterns in the GoT.

Keywords: Adriatic Sea, Currents, Wind, River input, Circulation

Introduction

In the period between October and November 2023, the Isonzo/Soca river catchment area experienced particularly heavy rainfalls. Remarkable surges in river discharge were recorded, exceeding all previous records for the year and leading to significant outflows into the GoT. Concurrently, sea level rise and coastal inundation were observed. The event at the beginning of November is of particular significance as it was also accompanied by strong storm surge and waves that caused severe damage to the coast. The aim of this study is to investigate how an exceptionally strong Isonzo outflow, together with the wind patterns associated with the meteorological event, influenced the ocean currents in the surrounding coastal region.

Data

Through an integrated analysis of hydrometric, meteorological and oceanographic data, we want to study the mechanisms and processes that regulate the interaction between fluvial discharges and ocean currents in the GoT. The river discharge data were provided by The Regional Agency for the Protection of the Environment (ARPA FVG); the wind data come from the Weather Research and Forecasting (WRF) model (available at the link https://www.mmm.ucar.edu/models/wrf), version 4.2.1; the data on surface ocean currents originate from the combination of four WERA-type [1] HF radar stations operating in the GoT. The description of the system and the data are available at the European HFR node website: https://www.hfrnode.eu/networks/hfr-nadr-2/ [2].

Results

The prevailing winds in the GoT come from the north-eastern (Bora wind) and southern sectors (Sirocco and Libeccio winds). During Bora events, the surface currents normally leave the GoT, while during Sirocco events the surface currents enter the GoT [3]. It was observed that in the days before a precipitation event, a wind with a strength of more than 3 m/s from the S-SE direction almost always affected the area. The strong precipitations acting on the hydrographic basin at the end of October and beginning of November led to exceptional increases in the Isonzo/Soca runoff into the GoT (October 27 and November 3). This is also clearly seen in the Sentinel-2 satellite images for November 4 (Figure 1).

Fig. 1. Image Sentinel-2 04th November 2023 10:11 UTC, from https://link.dataspace.copernicus.eu/l3n1.

HFR sea surface current data confirmed that wind-induced Ekman transport appears to dominate the surface current dynamics in the GoT (Figure 2). Nevertheless, exceptionally intense outflows from the Isonzo/Soca, triggered by heavy precipitation and accompanied by S-SE winds, can overlay the effects of wind-driven transport, leading to the dominance of river-induced circulation patterns in the GoT.
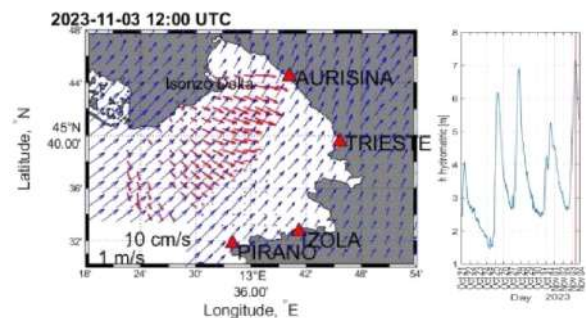

Fig. 2. Left: surface currents from HFR data (red),wind data from WRF data (blue) for November 3, 2023, 12:00 UTC; the red triangles represent WERA HF stations. Right: the hydrometric height of the Isonzo/Soca river.

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ANALYSIS OF WATER CIRCULATION ON IZMIT BAY UNDER DIFFERENT METEOROLOGICAL CONDITIONS WITH MITGCM

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Abstract

We used the MITgcm model with Orlanski boundary conditions and process-oriented modeling to examine the sensitivity of the Izmit Bay water circulation to wind speed, direction, and duration. The simulations demonstrated that there is little variation in seawater temperature, salinity, or stratification under modest forcing. Depending on the direction, substantial forcing at wind speeds of 4.9 m/s, 6.7 m/s, and 10.1 m/s produces notable and sub-mesoscale processes. Easterly component winds raises subsurface waters to the surface, whereas westerly component winds causes downwelling over the eastern shore. It is found that the hydrography of the bay is open to be largely impacted by extreme wind occurrences that exceeded 4.9 m/s.

In the study, we investigated the sensitivity of Izmit Bay to the wind, which is one of the most important driver of the Bay [1]. First, we classified the wind speeds using data from the weather station located on the nearest breakwater, Tuzla Breakwater. In addition, we built up a regional ocean circulation model by customizing the MITgcm based on the previous studies [2,3,4]. Since we followed the process-oriented hydrodynamic modeling [5], we omitted all forcing factors except the wind stress. The simulations were initiated with a state at rest and the forcing was gradually increased to the idealized wind speeds to avoid unwanted gravity waves. The runtime of the simulations is 11 days, the optimum runtime to balance computation cost and obtain distinctive model results. A late summer measurement was preferred for the homogeneous initial condition. The results of 48 adiabatic simulations are limited to the first 60 meters of depth due to negligible changes below 60 meters.

The simulation results indicate that the bay experiences quasi-stationary conditions or remains stagnant at weak wind speeds of 1.3 (10%), 2.1 (25%), and 3.3 (50%) m/s. The stagnancy of the bay under calm or weak wind conditions can encourage the degradation of the water quality because the bay is always under severe anthropogenic pressures. This can result in hypoxia or worse, eutrophic conditions, mucous formations and accumulations, heavy metal loads in sediment and biota, and a longer recovery period following any environmental disaster.
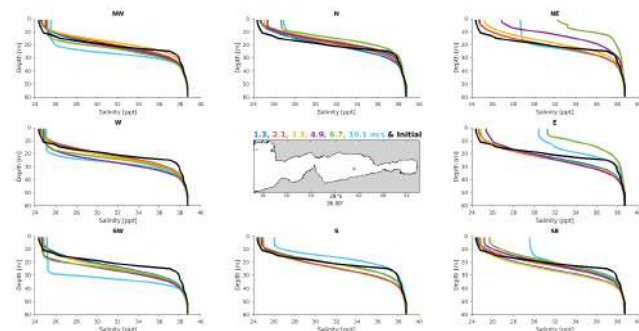

Fig. 1. Final profiles of salinity in the central basin after 11-day runtime with the initial conditions.

Stronger wind speeds (4.9 (75%), 6.7 (90%), and 10.1 (99%) m/s) show how the direction of the wind affects the forcing. The upper layer converges towards the east due to onshore winds, which have a west component, creating a deeper upper layer. The upper layer is transported outside the bay by winds with an east component, or offshore winds, which produce a jet that travels at around 50 cm/s. This jet breaches the permanent stratification, generates upwelling zones, and causes an overturning circulation in the bay. The greatest fluctuation in salinity and surface temperature is simulated under the NE 6.7 m/s forcing, which also produces the most remarkable upwelling event. A more salinized water mass is transformed at the top layer and accelerated westward, out of the bay, despite the forcing being adiabatic between the air and the sea. These mixing mechanisms under heavy winds were characterized by Altiok et al. [6] as the dominance of shear and the decrease in buoyancy frequency leading to mixing. The modeling results in our investigation are consistent with the storm-driven impacts reported before [7]. The results further show that the abrupt cooling (up to 5 °C) during strong wind events, one of which was observed by Tugrul et al. [8], is mostly caused by mechanical interactions. On February 13, 1975, the surface salinity was measured at 24 ppt. On February 24, eleven days after the scientific mission of Tugrul et al. began, the 10 m/s northeasterly wind caused an almost 5 ppt increase in the surface salinity [8].

It was discovered that the water circulation in Izmit Bay is also very sensitive to the wind's strength, direction, and duration, the bay's size and form, the vertical stratification, and the oceanographic conditions in the nearby offshore region. Severe winds are shown to have the power to control the mixing and water exchange across basins, as well as to shape the physical characteristics of strata down to a depth of sixty meters. Additionally, narrow passages prevent much water from moving between the basins, particularly because the Hersek Delta regulates both layers.

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ATMOSPHERIC STATE DURING HIGH FREQUENCY SEA LEVEL EXTREMES OVER EUROPEAN COAST

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Abstract

In this study we use 17 years long regional climate model version 4.6 (RegCM 4.6) developed by the International Centre for Theoretical Physics (ICTP) [1] to investigate atmospheric state during high frequency (HF) sea level extremes in order to asses impact of different atmospheric variables and subsequently possible formation of meteotsumamis. The results show that during winter and summer months, for most of the stations, variables such as mean sea level pressure, surface wind speed and geopotential height act in the opposite direction, indicating different triggers for HF extremes formation.

Keywords: Air-sea interactions, European Seas, Sea level

Introduction

Meteotsunami are tsunami like waves induced by atmospheric processes [2]. Although hazardous to coastal communities and infrastructure, due to their complex nature and rapid onset, unique identification index is still missing making them hard to predict. Due to their unpredictable onset, sea level measurements, of small sampling step, such as of a minute, are necessary. Such series were obtained from: (1) Intergovernmental Oceanographic Commission Sea Level Station Monitoring Facility (IOC SLMSF) and (2) National agencies for the 2004 to 2021 period. Altogether we used 282 sea level stations along the European coast.

Material and methods

In this study we examine atmospheric state during high frequency (T<2h) sea level extremes (HF extreme) which were determined in the following way. First, portions of the raw dataset had various data quality issues, hence quality control procedure was required. Following quality control, all data series were de-tided, and residuals were split into a low-frequency (T>2h) and a high-frequency (T<2h) component. From the high-frequency series, the five highest positive sea level extremes per year were extracted, with the condition that the extremes are separated by at least three days and designated as high-frequency extremes.

In order to assess atmospheric state during HF extremes we employed evaluation regional climate model version 4.6 (RegCM 4.6) developed by the International Centre for Theoretical Physics (ICTP) [1] in the framework of the Coordinated Regional Climate Downscaling Experiment (CORDEX). Herein we analyzed the period of 17 years starting at 1 January 2000 and ending on 30 November 2016. Altogether five different variables were analyzed: mean sea level pressure, surface wind speed, zonal and meridional wind components at 850 hPa and geopotential height at 500 hPa.

We divided European coast into 30 different regions and present atmospheric state during HF extremes of all stations confined inside specific region and contrast this state to the overall period of investigation.

Results

The results show that during the winter HF extremes besides lower mean sea level pressure and the increase in surface wind speed, which can be of up to 8 m/s above average, the zonal or meridional wind component are increasing/decreasing depending on the orientation of the coast in such a way that if the coast is oriented north-south, the zonal wind component will increase while meridional will stay unchanged or even slightly decrease. Moreover, a dipole in geopotential height is found, where negative values can be up to 100 m and positive of 50 m during HF extremes occurrences where region is usually located in the middle of the dipole, example for the Finish region is shown in Fig 1. However, if separating winter from the summer season, we see that during summer, mean sea level pressure, surface winds speed and geopotential height are around or above climatological mean of the respective station, being in complete contrast to winter season HF extremes.

Discussion and conclusions

Herein we present atmospheric state during HF extremes over European coast in order to search for a quantitative value of each variable and its significance to the HF extremes. This is done in order to include the most relevant atmospheric component into the meteotsunami identification process. In this way it would be possible to use mentioned identification process to predict future increase/decrease of meteotsunami events by usage of different climatological scenarios. Moreover, due to high contrast in atmospheric state during HF extremes during summer and winter season it is necessary to specify different identification processes of summer and winter HF extremes.
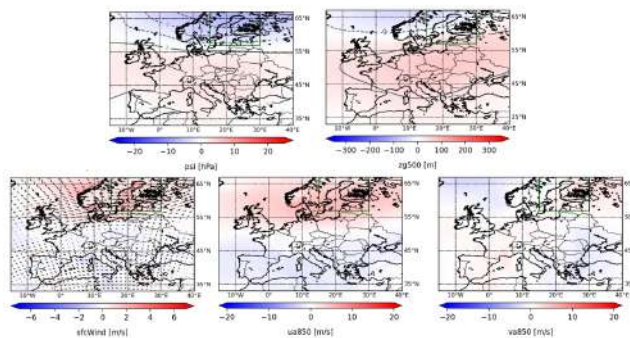

Fig. 1. Anomalies of sea surface pressure (top left), geopotential height (top right), surface wind intensity (colour shading) overlaid with the wind direction at 850 hPa (bottom left), zonal component of the wind at 850 hPa (bottom middle), meridional component of the wind at 850 hPa (bottom right) for the Finish region noted in green rectangle.

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THE SIMULTANEITY OF MEDITERRANEAN METEOTSUNAMI EVENTS: SELECTED CASE STUDIES

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Abstract

In the Mediterranean, meteorological tsunamis are common occurrences, but in May 2021 and June 2022 as well as in June 2014 unusually strong meteotsunamis hit multiple locations more than 500 km apart. Sea-level and atmospheric data analysis confirmed that their occurrence was under specific synoptic conditions, notably marked by a strong south-westerly jet stream in the mid troposphere. Apart from the synoptics, meteotsunamigenic properties of affected bays these events was studied revealing that the strongest meteotsunamis happen when the synoptic conditions are favourable for meteotsunami creation and the bays have characteristics that amplify the incoming long-ocean waves.

Keywords: Sea level, Mediterranean Sea, Adriatic Sea

Meteorological tsunamis (meteotsunamis) are long-ocean waves generated by atmospheric pressure disturbances. Following their generation, meteotsunamis can be amplified by different resonance mechanisms. These mechanisms, such as Proudman, Greenspan, and shelf resonances, contribute to increasing wave height as meteotsunami waves approach the coastline. Additionally, bays with resonant properties, such as Ciutadella in the Balearic Islands and Vela Luka in the Adriatic Sea, can further amplify the waves, heightening the risk of flooding coastal communities and infrastructure. General synoptic conditions that give rise to meteotsunami events have already been observed, characterized by (i) a surface pressure low to the west of the affected area; (ii) an inflow of warm and dry air at altitudes of approximately 850 hPa from the African continent; (iii) strong south-westerly winds at around 500 hPa; and (iv) the presence of unstable atmospheric layers at approximately 500 hPa, identifiable by a small Richardson number, $Ri < 0.25$ [1]. The conditions (ii)-(iv) are typically found directly over the area hit by a meteotsunami.

During June 22–27, 2014, several areas in the Mediterranean and Black Seas experienced significant tsunami-like waves. The event began with Ciutadella Harbour on Menorca Island, Spain, where sea-level oscillations of up to 1 meter occurred on the night of June 22–23. Subsequently, on June 25, waves reaching heights of up to 3 meters hit bays in the Adriatic Sea, Croatia. The following day, Mazara del Vallo inlet on the Sicilian coast experienced a 1.5-meter tidal bore [2]. In the Adriatic Sea, six harbours were hit by multiple meteorological tsunamis within a two-day span. In May 2021 and June 2022, a series of powerful meteotsunamis hit several bays in the western Mediterranean and Adriatic seas. Notably, Bonifacio in Corsica and Široka Bay in the Adriatic were both struck in May 2021, while Ciutadella in Menorca and Bonifacio faced a similar event in June 2022 while Široka Bay was not affected in the 2022. event.

These occurrences highlight the vulnerability of certain coastal regions to these atmospheric-induced phenomena, as well as the possibility of multiple meteotsunamis happening as a consequence of the same atmospheric instability traveling long distances (more than 500 km). While Ciutadella and Široka Bay have garnered attention as known meteotsunami hot spots, Bonifacio's susceptibility to such events emerged as a newer discovery, although anecdotal evidence suggests meteotsunami events are not entirely uncommon [3]. The influence of bathymetry and basin orientation on the generation of long-ocean waves was assessed thought Proudman length focusing on places shown in Figure 1. Subsequently, climatology of winds in the mid-troposphere during meteotsunamigenic conditions was studied showing that at most studied harbours an explanation can be drawn to why meteotsunamis are strong and frequent. Further research is needed, considering factors like wind velocity, synoptic conditions, and orography, to fully understand meteotsunami occurrences and especially their basin wide occurrences which may have a potential for future forecast.
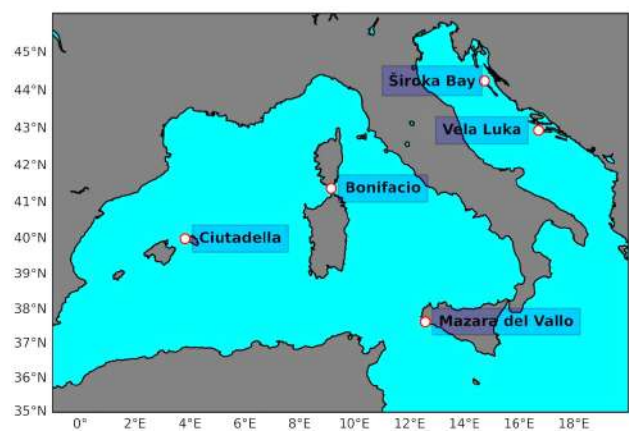

Fig. 1. The locations of meteotsunami events.

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CIESM Congress Session : Mesoscale and sub-mesoscale variability I
Moderator : Milena Menna – OGS, Trieste, Italy

Session's Synthesis

The session on "Mesoscale and sub-mesoscale variability - I" featured eight presentations focusing on different regions and dynamics within the Mediterranean and neighbouring areas. Topics covered a broad spatial range, from the Mediterranean Outflow Water's trajectory near the Iberian Peninsula—exploring its transformation as it exits the Mediterranean— to the detailed mesoscale and basin-scale circulation patterns observed in key Mediterranean sub-regions: the Western Mediterranean, Adriatic Sea, Sicily Channel, Ionian Sea, and Levantine Basin. This geographic spread provided a comprehensive look at the entire Mediterranean system, including its northern, southern, eastern, and western extents. The room was packed, with an engaged audience that showed sustained interest throughout the presentations and discussions. The presenters illustrated a wide array of oceanographic phenomena, utilizing diverse data sources and methodologies that ranged from satellite data (e. g. advancements from new satellite missions like SWOT) to in-situ observations and water tank experiments. The scope of research spanned from long-term variability to detailed, fine-scale measurements captured over shorter time frames. This multifaceted approach highlighted the Mediterranean's complex circulation patterns, driven by interactions between mesoscale and basin-scale processes and influenced by both internal and external forcings. Interactions between basin-wide and mesoscale circulation patterns were shown to influence interannual variability and impact thermohaline properties distribution across the basin. New, fine-scale observations also highlight some features of mesoscale structures that were previously unexplored in the basin, paving the way for future work and exploration. Discussions raised challenges around defining mesoscale and sub-mesoscale features in the Mediterranean and establishing consistent methods for identifying gyres and eddies—topics slated for further examination under the C2 CIESM Commission with broad community collaboration. Other engaging discussions centered on the mechanisms governing Rossby wave propagation within the basin and the role of transitional eddies, both of which have significant implications for regional circulation patterns. Overall, the session underscored the Mediterranean's status as a dynamic, multi-scale system, where interactions between mesoscale and larger processes shape oceanographic characteristics and drive variability. With ongoing advancements in observational technology and a collaborative research agenda, the community is well-positioned to deepen its understanding of these processes in the years to come.

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SATELLITE OBSERVATIONS OF SUB-MESOSCALE PHENOMENA IN THE ADVENTURE BANK IN THE STRAIT OF SICILY

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Abstract

Satellite observations show that the Adventure Bank (AB) in the Strait of Sicily is an area of high dynamical activity leading to the generation of sub-mesoscale phenomena, like filaments, sub-mesoscale eddies, and internal waves. In particular, high-resolution synthetic aperture (SAR) images have revealed, for the first time, the presence of internal waves in the AB in the summer months. When decaying, they generate turbulence and thus enhance mixing in the upper water layer which affects marine life in the AB.

Keywords: Remote sensing, Straits and channels, Sicily Channel, Coastal processes

Introduction

The Adventure Bank (AB), located at the western end of the Strait of Sicily, is a shallow sea area with an average depth of 80-100 m and steep slopes around it. The main oceanographic features affecting the dynamics in the AB are the meandering Atlantic Ionian Stream (AIS) and cold filaments and sub-mesoscale eddies that are generated in the wake of upwelling events at the Southern coast of Sicily [1], [2]. Synthetic aperture radar (SAR) images acquired from space have revealed, for the first time, that internal waves are also present in the AB. This is similar to the Strait of Messina, where also SAR images have revealed, for the first time, the presence of internal waves [3]. The existence of internal waves generated by interaction of the tide with topography in the AB area was unexpected since here, unlike in the Strait of Messina, the tidal currents are weak. However, there are a few locations at the AB margins with sufficiently swift flow where internal wave generation is possible by current- topography interaction. When decaying, the internal waves, as well as the filaments and the sub-mesoscale eddies, generate turbulence which affects marine life in the AB.

Material

In this study, we use SAR images from the Sentinel-1A and -1B satellites (launched in 2014 and 2016), which have a spatial resolution of 20 m, sea surface temperature (SST) images from the Sea and Land Surface Temperature Radiometer (SLSTR) onboard the Sentinel-3A and -3B satellites (launched in 2016 and 2018), which have a resolution of 1 km, and chlorophyll-a (Chl-a) images from the Ocean and Land Colour Instrument (OLCI) onboard the Sentinel-3A und Sentinel-3B satellites, with have a resolution of 300 m.
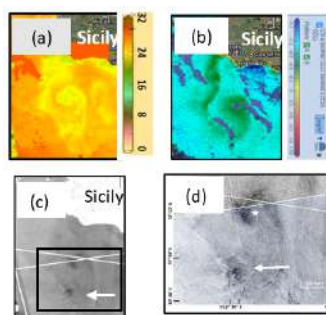
Results

Fig. 1. (a) Sentinel-3A SST image acquired over the AB on 6 August 2019 at 20:28 UTC showing a cold filament with a small-scale cyclonic eddy at its end; (b) Sentinel-3A Chl-a image acquired over the same area on 6 August 2019 at 09:08 UTC; (c) Sentinel-1B SAR image acquired over the same area on 6 August 2019 at 17:03 UTC; (d) Zoom on the area marked by a rectangle in (d) showing a complex short-scale internal wave field. The white star in Pane (d) marks the center of sub-mesoscale cyclonic eddy at the end of the filament, and the white arrow denotes an eddy-like feature within the filament. The white lines denote boundaries of SAR scenes.

The figure shows a typical example of our analysis of SAR, SST, and Chl-a images acquired over the AB. They were taken after a strong upwelling event at the south coast of Sicily, during which cold and nutrient-rich water was transported from deep waters to the sea surface. The SST image in Panel (a) shows that cold water (yellow color) intrudes southward into the AB, curls eastward ,then northward, and finally terminates in a sub-mesoscale cyclonic eddy. This feature finds its correspondence in the Chl-a image depicted in Panel (b), where enhanced Chl-a concentration (dark green color) is visible in a similar pattern as in the SST image. (The blue patches denote invalid data due to the presence of clouds). Upwelled cold water carries nutrients to the near-surface layer leading to plankton growth and thus to enhanced Chl-a concentration. This feature is also visible in the SAR image in Panel (c) by a reduction of the image intensity or radar backscatter. The reduction is due to the fact that cold surface water changes the stability of the air-sea interface from neutrally stable to stable and thus the wind stress, which determines the generation of the sea surface ripples, which are responsible for the radar backscatter [4]. The most noticeable feature visible in the zoomed area of the SAR image (Panel (d)) are the short-scale internal waves. The internal waves become visible on SAR images because they are associated with variations of the sea surface current, which modulates the sea surface ripples [5]. From the analysis of a large number of SAR images in conjunction with SST images, we conclude that there must be several mechanisms involved in generating internal waves in the AB. One mechanism is by interaction of tidal flow (modulated by the AIS current) with underwater bottom topography. Another mechanism is by instabilities which develop at sharp fronts associated with sub-mesoscale eddies and filaments. These sub-mesoscale phenomena are expected to affect marine life in the AB.

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CROSS VALIDATION OF SURFACE CURRENTS AT THE SPANISH MEDITERRANEAN SEA

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Abstract

Interannual variability of early summer circulation around the Balearic Islands has been studied since 2001 by geostrophic approximations in the framework of the TUNIBAL monitoring program. In the last years, the Acoustic Doppler Current Profiler (ADCP) was available during the TUNIBAL cruises. A detailed comparison of the geostrophic currents, deduced from interpolation of data obtained from CTD profiles, and currents, directly measured with the vessel-mounted ADCP, will be presented for various cruises. The results will also be compared with altimetry derived currents and modelled currents from the available Copernicus models

Keywords: Currents, Mesoscale phenomena, Western Mediterranea

Interannual variability of early summer circulation around the Balearic Islands has been studied since 2001 in the framework of the TUNIBAL monitoring program [1].

Data and methodology

During the Tunibal surveys, hydrographic stations were 10 nmi apart (approximately 18.5 km). Such spatial resolution allows to resolve the typical regional mesoscale structures, which range from 50 km to 100 km [2]. CTD were obtained from surface to 350 m. Measurements were extended down to 600 m for dynamic height calculations every two hydrographic stations (every 20 nmi).

Dynamic height was calculated by vertical integration of the specific volume, using 600 m as the level of no motion [3]. At shallow stations, or when data was recorded only down to 350 m, the density anomaly of the closest station (closer than 15 nmi) was assigned at the lower recorded level. Horizontal hydrodynamic fields were objectively analyzed onto a regular grid by using minimum error variance methods [4]. Geostrophic velocities were obtained by the first-derivative of the dynamic height profiles objectively analyzed onto the regular grid.

ADCP currents were measured using an ADCP Teledyne RDI 150 kHz system using alternative broadband ping (4 m bins) and narrowband ping (8 m bins) without bottom tracking. Data was analysed using the CODAS processing software from the University of Hawaii Currents Group [5]. Results were interpolated onto the same regular grid that had been used for geostrophic calculations.

Results

Preliminary results are obtained for summer 2023 TUNIBAL_0623 cruise. The top figure shows the measured ADCP speed at the bin centered at 20 m depth with the direction indicated by the arrows. Red line shows the vessel route. Bottom figure shows the geostrophic speed calculated from the interpolated CTD data at 15 m depth. Calculated geostrophic speed seems to be smaller than measured speed. This may be due to the correlation length used to smooth the interpolated data.

Detailed analysis of the effect of correlation lengths on the calculated geostrophic currents will be presented. Results will be compared with altimetry derived currents and modelled currents.
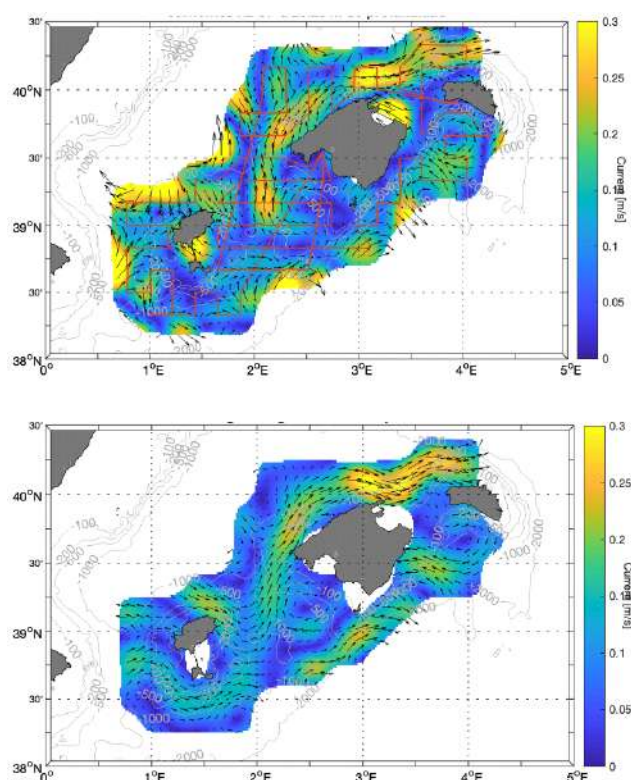
Acknowledgements

Fig. 1. Top: measured surface currents. Bottom: geostrophic currents calculated from CTD data

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FINE SCALE OBSERVATION OF THE PELOPS ANTICYCLONE (EASTERN IONIAN SEA) IN WINTER 2024

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Abstract

An extensive investigation the Eastern Ionian Sea was conducted during the oceanographic cruise PROTEION in March-April 2024 (R/V L'Atalante, La Seyne sur Mer – Kalamata – La Seyne sur Mer). The large collection of hydrological and dynamical data provided a fine scale description of a remarkable mesoscale structure: the PELOPS anticyclonic eddy, and its influence on the regional circulation, at the crossroads of Atlantic Water and Cretan/Levantine Intermediate Water. This new investigation contributed to refine the assumption of the Taillandier et al (2022) which pointed out the role of Pelops anticyclones in buffering newly formed LIW among the thermohaline circulation of the Mediterranean Sea.

Keywords: Ionian Sea, Mesoscale phenomena

Introduction

Pelops eddies have been mentioned in the literature for a long time [1] and many times since then (e.g. [2,3]). The reason this vortex is so often mentioned is because it is a very stable mesoscale anticylconical structure of large size (~150km diameter) and is quasi-permanent whatever the state of the Bimodal Oscillating System -BIOS- [4]. Its persistence can be explained by the formation mechanism advanced for the Ierapetra eddy by [5] but which transposes perfectly to PELOPS. On the other hand, very few studies have focused on its hydrological and dynamic structure a. For this dual reason, [6] proposed the hypothesis that its zone of residence acted as a buffer zone for the transport of intermediate Levantine water. The Proteion campaign (R/V L'Atalante), March/April 2024, focused on a PELOPS eddy at 35°30'N and 21°30'E. It collected a set of both hydrological and dynamic data, enabling us to put forward new hypotheses on its key role as a connector between the Ionian and Aegean Seas and the Levantine Basin.
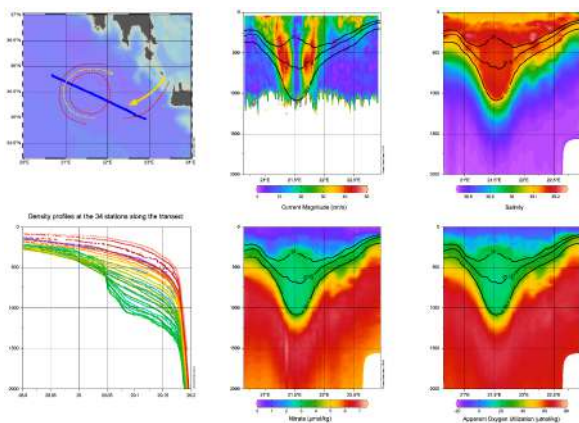

Fig. 1. Top lef map of the transect and sketch of PELOPS position ; top middle horizontal velocity magnitude along the transect and main isopycnal lines ; top right salinity and main isopycnal lines; bottom left collection of all vertical density profiles performed along the transect ; bottom middle : cross eddy vertical nitrate distribution ; bottom right cross eddy vertical oxygen distribution.

Results

A preliminary survey of the area by means of SeaSOAR and VM-ADCP sketched the presence of an intense dynamical structure and its spatial extension over more than 150 km. Then a transect composed of 27 oceanographic stations characterized the vertical extension of the structure, and its hydrological properties. Centered at (20°30'E, 35°30'N), a salty core isolated from the surface stretched down to 1200 m depth. The flanks of the eddy are marked by currents reaching 50 cm/s, which may provide vorticity barrier and avoid any lateral exchange. Thus, water inside the eddy is quite homogenous, in the density class of 29.05, well-oxygenized and depleted in nitrate. For these observations, the eddy can be acting as a large reservoir of newly formed LIW/CIW. The regional circulation looked strongly influenced by the presence of the anticyclone: the dynamical structure stirs around very saline water which undoubtedly originated from the Aegean Seas. As long as, this Cretan Water wraps around the structure, flowing within an intense surface geostrophic jet observed stuck to the western flank of the eddy. In this winter 2024 situation, the eastern side of the Ionian Sea (after 20°E) is retained within a large anticyclonic flow, entrained by the Pelops eddy, gathering surface waters of Atlantic origin and denser waters of Cretan/Levantine origin.

Discussion

Some crucial questions are pending to understand the origin and fate of such long-living Pelops anticyclone. In its stage of formation, the eddy might have been fed by an important discharge of LIW/CIW at the end of winter. The strong summer restratification might have encapsulated this volume by light surface waters, which have not been ventilated again during the following winter, but deepened by the accumulation of lighter water in its capping layer. The wrapping geostrophic jet of Cretan Water might have also inferred a vertical stretching of the eddy, reducing the horizontal extension of its core and intensifying its vorticity barrier. In the situation of winter 2024, the eddy seems stable and slow-moving, as it is trapped by the bathymetric bowl offshore the Peloponnese. However destabilizing processes are expected to act in the future, make the structure evolve and possibly move westwards. Such fate of the eddy is crucial in the perspective of LIW circulation in the Ionian Sea, how it is regulated to a nearly constant flow when leaving the basin at the Sicily strait.

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COMPARING A HIERARCHY OF IDEALIZED DETERMINISTIC-STOCHASTIC MODELS OF THE WIND-DRIVEN SEA SURFACE CURRENTS IN THE GULF OF TRIESTE TO HF RADAR OBSERVATIONS

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Abstract

A hierarchy of idealized deterministic-stochastic models is developed for the Gulf of Trieste (Northern Adriatic Sea), whose current dynamics is strongly influenced by the wind regime. The model includes the tidal signal, Ekman dynamics and a stochastic component that models unresolved processes. The observed velocity's probability density function with fat-tails is reproduced, permitting to study the extreme events statistics.

Keywords: North Adriatic Sea, Models, Currents, Air-sea interactions, Surface waters

Introduction. The Gulf of Trieste (GoT) is a shallow basin in the Northern Adriatic Sea, in which two main strong wind regimes occur: Bora, causing surface water outflow [1] and Sirocco, leading to Adriatic water inflow in the GoT [2]. High Frequency Radar (HFR) sea surface current measurements are performed in the GoT [3]. The amount of data allows us to move from considering low order moments of fluctuating observations to their Probability Density Functions (PDFs). Our study in [4] obtains the analytical fat-tailed PDF of the observed velocity increments in the GoT through superstatistics, a formalism for considering dynamics on two separated time scales, and the principle of maximum entropy. On the other hand, stochastic models [5] consider systems with a clear time scale separation: a rapidly varying "weather" system and a slowly responding "climate" one. As the fast dynamics shows a random-like behaviour, the fast variable is modelled using stochastic differential equations. The noise term can lead to fat-tailed PDFs. This study aims to develop a hierarchy of deterministic-stochastic models that reproduce not only the superstatistical observed fat-tailed PDF, with a focus on extreme power injection events, but allows also for a prediction and interpolation of the current velocities.

Results. The idealized models (DETerministic, ANalytical-Stochastic and STOchastic), defined in Fig. 1, for the sea surface current $\mathbf{u_o}$ include the tidal signal ($\mathbf{u_M}$), the Ekman dynamics ($\mathbf{u_E}$) and, in the cases of the latter two models, the stochastic velocity ($\mathbf{u_S}$). The models are wind forced, using the forecast data from ARPA FVG [6].

Fig. 1. Models definition and stochastic distributions characteristics. Tidal parameters are obtained from the harmonic analysis of the HFR data, h is the considered ocean surface layer depth, c_b is the underlying layer drag coefficient, f is the Coriolis parameter, c_a is the atmosphere drag coefficient, dW_i, dW_x and dW_y are independent Wiener processes. The subscripts "o" and "a" refer to the ocean and atmosphere variables respectively.

The models can be organized in a hierarchical order of complexity. The DET model is totally deterministic, it explains about the 56% of the observed variability, but completely fails in reproducing the velocity HFR/superstatistical PDFs (Fig. 2). The ANS model has a gaussian noise, its velocity PDF misses the fat-tails (Fig. 2) and therefore underestimates

the occurrence of extreme events. The ANS ensemble mean of the velocities do not differ significantly from the DET model results, while the ANS standard deviations differ from the analytical stochastic gaussians and, with the ensemble means, almost coincide with the STO model results. The STO model has an almost superstatistical noise, it shows a lower peak and fatter middle range velocity PDF, while the tails follow a superstatistical behaviour (Fig. 2). The stochasticity permits to reproduce the Ekman dynamics variability.
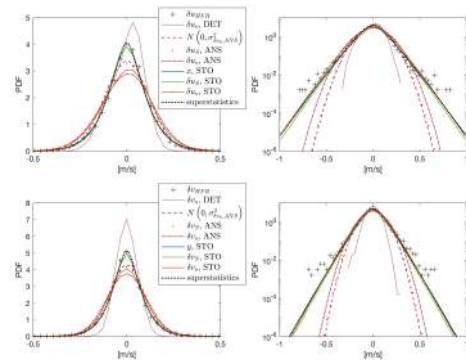

Fig. 2. Observed HFR velocity increments, models variables and superstatistical PDFs, where δu(t)=u(t+δ)-u(t).

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BIOPHYSICAL DYNAMICS IN A SUBMESOSCALE EDDY BY THE SYNERGY BETWEEN SATELLITE SWOT ALTIMETRY AND AUTONOMOUS PLATFORMS

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Abstract

The BioSWOT-Med cruise (https://doi.org/10.17600/18002392) was carried out in the northwestern Mediterranean Sea during the fast-sampling phase of the satellite SWOT mission (i.e., fixed tracks were revisited every 24h), between April and May 2023, contributing to the international efforts of studying the oceanic submesoscale to mesoscale (1 to 100 km) dynamics. The SWOT satellite captured a (sub)mesoscale anticyclone not recognized with conventional (i.e., pre-SWOT) altimetry. In this work, we present the preliminary outcomes derived by autonomous platforms (BGC-Argo floats, gliders, and surface drifters) with high-frequency sampling, in defining the sub mesoscale anticyclonic characteristics.

Keywords: Mesoscale phenomena, Circulation, Remote sensing, Western Mediterranean

Introduction

The ocean's fine scales, which spans around 1-100 km with a short lifetime of days to weeks, play a crucial role in ocean physics and ecology, influencing climate due to their energetic dynamics creating strong gradients. These gradients facilitate vertical exchanges between ocean's surface and its interior, impacting biogeochemical cycles, biodiversity, fish distribution, and mega-fauna foraging strategies. Numerical studies and field campaigns have enhanced our understanding of these processes, but empirical evidence remains limited [1; 2]. Efforts have focused on novel platforms like satellite missions, offering extensive coverage and high spatial-temporal resolution of the ocean surface. While remote sensing doesn't capture fine-scale processes, it provides valuable context, aiding in distinguishing spatial from temporal variability, guiding in-situ sampling strategies, and validating field data representativeness. The deployment strategy achieved high spatial-temporal resolution multidisciplinary measurements within SWOT swaths to resolve biological and physical interactions at fine scales.

Material and methods

The BioSWOT-Med cruise used an adaptive and Lagrangian sampling strategy, determined from near-real time satellite observations analysis, combining in-situ shipborne measurements with drifters, gliders and Biogeochemical (BGC)-Argo floats, to achieve high spatial and temporal resolution measurements within the SWOT passages. Drifters combined with SWOT observations have been able to observe distinct features such as frontal zones, cyclones, anticyclones, and filaments. BGC-Argo floats collected measurements within an anticyclonic eddy and along a meander of the North Balearic front visible in SWOT images. Lastly, glider and Zooglider collected information at the edge and in the center of the anticyclonic eddy, with high resolution sampling.

Results and discussion

The combination of SWOT-HR maps and in-situ observations from autonomous platforms allowed us to explore the three-dimensional structure of the anticyclonic eddy including its temporal evolution and giving new insight about the physical and biogeochemical properties both at the edge and the center of the eddy. As revealed by gliders measurements, the anticyclonic eddy, located south of the front, was characterised by fresher, warmer, and less productive Atlantic Water, and exhibited a distinct horizontal gradient compared with waters north of the front. The BGC-Argo floats captured the changes of the phytoplankton biomass along the water column and its temporal evolution. In addition, such robotic platforms enable to characterize the 4D changes of particulate organic carbon at the boarder of the gyres. This study demonstrates the importance of performing a synergic approach combining unprecedented high resolution satellite observations from SWOT and autonomous platforms (BGC-Argo floats, gliders, and drifters) to unveil the bio-physical dynamics at fine scales both in space and time which are at the base of ocean ecosystem functioning.
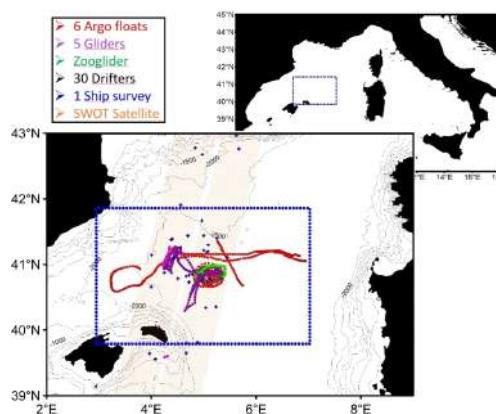

Fig. 1. Study area during the BIOSWAT-MED experiment, alongside with fixed ship survey (blue cross), glider (purple circle), BGC-Argo Float (red circle), drifter (black circle), zoo-glider (green circle) and SWOT swaths (orange area) in the Wester Mediterranean Sea.

BIOSWOT-Med Science Team: Francesco d'Ovidio, Maristella Berta, Aude Joel, Massimo Pacciaroni, Elena Mauri, Giulio Notarstefano, Pierre Marie Poulin, Luca Centurioni, Anthony Bosse, Anne Petrenko, Maxime Arnauld, Pascale Bouruet-Aubertot, Bàrbara Barceló-Llull, Roxane Tzortzis, Louise Rousselet, Robin Rolland, Sven Gastauer, Mark Ohman.

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EFFECTS OF ROSSBY WAVES ON THE EASTERN MEDITERRANEAN MESOSCALE DYNAMICS DRIVEN BY THE MID MEDITERRANEAN JET: EVIDENCE FROM A MULTI-METHODOLOGICAL APPROACH

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Abstract

The most prominent and persistent feature of the eastern Mediterranean Levantine Basin (LB) is the warm anticyclonic Cyprus Eddy (CE) located above the Eratosthenes Seamount (ESM). The center of the CE moves between 31.75° – 33°E and two smaller cyclonic and anticyclonic eddies, the South Shikmona Eddy (SSE) and North Shikmona Eddy (NSE), occasionally form downstream of the CE. The reason for this zonal drift and the formation mechanism of the CE, the SSE and the NSE is largely debated today. Using coherent results from a variety of research methods - theory, models, laboratory and field experiments - we give a precise answer to the CE, SSE and NSE formation mechanism, and we show that the LB and Ionian dynamics are highly correlated.

Keywords: Levantine Basin, Ionian Sea, Circulation models

In the present study we show that the Cyprus Eddy (CE) is an anticyclonic Taylor column generated by the eastward Mid Mediterranean Jet (MMJ) impinging over the Eratosthenes Seamount (ESM) and that the wake meandering downstream is a standing Rossby wave whose embedded cyclonic and anticyclonic eddies correspond to the South Shikmona Eddy (SSE) and North Shikmona Eddy (NSE), respectively (Fig.1).
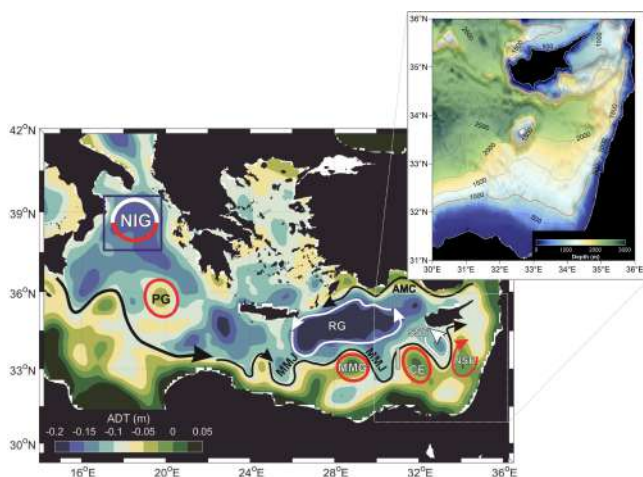

Fig. 1. Absolute Dynamics Topography (ADT) averaged for the period January-March 2015. Black arrow indicates the Mid Mediterranean Jet (MMJ). Red circles indicate anticyclonic eddies: Pelops Gyre (PG), Marsa Matrouh gyre (MMG), Cyprus Eddy (CE), North Shikmona Eddy (NSE), and North Ionian Gyre (NIG) anticyclonic mode. White circles indicate cyclonic eddies: Rhodes gyre (RG), South Shikmona Eddy (SSE) and the NIG cyclonic mode. The incoming flow Uo averaged in the upper 1000 m was computed across the section 33-34° N, 31° E highlighted by the gray line. The topography of the study area is shown in the upper corner of the figure.

Furthermore, we prove that the position of the CE center is regulated by the intensity of the incoming MMJ and thus, by the dynamics of the North Ionian Gyre (NIG). The formation mechanism of the mesoscale eddies in the Levantine Basin (LB) was demonstrated for the first time with scaled laboratory experiments (based on 2015 in-situ ocean data) in the Coriolis Rotating Platform LEGI rotating tank. These experiments were carried out under both homogeneous and stratified fluid conditions and following the work of [1]. The ESM was represented by a bump (L=34.5 cm, ho'=21 cm) placed on an inclined boundary (slope s=0.1) that reproduced the topographic ß-plane effect. The tank

was filled with water at a depth of H=47 cm at the section on the top of the bump on the inclined boundary. The barotropic inflow Uo=0.7 and 1.4 cm/s was considered. Results show that for both homogeneous and stratified conditions the system CE, SSE and NSE forms, although in the case of high Uo, the center of CE is more shifted to the west. This simulation is observable in the LB solely when the center of the CE is west of 32.7°E allowing room for the development of a Rossby wave with a zonal wavelength ranging between 180 and 250 km. Using 1993-2021 reanalysis data, a time series correlation analysis between the CE longitude center (detected with the TOEddies algorithm from[2]) and the velocity Uo averaged in the upper 1000 m depth at the section upstream the ESM (Fig. 1), is performed. It shows that the CE starts to move westward when Uo exceeds ~ 3 cm/s and reaches a maximum of ~ 6.5 cm/s (in agreement with the laboratory experiments and in-situ glider data) whereas, when Uo decreases from ~ 6.5 to ~ 3 cm/s the CE shifts eastward. We also show that this strengthening/weakening of Uo and therefore of the MMJ, depends on the cyclonic/anticyclonic mode of the NIG, respectively, about three years ahead. These results emphasize the key role that the central Mediterranean Sea plays on the LB mesoscale dynamics and that the coherent results of the multi-approach used are proof of the uniqueness and reliability of our work

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UPPER LAYER MEDITERRANEAN WATER REVEALED BY HIGH RESOLUTION OBSERVATIONS SOUTH OF CAPE SÃO VICENTE, WESTERN GULF OF CADIZ

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Abstract
The ocean at the shelf break off SW Iberian Peninsula, was intensively sampled during the summer 2022. High resolution (2 Hz) and high temporal density (5-6 profiles/hour) vertical profiles of temperature, salinity, Chla, turbidity and dissolved oxygen were acquired, along with the vertical description of the horizontal velocity. An abrupt temperature and salinity increase was detected between 20-140 m, along with a decrease in chlorophyll concentration, appearing as a "blob" of a water resembling the signature of Mediterranean Outflow Water (MOW). Ahead, an increase in westward flow was observed, followed by a sudden eastward veering at the time of the event, suggesting the appearance of a shallow eddy carrying MOW in its core. Although previously hypothesized, this is the first direct evidence of MW at such depths.

Keywords: Gulf of Cadiz, Mesoscale phenomena, Continental shelf

In the frame of the European Multidisciplinary Seafloor and water column Observatory (EMSO-ERIC) the Iberian Margin Cape São Vicente observatory (IbMa-CSV) was deployed at the edge of the continental slope, 10 nm south of Cape São Vincente (CSV), the SW tip of the Iberian Peninsula (Fig.1). The observatory comprise an EMSO Generic Instrument Module (EGIM), a vertical wave-powered profiler (Wirewalker), and an acoustic-doppler current profiler (ADCP) (Fig.1). The instruments operated for a period of four months during the summer 2022, at 200 m depth (EGIM), and from 150 m to near-surface (profilers). A time series of high resolution (2 Hz) and high temporal density (5-6 profiles/hour) of vertical profiles of temperature, salinity, chlorophyll-a, turbidity and dissolved oxygen was acquired, along with the vertical description of the horizontal velocity.
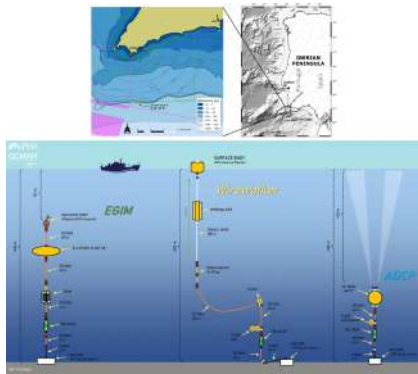

Fig. 1. Location of the EMSO-ERIC IbMa-CSV observatory (**top**) and the single point EGIM mooring anchored at 200 m depth (current velocity and direction, passive acoustics, conductivity, temperature, absolute pressure, dissolved oxygen, turbidity) (**left**), Vertical wave power profiler Wirewalker traveling the top 150 m of the ocean collecting data at 2 Hz and 5/6 profiles per hour (conductivity, temperature, pressure, dissolved oxygen, turbidity, chlorophyll-a) (**middle**), and the upward looking ADCP moored at 200 m depth profiling the top 150 m of the ocean (current velocity and direction, and temperature) (**right**).

The analysis of the data collected at the IbMa-CSV observatory reveal an abrupt temperature and salinity increase at depths between 20-140 m during a five day period in June, appearing as a "blob" of a water mass from a different origin, resembling the signature of MOW (Fig. 2 A-D). A decrease in chlorophyll concentration was observed in this period, an indicator for MOW (Fig. 2F). Ahead, an increase in westward current from averaged 0.09 ms-1 to 0.39 ms-1 was observed (Fig. 2G), followed by a sudden change in direction towards the east at the time of the event, suggesting the appearance of a shallow eddy carrying MOW in its core.
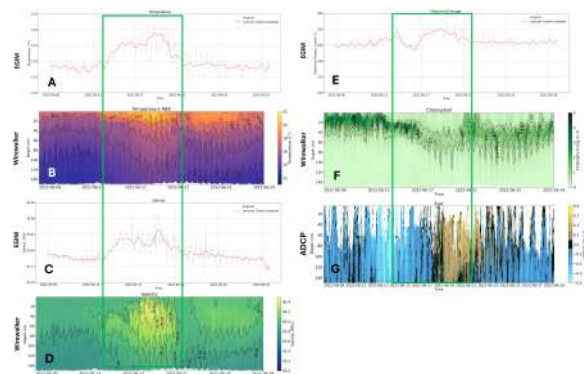

Fig. 2. Time series 8 to 30 June 2022: Temperature (**A**), Salinity (**C**), Dissolved oxygen (**E**), at the EGIM, at the 200 m depth; Vertical field of Temperature (**B**), Salinity (**D**), Chlorophyll-a (**F**), from the wave powered vertical profiler (Wirewalker) from near surface till the 150 m depth; Vertical field of the zonal component of the velocity from the ADCP data (**G**). The green box encompasses the five days period of anomalous parameters, claimed as a shallow sub-mesoscale eddy carrying mediterranean water.

A vein of MOW, leaning the northern continental slope of the GoC and turning poleward around the CSV, was identified before at depth as shallow as 350 m in the region (Ambar, 1983). The possible interaction of this MOW shallow core with the upper layers of the ocean, and consequent interaction with the upwelling mechanism, was already hypothesized by Fiúza (1982). However, the observation of MOW at such upper layers was never experienced. Our findings suggest that a sub-mesoscale eddy detached from the shallow vein of MOW, shoaling upwards the continental slope, reaching the upper 20-140 m layer. The rough topography, such as the Portimão Canyon, as well as the Ekman suction, characteristic of the enhanced upwelling center off CSV, are the major candidates to explain this feature, and must be further investigated. The moored observatory south of CSV offers great opportunities to acquire long-term and continuous water column data, able to capture sudden events such as the one described here and provides valuable datasets for model validation.

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UNLOCKING THE CIRCULATION PATTERNS OF THE LEVANTINE BASIN

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Abstract

The current contribution aims to unlock the circulation patterns of the Levantine based on, a) long term in-situ monitoring gathered mainly during CYBO and HaiSec cruises at the post POEM period, b) Mediterranean MEDREA16 reanalysis, c) the available reanalysis datasets from the Copernicus Marine Service, and d) dedicated numerical experiments, all of which provide answers not only about the generation mechanisms of the Cyprus and Shikmona eddies, but also on the Mid-Mediterranean Jet as an offshore, cross basin current.

Keywords: Circulation, Mesoscale phenomena, Levantine Basin

Introduction

The results from the pioneering POEM cruises (1985-1990) undoubtably revolutionized our understanding of the mesoscale circulation pattern in the Levantine basin, composed of cyclonic and anticyclonic eddies interconnected by an offshore cross basin jet, named as the Mid Mediterranean Jet (MMJ) [1]. It was shown that the dominant feature in the south-eastern Levantine was a non-permanent, multi-pole gyre, one eddy offshore Egypt, a secondary eddy offshore Israel-Lebanon and a third eddy closer to the Eratosthenes Sea Mount (SM) [2]. During the post POEM period the generation mechanisms of the Cyprus and Shikmona eddies remained unresolved, leading to confusion between the Shikmona eddy and the Cyprus eddy. Moreover, the existence of the MMJ as an offshore cross basin current was also challenged [3].

Discussion

To address the above-mentioned uncertainties, two large in-situ datasets (CTDs and XBTs) gathered in the SE Levantine from 1995-2015 were analysed recently by a collaborative team and combined with the Mediterranean MEDREA16 reanalysis [4], the Copernicus Marine Service reanalysis and with results from extensive numerical model simulations to investigate the generation mechanism of the Cyprus eddy [5].

The difference between eddies and gyres is primarily scale dependent with the gyres being the larger (sub basin or basin) and quasi-permanent features, while eddies are smaller and shorter lived. As noted by Beer (1996): "there is no single size characterising coastal and oceanic eddies. They exist in all sizes from globs of water a few centimetres in size to large eddies associated with boundary currents that can be 200 km across". A vortex with a mean spatial extent between 80-100 km, such as the Cyprus vortex, which is associated with a boundary current (MMJ), obviously cannot be defined as a gyre. Since POEM, the Cyprus vortex was defined as an eddy, that is documented to undergo strong seasonal and interannual variability [4]. The location of an anticyclonic eddy center along a vertical cross section is designated as the point with the deepest depression of the isotherms at the base of the warm, saline thermostad forming the core of the eddy, or the highest point in the horizontal map of the dynamic height topography. The thermohaline vertical structure of an anticyclonic eddy is an inverted cone, while for a cyclonic this is reversed.

The analysis of the dynamic height topography during two decades of post POEM data revealed that, a) the most prominent mesoscale features are the anticyclonic Cyprus eddy appearing in the vicinity of the Eratosthenes SM and the Shikmona eddy which appears to the southeast of the Cyprus eddy; b) there is significant migration of the Cyprus and Shikmona eddies' centers, where Cyprus eddy center migrates eastward and south-eastward from the Eratosthenes SM, while during periods of the appearance of the Shikmona eddy offshore along the Israel-Lebanon shelf and slope, the Cyprus eddy is forced to migrate westward or south westward from the Eratosthenes SM.

The trajectories of drifters deployed offshore Israel [7] showed that when the northward flowing current along the Israel-Lebanese shelf and slope becomes unstable and meanders offshore, an anticyclonic Shikmona eddy was formed. During these events the Cyprus eddy shifted westward or south westward from the Eratosthenes SM.

To examine the mechanism responsible for the generation of the Cyprus eddy, a three-layer quasi-geostrophic model was implemented to examine the topographic eddies generated around the Eratosthenes SM [5]. The numerical experiments were carried out using the Contour Dynamics Method, imposing an eastward flow with different inclinations and intensities along the western boundary of the model domain to imitate the MMJ. The consideration of baroclinicity simulated a single vortex attributed to the Cyprus eddy accompanied at its periphery by a small-scale cyclone. These numerical experiments showed qualitative agreement with the geostrophic patterns derived from the CYBO in-situ observations around the Eratosthenes SM.

Dozens of salinity profiles gathered along 33°E north-south cross sections, from Cyprus to Egypt, together with the geostrophic currents computed along the same transects clearly reveal a salinity minimum in subsurface layers, attributed to the Modified Atlantic Water (MAW) which is transported: a) eastward by a strong current flowing between the southern shelf of Cyprus and northern flank of the Cyprus Eddy, b) westward by a weaker flow along the southern flank of the Cyprus Eddy and c) eastward along the North Egyptian shelf and slope. The analysis of the CYBO and HaiSec datasets regarding the pathway of the MAW confirms the POEM group's results [1] describing the MMJ as a cross basin offshore current, thus putting to rest the dispute regarding its existence.

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CIESM Congress Session : Mesoscale and sub-mesoscale variability II
Moderator : Katrin Schroeder – ISMAR-CNR, Venice, Italy

Session's Synthesis

The main issues debated comprise physical and biogeochemical characteristics of water mass. The PIONEER Cruise provided a comprehensive overview of the physical and biogeochemical properties of the water masses in the Gulf of Taranto. The study highlighted the vertical structure, horizontal variability, and distribution of water masses, offering insights into the dynamics influenced by various oceanographic processes. We also discussed about the role of mesoscale eddies, crucial elements in the transport and mixing of heat, carbon, and nutrients. These eddies create unique habitats with distinct physicochemical conditions, supporting diverse marine life. The study examined the areas of influence and seasonality of these eddies in the Southeastern Mediterranean Sea. The coupling between fine-scale physical structures and biodiversity was explored, particularly in the context of phytoplankton dynamics across a frontal system in the Mediterranean Sea. The BIOSWOT-Med campaign utilized advanced remote sensing technologies to achieve high spatio-temporal resolution, revealing the intricate interactions between physical and biological processes. Furthermore, it was discussed that the effects of surface circulation in the Ionian Sea on the biodiversity of larval fish communities off southern Sicily were analyzed. The study found that the frontal area south of Cape Passero provides favorable conditions for fish larvae survival and development, with biodiversity patterns linked to the alternating cyclonic and anticyclonic modes of the North Ionian Gyre.

The discussions in this session emphasized the complexity and interconnectedness of marine ecosystems. The detailed studies on physical and biogeochemical variability, mesoscale eddies, and fine-scale dynamics provided a deeper understanding of the factors influencing marine biodiversity. The innovative use of remote sensing technologies and long-term datasets showcased the advancements in marine research. Overall, the session highlighted the need for continued multidisciplinary approaches to address the challenges in marine science and conservation.

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PHYSICAL AND BIOGEOCHEMICAL VARIABILITY IN THE GULF OF TARANTO. RESULTS OF THE PIONEER CRUISE

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Abstract

We present a description of the large-scale physical & biogeochemical characteristics of the water masses and their distributions in the Ionian Sea, along the transect closing the Gulf of Taranto. Oceanographic data were collected during the PIONEER cruise: a CNR initiative of a multidisciplinary cruise "Processes in the Ionian Sea:Exploring, Experimenting, researching" carried out in winter 2023. Physical & biogeochemical properties have been measured. Preliminary, results about the vertical structure,horizontal variability and the distribution of the water masses cores are discussed.This study delineates the large-scale physical & biogeochemical characteristics of water masses within the Gulf of Taranto transect. Our findings reveal insights into the dynamics of water masses influenced by various oceanographic processes.

Keywords: Eastern Mediterranean, Ionian Sea, Salinity, Oxygen, Circulation

The Ionian Sea, a sub-basin of the EMED, is a confluence zone for Atlantic Water (AW) and Eastern Intermediate Water (EIW), with origins traced to the Levantine and Cretan Seas. The sub-basin is an exceptional case study to investigate processes/dynamics of the deep layers in the light of turbulent and diapycnal mixing due to internal-wave breaking. Its proximity to the Gulf of Taranto, a strong industrialized coastal system considered as an important source of contamination for the intermediate and deep waters (DW). Nevertheless, this peculiar coast-to-sea Taranto system remains poorly investigated . Within this context, PIONEER-2023 has been carried out across the deep Ionian Sea and the Gulf of Taranto in November/December 2023. A total of 36 CTD stations (Fig. 1) were collected during which physical (temperature, salinity and velocity) and biogeochemical (oxygen, nutrient and carbonate system) tracers were measured to detect changes. Results indicate the presence of four distinct water masses (Fig.1). Surface waters, potentially linked to the Western Adriatic Coastal Current (WACC), exhibit considerable variability in O2 and salinity. Intermediate waters are characterized by salinity maxima and temperature gradients indicative of diapycnal mixing. DWs show a reduction in salinity and O2, with signals of O2 enrichment below 1000m depth. Warm surface waters, originating from the Adriatic and distinguished by their low salinity, are conveyed by the WAC Current. This current possibly transports the surface water. Notably, there is considerable variability in this surface layer; as depicted in Fig.1, the water masses at the transect's edges exhibit lower O2 levels compared to the central region. The central surface water mass is not only cooler but also possesses a higher salinity. Below 100meters, salinity reaches its maximum at 189m depth. Here, we identify two distinct intermediate water masses: the first is warmer, with a temperature of 15°C, has a salinity of 39.21, and a lower density of 29.2 σθ. In contrast, the second is cooler at 14.8°C, has a salinity of 38.19, and a higher density of 29.25 σθ. The T-S reveals variations in water properties below the 29.2 σθ isopycnal, which corresponds to depths between 100-200 meters, indicative of the intermediate water characteristics. This stratification suggests the presence of diapycnal mixing processes. In the deeper layers of the transect, a pattern emerges where lower salinity corresponds with diminished O2 levels. The DW here are both cold and dense, exhibiting a relatively reduced salinity that suggests an Adriatic origin, as pointed out by Pinardi et al. (2016). Notably, the S-O2 diagram in Fig.1 indicates an increase in O2 below 1000 meters. Further exploration is presented in Fig.1, clearly illustrates the influence of Adriatic waters, as evidenced by distinct salinity and temperature profiles. The stratification and exchange of various water masses are captured, highlighting the dynamic interactions at play. The surface layer, extending to a depth of less than 50 meters, exhibited warm temperatures ranging from 16-17.3°C. This layer also showed low salinity levels, both at the surface and the bottom, which is indicative of an outflow consisting of fresh and dense water. Notably, the surface water entering from the Adriatic was warmer compared to that on the western side of the transect. In the subsurface zone, between 100-200 meters, Fig. 1 highlights three distinct peaks in salinity that may signal the presence of the EIW core. Further down, >1000 meters, two streams of water with a relatively high salinity of 39.03 were identified. The vertical profile of O2, as shown in Fig.1, indicates a notable subsurface peak of O2 concentration, reaching 240 μmol kg-1. This peak suggests active downwelling processes that transport O2 to intermediate depths. At these depths, enhanced levels of O2 are

observed centrally and at both edges of the transect, indicative of a well-oxygenated water column. An influx of oxygen-rich water is evident from the Adriatic, contributing to this pattern. Moreover, O2 profile supports the presence of oxygen-enriched currents flanking the sill, which may play a role in the ventilation of DW layers. Pinardi et al.(2016) identified an anti-cyclonic gyre in 2014, while Federico et al.(2020) observed a shift in circulation patterns from anticyclonic to cyclonic. This suggests that the inflow of warm, saline Adriatic surface water into the GT, at depths ranging from 70-150 meters, supports the current evidence of cyclonic circulation. To understand the vertical mixing mechanisms at play, the Turner angle was analyzed, which helps to pinpoint regions within the water column where different types of double diffusion occur. The predominant regime is salt fingering, identified within the range of 45°<Tu<90° (Fig.1). Evidence of diffusive convection is apparent on both sides of the transect, corroborating the observations of fresh, cold water overlaying a saline vein near the seabed. Observations allowed to assess the mixing and the intrusion of the Adriatic water into the GT and inflow to the Ionian and EMED. This study underscores the region's role as a critical nexus for water mass transformation.
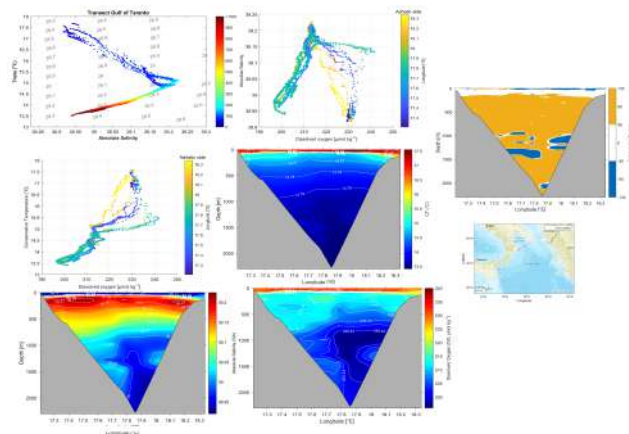

Fig. 1. Water mass properties and vertical cross-sections of Temperature, salinity, oxygen and Turner angle along the Gulf of Taranto transect.

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MESOSCALE EDDIES AS POTENTIAL ZOOPLANKTON TRANSPORT VECTORS

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Abstract

Ocean eddies play a vital role in the transport and mixing of heat, carbon, and nutrients. They form unique habitats with distinct physicochemical conditions, characterized by high (cyclone) or low (anticyclone) biological productivity, supporting a wide variety of organisms from phytoplankton to zooplankton, as well as the larvae and eggs of benthic organisms and fish. The mean lifetime of cyclonic and anticyclonic eddies in the Southeastern Mediterranean Sea (SEMS) is 122 ± 25 & 98 ± 9 days, respectively, suggesting this timeframe is sufficient for the accumulation of community composition changes due to increased or decreased reproduction and selection processes. We examine the areas of influence (AOI) of mesoscale eddies and their seasonality in the SEMS as a potential mechanism for species facilitation via selection and transport.

Keywords: Mesoscale phenomena, Zooplankton , Larvae, NIS, Eastern Mediterranean

Complex and persistent eddying activity was observed in the ultra-oligotrophic SEMS [1], where eddies are particularly important as they can create islands of high productivity within this impoverished, Low-Nutrient-Low-Chlorophyll region [2]. Furthermore, eddies can promote the dispersal of native and non-indigenous biota [3]. Current knowledge on the impact of eddies on biodiversity is scarce, and the contribution of submesoscale physical forcing to ecosystem dynamics remains uncertain, especially in the SEMS, which is experiencing a major biodiversity shift due to climate change and bioinvasions.

Here we used the DYNED Atlas [4] to characterize the estimated AOI of anticyclonic (ACE) and cyclonic eddies (CE) in the SEMS over a two-decade period (Fig. 1 a&b). The area of influence was calculated as the geometric convex hull of their trajectories buffered by their detected radius at each timestep. This analysis revealed that although some long-lived (>400 days) CE had a large area of influence, ACE area of influence is much denser in the southeast Mediterranean Sea (Fig. 1a) compared to CE areas of influence (Fig. 1b), with the exception of the Marsa Matruh area. The monthly analysis of eddy occurrences showed a bimodal pattern and months in which both ACE and CE activity are more pronounced (Fig. 1c). Whereas, during July there is less eddying activity in general. This dynamic might be critical for the dispersal of larvae and eggs of species that reproduce during these months with varying levels of dependency.

To analyze eddy connectivity, eddy trajectories were generalized and aggregated using the Douglas-Peuker algorithm to simplify and decrease the number of points along a trajectory, following the identification of regions of significance by clustering the coordinates along the trajectories, and lastly aggregating trajectories that cluster to and from those assigned clustered points [5]. The aggregated movement patterns of eddies reveal movement along the Israeli coast in both northward and southward directions. In some cases, the eddy origin and destination were located within the next adjacent point. The Israeli coast seems to be a birthplace of both ACE and CE.

These movement patterns demonstrate potential transport and entrainment processes that these eddies facilitate. Using an ocean glider mounted with a UVP6-LP [6], we map and quantify zooplankton abundance in CE and ACE in situ and observe the particle distribution profiles that can be sustained over the deployment time frame.
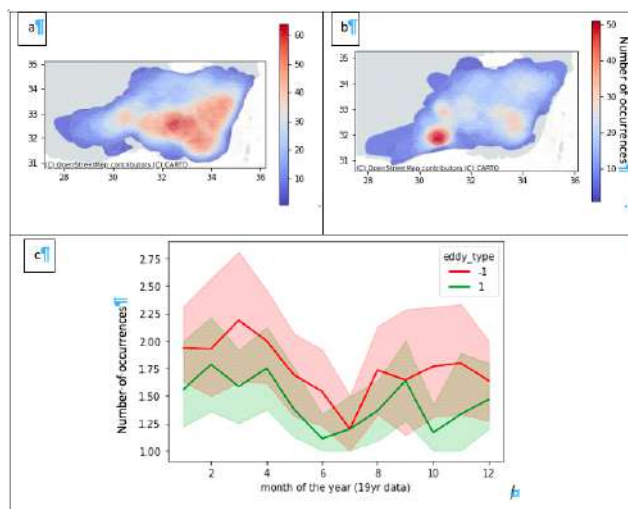

Fig. 1. Overlaid areas of influence of eddies for a 19-year Dyned Atlas dataset for Anticyclonic (a) and Cyclonic (b) over their lifetime. The area was calculated as a geometric convex hull of their trajectories buffered by their radius at each time step. (c) The monthly occurrences of mesoscale eddies.

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COUPLING BETWEEN FINE-SCALE STRUCTURE AND BIODIVERSITY: WHY PHYTOPLANKTON DYNAMICS IS CONTRASTED ACROSS A FRONTAL SYSTEM IN THE MEDITERRANEAN SEA

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Abstract
The oceanic fine scales (1-100 km, with lifetimes of days to weeks) profoundly influence ocean dynamics and ecology. Their energetic dynamics create strong gradients with vertical transport, linking surface and deep layers. Despite advancements in numerical modeling, empirical evidence for fine-scale processes remains limited. Remote sensing, with the new NASA-CNES SWOT satellite, offers synoptic views crucial for understanding spatio-temporal variability. The BIOSWOT-Med campaign (2023) focused on the Mediterranean Sea, known for high biodiversity and oligotrophic conditions. The adaptive sampling strategy and innovative methodologies achieved high spatio-temporal resolution. Preliminary results show the coupling between physical and biological processes at fine-scale.

The oceanic fine scales (1-100 km) have relatively short lifetimes (days to weeks) but crucially affect ocean physics and ecology up to the climate scale, due to the strong gradients created by their energetic dynamics. These gradients are associated with strong vertical transport connecting the ocean's upper layer to its interior. Moreover, the temporal scale associated with this horizontal and vertical dynamics is the same as that of many important oceanic processes including biogeochemical cycles, biodiversity, fish distribution, and even foraging strategies of the mega-fauna. Over the past few decades numerous numerical studies with physical and biophysical configurations for km-scale processes allowed significant progress in characterizing this regime. Field campaigns have also shown that individual fine-scale features may be experimentally targeted, but these in situ studies are usually biased by the choice of targeting the stronger and longer-lived features. Then, an important lack of empirical evidence for fine-scale processes remains. The scientific community has been focusing large efforts on novel platforms. Among these are satellite missions that provide extended coverage and high spatio-temporal resolution of the ocean surface. Obviously, remote sensing does not provide ground truth of all fine-scale physical and biophysical processes, but can provide a critical resource that helps to define the synoptic context of fine-scale features, helping to disentangle spatial from temporal variability, supporting adaptive in-situ sampling strategies, and assessing the representativeness of field data. In this context, the NASA-CNES satellite SWOT (Surface Water and Ocean Topography), launched on 16 December 2022, is the most ground-breaking mission for ocean science in the near future. Indeed, with respect to current nadir measurements the new SWOT altimeter sees two-dimensional scenes, like sea surface temperature and ocean color, but without being affected by clouds. Moreover, during its initial so-called « fast sampling phase », it associates to high spatial resolution a 1-day revisit period over ~150 km wide oceanic regions, a feat never achieved in the past, and not expected from other planned missions in the future. The BIOSWOT-AdAC project (PI F.d'Ovidio, A.Doglioli, G.Grégori, S.Speich and P.Garreau), funded by the NASA-CNES joint call for the SWOT Science Team, focuses on the specific opportunities of the SWOT fast sampling phase, promoting the international consortium SWOT-AdAC endorsed by CLIVAR, coordinating several field campaigns during this specific period of the satellite mission. The BIOSWOT-Med campaign contributes to this international effort, focusing on the Western Mediterranean Sea. The latter is the ideal area to verify the hypothesis considering the fine scale circulation as the driver of the plankton biodiversity. Indeed, here a high biodiversity is associated to conditions of oligotrophy and moderate energy, unlike oceanic areas as western boundary currents or eastern boundary upwellings that are largely explored and where the intense dynamics or the large nutrient input can mask the fine-scale coupled dynamics. An adaptive and Lagrangian sampling strategy was applied combined with innovative methodologies allowing to obtain high spatio-temporal resolution multidisciplinary measurements in the SWOT swaths (see figure below, with the SWOT ground tracks in gray and the ship's route colored by date).
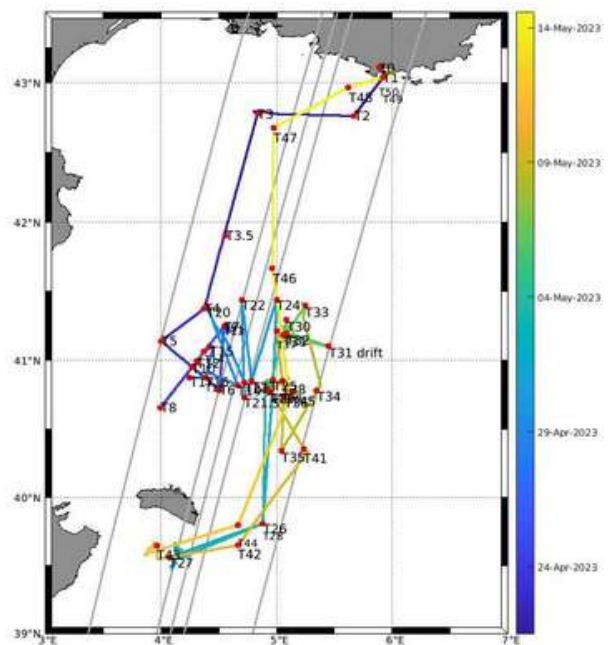

Fig. 1. Map of the region investigated in the Western Mediterranean Sea onboard the r.v. L'Atalante (F.O.F) during the BioSWOT-Med cruise (2023)

The BIOSWOT-Med cruise aims to improve our understanding of the coupling of physical processes to biological ones from viruses to zooplankton. As the Mediterranean conditions are representative of a large majority of the world Ocean, our research has a global significance. Moreover, our highly interdisciplinary research it aims to highlight the importance of the SWOT mission data for biogeochemical and ecological studies. Finally, our in-situ experiment will also bridge a long-standing gap between modelling and global observations for assessing the role of the ocean fine scale on the Earth system.

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EFFECTS OF SURFACE CIRCULATION IN THE IONIAN SEA ON THE BIODIVERSITY OF LARVAL FISH COMMUNITY OFF SOUTHERN SICILY (MALTA CHANNEL)

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Abstract
Off the southern coast of Sicily, the frontal area south of Cape Passero (Malta Channel) provides favorable conditions for fish larvae survival and development, and hosts a biodiversity hotspot for larval assemblages. Using data from 16 ichthyoplankton summer surveys carried out between 2001 and 2016, our results show in the same area a cyclical pattern in the Shannon index, which appears to be linked to the alternating cyclonic-anticyclonic modes of North Ionian Gyre's (NIG). Specifically, the cyclonic mode of NIG, in enhancing the advection of Atlantic Water towards the southern Levantine basin, is supposed to strengthen the frontal thermohaline structure, as indicated by lower surface current speeds across the front, so fostering the retention and the survival rates of fish larval stages.

Keywords: Biodiversity, Fishes, Larvae, Circulation, Malta Channel

Introduction
Local surface circulation in the Strait of Sicily (SoS) is dominated by the motion of the Modified Atlantic Water (MAW), which off the southern Sicilian coast is known as "Atlantic Ionian Stream (AIS)", a meandering current flowing towards the Ionian Sea. The path of AIS is characterized by year to year variability, with consequences on the predominant hydrological phenomena occurring in the region, such as, on the extension of coastal upwelling and on the formation of frontal structures, in particular in the eastern border of Malta Channel off the southern-most tip of Sicily (Cape Passero). The AIS affects the distribution on eggs and larvae of many fish species, in particular of small pelagic species, which are mostly distributed on the surface layer. Previous studies have shown that the frontal area off Cape Passero is characterized by environmental conditions that are good for the survival and development of fish larvae [1]. It was also supposed that a longer permanence over the frontal area of fish larvae might be beneficial for the recruitment success, and eventually even impact on the biomass of the entire parental fish stocks. For the anchovy stock, in particular, a recent study evidenced how the yearly biomass of adult population at time *t* can be largely predicted by just using simple indices of larval retention in the shelf area at time *t-1* built on the yearly distribution of eggs [2]. Using survey-based information involving the whole summer ichthyoplankton assemblages in the SoS over the period 2001-2016, a recent paper found a biodiversity hotspot in shelf stations located across the frontal structure South of Cape Passero [3]. This contribution reports on the temporal patterns of larval assemblages in this area and its relationship with local surface circulation.

Material and methods
Plankton data from 16 summer surveys carried out in the SoS every year from 2001 to 2016 were used for this study. Plankton samples were collected using a bongo net (Bongo40, with 40-cm opening) equipped with a 200-μm mesh size net. The sorting of this material produced in total about 10.000 classified larval specimens, distributed in 15 orders and 49 families. The analysis of temporal changes in the biodiversity of larval fish assemblages over the Malta Channel was addressed by calculating the average yearly Shannon diversity index (*H'*, at the family level) on selected sampling stations across the thermo-haline front South of Cape Passero. The surface circulation features in the same area were evaluated by using *u* and *v* components of geostrophic currents, as delivered by Copernicus Marine Environment Monitoring Service (CMEMS; http://marine.copernicus.eu/).

Results and discussion
Shannon index presented a cyclical pattern (Fig. 1a), which appears to be linked to the alternating cyclonic-anticyclonic modes of the North Ionian Gyre (NIG; [4,5]). Higher biodiversity levels (and total larval abundance; not shown) were found to be associated to the cyclonic mode of NIG, which is able to enhance the advection of MAW towards the southern Levantine basin and to reduce deflection toward the Adriatic, as testified by lower surface current speed across the frontal structure South of Cape Passero (Figure 1b). So, in conclusion, it is postulated that the larval retention induced by the frontal area could be modulated by the strength of the front itself as determined by the alternating cyclonic/anticyclonic modes of NIG.
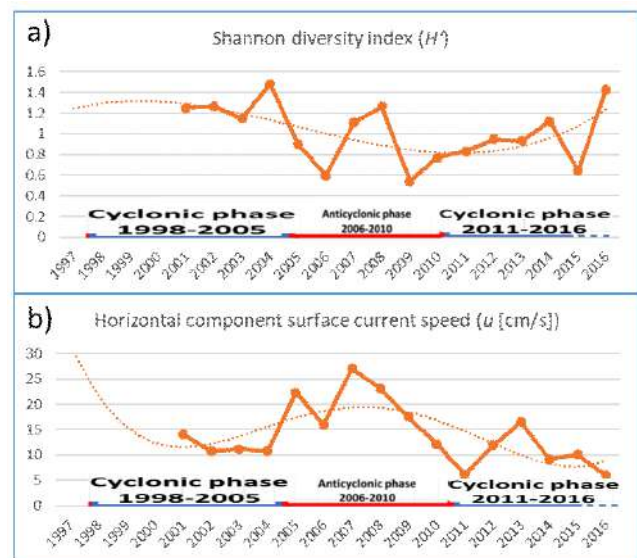

Fig. 1. a) Shannon diversity index of larval fish assemblages (*H'*) and b) Horizontal component of surface current speed (*u*). Data refer to yearly averages in the frontal area south of Cape Passero (Malta Channel) over the period 2001-2016

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Comité 3
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Biogéochimie marine
Président : Marina Mlakar

CIESM Congress Session : Environmental Toxicology I & II
Moderator : Marina Mlakar – Ruđer Bošković Institute, Zagreb, Croatia

Session's Synthesis

In the sessions "Environmental Toxicology I & II", 10 papers covered various topics related to environmental toxicology, apostrophizing topics such as monitoring and wastewater treatment, pollution of water, sediments and biota with various trace metals (Hg, Cd, Pb, Co, etc.) and toxic organic compounds (oils, pesticides). In the session "Bioaccumulation", 8 papers were presented on microplastics in the Mediterranean biota (mussels, copepods, maiofauna) with a focus on filtre-feeding organisms as bioindicators. In addition, the bioaccumulation of heavy metals (Hg, Cd, Pb, Cr, Cu, Fe, Zn, Ni), pesticides and radionuclides in different biota (muscles). The Sessions "Marine litter and nano/ microplastics I & II" included 12 papers dealing with the occurrence and distribution of microplastics in different environmental matrices (seawater, sediment and biota), the assessment of microplastic pollution and the effective treatment of the seawater system. It also dealt with the adsorption of trace metals on microplastics and the effects on the growth and development of various biota in the Mediterranean and Black Seas. warming-induced acceleration of metabolic rates is a systematic change in the spatial patterns of respiration and associated oxygen consumption in the water column. The biogeochemical cycle of the Mediterranean and Black Sea will show increasingly intense changes in the future with climate change having the greatest impact on temperature, salinity and acidity, which in turn will affect the growth and abundance of different species. Atmospheric inputs including the transfer of chemicals from the atmosphere to the ocean, will have a long-term impact on the oceans (e.g. nutrient source, influence on pH), so joint monitoring should be up to date. Effects of stratification and circulation changes - as the ocean warms from above, stratification tends to increase, which together with the effects of stratification and circulation changes leads to a net reduction in oxygen flux between air and sea. The interactions between microbes, trace metals and organic matter with microplastics have severe impact on distribution, circulation, transport and sedimentation of plastics and will be the most important topic for the incoming period. The ecological responses of microorganisms to the deposition of microplastics and plastic-containing chemicals in our seas and oceans are of great importance, leading to changes in phytoplankton community structure, resulting from the unique environmental sensitivity of these groups, as well as significantly altered elemental cycling from the local to the global scale. Therefore all sessions should be highly interactive and promote cross-disciplinary research as well as active and broad collaboration among Mediterranean scientists.

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COBALT CHLORIDE-INDUCED LIPIDOMIC CHANGES IN *CARCINUS AESTUARII* FLESH

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Abstract

This study, therefore, sought to establish the possible poisonous outcomes of progressive granulose cobalts (ii) chloride ($CoCl_2$) treatment on lipids of *C. aestuarii* flesh. The cobalt accumulation was significant according to a dosage manner compared to the control group. Further, the results showed great variations in fatty acid profile which confirmed that $CoCl_2$ induction of toxic damage in *C. aestuarii* flesh.

Keywords: Trace elements, Crustacea, Physiology, Redox, Mediterranean Sea

Introduction

Cobalt is commonly used in various applications and also as a vital constituent in the manufacture of many things. However, its main compound like cobalt chloride ($CoCl_2$) has become a matter of great concern due to its considerable risks to animals and human health. Known for its toxic nature, cobalt chloride represents significant hazards since it may accumulate within food chains and ecosystems [1].

Materials and methods

C.aestuarii were divided into four groups of 30 individuals each and placed in 100 L experimental aquaria in duplicates. They were then exposed to varying doses of $CoCl_2$: 0 µg.L-1 (CT), 25 µg.L-1 (D1), 50 µg.L-1 (D2), and 100 µg.L-1 (D3) for 10 days. After the experimental period, crab flesh samples were stored at 30°C for cobalt content [2] and fatty acid determination [3]. Statistical analysis was conducted using R software.

Results and discussion

Our results revealed a significant increase in $CoCl_2$ accumulation after exposure to 50 and 100 µg/L, respectively, compared to the controls, while no significant change was observed in flesh exposed to 25 µg/L (Table 1). The accumulation of cobalt (Co) in the flesh led to excessive production of reactive oxygen species (ROS), causing damage to lipids. Correspondingly, our findings indicated a significant increase in malondialdehyde (MDA) levels in $CoCl_2$-exposed flesh at concentrations of 25, 50, and 100 µg/L ($p < 0.01$) (Table 1). Furthermore, a decrease in lipid content was observed in flesh exposed to 50 and 100 µg/L, showing a concentration-dependent pattern compared to the control group (Table 1). Particularly noteworthy was the significant decrease in polyunsaturated fatty acid (PUFA) content, notably PUFA-3, including C20:5n-3 (EPA) and C22:6n-3 (DHA), in $CoCl_2$-treated flesh at the highest dose of 100 µg/L. The inhibition of elongase activity was evident in all exposed crabs across concentrations of 1, 10, and 100 µg/L of $CoCl_2$ ($p < 0.01$). Conversely, there was a marked increase in PUFA-6, especially C20:4n-6 (ARA) and its precursors such as C18:2n-6 and C20:2n-6, in $CoCl_2$-exposed flesh at concentrations of 50 and 100 µg/L (Table 1). Such findings could reflect a protective mechanism against membrane oxidation caused by $CoCl_2$ exposure via eicosanoid pathways [4]. Our results underscored the sensitivity of C. aestuarii to graded $CoCl_2$ concentrations at the lipidomic level, as evidenced by significant increases in saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA), particularly at higher doses compared to the control group. This finding was particularly pronounced in the elevation of C16:0, C18:0, C16:1, and C18:1 acid levels ($p < 0.01$). Our work was in accordance with the previous investigation carried out on invertebrates under exposure to metals [5] [6].

Tab. 1. Cobalt content, Malondhualdehyde (MDA), total lipid and fatty acids profile of C.aestuarii flesh under graded-CoCl2-exposure. Statistical difference in CoCl2-treatments vs control group was detected at 5%.

	CT	25µg/L	50µg/L	100µg/L
Cobalt content	0.01±0.00	0.03±0.00*	0.10±0.02***	0.15±0.05***
MDA	22.12±1.19	22.20±2.61	32.61±1.96***	38.10±2.45***
Total Lipid	19.01±1.11	19.41±1.21	12.66±1.33***	8.96±0.45***
Satunsated FA (SFA)	22.81±1.33	25.11±1.36	24.09±1.45***	39.47±1.95***
16 :0	15.01±0.79	17.22±0.79	15.16±2.63	28.63±1.14***
18 :0	7.74±0.52	8.71±0.96	8.18±0.08	10.99±0.30**
Monounsaturated FA (MUFA)	6.39±0.22	7.21±0.26	18.38±1.23	17.96±1.41***
C16 :1	1.42±0.23	1.24±0.21	1.48±0.07	3.44±0.57***
C18 :1	4.95±0.80	4.59±0.21	16.85±1.47***	14.36±1.32***
Polyunsaturated FA (PUFA)	41.44±2.91	39.10±2.36	39.41±2.41	31.62±3.06***
PUFA-6	11.26±1.17	11.29±1.63	19.65±1.69***	25.69±2.12***
18 :2n-6	4.06±0.67	3.33±0.56	11.06±1.22***	10.15±1.93***
18 :3n-6	1.12±0.16	1.46±0.08	0.76±0.05	3.88±0.39***
20 :2n-6	1.51±0.12	1.98±0.46	1.02±0.32	2.39±0.45**
20 :3n-6	1.19±0.51	0.79±0.09	2.29±0.29***	2.36±0.20***
20 :4n-6 (ARA)	3.58±0.58	3.47±1.00	3.91±0.07	5.93±0.31***
PUFA-3	30.18±2.15	27.81±1.66*	19.77±1.36***	5.93±0.31***
18 :3n-3	1.59±0.61	0.91±0.04	4.50±0.68***	5.51±0.28***
18 :4n-3	1.84±0.35	1.13±0.16	1.44±0.43	1.48±0.09
20 :3n-3	0.15±0.02	0.13±0.02	1.50±0.42	0.15±0.01
20 :4n-3	0.13±0.09	0.18±0.03	0.13±0.00	0.15±0.01
20 :5n-3 (EPA)	13.43±0.78	12.22±0.25	4.09±0.02***	1.76±0.15***
22 :5n-3	2.64±0.27	2.98±0.36	1.13±0.27**	0.98±0.14***
22 :6n-3 (DHA)	10.23±0.97	9.30±1.24	5.33±0.50***	2.52±0.33***
Elongase activity	1.18±0.13	0.83±0.04**	0.56±0.05***	0.27±0.02***

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BEYOND THE SHELL: DECRYPTING HEPATOPANCREATIC LIPID DYNAMICS OF THE MEDITERRANEAN GREEN CRAB (*CARCINUS AESTUARII*) UNDER SUBLETHAL DIMETHOATE STRESS

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Abstract

Our 24-hour investigation delves into the repercussions of sublethal dimethoate (DMT) exposure on the fatty acid (FA) composition of the hepatopancreas in the Mediterranean green crab, *Carcinus aestuarii*. Our findings uncover significant alterations suggestive of oxidative stress and lipid peroxidation (LPO), followed by a significant variation in the FA composition in all treated crabs, emphasizing the potential of FA analysis as a pivotal tool for assessing DMT toxicity in crustaceans.

Keywords: Ecotoxicology, Crustacea, Monitoring, Pesticides, Mediterranean Sea

Introduction

Despite its widespread agricultural use, DMT poses unavoidable hazards to non-target organisms, with documented presence in Mediterranean surface and groundwater [1; 2]. Previous research has primarily focused on the oxidative potential of DMT, thus requiring new toxicity assessment methods to comprehensively understand its effects, and monitor ecosystem health. FAs serve as vital physiological indicators in invertebrates [3], yet investigations into *C. aestuarii*'s response to organophosphate pesticide (OPP) exposure, particularly DMT, remain limited. Our study addresses this gap by examining FA composition as an indicator of *C. aestuarii*'s responsiveness to DMT treatment.

Material and methods

Green crabs (*C. aestuarii*) from the Bizerte lagoon were exposed to sublethal doses of DMT (0, 00; 50; 100 and 200 µg.L^{-1}) for 24h. Following exposure, hepatopancreas samples were collected for Oxidative stress, LPO and FA analysis. The significance of differences between all DMT conditions was estimated by the one-way analysis of variance (ANOVA), with post hoc analysis Tukey test.

Results and discussion

During the 24-hour exposure to sublethal doses of DMT, all treated crabs exhibited an overgeneration of H_2O_2, peaking under the highest DMT dose (200 µg.L^{-1}), when compared to the control group, indicating oxidative stress. This was evidenced by elevated levels of LPO biomarkers; including LOOH levels which were significantly ($p<0.05$) 10 times higher than those in the control group across all treated crabs, as well as a significant ($p<0.05$) increase in MDA amounts by nearly +50% under 100 µg.L^{-1}. Previous research has highlighted the acute toxicity of DMT, leading to the excessive production of reactive oxygen species and subsequent LPO byproduct formation [4]. Accumulation of these byproducts in the membrane bilayer contributes to structural changes in the membrane. In line with this, significant variations in FA composition were observed in the treated crab's hepatopancreas (fig.1), characterized by decreased levels of saturated fatty acids (SFA), indicating probably their retention in order to meet essential energy demands to support detoxification of the pesticide. Moreover, increased levels of monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), particularly in the omega-3 series, such as eicosapentaenoic acid (EPA, C20:5) and docosahexaenoic acid (DHA, C20:6), were noted. Furthermore, there was a notable increase in the omega-6 series, and its precursor, linoleic acid (LA, C18:2), particularly under the medium dose of DMT. Such results suggest an adaptive response of *C. aestuarii* hepatopancreas cells to mitigate pesticide effects by initiating repair processes that alter FA composition.
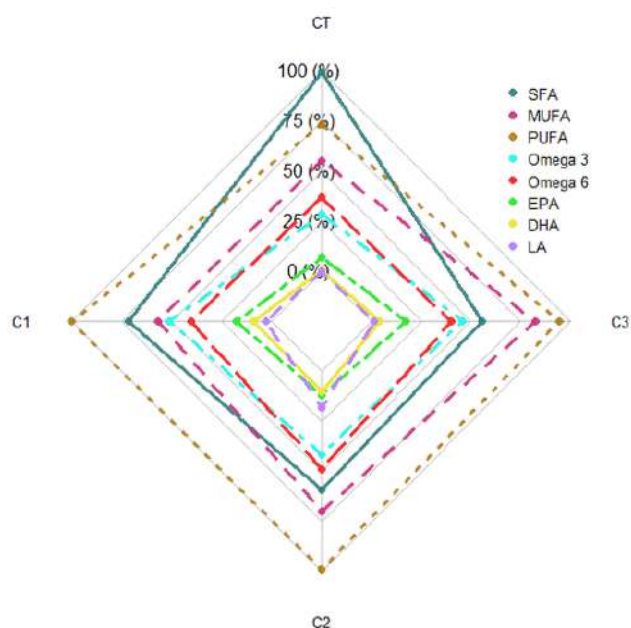

Fig. 1. Radar chart diagram summarizing FAs levels in *C. aestuarii* hepatopancreas upon 24h of exposure to DMT, using the following exposure concentrations: 50 µg.L^{-1} (C1), 100 µg L^{-1} (C2), and 200 µg L^{-1} (C3) and non-contaminated seawater as negative control (CT)

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VARIABILITY OF BIOMARKER RESPONSES AND HISTOPATHOLOGICAL DISRUPTION IN THE SIPHONS OF THE MARINE CLAM *RUDITAPES DECUSSATUS* FOLLOWING PENCONAZOLE EXPOSURE

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Abstract

Penconazole (PEN) is a widely used pesticide in agriculture that is reported to contaminate a variety of aquatic organisms. This study aims at evaluating the PEN toxicity on the siphons of the marine clam *Ruditapes decussatus* by investigating oxidative stress parameters (H2O2, MDA, SOD) and examining histopathological injuries caused by different concentrations of PEN. The results showed that PEN exposure enhanced the levels of hydrogen peroxide, malondialdehyde, along with altering antioxidants status in all treated clams. Eventually, histopathological changes detected in treated animals varied in a concentration-dependent manner and were consistent with our biochemical findings.

Keywords: Bivalves, Ecotoxicology, Pesticides, Western Mediterranean

Introduction

Penconazole, (1-(2-(2,4-dichlorophenyl)-pentyl)-1H-1,2,4-triazole) a systemic triazole fungicide with preventive and curative properties for plant growth [1]. It is an active ingredient of many fungicides that are used worldwide such as Topas, Omnex, Oron, Ofir and Dallas [2]. Ecosystem pollution can be assessed by using sentinel organisms as bioindicators. Bivalve mollusks are used worldwide as marine pollution sentinels due to their sessile nature, filter-feeding habits, and ability to concentrate pollutants [3]. Thus, in the present study, we investigated the damages to the antioxidant defense system and histoarchitecture in the *Ruditapes decussatus'* siphons caused by exposure to PEN- different concentrations (4, 40 and 400µg/L). Hence, the use of the battery of cellular and biochemical biomarkers as well as histological analysis could be a useful approach to assess PEN contamination in marine invertebrates.

Material and Methods

Clams were collected from the Bizerte lagoon and transported to the laboratory. They were acclimatized in filtered seawater for 72 hours. After acclimatization, clams were exposed to different concentrations of penconazole (negative control, D1 (4µg/L), D2 (40µg/L) and D3 (400µg/L)). Following PEN exposure, the animals were euthanized, and siphons tissues were extracted for subsequent analyses.

Results

Our study reveals significant enhancement of H_2O_2 levels with the highest dose (400µg/L). Moreover, for MDA amounts results revealed significant induction compared to the negative group. In addition, SOD activities were significantly affected by PEN treatment (+59%) at the highest dose. Histopathological observations showed significant lesion of tissues analyzed. In the control group, no morphological abnormalities were detected. Contaminated siphons exposed to 4 µg/L and 40 µg/L of PEN show changes such as lipofuscin granules degradation and rupture (Fig. B & C). The upper dose of PEN (400µg/L) caused severe histological damages ranging from lipofuscin granules degradation to rupture, haemocytes infiltration, epithelial alterations and deformation of epithelial cells, when compared to the control group (Fig. D).
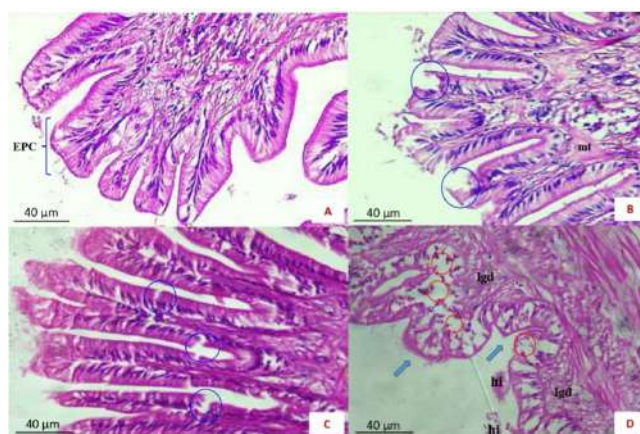
Fig. 1. Representative histological sections of the siphons of control (A) and exposed *Ruditapes decussatus* to different PEN concentrations ((B): 4 µg/L; (C): 40 µg/L and (D): 400 µg/L) after 96H of exposure, stained with hematoxylin-eosin. EPC: epithelial cells; mt: muscular tissue; hi: haemocyte infiltartion; lgd: lipofuscin granules degradation; blue circles indicate: rupture; red circles indicate: epithelial alterations; ⇒ deformation of epithelial cells; Scale bar = 40 µm,

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EFFICIENCY OF WASTEWATER TREATMENT BY USING ZEBRAFISH MODEL AS A USEFUL METHOD TO DETECT POTENTIAL ADVERSE EFFECTS.

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Abstract

Monitoring irrigation water is critical to ensuring water quality for agriculture, promoting sustainable production and protecting the environment. Membrane Biological Reactor (MBR) implants treat wastewater effectively, preventing pollution and harm to ecosystems. Zebrafish are used to assess wastewater toxicity. The aim of the study was to investigate the toxicity to zebrafish embryos of effluents from wastewater treatment plants using different treatment systems, namely activated sludge and MBR. The results suggest that the MBR method is safer for zebrafish survival compared to the activated sludge method, which caused mass larvae mortality at 96hpf. The MBR system is an advanced wastewater treatment technology with significant benefits in terms of effluent quality and water reuse.

Keywords: Fishes, Pathology, Global change, Mediterranean Sea

Introduction

In view of the global warming, and the consequent increase in periods of drought, it has become essential to adopt innovative approaches to ensure the availability, safety of water resources [1]. This involves the reuse of treated wastewater, in accordance with the 'drought decree' regulation 68/2023. In the context of the Sicilian territory, it is crucial to preserve the sustainability of agriculture and protect water resources and the environment. The Membrane Biological Reactor (MBR) is a water purification system that combines activated sludge with a filter membrane separation system. This method is particularly suitable to delate proteins, heavy metals and discharge of agri-food companies [2]. These contaminants can harm aquatic ecosystems and negatively impact biodiversity. Inside the Samothrace project, the aim of the study was to investigate the toxicity of effluents of sewage treatment plants using different purification systems, namely activated sludge and MBR, on zebrafish embryos.

Material and Methods

To verify wastwater toxicity, we conducted several samplings at wastewater treatment plants in Sicily using two different depuration technologies, activated sludge (AS) and MBR. At each wastewater treatment plant, a raw sample, consisting of unpurified water, and a post-purified water sample were taken. The samples were tested on fertilized zebrafish embryos at the Zebrafish Facility of the Institute for Experimental, Comparative, Forensic and Aquatic Pathology "Slavko Bambir", University of Messina. Experimental groups were kept in raw and depurated water, while control group was kept in only embryo medium. Each group was tested following the OECD n. 236 Guideline.

Results and Discussions

Results showed that the untreated water, in both AS and MBR treatments, resulted in 100% mortality of zebrafish embryos at 24 hpf. The embryos subjected to the activated sludge system developed normally up to 72 hpf without showing any pathological changes. A slight delay in hatching was observed compared to the control group. However, 100% mortality was observed at 96 hpf. On the contrary, MBR depurated water had no toxicity effect on zebrafish larvae, resulting in 100% of survival rate, and the heart rate was comparable to the control group (fig.1).
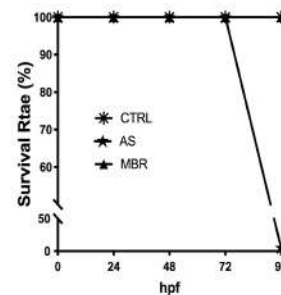

Fig. 1. Survival rate of zebrafish larvae up to 96hpf

The results of the study indicate that the toxicity observed in AS sample was likely caused by the presence of toxic substances that were not removed through the purification process.

Conclusions

All results indicated that MBR method is economical and eco-friendly for treatment of wastewaters. In addition, the use of treated wastewater for irrigation purposes can be a valuable solution to address water scarcity challenges and improve the sustainability of the agricultural sector.

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EVALUATION OF TOXIC EFFECTS OF COBALT CHLORIDE EXPOSURE ON STRESS BIOMARKERS RESPONSES OF *CYPRINUS CARPIO* INTESTINE

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Abstract

The present study aimed to illustrate the toxic effects of chloride cobalt concentrations (0(CT), 2.5(D1), 25(D2), 100(D3) µg/LCoCl$_2$) on oxidative biomarkers responses of *Cyprinus carpio* intestine. After 3 days of treatment, Co caused increases in MDA levels. MT's and PCO levels raised in carp of all treated groups. We revealed elevation in enzymatic (GPx and GST activities) and non-enzymatic (GSH and NPSH levels) antioxidants defense system.

Keywords: Fishes, Metals, Pollution, Stressors, Tunisian Plateau

Introduction

Common carp (*Cyprinus carpio*, Linnaeus 1758) is considered as the most abundant cyprinid species in the world's aquaculture with 54% of total world fish production Common carp is known for its resilience to various environmental stressors, making it a valuable model for toxicological studies [1]. Cobalt (Co) is an essential element for animals due to its crucial role for the synthesis of vitamin B12 [2], when it's concentration in aquatic ecosystem exceed the authorized limit, Co becomes toxic element. At high concentrations, one of the mechanisms of cobalt toxicity can be generated by the induction of oxidative stress through the overproduction of ROS affecting the macromolecules such as proteins, lipids and DNA [3].

Material and methods

Cyprinus carpio with body weight (4.59g±0.05) and length (3.88±0.11cm) exposed to unmixed CoCl$_2$ metal (Cobalt chloride; CoCl$_2$; Sigma-Aldrich; powder 98%) which was dissolved in pure water. Experiment was maintained for a period o 3 days under graduated CoCl$_2$ concentrations as following: CT: control; D1: 2.5µg/L; D2: 25µg/L and D3: 100µg/L. Intestines were homogenized in Tris-HCl buffer (20mM; pH=7.4) at cold. Supernatants were stored in eppendorf tubes at -80°C for oxidative stress.MDA level was determined according to [4] method. GSH and Non protein –SH levels were measured according to [5]. SOD activity was assayed according to the method described by [6]. GPx activity was measured Using [7]. MTswere determined according to the method developed by [8].

Results and Discussion

The impact of cobalt on the antioxidant response in *C. carpio* intestine after exposure to graded CoCl$_2$ doses suggest an installation of oxidative stress due to the increase of formation of free radicals (ROS) in cells [9]. Similar MT's induction recorded in our treatment suggested the better response of intestine cell against the cobalt toxicity. A lipid peroxidation induced by Co toxicity revealed by an increase in MDA levels in all treated groups (Table1).

Tab. 1. The stress biomarkers response in control and treated C.carpio intestine with graded CoCl doses for 3 days Results are expressed as means ± SD (n=9) CT : 0µg/L CoCl D1: 2.5µg/L CoCl ; D2: 25µg/L CoCl ; D3: 100µg/L CoCl CoCl groups VS controls : *p < 0.05; ** p < 0.01; *** p < 0.001.

Stress biomarkers	CT	D1	D2	D3
MDA(nmol/mgPr)	0.97±0.177	1.89±0.033***	53.61±5.320***	75.36±9.425***
NPSH (µmol GSH/mg Pr)	0.275±0.063	0.28±0.068	0.345±0.069*	0.391±0.062***
GSH(µg GSH/mg Pr)	19.12±2.297	24.18±3.528***	26.88±2.803***	19,46±2.798
MT(µmol GSH/mg Pr)	0.496±0.093	1.099±0.15***	1.337±0.169***	1.3570.166***
GST(mmol/min/mg Pr)	0.074±0.011	0.082±0.026	0.084±0.019	0.115±0.023***
SOD (U/µgPr)	1.132±0.144	1.157±0.199	1.047±0.108	1.015±0.173
GPx (mol/mgPr)	81.1±9.443	189.0±12.91***	194.6±9.639***	155.8±6.239***

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THE POLLUTED-UNPOLLUTED, THAT IS THE QUESTION: THE MERCURY CASE IN KAŠTELA BAY, ADRIATIC SEA, CROATIA

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Abstract

Kaštela Bay has been a black spot polluted by various industries developed in a previously pristine area, such as the Hg cell chlor-alkali plant, closed in 1990 (active 40 years). During this time and since, Hg speciation has been periodically analyzed in all Bay environments. Even after 30 years, the Hg results in sediment do not show positive change, so that Hg levels are still as high as 6 mg/kg. Similarly, various fish species contain Hg amounts (1-6 mg/kg) above the levels permitted by law. The Hg conc. in the water column during the plant active time and 10 years after closure were up to 1 μg/L. 30 years later they stabilized at up to 0.02 μg/L. The self-purified water column is significant and calls for caution, as it gives the appearance of an unpolluted environment, although it contains contaminated fish and polluted sediment.

Keywords: Mercury, Adriatic Sea, Sediments, Fishes

The semi-enclosed and oval-shaped Kaštela Bay is located in the central part of the eastern coast of the Adriatic (Fig. 1). It has an area of 61 km^2 (maximum length 14.8 km, maximum width 6.6 km) and a total volume of 1.4 km^3, which is polluted by mercury discharged into the sea from the former polyvinyl chloride (PVC) plant. According to rough estimates based on possible mercury losses during the production of one ton of chlorine, between 250 and 500 tons of mercury were released into the sea in front of the plant over 40 years. The systematic measurement of mercury and its species in seawater, solid samples and air began in the 1980s and continues to this day [1-6].

Fig. 1. Research area. Red dot - chlor-alkali plant

The seawater samples were taken directly by scuba diver or manually from the boat against the current. Sediment samples were also collected by scuba diver with an acrylic tube (20 cm length, 6 cm inner diameter) or from the boat with a Uwitec core sampler (6 cm inner diameter). To ensure authenticity of origin, fish were caught *in situ* with a longline by laboratory staff during water and sediment sampling. Analyzed fish specimens were common pandora (*Pagellus erythrinus*, Fig. 2), gilthead seabream (*Sparus aurata*), comber (*Serranus cabrilla*), common seabream (*Pagrus pagrus*), and from shellfish limpet (*Patella caeruela*) and marine mussels (*Mytilus galloprovincialis*). CVAAS (Cold Vapor Atomic Absorption Spectrometry) was used for mercury measurements in all sample matrices. It is evident, and what could have been expected that after the closure of the PVC plant, mercury first began to be lost from the seawater column of the Kaštela Bay, which means that the concentrations in a slow process began to approach the values from before industrial activity. Of course, in the conditions of a purified water column shellfish living on or in immediate vicinity of its surface will have mercury concentrations that correspond to concentrations in shellfish from clean and unpolluted environment.

Fig. 2. Sampling of common pandora (*Pagellus erythrinus*) in Kaštela Bay.

Contrary to the water even after thirty years, the sediment is still heavily polluted with mercury which results in the contamination of various fish that feed on the benthos of such seabed.

In conclusion, it can be said that fish heavily polluted with mercury live in seawater with relatively low mercury concentrations.

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LITHIUM-INDUCED CHANGES IN LIPID METABOLISM AND FATTY ACIDS COMPOSITION OF NILE TILAPIA FISH MUSCLE TISSUE

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Abstract

The present study aimed to asses the potential toxic effects of LiCl on the fatty acid composition, malondialdehyde (MDA) and lipid hydroperoxides (LOOH) in the muscle of fish Nile Tilapia (*Oreochromis niloticus*). Tilapia juveniles were exposed to LiCl graded doses (20, 40, and 80 mg/L) for 48 h. Compared with the control group, the monounsaturated fatty acids (MUFA) increased while saturated (SFA) and polyunsaturated fatty acids (PUFA) decreased upon exposure to LiCl. Results showed that LiCl mechanism of toxicity involves lipid metabolism disruption and induced oxidative damage.

Keywords: Mediterranean Sea, Ecotoxicology, Redox, Trace elements

Introduction

Lithium (Li) is the lightest metal that occurs naturally at low concentrations in water and can easily enter the food chain. Li has been used worldwide in household items common to industrial applications (e.g., air conditioners, TV screens, batteries…) [1]. Last decades, the use of Li-ion batteries has strongly increased; raising concerns about its potential toxic impacts on aquatic organisms. Fish are key components of aquatic food webs as well as an important source of nutrition for human. Understanding the toxic effect of this metal is essential to evaluate the possible risks on fish and ultimately on the fish consumers. Nile tilapia fish has been often used in ecotoxicological studies as a bioindicator of water pollution because it is sensitive to physical changes and contamination. The current study explores the toxic effects of lithium on tilapia (*Oreochromis niloticus*) under controlled conditions in order to assess how Li exposure affects oxidative stress levels and lipid metabolism.

Material and Methods

Prior to the experiment, *O. niloticus* specimens were maintained in natural filled fresh water for 15 days at a temperature of 20°C for acclimation with 12 h: 12 h (light–dark) photoperiod. During this period they were fed twice a day with commercial fish feed with a daily ration of 3% of their biomass. Following acclimation, Tilapia juveniles were divided into 4 groups (CT, D1, D2 and D3) of 20 individuals placed in 80 L experimental glass aquaria in duplicate design (n=10) under controlled conditions. Fish were exposed to graded doses of LiCl (20, 40 and 80 mg/L) for a short duration (48 hours). Total lipids were extracted following [2] method using chloroform-methanol buffer (2V:1V). FA composition in fish muscle was determined by gas chromatography (GPC) as described by [3]. The levels of MDA were determined according to [4] and LOOH levels were quantified according to [5].

Results and Discussion

Results showed that in the control group, saturated fatty acids (SFA) were the major FA class (38.35%) followed by polyunsaturated fatty acids (PUFA) and monounsaturated fatty acids (MUFA) with 32.92% and 28.73%, respectively. Significant decrease of SFA and PUFA against an increase of MUFA after LiCl exposure was observed. The decrease in PUFA n-3 levels in all treated groups from D1 to D3 was closely associated to the reduction of eicosapentaenoic (EPA, C20:5n-3) and docosahexaenoic (DHA, C22:6n-3) FA. While, the arachidonic acid (C20:4n-6) was the most affected FA by LiCl contamination among PUFA n-6. In exposed fish groups, starting from the lowest (D1) to the sharpest dose (D3), MUFA levels increased upon exposure to LiCl by 15%, 26% and 34%. In the current work, LOOH concentrations increased significantly when compared to CT group. This probably indicate the presence of oxidative damage to lipids, potentially compromising the structural integrity and functionality of cellular membranes. The enhanced MDA levels in D1, D2 and D3 suggest increased lipid peroxidation, reflecting the extent of oxidative damage to cell membranes and overall cell health. Overall, the observed increased levels of MDA and LOOH would suggest a higher degree of oxidative stress and potential damage to the muscle tissue. The usefulness of FAs profile as a biomarker of Li toxicity has been reported previously by [6] in sea worms.
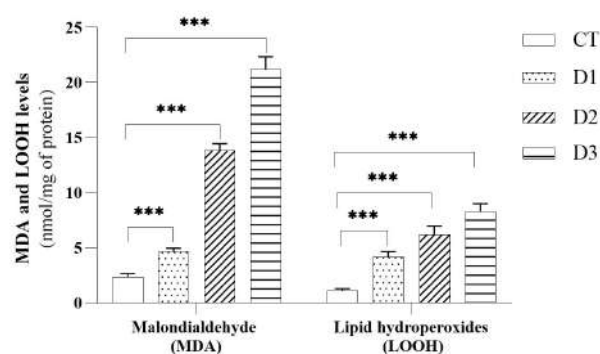

Fig. 1. Malondialdehyde (MDA) and lipid hydroperoxides (LOOH) levels in control and treated O. niloticus. The letters above the columns, a, b, and c, indicate significant differences (p<0.05) between exposure concentrations.

Conclusion

The observed changes in fatty acids composition suggest potential disruptions in cellular membrane integrity and metabolic processes. Our findings give new insights on the toxic effect of LiCl on the lipid metabolism of O. niloticus muscle and highlighted the usefulness of the FA composition as an early sensitive bioindicators of lithium toxicity in fish.

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EFFECTS OF WATER-SOLUBLE OIL FRACTIONS ON PHYSIOLOGY OF MARINE MICROALGA
NANNOCHLOROPSIS GADITANA

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Abstract
Petroleum industries generate wastewater with crude oil emulsions, posing environmental risks. Marine microalgae like *Nannochloropsis gaditana* play vital roles in ecosystems and offer potential solutions for pollution mitigation. This study investigates the impact water soluble oil fraction (WSOF) on *N. gaditana* physiology, revealing insights into its growth, biomass yield, and physiological properties under exposure.

Keywords: Adriatic Sea, Ecotoxicology, Physiology, Phytoplankton

Introduction
Petroleum industries generate significant quantities of wastewater containing stable crude oil emulsions, formed spontaneously during oil production. These emulsions or water-soluble oil fractions (WSOF) pose environmental risks due to their toxic substances [1]. Marine microalgae play vital roles in aquatic ecosystems, contributing to primary production, ecological balance, and pollution degradation [2]. Microalgae can represent an excellent solution given their ability to metabolize various pollutants, using them as carbon sources, in green process, releasing oxygen into the atmosphere and subtracting CO_2 [3]. However, the effectiveness of microalgae in treating water contaminated with WSOF remains uncertain. This study aims to assess the impact of WSOF on the physiology of the marine microalga *Nannochloropsis gaditana*.

Materials and Methods
Marine microalga *Nannochloropsis gaditana* (SAG 2.99) was obtained from the Culture Collection of Algae at Gottingen University (SAG). Experiment was performed in four 2.6L photobioreactors (PBRs) controlled by SCADA system. Conditions included a light intensity of 130 µmol photon m-2s-1 with 12:12h day/night cycle and the temperature was set at 26°C. WSOF was prepared by mixing crude oil with 50:50 mixture of distilled and sea water for 24 hours. One PBR served as a control, and other three reactors had different percentage of WSOF: 1, 5 and 10%. The growth of N. gaditana was monitored daily. Biochemical analyses in order to determine protein content, lipid accumulation, fatty acid profile, and pigment production were performed according to protocols [4;5]. Daily samples were taken for dissolved nutrients analysis. The extent of lipid peroxidation was estimated by [6].

Results
Cultures grown under 5% and 10% WSOF demonstrated faster initial cell division, however the final biomass yield was similar under all experimental conditions (Fig.1).
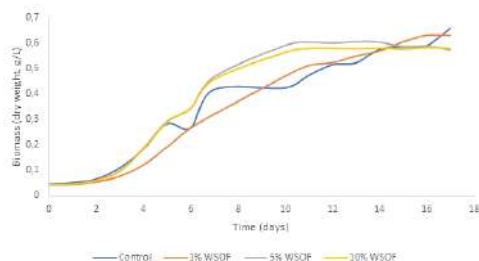

Fig. 1. Biomass growth of *N. gaditana* when exposed to different levels of WSOF

However, chlorophyll *a* concentration was notably lower in culture grown under 5% and 10% WSOF (0.43 and 0.39 µg/mL). Protein percentage in dry biomass ranged from 14% to 19% during the exponential growth phase. The highest lipid productivity (43.76%) was observed in PBR with 10% WSOF. The fastest inorganic nitrogen removal, on day 3, was observed in PBR with 10%WSOF. Elevated MDA levels were observed in cultures grown under 5% and 10% WSOF (115.08 µM/mg and 117.36 µM/mg) (Fig.2). The lipid accumulation under the highest concentration of WFOS was followed by highest unsaturation degree, mostly contributed by C18:1 and C18:2 fatty acids.
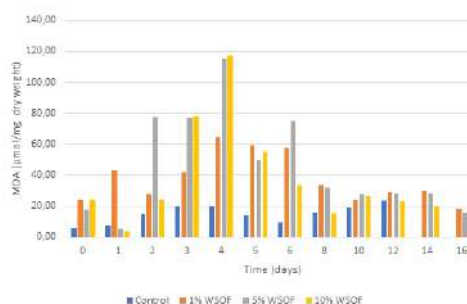

Fig. 2. Malondialdehyde levels measured in PBRs

Discussion
N. gaditana demonstrated increase in growth rate in presence of WFOS, however without contribution to the final biomass yield. In accordance with the later, the chlorophyll *a* analysis confirmed decrease in primary productivity, leading to the stationary growth phase. While the growth was stagnant under the highest WSOF concentrations due to the toxicants inhibition of the photosynthetic apparatus, accumulation of lipids and high proportions of unsaturated fatty acids show overall satisfying physiological condition. These results prove the successful adaptation of *N. gaditana* on harsh environment in spite of the toxicants interference with the cell membrane permeability and low pigment production [1;8]. Greater extent of lipid peroxidation was related to the presence of oil derived toxic substances. However by the end of experiment MDA peroxidation decreased by the end of the experiment which is in correlation with progression in N starvation [9]. Resulting oxidative stress led to the alternations in cell metabolism of N. gaditana such as lower protein content and higher lipid accumulation [8].

Conclusions
N. gaditana demonstrated potential for cultivation in crude oil-water emulsions.These findings provide insights into the physiological responses of marine microalgae to emulsified oil exposure, informing potential applications in pollution remediation.

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EFFECTS OF BENZISOTHIAZOLINONE (BIT) ON CELLS FROM *MYTILUS GALLOPROVINCIALIS*

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Abstract

Benzisothiazolinone (BIT) is a biocide widely used in building materials and cleaning products, but its potential toxic effects on aquatic organisms are poorly explored. The present study aims at investigating the cellular and physiological responses of *Mytilus galloprovincialis* cells to BIT exposure. Haemolymph and digestive gland (DG) cells were exposed to two different BIT concentrations ($0.03\ \mu g\ mL^{-1}$ and $0.3\ \mu g\ mL^{-1}$) for three different exposure times (1 h, 3 h, and 24 h). Cell viability was assessed by the Trypan blue exclusion test and the Neutral Red retention assay, and through cell phagocytosis ability. Furthermore, oxidative stress-related gene expression was evaluated by qPCR, to investigate the antioxidant response to BIT exposure. The study revealed physiological, cellular and gene expression changes following BIT exposure.

Introduction

Biocides are chemicals commonly used for the elimination of harmful organisms or the prevention of microbial contamination [1]. Their increasing use, especially following the emergence of the COVID-19 pandemic, has increased their release into aquatic environments via sewage systems, negatively affecting the well-being of organisms [2]. Among these substances, benzisothiazolinone (BIT) has been studied for its toxicity [3]. This biocide is found in several household cleaning products, such as dish soap and laundry detergents. [4; 5]. The study evaluated the effect of BIT on *M. galloprovincialis* after in vitro exposure to two concentrations (0.03 and $0.3\ \mu g\ L^{-1}$) for three exposure times (1h, 3h, and 24h).

Material and Methods

Cytotoxicity assays were conducted on haemolymph and DG cells using the Neutral Red (NR) retention assay that provides information on the stability of intracellular lysosomal membranes and the Trypan Blue (TB) exclusion test that distinguishes viable cells (which appear unstained) from non-viable cells. Additionally, we evaluated the phagocytosis activity levels of immune cells and the volume regulation capacity of DG cells. The regulation volume decrease (RVD), was determined in DG cells isolated both mechanically and chemically and then exposed to a hypotonic solution to determine their ability to restore their original volume when subjected to stress-inducing compounds. Furthermore, the oxidative stress-related gene expression has been evaluated. Total RNA was extracted from DG and haemolymph cells and, subsequently, cDNA was synthesized, for amplification of specific genes involved in the antioxidant response using qPCR analysis.

ecological impact associated with BIT exposure in the *M. galloptovincialis* model and suggest the need to explore and develop environmentally friendly and sustainable alternative compounds.

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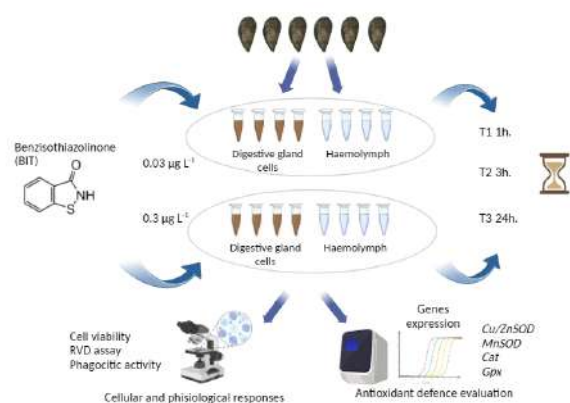
Fig. 1. Experimental plan

Results

Overall, findings on the physiological and cellular changes as well as the modulation of the gene expression showed that BIT can affect the lysosomal membrane stability and the phagocytosis activity while impairing the antioxidant cellular system in aquatic organisms.

These data provide a significant contribution for elucidating the potential

EXPLORING THE EFFECTS OF MERCURY CHLORIDE EXPOSURE ON PHOSPHOLIPIDS IN *CERASTODERMA EDULE* GILLS

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Abstract

Mercury (Hg) is a highly toxic metal in aquatic ecosystems, raising significant concerns in recent years. Despite this, the precise effects of $HgCl_2$ on the bilayer structure in aquatic organisms remain poorly understood. This study aimed to investigate the effect of mercury chloride ($HgCl_2$) exposure at different concentrations (1, 10, and 100 μg/L) on phospholipids composition in *Cerastoderma edule* gills. Analysis of phospholipids in the exposed gills revealed reductions in phosphatidylcholines (PC), phosphatidylethanolamines (PE), phosphatidylserines (PS), and phosphatidylinositols (PI) across all treatment groups. These findings highlight the specific toxicity of $HgCl_2$ on phospholipids, which may disrupt cellular homeostasis in organisms.

Keywords: Bivalves, Bio-accumulation, Ecotoxicology, Mediterranean Sea

Introduction

Biological membranes play a crucial role in the adaptive responses of organisms especially marine species [1]. Mercury pollution poses significant threats to aquatic ecosystems, affecting the health and physiology of aquatic organisms. Phospholipids (PL), vital components of cell membranes, play crucial roles in maintaining cellular integrity and function [2]. Mercury interaction with PL, can cause changes in membrane structure and integrity. This disruption can compromise the selective permeability of cell membranes, affecting cellular processes such as ion transport and nutrient uptake. The current study explores the effects of mercury chloride ($HgCl_2$) exposure on phospholipids in *Cerastoderma edule* gills, highlighting the interconnection between mercury toxicity and membrane composition.

Materials and methods

Cerastoderma edule specimens (average length: 45.25 ± 4.65 mm; average weight: 22.54 ± 2.50 g) were sourced from a bivalve shellfish farm within the Bizerte Lagoon in northern Tunisia. The specimens were divided into four groups of 30 individuals each, arranged in triplicate, and housed in 50 L experimental tanks. After acclimation, these groups were subjected to graded concentrations of $HgCl_2$ (0, 1, 10, and 100 μg/L) for 6 days. Lipids were extracted following the method of [3]. Subsequently, lipid classes analysis was conducted via thin-layer chromatography (TLC) based on the method of [4].

Results and discussion

Phospholipids fractions (PC, PE, PS and PI) of control and treated *C. edule* gills are given in Figure 1, showing significant fluctuations in PC, PE, PS and PI levels. Our results demonstrated that short-term exposure to $HgCl_2$ graded doses had the strongest binding affinity to PC and PE resulting by significant decreases of their levels in all treated gills. Additionally, significant lower levels of PS and PI were observed in treated *C. edule* with the sharpest dose.

Phospholipids are essential for maintaining the fluidity and permeability of cell membranes, as well as facilitating important signaling activities crucial for cell survival. The decrease in levels of phosphatidylserine (PS), phosphatidylinositol (PI), phosphatidylcholine (PC), and phosphatidylethanolamine (PE) indicates changes in membrane composition and behavior induced by mercury. These alterations could disrupt cellular balance, impair normal functions, and heighten vulnerability to environmental stressors. Consistent with our results, depletion of the major phospholipids contents has been recorded in *Mytilus edulis* following copper and cadmium exposure [5].

Conclusion

Exposure to mercury can potentially disrupt the composition and organization of phospholipids, causing shifts in membrane fluidity. This alteration can impact the movement and function of proteins and enzymes associated with the membrane. Recent studies suggest that variations in lipid classes could be indicative of exposure to mercury chloride (HgCl2), providing important information about its varying levels of toxicity on different membrane layers.
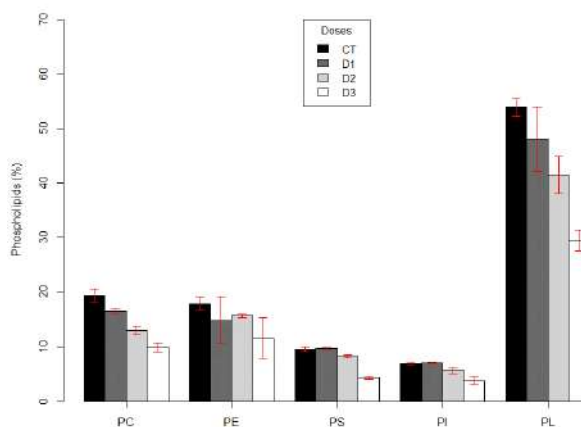

Fig. 1. Phopholipids fractions in control and treated *C. edule* specimens.

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CIESM Congress Session : Lagoons, estuaries and lakes
Moderator : Jamila Ben Souissi – INAT, Tunis, Tunisie

Session's Synthesis

N/A

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SUMMER COPEPOD ASSEMBLAGES IN THE LAGOON OF EL BIBANE (TUNISIA, EASTERN MEDITERRANEAN)

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Abstract
The distribution of Copepoda in relation to environmental factors in the El Bibane lagoon was studied during summer. Copepoda were the most abundant mesozooplankton group (occurrence ranged from 69.8 to 83.1% of total specimens). Small copepods reached important abundance, particularly with the presence of *Oithona similis*, *Acartia clausi*, *O. nana, Paracalanus parvus* and *Centropages typicus*. The summer spatial distribution of Copepoda appeared to be mainly affected by salinity fluctuation and eutrophication.

Keywords: Copepoda, Gulf of Gabes, Eutrophication, Salinity

Introduction
El Bibane lagoon is recognized as a Ramsar Wetland since 2007 and as the most important fishery resource. This shallow lagoon is under eutrophication stress. The objective of this study was to investigate the summer spatial distribution of Copepoda in relation to environmental factors.

Material and Methods
Samples for physicochemical and zooplankton data were collected during summer of 2019 in four stations (Fig.1).

Fig. 1. Location of sampling stations (S1-S4) in the El Bibane lagoon.

Mesozooplankton was captured using a cylindro-conical net. Temperature, salinity, and pH were measured immediately (Multi 340 i/SET). Nutrients were analysed with a Bran and Luebbe type 3 autoanalyzer. Zooplankton enumeration was performed under a vertically mounted deep-focus dissecting microscope (Olympus TL 2). The Eutrophication Index (E.I.) developed by Primpas et al. [1] was employed to evaluate the eutrophication level. This index incorporates nutrients and chlorophyll-*a* (Chl-*a)*, categorizing the results into a five-scale scheme aligned with the criteria outlined in the Water Framework Directive (WFD), based on specific threshold values: 1. (High ecological water quality, E.I. < 0.04); 2. (Good E.I. = 0.04–0.38); 3.(Moderate, E.I. = 0.38–0.85); 4. (Poor, E.I. = 0.85–1.51); 5. (Bad, E.I. > 1.51).

Results and discussion
The physical characteristics of the study are summarized in Table 1. This study's high-water temperature and salinity are typical of the arid Mediterranean climate. E.I. values were indicative of a generalized eutrophication (Table 1). High eutrophication levels of the coastal waters of the Gulf of Gabès were confirmed [2]. Mesozooplankton assemblages were dominated by opepoda accounting for 69.8 (S3) and 83.1% (S1). The highest total adult copepod density (41.8×10^3 ind m^{-3}) was observed at station 3. Sampling station S2 showed the highest eutrophic situation together with the lowest abundance of mesozooplankton and total copepods. E.I. was negatively correlated with total mesozooplankton ($r = -0.812$, $p < 0.05$) and total copepods ($r = -0.760$, $p < 0.05$).

Tab. 1. Physicochemical and biological variables measured off the coast of the El Bibane lagoon.

	S1	S2	S3	S4
Physico-chemical variables				
Temperature (°C)	28.0	28.7	28.4	28.7
Salinity (psu)	45.3	46.6	45.4	45.2
pH	8.4	8.2	8.3	8.4
Ammonium (µM)	1.2	1.4	1.2	1.4
Nitrates (µM)	1.0	1.6	1.6	0.9
Nitrites (µM)	0.2	0.3	0.3	0.2
Phosphates (µM)	2.4	3.8	3.1	2.2
E.I.	1.6	2.2	1.9	1.6
Biological variables				
Chlorophyll-*a* (µg l^{-1})	1.3	0.9	0.9	1.5
Total mesozooplankton ($\times 10^3$ ind m^{-3})	51.4	9.3	68.6	43.9
Nauplii of copepoda ($\times 10^3$ ind m^{-3})	12.4	0.5	6.1	8.3
Calanoida copepodids ($\times 10^3$ ind m^{-3})	21.31	4.19	20.58	17.79
Cyclopoida copepodids ($\times 10^3$ ind m^{-3})	7.27	2.82	20.65	9.82
Harpacticoida copepodids ($\times 10^3$ ind m^{-3})	1.76	0.12	0.57	0.26
Oithona similis ($\times 10^3$ ind m^{-3})	6.3	1.4	10.5	6.9
Acartia clausi ($\times 10^3$ ind m^{-3})	4.6	0.1	10.9	5.5
Oithona nana ($\times 10^3$ ind m^{-3})	0.8	1.4	9.8	2.3
Paracalanus parvus ($\times 10^3$ ind m^{-3})	0.7	2.6	0.7	2.5
Centropages typicus ($\times 10^3$ ind m^{-3})	2.6	0.5	1.4	0.9

Calanoida dominated the Copepoda during the summer of 2019, accounting for 59.6% of total specimens. Nauplii abundance was negatively correlated with salinity ($r = -0.976$, $p < 0.05$) and E.I. ($r = -0.937$, $p < 0.05$). A total of 23 different copepod species were identified belonging to three different orders such as Calanoida (11 species), Cyclopoida (7 species) and Harpacticoida (5 species). The lagoon of El Bibane showed a low copepod species richness than the Boughrara lagoon (43 species) [3]. Smal neritic and tolerant species to eutrophication and pollution: *Oithona similis, Acartia clausi, O. nana*, *Paracalanus parvus* and *Centropages typicus* are characterised by high abundances (Table 1) with contributions of 22.4, 15.6, 13.4, 12.4 and 5.6% respectively of adult Copepoda. *O. similis*, *A. clausi* were negatively correlated with salinity *(*$r = -0.949$, $p < 0.05$ and $r = -0.966$, $p < 0.05$, respectively*)*.

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GEODIVERSITY-BASED BIODIVERSITY IN THE ALKALINE VOLCANIC LAKE "BAGNO DELL'ACQUA", PANTELLERIA ISLAND, SICILY CHANNEL

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Abstract

Bagno dell'Acqua Lake, holds a unique blend of volcanic and biogenic features. A multidisciplinary project was realized to define the biodiversity of the lake and the geological and biological processes occurring there. The study involved many researchers from different universities and research centers and was coordinated with the National Park activities. The study encompasses several disciplines such as hydrogeology, geochemistry, petrography, geophysics, sedimentology, microplastics, microbiology, botany, zoology, limnology, ecology. The interest of the lake is due to the peculiar alkaline chemistry (pH9) and the widespread emission of CO_2 from diffuse and punctual sources, feeding large microbial communities that form seasonally varying mattes, loose and soft sediment on the lake floor and hard crust on the lake shores.

Keywords: Bacteria, Biodiversity, Geochemistry, Lagoons, Sicily Channel

Pantelleria Island is the emerged portion of an active volcano located in the central Mediterranean Sea; Bagno dell'Acqua lake is the only body of water on the island. It is an endorheic basin of 0.2 km^2 formed within the "Caldera dei Cinque Denti." It has a sub-circular shape, an average depth of about 2 m and a max. depth of 12 m. Two-thirds of the lake is a vast platform (from 0 to about 2 m in depth), mainly present in the western and southern parts, followed by a steep slope down to 10 m water depth and an almost flat basin floor. The lake is affected by hydrothermal emissions mainly located along the southwestern sector. The emitted gas is mainly CO_2 (about 98%), although significant amounts of CH_4 have been detected at shallow depth within the sediment, where reflection seismic profiles show widespread presence of fluids. Gas emissions led to the formation of pockmarks, two of which are giant and located in the deepest parts of the lake. The slopes are morphologically characterized by instability phenomena, both localized or widespread. Gravitational instability is also recognized in the subsurface. The water composition is controlled both by surface meteoric input and inputs from groundwater mixed with seawater and hydrothermal fluids [1]. The lake waters are chemically relatively homogeneous, both vertically and spatially, with temperatures ranging between 14-25 °C and pH values of approximately 9. The most characteristic and predominant biota of the ecosystem is that of cyanobacteria, photosynthetic prokaryotes that produced free oxygen in the primordial Earth atmosphere approximately 2.3 billion years ago. Cyanobacteria represent the first level of the aquatic food chain and contribute to the biodiversity of the lake along with a wide range of other microbial organisms. Bacteria form thick bacterial mattes on the lake bottom, are responsible for the formation of the characteristic carbonate mud which gives the lake bottom its white/turquoise color (however, becoming anoxic immediately below the water/sediment interface) and generate peculiar microbialite crusts present along the shores and in the sub-bottom of the coastal platform. Microbialites are organo-sedimentary deposits made up by carbonate/silicate mineral components formed through the interaction of bacterial activity with the lake water, a process that was reconstructed with laboratory experiments in which bacterial communities were nourished with lake waters. Subsurface microbialites appear organized in centimeter-thick laminae, possibly due to seasonal variability in environmental conditions. Water biota only includes invertebrates. Due to the peculiar hydrochemical conditions of the lake water (i.e. pH, salinity), many common groups are excluded (Gastropods, Polychaetes, etc.), fishes are absent and the trophic chain strongly simplified: photosynthetic prokaryotes constitute the production level, utilised by the crustaceans *Moina salina* and *Arctodiaptomus salinus*, while few species of insects of the order Heteroptera and Coleoptera (Dytisciidae, Hydrophilidae), both larvae and adults, represent the next consumers level. On the bottom the anoxic conditions at the water/sediment interface lead to the absence of common burrowing animals (such as worms, bivalves, etc.), allowing the occurrence of only some dipteran larvae of the families Chironomids and Ceratopogonids. Some ostracods occur in marginal micro-biotopes feeded by freshwater. As for the subaerial shores, botanical and zoological communities are rich in endemism such as *Limonium secundirameum*, whereas the zoological communities are characterized by the presence of the endemic *Gryllotalpa cossyrensis* and by several reptiles as *Chalcides ocellatus*, *Hemorrhois hippocrepis* and *Podarcis siculus*. All of them are included in the Annex IV of the EU-Habitat Directive and thereby strictly protected by European law. Three species of geckos are reported around the lake, one of which, *Tarentola fascicularis*, has been found in the island for the first time. Among mammals noteworthy is the presence of the autochthonous *Crocidura pachyura* in sintopy with three invasive mammal species (*Rattus rattus*, *R. norvegicus* and *Mus domesticus*). Finally, the lake represents an important element of attraction for at least 50 species of migratory and/or wintering birds.

Fig. 1. Lake Bagno dell'Acqua, red dots point pockmarks, bubbling and mofettas.

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PHYTOPLANKTON COMMUNITIES' STRUCTURE IN RAMSAR SITE: A CASE STUDY OF LAGOONS EL-BIBANE AND BOUGHRARA WITHIN THE SOUTH OF GULF OF GABES (TUNISIA)

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Abstract

The richness and diversity of phytoplankton in EL-Bibane and Boughrara lagoons were low suggesting a pioneer community. This pattern may be due to the unbalanced nutrient loading in the lagoons causing the eutrophication of the water body. The low DIN/DIP (0.91) recorded in El-Bibane may induce the proliferation of dinoflagellate coupled with a bloom of the harmful species, especially *Peridinium*. Phytoplankton in Boughrara Lagoon seems to be more structured than that in EL-Bibane.

Keywords: Phytoplankton, Gulf of Gabes, Eutrophication, Nutrients

Introduction

Phytoplankton plays a crucial role in the transfer of energy and biomass through the pelagic food webs and the Redfield ratio in the ocean [1]. Phytoplankton, which quickly respond to environmental variations, has widely been used as a bioindicator of marine ecosystems. The Gulf of Gabes is a heavily anthropized area and exposed to the pressure of anthropogenic activity such as fishing and industry [2]. The Boughrara and El-Bibane lagoons, RAMSAR sites of ecological importance, are exposed to specific climate forcing such as high evaporation, Saherian winds and flooding. This study aims to compare the phytoplankton community structure in Boughrara and El-Bibane.

Material & methods

The Gulf of Gabes located in the south of Tunisia in the southwestern Ionian Sea (between 35° N and 33° N) has a dry Mediterranean climate. The Gulf shelters two natural lagoons Boughrara and El-Bibane which are delimited by Djerba Island to the north and by the governorate of Medenine. Phytoplankton samples were collected at the surface of the two lagoons in July 2019 with a Niskin bottle. Physical parameters, nutrients and chlorophyll-*a* (Chl-*a*) content were assessed. Phytoplankton taxons were identified and enumerated (cells. L^{-1}) with the Utermöhl technique. The eutrophication state was evaluated using the eutrophication index E.I [3]. Nutrient limitation for phytoplankton was assessed by the Redfield ratio (DIN/DIP). To assess the phytoplankton structure in the lagoons the species richness (S), Shannon diversity index (H') Pielou (J) and dominance indices were calculated. The interrelationship between phytoplankton and abiotic factors was assessed using multiple linear regression.

Results

The surface layer of the two lagoons showed the same salinity of 45 PSU (Table 1). The DIN/DIP was highest in Boughrara reaching 20.84 ± 3.15 suggesting that phosphorous was the limiting nutrient. However, DIN/DIP ratio was very low not exceeding 1 in El-Bibane. However, the eutrophication index (E.I) was similar in the two lagoons averaging 2. In summer, the phytoplankton was composed of 25 and 29 taxons in the lagoon EL-Bibane and Boughrara, respectively (Table 1). The total phytoplankton density was quite similar between the two lagoons (*Student*, P > 0.05) (Table 1). While the total dinoflagellate dominates in El-Bibane (74% of total phytoplankton), the diatoms bloomed in Boughrara reaching 8241 ± 20390 cells L^{-1} corresponding to 96.5 % (Table 1). According to the dominance index, the lagoon El-Bibane was mainly dominated by the dinoflagellates due to the proliferation of *Tripos furca*, *Peridinium* sp., and *Prorocentrum micans*. However, in Boughrara the phytoplankton communities were dominated by diatoms such as *Pleurosigma* sp., and *Fragilaria unipunctata* representing 26 and 25%, respectively. While cyanobacteria were absent in EL-Bibane, harmful species *Gonyaulax spinifera*, *Peridinium* sp., and *Prorocentrum lima* have been recorded.

Discussion

Nutrient enrichment has become a major issue in many coastal ecosystems around the world [4]. The values of E.I exceeded >1.5, and thus they indicate a generalized eutrophication in the two lagoons. The lowest values of DIN/DIP (redfield ratio = 16) recorded in El-Bibane reflect a bad water quality which may

explain the low richness of phytoplankton in the lagoon (25 species).

Tab. 1. Mean ± SD of physical and chemical variables and phytoplankton communities in the lagoon El-Bibane and Boughrara. t-values were determined by a T- test analysis (*p<0.05, **p<0.01)

Parameters	El-Bibane	Boughrara	t-values	P
Physical parameters				
Temperature (°C)	28.20 ± 0.39	26.96 ± 0.28	5.16	0.002**
Salinity (PSU)	45.77 ± 0.97	45.75 ± 0.35	0.047	2.447
Chemical parameters				
T-N (μM)	5.67 ± 0.81	8.83 ± 0.19	−7.543	0.003**
T-P (μM)	12.65 ± 2.75	2.39 ± 0.44	7.334	0.004**
Si(OH)$_4$	3.51 ± 0.97	2.64 ± 0.23	1.753	0.169
DIN/DIP	0.92 ± 0.35	20.84 ± 3.15	− 12.585	0.001**
Chl-a (μg L^{-1})	1.00 ± 0.16	5.32 ± 4.56	− 1.894	0.154
E.I	1.82 ± 0.48	2.24 ± 1.05	− 0.727	0.495
Biological parameters				
Total-phytoplankton (cells L^{-1})	7475.0 ± 6109.8	8540.91 ± 20343.71	− 0.232	0.817
Dinophyceae (cells L^{-1})	5525.0 ± 3645.0	286.4 ± 353.6	2.202	0.041*
Bacillariophyceae (cells L^{-1})	1950.0 ± 2903.4	8240.9 ± 20390.1	−1.681	0.107
Cyanobacteria (cells L^{-1})	nd	9.09 ± 30.15		
Dictyochophyceae (cells L^{-1})	nd	4.55 ± 15.08		
community structure				
S	25	29		
H'	1.89 ± 0.37	1.48 ± 0.73		
J	0.77 ± 0.08	0.78 ± 0.17		

Diversity index (< 2) assumed a pioneer stage development of phytoplankton in the two lagoons. These results revealed that phytoplankton communities were not well structured probably due to the unbalanced nutrient loading, especially in the El-Bibane lagoon. In this later dinoflagellate dominates and we recorded a bloom of harmful species *Peridinium* spp. (20% of total phytoplankton). Linear regression shows that mainly PO_4^{3-}, DON and silicate explain the variability of the total phytoplankton in two lagoons. Studying the non-indigenous and harmful species in future could better explain the phytoplankton structure in Boughrara and EL-Bibane lagoons.

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COMMUNITY STRUCTURE OF TINTINNID CILIATES IN THE TRANSITIONAL WATERS OF THE NERETVA ESTUARY (SOUTH-EASTERN ADRIATIC SEA, CROATIA)

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Abstract
This paper presents the results of the first study on tintinnids in the Neretva estuary (Adriatic Sea), the most abundant group of microzooplankton, whose abundance variability shows a clear seasonal pattern with maxima in spring and autumn. Total abundance was positively correlated with species richness, while the negative correlation with evenness indicated the presence of dominant species. A total of 37 taxa were identified, with *Tintinnopsis karajacensis*, *T. nana* and the alien tintinnid *Rhizodomus tagatzi* being the dominant species. The distribution of tintinnids was significantly influenced by hydrographic parameters. The abundances confirm their successful adaptation in the estuary and emphasise the importance of such a study for the assessment of trophic status, conservation of natural diversity and ecosystem functioning.

Keywords: Zooplankton , Estuaries, Adriatic Sea

The Neretva River is the largest watercourse on the eastern coast of the Adriatic, and its delta is one of the most important and fertile agricultural areas in Croatia. In recent decades, the sea has penetrated the bottom of the Neretva as a salt wedge, and vertical mixing is limited to a narrow transition layer between fresh water on the surface and salt water below [1] . In this paper we have focussed on the characteristics of the tintinnid community in the estuary and its relationship to the thermohaline features of the environment.

According to hydrographic features, the water column is stratified into: a surface layer (0-2 m) with strong seasonal temperature fluctuations and low salinity, a middle transition layer (3-4 m) with the seasonal occurrence of thermocline and halocline and a lower layer (5-8 m) with higher temperatures (>20°C) and a salinity of over 38 from midsummer to early autumn and minor fluctuations from December onwards.

Zooplankton was collected biweekly from May 2022 to January 2023 using 5-L Niskin bottles in three layers (1, 5 and near bottom ~8 m) at the mouth of the Neretva River (S1) and at the station 16 km upstream (S2) (Figure 1).

Fig. 1. Study area with the sampling stations in the Neretva River estuary (Southern Adriatic Sea) (S1, 43°1′10.0″ N 17°26′36.0″ E and S2, 43°1′4.65″ N 17°33′57.7″ E).

Tintinnids were the most abundant microzooplankton group with pronounced seasonal variation, a significantly higher abundance at the upstream station S2 (p=0.039) and the highest monthly mean of 4184±2260 cells L-1 in October. Total abundance is positively correlated with species richness (S, H') (p<0.05) and negatively correlated with the evenness index (J') (p<0.001), indicating the presence of dominant species. Of the 37 taxa recorded, *Tintinnopsis karajacensis* (61.79%) and the alien tintinnid *Rhizodomus tagatzi* (17.54%) were most abundant on S2 and *Tintinnopsis nana* (20.27%) and *Codonellopsis schabi* (18.51%) on S1. The strong positive correlation (p=0.001) between the tintinnids and the hydrographic parameters (temperature and salinity), especially at S2, indicates the importance of these factors in controlling their populations (Figure 2). As there are relatively few data on the status of

zooplankton communities in estuaries, this study can provide a good basis for a better understanding of the functioning of vulnerable pelagic habitats. It also demonstrates the importance of zooplankton research for the assessment of the trophic state of the environment and the conservation of natural biodiversity.
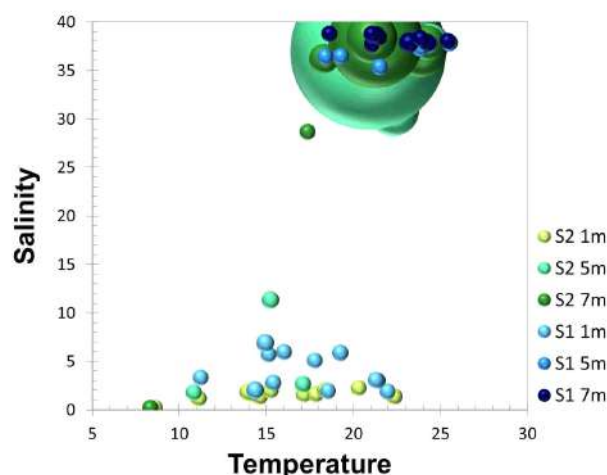

Fig. 2. Scatterplot of total abundance of tintinnids as a function of thermohaline water properties at two stations (S1 and S2) and three layers (1, 5 and 7 m) in the Neretva estuary. (Bubble width is proportional to the abundance of tintinnids)

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CIESM Congress Session : Bioaccumulation
Moderator : Blazenka Gašparovic – Ruđer Bošković Institute, Zagreb, Croatia

Session's Synthesis

In the session "Bioaccumulation", 8 presentations were given on the bioaccumulation of heavy metals, microplactics, organic pollutants and radionuclides in various Mediterranean organisms. The speakers came from all over the Mediterranean, including Spain, Tunisia, Greece, Croatia and France. The lectures lasted 3 minutes and were followed by a short discussion about the presentation. In the opening presentation I gave a brief overview of recent research trends: understanding the long-term effects of bioaccumulation, understanding the processes that contribute to bioaccumulation, identifying new classes of chemicals and how to recognize them, understanding the role of climate change in altering pollutant dynamics, and developing bioremediation strategies to reduce pollution in the marine environment. My idea was to ask them to think about what problems should be identified or solved in the Mediterranean in terms of pollution and bioaccumulation.

The discussion took place after the last lecture. One of the outcomes of the discussions was that a One Health concept needs to be developed to promote a holistic approach to health that recognizes the complex interactions between species and their environment. The question was also raised as to whether the wars in Ukraine and the Middle East could have a negative impact on the bioaccumulation of new pollutants.

The participants in the session emphasized the problem that it is impossible to compare the results of different scientists. It is suggested that several key components need to be developed, including: standardization of methods (development of standard protocols and research methods), development of common analytical and statistical frameworks, data open access, and interdisciplinary collaboration.

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ASSESSMENT OF MICROPLASTICS AND TRACE METALS IN PORT AREAS USING A FILTER-FEEDING ORGANISM AS A BIOINDICATOR SPECIES

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Abstract

Port areas in the Mediterranean Sea have an important role in Blue Economy sectors but they are heavily impacted by human activities including marine pollution due to trace metals and microplastics. This study investigates the role of a filter-feeding bivalve organism (*Mytilus galloprovincialis*) as a valid bioindicators to assess the environmental health of these areas. A total of 350 individuals were analyzed in a port area (Mallorca) giving evidence of bioaccumulation of trace metals, especially Hg, Pb and Cu, as well as a microplastic ingestion frequency of 88%.

Keywords: Marine litter, Balearic Islands, Trace elements, Coastal systems, Bio-indicators

Introduction

Coastal areas are heavily impacted by human activities (overfishing, maritime transport, aquaculture, seaweed production, power generation, intense urbanization and development, resource extraction, and coastal tourism) having negative consequences for marine ecosystems. In the Mediterranean Sea, especially in islands, port areas are a key element for their development and an important sector for Europes' Blue Economy providing with over 4.5 million direct related marine jobs [1]. Regardless of economic benefits and job creation, ports have an impact on the marine ecosystem: direct and indirect discharges of chemical products, trace metals and microplastics (MPs). Mussels are sedentary filter-feeders with a large filtering capacity simultaneously intaking dissolved contaminants and MPs and are widely used as bioindicator species for monitoring coastal and marine waters. The main aim of this research is to study and evaluate the feasibility of *Mytilus galloprovincialis* as bioindicators of human pollution in a port area by assessing i) the accumulation of trace metals (Copper (Cu), Zinc (Zn), Arsenic (As), Nickel (Ni), Cadmium (Cd), Lead (Pb) and Mercury (Hg)) in their soft tissue and ii) the intake of MPs.

Material and Methods

For this study, three sampling sites inside the Port of Palma de Mallorca (Balearic Islands, Spain) and one control site outside this port were selected. A total of 350 individuals were deployed in May and left during three summer months in the study area. Mussel's biological parameters were measured at the beginning of the study and at each sampling site and mortality rate was also measured after the study period. In order to assess the viability of mussels as indicators of the environmental status in port areas seven different trace metals (Cu, Zn, As, Ni, Cd, Pb and Hg) [2] were measured in their soft tissue and microplastic ingestion was analyzed [3].

Results and discussion

Regarding trace metals, Zn, Cu and As predominate in the soft tissue of mussels with mean values reaching up to 251.23 ± 14.01 µg/g (Zn, Site 3), 55.70 ± 0.95 µg/g (Cu, Site 3) and 23.25 ± 0.74 µg/g (As, Site 4). Pb (11.85 ± 2.20 µg/g; Site 3), Cd (1.02 ± 0.07 µg/g; Site 4), Ni (1.01 ± 0.22 µg/g; Time 0) and Hg (0.36 ± 0.01 µg/g; Site 3) showed lower concentrations in the soft tissues of mussels. The regression analyses indicated a strong and positive correlation between Hg and Pb ($r = 0.95$) and Cu ($r = 0.94$) (Fig. 1). Concentrations of Zn and As were particularly higher than in other studies (2) indicating especial affectation of the study area to these two trace metals. Regarding microplastics ingestion, 88% of the individuals had ingested microplastics showing similar values to those previously reported in the same study area (94% [4]) but much higher than in an Adriatic port (48% [5]).

Conclusion

This study gives evidence of the bioaccumulation of trace metals, especially Hg, Pb and Cu and the ingestion of MPs in mussels deployed in every sampled site of a port area, indicating not only that mussels are good indicators on environmental health but also possible active biofilters for the remediation of metals and MP pollution.
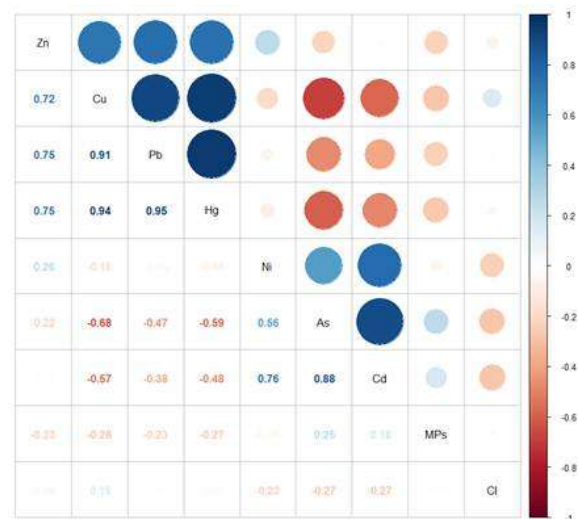

Fig. 1. Correlation analyses for the different trace metals, condition index and microplastic ingestion.

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BIOACCUMULATION OF HEAVY METALS IN *SQUALUS MEGALOPS* (ELASMOBRANCHII) FROM THE NORTHERN AND SOUTHERN COASTS OF TUNISIA

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Abstract

This work constitutes an evaluation of the accumulation of lead, cadmium and mercury in the tissues (muscle, liver and intestine) of the Shark *Squalus megalops* collected from two study areas: Bizerte Bay and Gulf of Gabes. The results revealed that muscle tissues, collected from both sampling areas, displayed concentrations exceeding the maximum limit for Hg, Pb and Cd, which presents a risk for this organism and a serious threat to the health of consumers.

Keywords: Bio-accumulation, Metals, Elasmobranchii, Mediterranean Sea

Introduction

In Tunisia, elasmobranchs are under increasing pressure from expanding anthropogenic activities (industrial and public discharges, fishing, maritime traffic...) [1]. No consideration has been given to the uptake of metals by elasmobranchs in Tunisian waters, compared to other vertebrates, which is particularly worrying given their high trophic position and the continuing decline in their populations [2]. This data deficiency despite the ecological and economic interest of this group, led us to evaluate the bioaccumulation of lead, cadmium and mercury in the tissues of *Squalus megalops* (Macleay, 1881), a shark highly appreciated by tunisian consumers and constantly available on the market.

Materiel and methods

Specimens of *S. megalops* were caught by local fishermen between November 2022 and November 2023 from 2 localities: Bizerte Bay (24 specimens) and Gulf of Gabes (17 specimens). Then, muscle, liver and intestine were taken and frozen at -20°C for metal analysis. A sample of 0.5 g (wet weight) of every tissue was homogenized and placed in 30 ml Teflon containers with the addition of 2 ml 65% nitric acid ($HNO3$) and 1 ml 30% hydrogen peroxide (H_2O_2). After, the vessels were heated to 170°C using a digestion system (microwave unit). Lead (Pb) and cadmium (Cd) concentrations were measured using an inductively coupled plasma optical emission spectrometer (ICP-OES). To estimate mercury (Hg) concentration, 0.1 g of each tissue sample was inserted in a nickel capsule and introduced into the DMA-80 direct mercury analyzer.

Results and Discussion

Cadmium (Cd) concentration in *S. megalops* tissues ranged between 0.60 µg/g in the liver from the Gulf of Gabes and 2.42 µg/g in the intestine from Bizerte Bay (Figure 1). The spatial variation of this metal did not indicate a significant difference between the 2 stations (p-value > 0.05). Referring to the standards indicating maximum cadmium levels in food (0.050 µg/g), defined by the European legislation and by [3], muscle tissues from the examined specimens showed concentrations exceeding the maximum limit for this metal at both study stations. For Lead (Pb) concentration was higher in the tissues of the specimens collected from Bizerte Bay (non-significant difference). The highest Pb accumulation was noted in the muscle of specimens from Bizerte Bay (2.6 µg/g). The Pb levels estimated in the present work (Figure 1), at both stations, exceeded the international limits set for this metal (0.30 µg/g). For Mercury (Hg), the muscle of *S. megalops* accumulated a high concentration of Hg, reaching 2.7 µg/g in Bizerte Bay (non-significant difference with that recorded in the Gulf of Gabes). Our concentrations exceed the maximum limit for Hg at both sites (1 µg/g).

Conclusion

When compared to the maximum levels of heavy metals in food defined by European legislation, the Food and Agriculture Organization of the United Nations and the World Health Organization, muscle tissues taken from *S. megalops*, showed concentrations above the maximum limit for Hg, Pb and Cd at both sampling sites. As top predator that occupies high trophic position, this shark seems to accumulate high metal doses from its prey, which could disrupt its metabolic activities and degrade its immune and reproductive systems, thus threatening its persistence in Tunisian marine waters. This elasmobranch, highly appreciated by tunisian consumers, seems to threaten the public health in the event of heavy consumption.
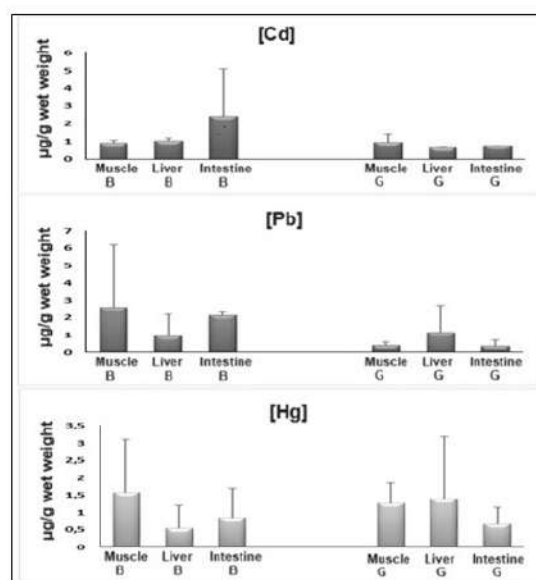

Fig. 1. Spatial variation of Cd, Pb and Hg accumulation in muscle, liver and intestine of *S. megalops* between 2022 and 2023. (± SD; B: Bay of Bizerte; G: Gulf of Gabes)

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POTENTIAL RISK ASSESSMENT OF TRACE METALS IN *LOPHIUS BUDEGASSA* FOR HUMAN CONSUMPTIONIN GREECE

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Abstract

Although seafood is considered important for a healthy diet, the frequency of certain species consumption has to be considered. In this study, Hg, Pb, and Cd were measured in the *Lophius budegassa* (black-bellied angler fish) collected from the Ionian Sea and Argosaronikos. Total Hg (THg) levels were similar in both GSAs and higher than the tolerable limits reported by the European Union for seafood. Cd and Pb concentrations were lower than respective tolerable limits. The estimated weekly intake for THg exceeded the provisional tolerable weekly intake recommended by the European Food Safety Authority and consequently, the regular consumption of this species is not recommended, especially for children.

Keywords: Metals, Fishes, Eastern Mediterranea, Ionian Sea, Saronikos Bay

Seafood is a rich source of high-quality protein and polyunsaturated fatty acids (n-3 PUFAs). Concern has risen, over the hazardous effects of contaminants such as heavy metals, bioaccumulation in fish tissues, and transferring to humans through the trophic web. In this study, we aim to determine the concentration of toxic heavy metals (Cd, Pb, and Hg) in the soft tissue of *Lophius budegassa* (black-bellied angler fish) and to give recommendations regarding the safety consumption of this species for adults and children. Twenty-five *L. budegassa* from 342 to 592mm were collected during June 2021 in the framework of the Mediterranean International Trawl Survey (MEDITS) from the Argosaronikos (GSA 22) and the Ionian Sea (GSA 20) (Figure 1).

Fig. 1. Map of the study area. Samples were collected from Ionian Sea (GSA 20) and Argosaronikos (GSA 22).

This species is one of the target species of the Mediterranean trawl fishery. The soft tissue of each individual was collected and analyzed for Hg by the Direct Mercury Analyzer DMA-80 (Milestone), Pb, and Cd by graphite furnace AAS using a Shimadzu AA 7000 apparatus. The accuracy and precision of metal analysis were verified by the analysis of reference materials (NIST 2976, and Dorm 4). The range concentration of each metal as well as the depth range of sampling are given in Table 1.

Tab. 1. The range concentration of metals in the soft tissue of *Lophius budegassa* from the Ionian Sea and Argosaronikos. N= number of individuals. The values are mg/kg wet weight. *= European Commission standard limit (EC, 2006)

	N	Depth range (m)	Hg (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
Ionian Sea (GSA 20)	15	63-384	0.36-2.45	0.007-0.013	0.063-0.39
Argosaronikos (GSA 22)	10	113-533	0.12-2.44	0.005-0.008	0.101-0.38
EC standard limit			0.5*	0.05*	0.3*

Hg and Pb were similar between sampling areas while Cd was higher in the Ionian Sea. The Saronikos Gulf is subjected to many anthropogenic activities such as intense maritime traffic from the port of Piraeus, industrial facilities, and rapid urbanization. On the contrary, the Ionian Sea is an oligotrophic and low-productivity system with no intense human-induced pressures except moderate maritime traffic. We consider that higher Cd level in the Ionian Sea is assumed to be related to natural sources. The average concentration of THg (0.85 ± 0.59 mg/kg wet weight) was the only metal that exhibited a higher level than the European limit for human safe consumption (0.5 µg/g wet weight; [1]). A similar high concentration of Hg in *L. budegassa* was found in the west Mediterranean Sea and South Africa as well. The high level of mercury contamination in the Mediterranean Sea is due to large deposits of cinnabar (HgS) and thus it has been the subject of extensive studies concerning seafood consumption [2]. The estimation of human health risk derived from seafood consumption was evaluated by calculating the EWI (Estimated Weekly Intake-[3]) for each analyzed contaminant, both for adults and children. The EWI was calculated for adults (70kg) and children (32kg) for fish consumption 3 times a week (according to the Greek authorities' recommendation). The results were compared to those recommended by the Provisional Tolerable Weekly Intake (PTWI) [4]. The highest EWI value for Hg in this study was 0.89 mg/kg for adults and 1.53 mg/kg for children which are higher than those recommended (1.6 µg/kg). Based on THQ (Target Hazard Quotient) results, which are used to express the risk of non-carcinogenic effect, the consumption of this species is not recommended for more than 3kg annually for adults and 1kg for children. *L. budegassa* is a target of trawl fishery in the Mediterranean Sea. THg, Cd and Pb were measured in the soft tissue of this species collected from the Ionian Sea and Argosaronikos. Although Cd and Pb mean values were lower than the EU limits for safe seafood consumption, the average concentration of THg was higher than the corresponding limits set by the EU [1]. The EWI was also found high for this metal than the recommended weekly intake standard for both children and adults. Consequently, the regular consumption of this species is not advised for adults and in particular for children.

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HEAVY METALS IN *NEPHROPS NORVEGICUS* (LINNAEUS, 1758) FROM THE AEGEAN SEA

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Abstract

This paper presents the concentrations of heavy metals (Hg, Ni, Cr, Cu, Fe, Zn) in the tissues of the crustacean *Nephrops norvegicus* collected from the Aegean Sea (N=176), during the years 2021–2022. In ascending order, the metal concentrations (mean value, mg/kg wet weight) were as follows: Hg (0,32) < Cr (0,87) < Ni (1,13) < Cu (10,40) < Fe (25,03) < Zn (26,46). Hg and Cr levels were influenced by the size of the animals. Hg concentrations increased ($R^2=0,21, p<0,05$) with the growth, while Cr concentrations decreased ($R^2=0,27, p<0,05$). Since the Target Hazard Quotient (THQ) was lower than 1, the risk to human health from the consumption of crustaceans is negligible. In comparison to other areas and species, the concentrations of heavy metals are relatively low.

Keywords: Crustacea, Decapoda, Metals, Mercury, Aegean Sea

Introduction - Heavy metals are among the most common pollutants that deteriorate the quality of aquatic ecosystems, due to their toxicity, persistence and tendency to bioaccumulate in biota, thus seriously threatening human health [1]. The aim of this study is to investigate the metal concentrations of *Nephrops Norvegicus* in a semi – enclosed Gulf of the Aegean Sea (North Euboean Gulf), estimate risks arising from the consumption of the crustacean, and compare the results with other studies in the N. Euboean Gulf and elsewhere in Europe.

Material and Methods - A total of 176 individuals of *N. norvegicus* were collected from the North Euboean Gulf during the years 2021 – 2022. They were examined in 48 pooled samples and divided by season, sex and size. Four size classes were created and one independent of size. We calculated the Estimated Daily Intake (EDI):EDI = (C x IR x 10^{-3}) / BW, and the Estimated Weekly Intake (EWI) [2]. Health risk from consumption was calculated by the means of the Target Hazard Quotients (THQ): THQ = (EF x ED x IR x C)/(RfD x BW x ATn) x 10^{-3} [2].

Results - Statistically significant differences were observed in the mean concentration of Hg among the seasons (p<0,05), and among the sizes (R^2:0,21, p<0,05) (Fig.1). In addition, statistically significant differences were observed in the mean concentration of Cr among the seasons (p<0,05), and among the sizes (R^2:0,27, p<0,05) (Fig.1). Moreover, statistically significant differences were observed in the mean concentration of Cu and Fe among the seasons (p<0,05). No statistically significant differences were observed between the concentrations of Ni and Zn with any other parameter.The dose of metals did not exceed the limit reported by the world literature (RfD) of metals and the risk index was found to be lower than 1 (HI= 0,1009<1).
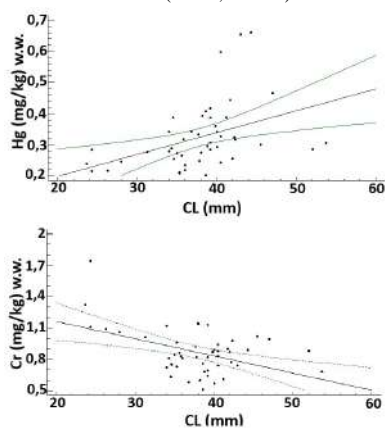

Fig. 1. Concentration of Hg (mg/kg) w.w. and Cr (mg/kg) w.w., in *N. norvegicus* species from the N. Euboean Gulf.

Discussion - The increasing concentration of Hg with increasing CL is a result of its continuous accumulation as Hg is not regulated by the body. In contrast, the negative correlation of Cr with CL could be attributed to the fact that Cr is an essential metal for the body. A higher concentration of metals was detected during the summer season (Hg, Cr, Cu, Fe). These seasonal changes could be related to the fluctuations in the concentration of metals in the water, perhaps due to the high temperature, but also possibly related to biological needs as well as differences in metabolic activities, nutrition, the rate of growth and the reproductive period of the species. Comparing our results with other studies, they reported higher levels of Ni, Cr, Cu, Fe and Zn [3]. Also, in other species from the area, metal concentrations were higher than *N. norvegicus* [3,4]. Furthermore, higher concentrations in *N. norvegicus* were observed in the Clyde Sea [5], in the Gulf of Lions [6], in Bay of Biscay [6], in Barcelona Bay [7] and in the Adriatic Sea [8]. In conclusion, there is no risk for human consumption of *N. norvegicus* species from the N. Euboean Gulf, as the metal concentrations were found within the safe intake limits.

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BIOINDICATOR SPECIFIC RESPONSES TO HISTORICALLY METAL POLLUTED ENVIRONMENT: PULA BAY CASE STUDY

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Abstract

In order to analyse biological response of musssel and meiofauna taxa to metal pollution in Pula Bay 7 metal concentrations in sediment and mussel, meiofauna abundance as well as metallothionein content and anoxic survival in mussel were investigated. Site-specific metal concentrations in sediment and mussel indicated multiple metal pollution sources. The highest metal pollution index (PLI) and lowest meiofauna abundance was found near big shipyard sites and in marina. Mussel expressed specific physiological response to metal content pattern. Anoxic survival time was correlated to PLI in sediment indicating that mussel physiological status could be related to chronic toxic metals presence in seawater. Both meifauna higher taxa abundancy as well as mussel physiological features are good indicators of metal pollution.

Keywords: Pollution, Ecotoxicology, Metals, North Adriatic Sea

Introduction - Pula bay is semienclosed bay in Istrian peninsula historically under influence of various anthropogenic activities acting as a pollutant source for the marine environment. Among pollutants entering marine environment metals are considered as potentially highly toxic capable to affect local biota. Marine sediments act as a deposition pool for heavy metals, thereby posing an ecological risk starting with sediment dwelling organisms as meiofauna. Meiofauna represent a group of small-sized benthic animal comprising of various taxa (Nematoda, Copepoda, Polychaeta, Turbellaria, etc) playing important role as indicators of environmental health (1). Also, in monitoring marine environmental quality bivalve mussel _Mytilus galloprovincialis_ are commonly used for assessment environmental status by measuring mussel anoxic survival (2) that reflects the integrative impact of contaminants to survival potential of mussel. Exposure of mussels to heavy metals, is associated with induction of metallothioneins, polypeptides involved in homeostasis of essential and detoxification of non-essentail metals (3). In this study heavy metal concentration in sediment and mussel tissue were determined as well as meiofauna composition and metallothionein content and anoxic survival in mussel to analyse diverse biological response to metal pollution in marine environment. Investigated area comprised 7 sampling sites inside the Pula bay situated in vicinity of shipyards (S4, M5, S7), cement factory (S6), former military base (S1), marina (M3), small port (M2), and one outside the bay (M8) in mariculture area where sediment, meiofauna, and mussel _M. galloprovincialis_ specimen were sampled. In sediment grain size and Pb, Cd, As, Hg, Cu, Zn, Fe and organic matter content as well as abundance of meiofauna major taxa were determined. In mussel Pb, Cd, As, Hg, Cu, Zn, Fe and metallothionein content as well as anoxic survival time were determined.

Conclusions - Seven metal concentration in sediment were site-specific and there were no correlation among metals indicating multiple sources of metal pollution. A total of 15 meiofauna higher taxa were identified in the bay including Nematoda, Copepoda, Polychaeta, Turbellaria, Ostracoda, Bivalvia, Acari, Kynorhyncha, Amphipoda, Anisopoda, Cumacea, Solenogastres, Gnathostomulida, Gastrotricha, Decapoda. Negative correlation was found between meiofauna abundance and overall pollution load expressed as pollution load index (PLI)) indicating sinergistic and cummulative effect of pollutant mixture. The highest pollution index (PLI) in sandy sediments was found near big shipyard (S4) and in marina (M3) for muddy sediments (Fig 1 A,B). The highest meiofauna abundance and lowest PLI was found outside the Pula bay (S8). Moreover, when examining individaul higher taxa, Nematoda was found to be negatively correlated to Cu content while Copepoda and Varia (all taxa comprising less then 5%) were negatively correlated to PLI. It confirmed meiofauna taxa as sensitive indicator of metal pollution in sandy and muddy sediments (1). As in sediment 7 metal concentration in mussel tissue were site-specific. According the PC 1 and PC2 load, sites with musssel containing the lowest metal content was situated in lower left quadrant (S8- outside the bay) while sites with mussel containing the highest metal content was situated in upper right quadrant (S5, S7- shipyards) (Fig.1C).Metallothionein content was positively correlated to Cd i Hg and mussel anoxic survival time, while mussel survival time was negatively correlated to As suggesting specific physiological response for each metal (4).Mussel anoxic survival response was not correlated to either PC1 or PC2 but rather to PLI in sediment indicating that physiological status of mussel could be related to chronic toxic metals presence in seawater that is reflected as sediment PLI. It can be concluded that both meifauna higher taxa abundancy as well as mussel _M. galloprovincialis_ physiological features are good indicators of metal pollution in marine environment.
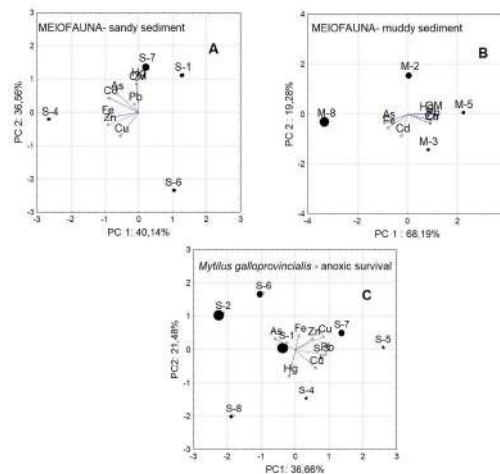

Fig. 1. PCA of metals in sandy (A) and muddy (B) sediments of Pula bay. Superimposed is meiofaunal abundance (circle size represent relative abundance).PCA of metals mussel. Superimposed is mussel anoxic survival (circle size represent relative survival time).

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COMPARATIVE ANALYSIS OF PROTEIN LEVELS IN MUSCLE AND GILLS OF *CHELON RAMADA* EXPOSED TO MYCLOBUTANIL

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Abstract

This study investigates the effects of myclobutanil exposure on protein levels in the muscle and gills of *Chelon ramada*, an important euryhaline fish species in aquaculture in Tunisia. Myclobutanil, a widely used fungicide in agriculture, can have unintended consequences on non-target organisms like fish. Fish were exposed to varying concentrations of myclobutanil, and protein levels were analyzed as biomarker of effect. Results indicate significant alterations in protein levels, suggesting potential physiological impacts on fish health. This research highlights the importance of understanding the effects of fungicides on aquatic organisms and the need for further studies to mitigate potential risks in aquaculture systems.

Keywords: Ecotoxicology, Aquaculture, Mediterranean Sea

Introduction

The transport of myclobutanil from agricultural fields to the sea *via* rainfall runoff represents a significant pathway for the introduction of this fungicide into dam reservoirs and marine environments. This can have implications for freshwater and marine ecosystems, as myclobutanil can impact non-target organisms, including fish, and may contribute to the broader issue of chemical pollution in aquatic ecosystems. It has been detected in water and sediment samples from aquaculture systems around the world [1-2]. The potential impact of myclobutanil on fish in aquaculture systems has received relatively little attention, despite the potential risks. Few studies have investigated the effects of myclobutanil on fish [3-4], and there is limited information on the ecological consequences of myclobutanil exposure in aquatic environments. This knowledge gap is particularly concerning given the important role of fish in aquatic ecosystems, as well as their value as a food source for humans. Therefore, there is a need for research to better understand the potential effects of myclobutanil on fish and to inform regulatory decisions regarding its use in agriculture. This study investigates the impact of myclobutanil on protein levels, used as a biomarker of effect, in the muscle and gills of *Chelon ramada*, a fish species commonly used in aquaculture in Tunisia.

Material and Methods

Fish were exposed to myclobutanil concentrations of 0.06, 0.1, and 0.2 mg/L for 11 days, with protein quantity analyzed in both exposed and control groups. The results will provide valuable insights into the physiological responses of fish to myclobutanil exposure, aiding in the development of more sustainable aquaculture practices.
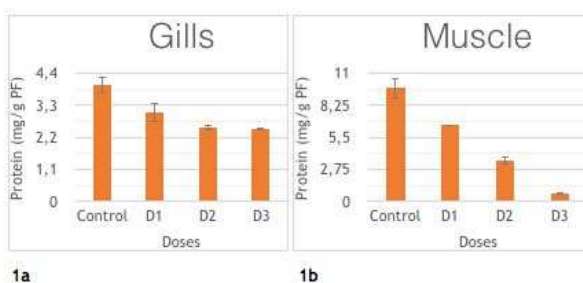

Fig. 1. Protein level in *Chelon ramada* gills (1a) and muscle (1b) of control (CT) and treated specimens with a series of Myclobutanil concentrations, D1 (0.06 mg/L), D2 (0.1 mg/L), and D3 (0.2 mg/L) during 11 day of treatment. Data were expressed as means ± SE for 10 animals in each dose. D1, D2, and D3 dose versus Control (CT) group: *$p < 0.05$.

Results and Discussions

Based on the findings depicted in Figure 1.a, it is evident that there was a statistically significant reduction in the protein concentration within the D1 treatment group compared to the control ($p < 0.05$). Specifically, the protein content decreased from 4.005 mg/g in the control to 3.061 mg/g in the D1 treatment group. Furthermore, the gills subjected to treatments D2 and D3 exhibited a highly significant decrease in protein content, measuring 2.538 mg/g and 2.475 mg/g, respectively, in comparison to the control group ($p < 0.001$). These observations suggest a pronounced impact of D1, D2, and D3 treatments on the protein levels in the gills. In the muscle tissue analysis (Fig. 1.b), D1 demonstrates a notably significant reduction of approximately 3.171 mg/g compared to the control group ($p < 0.01$). Furthermore, treatments D2 and D3 induced a highly significant decrease in protein concentration, with D2 measuring at 3.544 mg/g and D3 at 0.709 mg/g ($p < 0.001$). Overall, the results indicate a significant reduction in protein concentration in both gills and muscle tissues following treatments D1, D2, and D3, suggesting a pronounced impact of these treatments on protein levels in the respective organs.

Conclusion

In conclusion, the results of this study underscore the profound physiological alterations induced by myclobutanil exposure in fish, as evidenced by the marked reductions in protein concentration observed in both gills and muscle tissues. Through rigorous validation procedures, we have established protein levels as robust biomarkers reflective of myclobutanil's impact. This validation enhances the credibility of our findings and accentuates the utility of protein concentration as a sensitive and reliable indicator of myclobutanil exposure in aquatic organisms. Further investigation into the mechanistic underpinnings of these effects and their potential long-term ramifications is imperative for informing regulatory measures and mitigating ecological repercussions associated with myclobutanil usage.

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SEASONAL MONITORING OF ACTIVITY CONCENTRATIONS OF RADIONUCLIDES IN MUSSEL *MYTILUS GALLOPROVINCIALIS* ALONG THE CROATIAN ADRIATIC COAST

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Abstract

Activity concentrations of radionuclides (^{7}Be, ^{40}K, ^{232}Th, ^{226}Ra, ^{238}U and ^{137}Cs) were determined by gamma-spectrometry in mussels *M. galloprovincialis* and the radioecological condition of the Croatian Adriatic coast was assessed during a period from 2008 to 2023. While activity concentrations of ^{137}Cs in dry tissue of mussels sampled at all locations were generally below the detection limit, measurable low activity concentration values were occasionally noted at almost all locations. In the spring, activity concentrations of ^{7}Be in mussels were regularly higher than in autumn for all locations. The average activity concentration of ^{40}K in mussels did not vary significantly with respect to sampling season or location. Activity concentrations of other naturally occurring radionuclides were generally below the detection limits.

Keywords: Radionuclides, Mollusca, Monitoring, Adriatic Sea

Introduction - The naturally occurring radionuclides (^{7}Be, ^{40}K, ^{232}Th, ^{226}Ra and ^{238}U) and anthropogenic ^{137}Cs are omnipresent in seawater, and may also enter the marine environment through atmospheric deposition, underground freshwater discharges and river flows [1]. ^{137}Cs has the half-life of 30 years and it is still present in the environment after nuclear weapon testing and the Chernobyl accident [2,3]. In particular, the mussels *M. galloprovincialis* has found wide use as an indicator organism in marine pollution monitoring programmes since it filters up to 3 L/h seawater, and readily accumulates dissolved/particulate matter from seawater [4,5].

Material and methods - Samples of mussels *M. galloprovincialis* (4-5 kg) from 13 locations along the Croatian Adriatic coast were collected and analysed in spring and autumn from 2008 to 2023. At all sampling locations seawater temperature and salinity were measured (Fig. 1). Activity concentration of radionuclides ^{137}Cs, ^{7}Be, ^{40}K, ^{232}Th, ^{226}Ra and ^{238}U with associated expanded uncertainty (2k) were determined by gamma-ray spectrometry. Samples of mussels drie tissue were measured using a high-resolution HPGe detector (Canberra). The sample counting time was between 80,000 and 200,000 seconds, and the obtained spectra were analysed with Genie 2000 software.
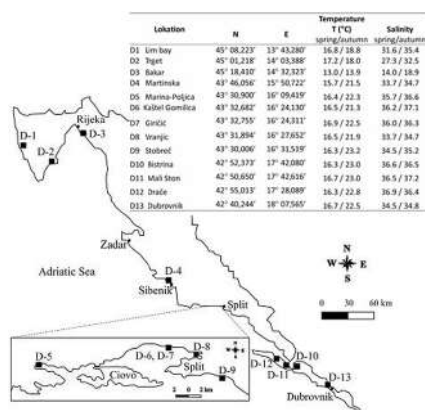

Fig. 1. Sampling locations of mussels *M. galloprovincialis* with seasonal average temperature and salinity of seawater along the Adriatic coast.

Results and Discussion - All research locations are in bays under significant influence from freshwater discharges, as evidenced by salinity values that are below average for the Adriatic (Fig. 1). Irrespective of sampling season, ^{137}Cs was sporadically detected in mussels on almost every location with low activity concentrations (max.1.05 Bq/kg), most of the results were below the detection limits (<0.3 Bq/ kg). Average activity concentrations of ^{7}Be were regularly higher in spring than in autumn for all locations. Activity concentrations of ^{40}K in mussels did not vary significantly with season or location, with the average value was 302 Bq/kg (Fig. 2). However, the autumn values were generally slightly higher than the activity concentrations measured in spring. Activity concentrations of ^{232}Th, ^{238}U and ^{226}Ra in mussels were mostly below the detection limits with no seasonal changes at all locations.
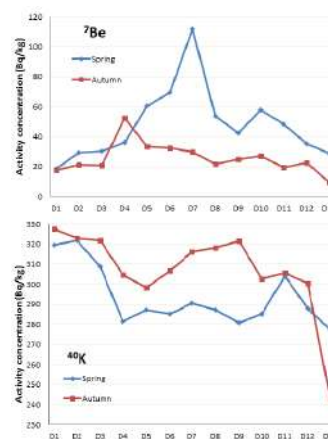

Fig. 2. Average activity concentrations of ^{7}Be and ^{40}K (Bq/kg) in mussel tissues sampled in spring and autumn in the period from 2008 to 2023.

Conclusion - Activity concentrations of ^{137}Cs in mussels were below the detection limit, except on a few occasions when, regardless of the sampling season and location, low activities were detected. Activity concentrations of ^{7}Be in mussels were the highest in spring periods for all locations which can be attributed to the impact of rain and fresh water inflow. Activity concentrations of ^{40}K did not differ significantly, irrespective of the season or location and can be attributed to its high and uniform concentration in the sea. The radioecological condition of the Adriatic Sea is satisfactory and without significant radionuclides input from fallout and rivers.

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TEMPORAL VARIABILITY OF MERCURY AND MONOMETHYLMERCURY IN PLANKTON FOOD WEBS IN THE BAY OF MARSEILLE

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Abstract
Human populations are mainly exposed to mercury (Hg) through seafood consumption. Mediterranean fishes contain more Hg than their counterparts in other oceanic basins, a phenomenon known as the 'Mediterranean Hg anomaly'. The study of Hg accumulation and transfer within the planktonic compartment in a human-impacted bay could help to better understand the mechanisms responsible for this phenomenon. The results of our study showed: 1) high bioconcentration of Hg in small-sized phytoplankton, 2) bioreduction of Hg inorganic forms and biomagnification of organic ones, 3) influence of both environmental trophodynamics and anthropogenic emissions on Hg accumulation and transfer in plankton food webs, and 4) the importance of the planktonic biological pump for explaining the higher Hg concentrations in Mediterranean organisms.

Keywords: Plankton, Mercury, Food webs, Bio-accumulation, Gulf of Lyon

The 'Mediterranean Hg anomaly' has been debated for decades [1,2]. Plankton, at the base of pelagic food webs, is suspected to play a significant role in the high bioaccumulation of Hg observed in marine Mediterranean organisms. However, few studies have been conducted on this compartment in the Mediterranean [3,4].

The aim of our study was to investigate the temporal variations in the accumulation and transfer of total Hg (THg) and monomethylmercury (MMHg) in plankton food webs in the Bay of Marseille.

Between 2020 and 2021, large quantities of seawater and plankton were sampled monthly by pumping and trawling nets at the maximum chlorophyll depth. Plankton was separated into different size fractions of phytoplankton (0.7-2.7, 2.7-20, 20-60 and 0.7-60 µm) and zooplankton (60-200, 200-300, 300-500, 500-1000, 1000-2000 and >2000 µm). THg and MMHg, carbon and nitrogen stable isotope ratios (d13C, d15N), and taxonomic composition were determined in all size fractions.

Bioconcentration of Hg in phytoplankton is the first and by far the most important accumulation step of Hg in biota, with concentrations in phytoplankton millions of times higher than those in seawater (Fig. 1).
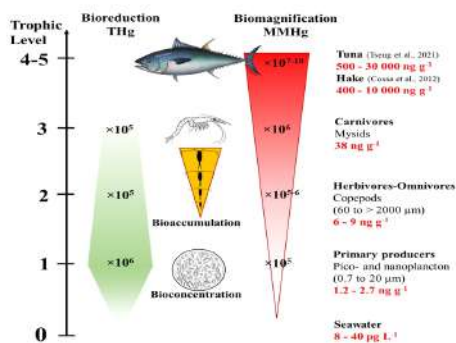

Fig. 1. Accumulation and transfer of THg and MMHg in a Mediterranean food web.

In a plankton food web constituted of three trophic levels, THg bioreduces while MMHg biomagnifies, leading to maximum concentrations in carnivores. This contrast is mainly related to different partitioning between inorganic and organic forms of Hg at the phytoplankton cellular level, associated with an efficient accumulation of the organic form during ingestion.

MMHg concentrations in seawater and zooplankton are lower when phytoplankton biomass is high. Conversely, higher dissolved MMHg concentrations in seawater favour higher direct MMHg uptake in zooplankton when phytoplankton biomass is low. Under productive conditions, the abundance of herbivore-omnivore consumers reduces MMHg concentrations in zooplankton, while in oligotrophic conditions the omnivore-carnivore consumers of higher trophic-level leads to greater accumulation of MMHg in zooplankton.

Finally, our results show higher concentrations of THg and MMHg in both seawater and plankton in the Bay of Marseille compared to other Mediterranean areas, suggesting a significant impact of human emissions on the marine coastal food webs.

This study highlights the role of biological pump of Hg by plankton and the influence of food web structure, organic matter fluxes and anthropogenic emissions in the accumulation of Hg in marine coastal ecosystems.

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CIESM Congress Session : Marine Litter and Nano/Microplastics I
Moderator : Serena Savoca – Univ. of Messina, Italy

Session's Synthesis

The session "Marine Litter and Nano/Microplastics I" hosted seven presentations focusin on different aspects related to marine plastic pollution, with a special focus on environmental matrices. A total of 31 authors contributed to the session, supporting the field of plastics research through the development of innovative methods or integration with existing methods, for sampling and identification of plastics (from micro to macroplastics) in different environmental matrices and in different areas of the Mediterranean. Contributions included observations on occurrence and distribution of microplastics, using a chemometric approach in water samples, sediment and *Holothuria* sp. from Malta. While surface marine sediments were analyzed in a Shipyards Region, located on the southwestern coast of Izmit Bay (Marmara Sea), demonstrating how the Shipyard regions were more contaminated than in a nearby location.

One of the most discussed aspects of the session concerned occurrence, transport and distribution patterns of plastics in aquatic matrices. Transport and distribution of microplastics were investigated in the Krka River estuary, Croatia. One study focused on the vertical distribution of microfibers in surface, intermediate and deep water masses in different Mediterranean regions, focusing on how they can significantly accumulate in deep Mediterranean waters. Another contribution introduced an innovative method for sampling microplastics in North Atlantic surface waters.

Two contributions focused on the problem related to the ability of plastics to act as a vector for other classes of contaminants. In particular, one study highlighted how plastics are able to adsorb metals, even traces, and how this ability can be influenced by the duration of exposure but also by the depth of exposure, especially in particular environments such as Krka River estuary (Croatia). The second study investigated the ability of plastics to release additives into the aquatic medium, providing an overview of the release of phthalic acid esters or phthalates (PAEs) and organophosphate esters (OPEs) in the Mediterranean Sea and Rhone Rivers.

The session was characterized by an open discussion at the end of each presentation, in most cases emphasizing the need both to adopt standardized methods and to employ multidisciplinary approaches to achieve accurate and complete results, which can clarify the impacts of plastic pollution on natural ecosystems.

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THE OCCURRENCE AND DISTRIBUTION OF MICROPLASTICS IN DIFFERENT ENVIRONMENTAL MATRICES: A CHEMOMETRIC APPROACH

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Abstract

The distribution of microplastics (MP; particles ranging from ≥1µm to <5 mm in size) was comprehensively assessed within the Maltese marine environments through systematic sampling of seawater, sediment, and *Holothuria* sp. Employing chemometric techniques provided crucial insights into the distribution patterns of MP, uncovering distinct compositional differences between sites, as well as between the environmental matrices. A consistent pattern emerged with *Holothuria* sp. and sediment samples clustered together across both sites, suggesting similarity in chemical composition. Nonetheless, samples from each sampling site formed distinct clusters, indicating a variance in the chemical composition of MP between the two locations and hinting at the probability of distinct sources for MP.

Keywords: Mediterranean Sea, Plastics, Chemical analysis, Sediments, Coastal waters

Introduction

Present-day plastics have experienced a notable upsurge in recent years. This surge can be attributed to the versatility, lightness, resilience, strength, and cost-effectiveness of plastic materials. However, these advantageous properties have also led to plastic becoming a pressing environmental concern due to its persistent nature and resistance to degradation. In recent years, there has been an emerging environmental concern regarding microplastics (MP) [1].

This study aims to determine the presence of MP in various environmental matrices within the Maltese marine environment, and to identify for any relationships between the different matrices through the utilisation of chemometric techniques on FTIR spectra.

Materials and Methods

Two sandy beaches were sampled from the North of Malta (Slugs Bay [SB] and Mistra Bay [MB]). The sample collection process entailed laying out three 20-metre transects perpendicular to the shoreline, spaced 5 metres apart at each site. Sediment and seawater samples, together with *Holothuria* sp. specimens were collected at 5m intervals from each transect. Treatment and analysis of samples were done according to published guidelines and literature [1, 2].

Following physical characterisation, spectral acquisition was conducted using a Shimadzu IR-Affinity 1 spectrophotometer. The spectral data, processed in The Unscrambler X 10.3, underwent various spectroscopic signal processing techniques, including normalisation, detrending, and deresolving, eliminating nonlinear trends and reducing noise.

Results and discussion

MP of diverse shapes, types, and colours were detected in all three matrices in both SB and MB, with a combined total of 6,408 MP recovered from MB and 5,275 MP from SB. Overall (Tab 1.), sediment and *Holothuria* sp. exhibited increased MP contamination levels in contrast with surface water, aligning with studies indicating seafloor sediments as prominent sinks for MP.

Tab. 1. Quantities of MP found in the two sampling sites.

	Mistra Bay	Slugs Bay
Seawater	0.059 MP/kg	0.089 MP/kg
Sediment	212.62 MP/kg	157.35 MP/kg
Holothuria sp.	1,042.88 MP/kg	777.22 MP/kg

Combining microscopy and chemometric approaches showcased a variation in chemical composition among the two sampling sites, particularly notable in sediment and *Holothuria* sp. As evidenced in Fig 1, samples from *Holothuria* sp. and sediment in SB clustered together, contrasting with those from MB. The optimal spectral pre-treatment effectively elucidated dataset variations, explaining 76% through the first two PCAs. PCA analysis revealed distinct clustering, with samples from sediment and *Holothuria* sp. from the respective beaches exhibited close proximity within the clusters, while those sourced from seawater demonstrated greater diversity. Loading plot analysis identified spectral features, implying that seawater demonstrated greater diversity. Distinctive

patterns within spectral regions for PC1 were revealed, spanning 3800-3400 cm^{-1} and 3400-2900 cm^{-1}, which conversely exhibited positive loadings for PC2. These regions represent various characteristic vibrational modes, including the O-H stretches of alcohols (including phenols) and carboxylic acids, the N-H stretches of amines and amides and the C-H stretches of terminal alkynes.
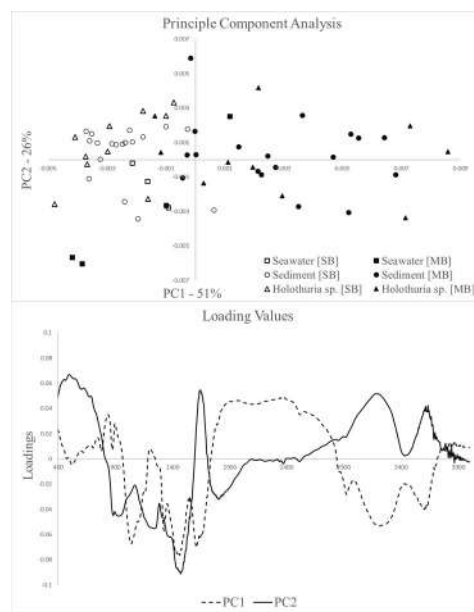

Fig. 1. Principal component analysis (PCA) showcasing all the matrices from both SB and MB, together with the loading values (PC1 and PC2).

Analysis of the loading plots identified spectral features with minimal noise interference, implying that observed variations in the score plot predominantly stem from MP and other organic compounds present within the different sites and matrices under investigation.

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MICROPLASTIC CONTENT IN THE WATER COLUMN OF THE KRKA RIVER ESTUARY, CROATIA

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Abstract

Microplastics enter the aquatic environment from a variety of sources, including the breakdown of larger plastic debris, microbeads used in cosmetics, textiles and industrial processes. Because of their small size and buoyancy, microplastics can be transported long distances by ocean currents and atmospheric circulation, leading to their wide distribution in the aquatic environment. In this study, we investigated the distribution of microplastics in the Krka River estuary.

Keywords: Estuaries, Adriatic Sea, Marine litter, Monitoring

Introductions

Microplastics (MPs) are plastic particles (synthetic polymers) smaller than 5.0 mm in size. The lower limit is still not specified, but often the mesh size (300 μm) of neuston or manta nets is considered, which are used for sampling in the natural waters. MPs remain in the environment for a long period of time, during which they can be translocated by winds or currents, changing their distribution throughout the water column. Moreover, MPs have been recognized as an ubiquitous anthropogenic contaminant in aquatic ecosystems. Most of the plastic in the aquatic environment comes from land, most often by rivers, so research in estuaries is very important. Continued research on microplastics is essential to better understand the sources, distribution, behavior and impacts of microplastics, as well as to develop effective strategies for mitigation and remediation.

Materials and Methods

Sampling was done using the "Net for Microplastic Sampling" (Hydro-Bios, Apparatebau GmbH, Altenholz, Germany; meshsize: 300 μm; net aperture: 0.28 m2 [width 70 cm, height 40 cm, in the lower part of the Krka River estuary.
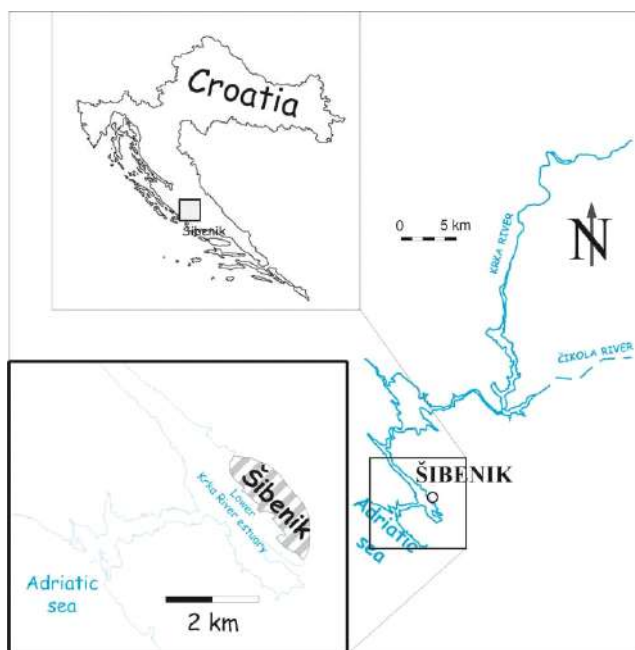

Fig. 1. Map of the study site

The volume of water that passed through the net was calculated with a flow meter (Mechanical Flow Meter, Hydro-Bios, Apparatebau GmbH, Germany) positioned at the net rim, according to the given manual by the manufacturer. After towing, the net was rinsed from the outside with Mili-Q water from a pressure container to avoid sample contamination. All sampled MP particles were gathered in the collecting glass jar with a lid from the cod end. The samples were refrigerated at +4°C until further laboratory processing. Obtained samples were wet sieved through a 250 m sieve, the organic matter was removed, and the solution was filtered through glass microfiber filters (LGG Labware; pore size 1.6 m; filter diameter Ø 47 mm) Before visual inspection of each putative microplastic particle using a stereomicroscope (Nikon SMZ745T, Tokyo, Japan) equipped with Bresser MikroCam PRO HDMI 5 MP, a Nil Red was used.

Results In the first sampling (March, 2022.) only surface water was sampled and total of 507 particles were visually detected and considered as MPs from the sampled surface waters with a mean abundance of 0.730 items/m^3 and 0.292 items/m^2, respectively. The maximal abundance (1.364 items/m^3, 0.545 items/m^2) was recorded in the proximity of the Mandalina marina, gradually decreasing as the sampling proceeded further from the marina, with a minimal abundance of 0.310 items/m^3 and 0.124 items/m^2 Parac etal. 2022a). During second sampling (June, 2022) a total of 910 microplastic particles were collected in the water column. As shown in Table 1, the number of detected particles ranged from 389 in Surface layer, to 372 in subsurface layer, 86 in halocline layer, and 63 in marine layer. The total sampled volumes varied from 108.07 m3 to 980.00 m3. The highest plastic abundance was found in surface layer (3.68 particles/m^3), followed by the subsurfacelayer (0.38 particles/m3), then in halocline layer (0.19 particles/m3), and the lowest in marina layer (0.13 particles/m^3) (Parac etal, 2022b). MPs were found in different shapes, sizes, and colors. Fragments (58.38%) were the dominant shape, followed by foams (14.40%), filaments (10.06%), fibers (8.28%), microbeads (3.94%), films (3.55%) and pellets (1.38%).
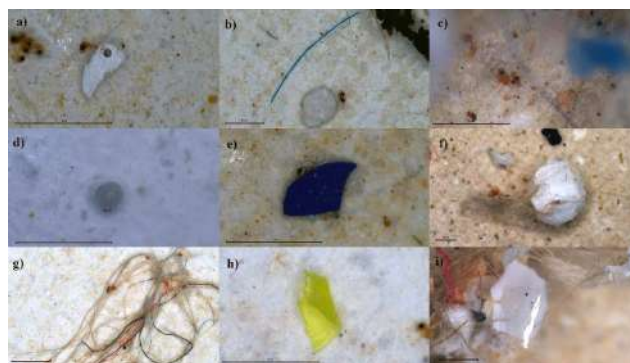

Fig. 2. Images of MPs visually identified by Nikon SMZ745T stereomicroscope: a), e), h) fragments; b)fiber; c) microbeads; d) pellet; f) foam; g) filaments; i) film.

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ASSESSMENT OF MICROPLASTIC POLLUTION ALONG THE SHIPYARDS REGION IN THE SOUTHERNWEST COAST OF IZMIT BAY (THE MARMARA SEA)

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Abstract

Activities in shipyards, may contribute microplastic pollution. In the present study, microplastic particles (MPs) in marine surface sediment were investigated in six stations in a Shipyards Region, located on the southwestern coast of Izmit Bay (the Marmara Sea). The data also compared with a control station. A total microplastic number ranging from 444 to 844 particles/m^2 in the shipyard area. The microplastics were predominantly High Density Polyethylene. Microplastic particle numbers in the Shipyard Region were significantly higher than in a nearby location. The data suggests that MPs likely reach the marine sediment and cause contamination following various processes in the Shipyard Region. Therefore, effective treatment systems should be established to prevent MP pollution that will originate from shipyards.

Keywords: Marine litter, Marmara Sea

Introduction Microplastics are manufactured for numerous industrial and domestic usages and categorized as primary (originally < 5 mm) and secondary microplastics (formed from larger plastics) [1]. It is estimated that 2% of the plastic produced worldwide each year, which is 6.5 million tons, reaches the seas and this phenomenon is a serious concern for marine pollution [2]. Activities such as ship construction, maintenance, repair, loading/unloading processes are carried out in shipyards. These are very important for the sustainability of the maritime industry. However, a lot of plastic materials are used during these processes and there is a risk of contaminating the sea. There are no studies in the open literature regarding microplastic pollution from operations carried out in shipyards or particularly in the regions where shipyards are located. Therefore, in the present study, microplastic particles (MPs) in marine sediment were investigated along the Altinova (Yalova, Turkey) Shipyards Region, located on the southwestern coast of the Izmit Bay (the Marmara Sea) (Figure 1).

Fig. 1. Sampling station locations along the Shipyard Region in the Izmit Bay (the Marmara Sea).

Methodology Surface sediment samples (5 cm cross-section depths) were taken by Ekman grab sampler from six locations (ST-H, St-S, St-D, St-G, St-T, St-Ge) which were selected based on their existence in the shipyard region during 2022-2023. One more sampling was carried out for control (St-C) in the southern Marmara Coast (Figure 1).The sampling depths, and distance to the coast were given in the table (Table 1).

Tab. 1. Basic data and MPs numbers addressing the Shipyard Region surface sediments.

	St-H	St-S	St-D	St-G	St-T	St-Ge	Control St.
Date	27/5/22	24/6/22	27/5/22	9/12/22	8/6/23	18/12/23	9/12/23
Depth	7 m	10 m	13 m	10 m	17 m	20 m	15 m
Distance	300 m	300 m	300 m	250 m	300 m	300 m	300 m
MP particles number/m^2							
HDPE	267	311	222	356	400	267	133
PP	133	133	178	267	178	133	89
PS	44	88	133	133	89	44	0
PET	44	44	0	44	44	0	44
Other	11	33	22	44	33	0	0
TOTAL	499	609	555	844	744	444	266
Film	145	176	145	328	272	220	134
Filament	292	353	318	412	328	176	88
Fragment	62	80	92	104	144	48	44

Approximately 0.5 kg (wet weight) sediment Samples kept in a glass jar and transported to the laboratory for detailed examination. In the first step, sediment samples were passed through a 500 μm stainless-steel sieve and dried in an oven at 55 °C for 72 hours. Then hydrogen peroxide (%10 v/v) was added to remove organic substances during a day. ZnCl$_2$ (d:1.6) solution was added onto the dried samples to separate microplastics which have different densities. Floating samples were collected, stained Nile Red, and examined under a fluorescence microscope. Also, FTIR analysis was performed for molecular characterization (i.e., High Density Polyethylene-HDPE, Polypropylene-PP, Polystyrene-PS and Polyethylene Terephthalate-PET, and other) of the particles.

Results and Discussion The total number of MP in surface sediments taken from stations in the Shipyards area varied between 444 and 844 particles/m^2. The highest number of MPses were found at St-G station, where located in the central part of the shipyards region. This station is also the closest one to the coast. It is remarkable that MP particle numbers at all stations in the Shipyards Region were 1.7 to 3.2 times higher than the control station (St-C). HDPE particles were found in the highest amount at all stations. This was followed by PP, PS and PET particles, respectively. The most abundant MP form in all stations except ST-D and Control stations was Filament. The least common MP form in all stations was Fragment (Table 1). No significant correlations were determined among the variables (p>0.05). Comparison with a previous study [3] carried out in a nearby location out of the Shipyard Region shown that MP particle numbers are significantly higher in the Shipyard Region. The number of MPs in surface sediments may vary greatly depending on the region, depth, and distance to the coast. Accordingly, since there is no study in the open literature on shipyard regions, it is difficult to make a direct comparison.

Conclusion Obtained data regarding MPs abundance in the Shipyard Regions indicate that MPs probably occurred after numerous processes in the facilities reach to the marine sediment and cause contamination. Studies show that marine organisms, such as fish [4], are affected by MP pollution. Therefore, it is thought that waste management and water treatment systems should be used effectively to prevent MP pollution in shipyards. This is necessary both to protect the marine ecosystem and to reduce potential risks that could adversely affect sustainable life of marine organisms.

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MICROPLASTIC DISTRIBUTION IN THE NORTH ATLANTIC ALONG A SAILING ROUTE OF THE SPINDRIFT TRIMARAN (FRANCE TO THE U.S.)

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Abstract
We report the results of a study on microplastic pollution conducted in the North Atlantic waters in 2023 using a maxi trimaran of the Spindrift Team (https://spindrift-racing.com/) as a ship of opportunity. A total of 40 items were counted (being 85.0% fibers), with an average concentration of 4.4 ± 1.9 items/m^3 (mean ± SD) at 8 sampling stations. According to the LDIR analysis (n=29), 69.0% of the items were made of non-synthetic materials such as cellulose and natural polyamide. PET, followed by PP, PU and polyamide were the polymers identified in synthetics.

Keywords: North Atlantic, Marine litter, Plastics, Pollution

Microplastics have become a global concern due to their ubiquity, persistence and toxicity to both wildlife and humans. Therefore, determining their distribution, concentration and composition in the natural environment is crucial to assess their potential environmental impact. Here, we present the results of a microplastic pollution survey conducted between Trinité-sur-Mer (France) and New York (USA) in May 2023 aboard a spindrift trimaran "Spindrift 2", used as a ship of opportunity.

Samples (one replicate per site) were collected at 8 different sampling stations, using a microplastic sensor that continuously pumps seawater through up to three stainless steel filters of 300, 100 and 30 µm mesh filters. Filters were changed very 24 hours (volume filtered ranging from 1.03 to 1.28 m^3) and securely packed in aluminium bags and stored at room temperature until transport to the Marine Laboratory UA-Dénia (University of Alicante, Spain). In the laboratory, the 24 filters were examined and sorted with a Leica S8AP0 stereomicroscope to determine their shape and color. All items found were photographed using a Nikon D300s and measured with the ImageJ software. The chemical composition were analysed using an Agilent 8700 Laser Direct Infrared (LDIR). Spectra of individual items were compared with commercially available standard libraries. Only matches ≥70% with reference spectra were accepted as valid identifications. Throughout sample processing, measures were implemented to avoid cross-contamination (e.g. air contamination controls).
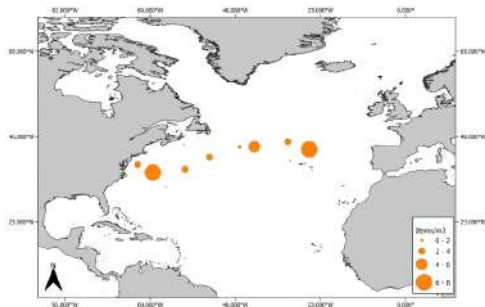

Fig. 1. Map of the study area showing the location of all sampling stations and the mean items concentrations expressed in items/m^3. Size of circles is proportional to concentration values on a logarithmic scale.

A total of 40 items were counted in all samples (85% being fibres, 12.5% fragments and 2.5% films), with concentration ranging from 7.83 items/m^3 at sampling station 1 (closest to Europe) to 1.76 items/m^3 at sampling station 4 (midway across the North Atlantic). 57.5% of the items were collected on 300 µm mesh filters, 30.0% on 100 µm mesh filters and 12.5% on 30 µm mesh filters. Almost half of the items were black (42.5%), followed by white (27.5%), blue (12.5%), transparent (7.5%), yellow (5.0%), green (2.5)

and red (2.5%) colors. Mean fiber length was 1.98 ± 1.62 mm (mean ± SD, N=32).

LDIR analysis (n=29) revealed that 69.0% of the particles were made of non-synthetic materials, the majority being made of cellulosic (65.0%) and natural polyamide (35.0%). Among the synthetics, the most abundant polymer was polyethylene terephthalate (PET)(66.7%), followed by polypropylene (PP) and polyurethane (PU) and polyamide (11.1% each).Although direct comparison between studies is difficult due to the different sampling and analysis methodologies used, the characterization of the items found would be consistent with other studies performed worldwide, in which fibers typically accounted for 60 to 96% of the elements present in seawater [1], with 75-80% of them being cellulosic when analyzed [2,3].

In terms of abundance, our results are mainly at the lower end of the range of concentrations obtained by Tanhua et al. [4](0-43 items/m^3) when they sampled at similar coordinates during the Ocean Race 2017/2018 edition. Considering that they only counted particles (excluding fibers) within the 100-500 µm size fraction, this difference could be even larger. To the best of our knowledge, no other studies with comparable units/methodology have been conducted in the area surveyed (36-48ºN, 3-73ºW).

This study demonstrates that collaboration between academia and competitive boating through the use of convenience vessels provides a unique opportunity to collect data from under-sampled marine areas. Furthermore, harmonization is still needed not only in sampling, but also in data reporting in microplastics studies.

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MEDITERRANEAN INTERMEDIATE AND DEEP WATERS AS RESERVOIRS AND CARRIERS OF SMALL MICROFIBERS

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Abstract

The vertical distribution of microfibers in surface, intermediate and deep water masses in different Mediterranean regions are affected by the complex circulation pattern of circulation typical of the Mediterranean Sea. MF in surface waters were generally homogenous in all regions. MF in intermediate and deep layers were different from different water masses. Along the path, the MF content in the Levantine water decreases and the fibers shorten, while in deep waters the MFs were longer and more abundant. Short fibers have a high potential to persist in the water column and spread in the ocean.

Keywords: Mediterranean Sea, Plastics, Water transport, Deep waters, Intermediate waters

Microfibers (MFs) are emerging pollutants that are generally reported as the predominant fraction among microplastics (MPs) in the environment and are now considered as a global concern [1]. Approximately 2 million tons of MFs are released into the ocean every year and it has been estimated that approximately 1.5 million trillion of MFs are now in the ocean, thus representing one of the most abundant pollutants in the marine environment [2]. Once in the sea, little is known about their distribution and dynamics, especially in the water column, although well known oceanographic processes may play a key role controlling their accumulation and transport. This seems to be the case of the Mediterranean Sea, where the current's high spatio-temporal variability and the intense mesoscale activity prevent the formation of persistent accumulation regions, promoting a high dynamic scenario where the largest faction of MPs is transported through several preferential surface crossroad regions and sinking areas [3]. Previous studies focused on the transport, and accumulation of large plastic particles on Mediterranean surface waters, while the dynamics occurring at intermediate and deep layers has not yet been investigated. To fill this gap, we studied the MFs distribution in the water column and in different water masses in several Mediterranean regions.

MFs samples were collected at 38 stations located in the Eastern and Western Mediterranean Seas during the two research cruises (ICHNUSSA17 and Infra-Oce17). Sampling stations were located in strategic locations to study the exchanges between Mediterranean basins and sub basins. At each station, triplicate water samples were collected at four different depths from the surface to the seafloor (down to 3465 m), including different water masses identified as surface Atlantic Water (AW), Levantine Intermediate Water (LIW), Western Mediterranean Deep Water (WMDW) and Tyrrhenian Deep Water (TDW). The aim of our study was to investigate the MFs distribution in different water masses and the large-scale transport of MFs through Mediterranean basins.

MF Vertical Distribution. MFs were detected in all samples with a median concentration of 3.8 MF L^{-1} (IQR: 3.1 MF L^{-1}) and a median fiber length and diameter of 1023 µm (IQR: 1007 µm) and 15 µm (IQR: 3 µm), respectively. µFTIR analysis highlighted cellulosic fibers as the dominant polymer type (85 %) in the whole water column over synthetic fibers (5 %) and processed cellulose (8 %), while animal fibers were only detected occasionally. In general, no significant differences in MF concentration and composition were found in different water masses. However, the highest MF concentration was detected in the LIW with 3.4 MF L^{-1} (IQR 5.0 MF L^{-1}), while the lowest concentrations were found in the AW with 3.0 MF L^{-1} (IQR 2.9 MF L^{-1}). Deep water masses were characterized by a MF median concentration of 3.2 MF L^{-1} (IQR 4.4 MF L^{-1}). On the other hand, relevant vertical variations (Kruskal-Wallis test, $p < 0.05$) result between water masses in the same sub-area in most of the transects and stations studied. LIW in Southern Sicily was characterized by the highest MF levels (14.0 MF L^{-1}) and higher than the AW in the same area (2.55 MF L^{-1}). In the TDW, in the outflow section in the Sardinia-Sicily Channel the highest deep MF concentration was detected (9.1 MF L^{-1}), while LIW and AW showed lower MF concentration of 2.0 and 1.9 MF L^{-1}, respectively.

Microfiber size in the water column. While MF size shows small diameter variations between sampling depths, median fiber length (L) is not homogeneous between different layers (Kruskal-Wallis test, $p < 0.05$).

Surface fibers (L: 1121 µm; IQR: 1094 µm) are slightly longer than intermediate (L: 969 µm; IQR: 1112 µm) and deep water (L: 1002 µm; IQR: 1118 µm) fibers. Length frequency distribution highlights a substantial difference between surface, intermediate and deep layers with a relevant increase of the smallest MFs fraction (< 500 µm) going from 8 % in AW to 15 % in LIW and 21 % in deep waters. On the other hand, larger MFs (> 2300 µm) are more frequently detected in the AW (17 %) compared with LIW and deep waters (11 and 12 %, respectively).

MF Horizontal distribution in the Mediterranean circulation. Over the entire study area, AW showed a homogeneous MF content (2.3-4.1 MF L^{-1}) which is likely suggesting a constant atmospheric input over the sea surface. On the other hand, intermediate and deep waters are affected by significant variations in MFs size and concentrations and are also characterized by two opposite trends following the Mediterranean circulation pathway. From the Eastern to the Western Mediterranean basin, LIW showed a decreasing MFs median concentration (14-0.8 MF L^{-1}) while MF content increased in deep waters along the same path (3.1-9.1 MF L^{-1}). MF size distribution also shows a similar pattern during the circulation pathway, with MF length decreasing in LIW (1120-627 µm) and increasing in deep waters (797-1341 µm). A significant negative linear relationship was found between the MF length in the two layers ($R^2 = 0.84$). Moreover, a negative correlation was found between the MF fraction >1500 µm in the two layers ($R^2 = 0.75$) as well as a positive linear relationship between MFs <500 µm in the LIW and the fraction >1500 µm in deep waters ($R^2 = 0.88$). Together with the MF distribution pattern, it seems that vertical exchanges are taking place between the two layers, of which the most relevant are due to the movement of larger MFs from the LIW to the deep water masses. On the other hand, being more easily resuspended, small MFs could be characterized by a longer residence time in the water column, especially if compared to larger fibers which could reach the bottom water in shorter time after their introduction in the marine environment.

Conclusion. These results represent a simplified overview of the more complex processes that are taking place on a larger scale. However our findings suggest: i) a predominant and constant MFs input over the Mediterranean surface probably by atmospheric deposition; ii) MFs vertical distribution is size-dependent while sinking dynamics are generally independent from the polymer density; iii) high potential of short fibers to persist in the water column and spread horizontally; iv) MFs transport between Mediterranean basins mediated by Levantine water.

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LONG-TERM EXPERIMENT OF TRACE METAL ADSORPTION ON VARIOUS PLASTICS IN A STRATIFIED ESTUARY

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Abstract

The influence of a stratified estuarine water column (Krka River estuary, Croatia) and exposure duration on adsorption of trace metals (TM) was investigated by immersing various plastics at three depths. It was found that the adsorption of Zn, Cd, Pb, Ni and Co depended on both the duration of exposure and the stratified layers of the water column, with the exception of Cu, which was solely influenced by duration of exposure. Expressing TM amounts in two ways - by plastic sample mass and by sample surface area - produced differing results in the statistical analysis, which can be atributed to the different specific surface areas of the various plastic polymers.

Keywords: Adriatic Sea, Marine litter, Coastal processes

Introduction: Plastic pollution poses a significant threat to the marine ecosystem. The ability of plastics to adsorb other pollutants, including trace metals (TM), contributes to this risk [1]. Understanding the environmental factors that influence TM-plastic interactions is essential for predicting their synergistic effects. Research on TM adsorption to plastics in the estuarine environment is limited [2, 3], particularly regarding the impact of stratification. Our study aims to fill this gap by investigating how time and depth of a stratified estuary affect TM adsorption to various plastic products.

Fig. 1. Mass fraction of Cd adsorbed on plastic samples 6, 7 and 8 (Lab group), at depths 0.5, 1.5 and 2.5 m.

Materials and methods: Eight different types of plastic products were placed in each of three mesh-lined fiberglass tubes and deployed at three depths (0.5, 1.5, and 2.5 m) within the stratified water column of the Krka River estuary. These products consisted of: three types of preproduction pellets (black and white polyethylene [PE] and white polypropylene [PP]), a single use cup (PP), a water bottle (poly(ethylene terephthalate) [PET]), two laboratory bottles (PE and fluorinated ethylene propylene [FEP]) and a laboratory sediment container (PE). Plastic products were categorized in three groups based on their use: pre-production pellets (Pellets), single-use products (SUP) and laboratory vessels (Lab). The experiment lasted 16 months, with samples collected before immersion, after one, four, seven, and 16 months. The plastic samples were examined by scanning electron microscopy (SEM) and Raman spectroscopy. The metals were extracted from the surface by acid leaching with concentrated nitric and perchloric acids. To ensure complete release of the metals bound in organic forms, the plastics-acid mixture was exposed to UV light overnight. The amounts of TM (Zn, Cd, Pb, Cu, Ni, and Co) were quantified using anodic and cathodic stripping voltammetry.

Results and discussion: After just one month in the estuarine environment, biofilm and mineral formations were visible in SEM images. However, Raman spectroscopy showed no changes in the spectra, attributable to the absence of UV light exposure — a key factor in altering the polymer surface structure. Early in the exposure period (after one month), the amounts of some adsorbed TM reached those found on beached plastics from Croatian islands (Zn, Pb, and Cu in [3]; Zn, Pb, and Ni in [4]). Statistical analyses showed that the adsorption of Zn, Cd, Pb, Ni, and Co depended on both time and the stratified water column, whereas Cu adsorption was influenced solely by exposure duration. Fig. 1 shows Cd adsorption on samples from Lab plastic group (sample 6 - PE laboratory bottle, sample 7 - FEP laboratory bottle, sample 8 - PE sediment container), as an example. The TM adsorbed to the SUP group differed from the other groups when quantified by plastic sample mass. This is due to the larger specific surface area of the SUP samples, which emphasises the importance of also presenting the results based on plastic surface area. When quantifying the TM by plastic sample surface area, Pellets group differs from the SUP and Lab groups, likely due to the different surface properties of the preproduction plastics (pellets). This emphasises the importance of reporting TM adsorption data by both plastic mass and surface area in studies involving plastics with varied specific surface areas.
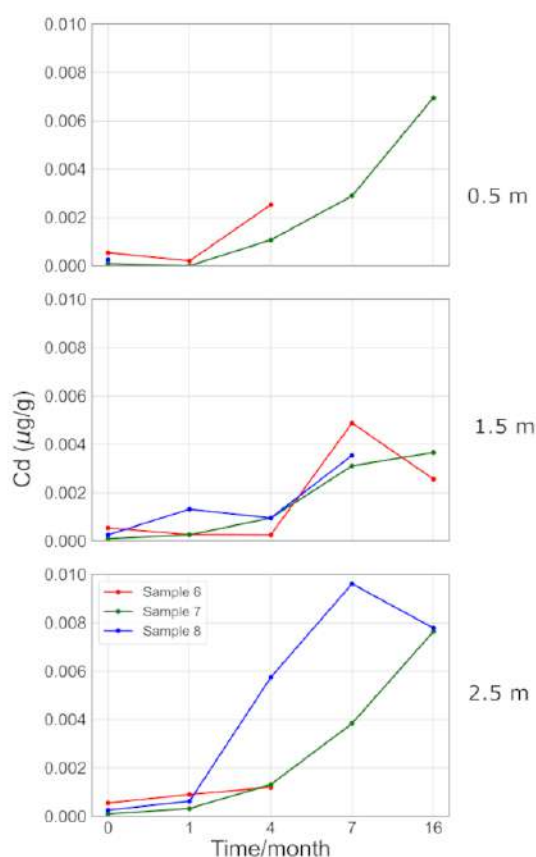
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RELEASE AND DYNAMICS OF ORGANIC PLASTIC ADDITIVES IN THE MEDITERRANEAN SEA AND THE RHONE RIVER: AN OVERVIEW.

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Abstract

Most plastics contain a number of organic additives such as phthalic acid esters or phthalates (PAEs), organophosphate esters (OPEs) or bisphenols (among others) that are used to give specific properties to commercialized plastics. They are not covalently bound to the plastic polymer and are thus likely to leach out of the plastic into the environment or inside an animal's stomach or tissue during abiotic/biotic aging. These compounds are toxic molecules whose migration kinetics from plastic fragments and subsequent dynamics have attracted the attention of researchers in recent years. In this presentation, we give an overview of recent studies dealing with the distribution of PAES and OPEs in the Mediterranean Sea and the Rhone River.

Keywords: Plastics, Mediterranean Sea, Rhone Delta

Introduction

Plastics, which are only degraded over periods of tens and hundreds of years, constitute between 8-15% of the waste mass generated by human activities. As a semi-enclosed marine environment with intense maritime transport and fishing, strong anthropogenic pressure, the Mediterranean has been reported as one of the major hotspots of plastic contamination in the World. Since the beginning of plastic production, a panel of additives have been added to polymers by manufacturers to confer specific properties to plastic polymers. Most of the time, these compounds are toxic molecules whose migration kinetics from plastic fragments is not well established. In this article, we report and summarize our recent studies dealing with additives diffusion from degraded plastic fragments.

Methods and Results

Surface and deep seawater were collected and studied for their degradation in laboratory-controlled conditions (temperature, light, hydrostratic pressure) during a few weeks.

Our results showed that a variety of organic compounds such as bisphenol A (BPA), phthalates, polybrominated diphenyl ethers (PBDE), tetrabromobisphenol A (TBBPA), bisphenol S (BPS), organophosphate ester (OPEs). Similarly, benzothiazoles and phenylguanidines as well as phenylendiamines may be released from car tires, which are commonly made of styrene-butadiene-rubber and butadiene rubber [1]. All these molecules, once emitted into the environment, are submitted to sunlight photo-oxidation and bacterial degradation that may lead to the formation of derived intermediate products [2] during long range transport in the aquatic and atmospheric environments [3]. The kinetics of emission, degradation and residence es can vary according to the intensity of bacteria activity, photo-oxidation, temperature processes as well as the sedimentary or hydrostatic pressure environment [2; 3; 4]. We showed that in abiotic conditions, increasing hydrostatic pressure inhibits the leaching of the heaviest organic additives such as tris(2-ethylhexyl) phosphate and diisononyl phthalate from polyethylene and polyvinylchloride materials, whereas deep-sea and surface marine prokaryotes promote the release of all targeted additives (phthalates, bisphenols, organophosphate esters).

Conclusions

This study provides empirical evidence for more efficient additive release at the ocean surface than in deep seawater, where the major plastic burden is supposed to transit through before reaching the sediment compartment. We found that among the organic additives, phthalates and OPEs are particularly abundant and can accumulate during several decades in aquatic sediments (Figure 1). In recent years, studies have highlighted the ecotoxicological concerns of these chemicals for living aquatic organisms, that have been reported at significant concentration level in several large European River.
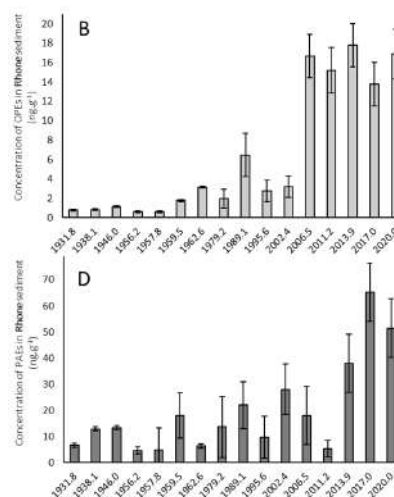

Fig. 1. Environmental levels (ng.g^{-1} dw) of OPEs (A) and PAEs (B) measured in the sediments of the Rhone River. From [5] during the period 1931-2020.

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CIESM Congress Session : Marine Litter and Nano/Microplastics II
Moderator : Claudio D'Iglio – Univ. of Messina, Italy

Session's Synthesis

The session "Marine litter and nano/microplastics II" featured five contributions that examined the connections between marine organisms and nano/microplastics. The presentations focused on the role as vector of the marine biotic component for the spread of microplastics, especially regarding planktonic and benthic domains. It was discussed the role of copepods and aegagropiles of *Posidonia oceanica*, (Linnaeus) Delile, 1813, as environmental reservoirs of plastics in the world oceans, with a serious concern regarding the entering of microplastics (and associated organic and inorganic pollutants) in the marine trophic food web mediated by zooplanktonic crustaceans. It was documented the presence of microplastics in organs and tissues of commercially relevant species, including those inhabiting the deep habitats (as stated for *Nephrops norvegicus*, Linnaeus, 1758). This was addressed as an alarming issue for human's health. Indeed, sea food represents one of the main microplastics' contamination vectors for humans, especially when plastics microfibers and fragments are located not only in the gastrointestinal tract, as the case of the particles detected in gonads and muscles of *Engraulis encrasicolus*, Linnaeus, 1758, debated during the session. In addition, it was focused the attention on the effects of microplastics on the growth and development of benthic habitat forming species. It was highlighted the needing for an increased knowledge base regarding their sensitivity to the several co-occurring anthropogenic impacts. The session underscored the necessity to create standardized analytical methods able to improve plastics detection and characterization in marine organisms from different domains. This is an essential step to better analyze and understand the dynamics of microplastic transportation along trophic food webs, and how this can affect marine ecosystems at population and community scales. It should be also highlighted the absence of contributions regarding marine litter and their interaction with marine biota. This is a sensitive research topic that require more attention, considering the lack of knowledge regarding the influence of biotic colonization on debris fragmentation (especially regarding macro-plastics), and the role of marine litter as new available space for the spreading and settlement of non-indigenous species.

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MICROSCOPY IDENTIFICATION OF MICROPLASTICS IN AEGAGROPILESON THE TUNISIAN COASTS

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Abstract

Plastic pollution is an emerging concern worldwide, with the majority of studies focusing on microplastics in marine environments. *Posidonia oceanica* (L.) Delile is the main marine herbarium of the Mediterranean basin which forms immense underwater meadows. The aegagropiles are evaluated for their potential of accumulation of microplastics. Through the microscopy identification, different colors and shapes are determined in the studied areas and which are characteristic of the urban, agricultural and industrial activities that define these regions.

Keywords: Plastics, Gulf of Tunis, Posidonia, Coastal management

Introduction

Microplastics (MPs) have been detected on a global scale in aquatic and marine environments [1]. 192 coastal countries have released a total of 480 to 1,207 million tons of plastic waste into the marine environment [2]. MPS are polymer particles with a dimension of at least 5 mm. MPs possess complex physicochemical properties that vary their mobility, their bioavailability and their toxicity on organisms and their interactions with surrounding pollutants [1]. On the other hand, seagrass beds play an important role in the dynamics of sediments and natural debris, and probably also in the storage and treatment of non-floating waste. The seagrass beds are distributed along the coast of the Mediterranean Sea, the endemic species is the *Posidonia Oceanica*. Two forms of *P. Oceanica* could be found in sandy beaches "banquettes and aegagropiles". Aegagropiles (EGs) are formed by roots and rhizome fragments gathered in fibrous marine balls that are shaped and accumulated by the waves along the shore. Seagrass deposits usually cover the facades of sandy beaches. These deposits have the ability to effectively trap organic and inorganic particles [3].

Material and methods

Samples of aegagropiles were taken from four different sites in Tunisia, from northern (two sites S1 and S2) from Bithe coasts of Bizerte and Hammamet and two sites (S3 and S4) from central-eastern Mahdia and Chebba. The microplastics were extracted by chemical digestion using hydrogen peroxide (H_2O_2) and hydroxyl of potassium (KOH) followed by microscopic identification to provide information on its physical properties such as size, colors and shape.

Results

Microscopic analysis showed the presence of different fragments and filaments in shape and color (colorless, blue and red).The frequent colors of microplastics were mainly blue and red. For the site S1, the microplastic elements were blue, black, redandwhilein the site S2 the fragment were almost red, blue and transparent filaments. The same coulors were observed in the southern sites S3 and S4 with dominance of black and red fragments are identified. It's important to notify that red filaments correspond to polyethylenetrephtalate (PET) [4]. Same results were observed in OTTAWA River where similar colors and shape are detected [5].

Fig. 1. Different filaments and fibers shapes and colors indentified in Hammamet (S2)

Fig. 2. Different filaments and fibers shapes and colors indentified in Mahdia (S4)

Conclusion

The present study provides new information on the physical properties of interlaced microplastics in aegagropiles and reinforces the hypothesis that aegagropiles have a role in protecting the sea by accumulating pollutants such as microplastic and make it come out of the water matrix.

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THE ROLE OF COPEPODS AS MICROPLASTIC RESERVOIR ACROSS GLOBAL OCEANS – INSIGHTS FROM A COMPREHENSIVE REVIEW AND META-ANALYSIS

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Abstract

Plastic pollution is present through every part of the marine environment, representing a significant threat to species and ecosystems. This study investigates the role of copepods as a widespread microplastic (MPs) biotic reservoirs in the marine environment. For this a systematic review, meta-analysis, and semiquantitative analysis of scientific articles focusing on the interaction between copepods and MPs under field conditions has been performed.

Keywords: Marine litter, Copepoda, Global change, Conservation, Worldwide

The pervasiveness of MPs in marine environments is one of the foremost environmental threats, impacting marine life at multiple levels—from species to food webs and ecosystems . Despite the extensive studies at species and food web levels the potential implications of marine plastics on global earth processes, such as nutrient cycling and climate regulation, have only recently begun to receive attention. Research is beginning to consider plastics as elements characterized by biogeochemical cycles, akin to carbon, that in the marine environment are stored in interconnected reservoirs and sinks. Copepods, with their extensive distribution and significant presence in all marine environments, are emerging as potential key players in the marine plastics cycle, possibly serving as a major reservoir for MPs. First studies under laboratory-controlled conditions have revealed low levels of MP ingestion across various copepods´ species. This study hypothesizes that, although marine copepods are at low risk of ingesting MPs, their vast abundance in the marine environment potentially positions them as a significant biotic reservoir of MPs within the 'biogeochemical' plastic cycle. To address these questions, an integrated approach that combines a systematic review, semi-quantitative analysis, and meta-analysis of the interaction between microplastics and copepods have been conducted, focusing on both the number of particles ingested by individual copepods (**ingestion**) and the number of particles retained by copepods per cubic metre (**retention**).
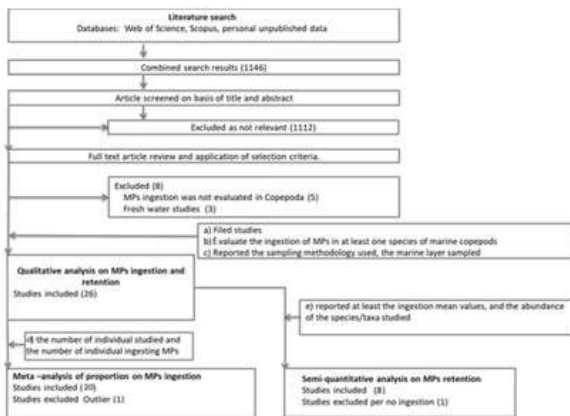

Fig. 1. Summary of the systematic review, meta-analysis and semi-quantitative analysis.

The results of the systematic review underscore that, under field conditions, copepods exhibit a low risk of ingesting microplastics (MPs), with mean ingestion rates ranging from 0.00 to 0.82 MPs per individual, which are among the lowest reported for marine species.. The meta-analysis supports this trend, estimating a combined microplastics (MPs) ingestion proportion of 0.05. Conversely, MPs retention exhibits high variability across studies and generally high values, with a median of 8.7 MPs/m³, reaching up to 2700 MPs/m³. Moreover, studies assessing MPs ingestion and retention across various biotic assemblages, including different zooplanktonic taxa and fish larvae, consistently report copepods as among the taxa with the lowest MPs ingestion, yet they retain the highest fraction of the total MPs retained by the studied taxa. The retention resulted significantly correlated with copepod´s abundance (Spearman test; $p<0.001$), while any correlation was found with MPs ingestion mean values.

Fig. 2. Circular plot summarizing copepods mean plastic ingestion (MPs/ind.) in blue, mean copepod´s abundance (ind./m3) in green and mean plastic retention (MPs/m3) in pink. Y-axis values are log-transformed.

The results emphasize the importance of evaluating the number of MPs retained by copepods to assess the magnitude and potential ecological consequences of their interaction with MPs. This work suggests that copepods constitute a significant and transferable reservoir of microplastics across the oceans. These reservoirs may be transferred within food webs through predation on copepods and shifted between marine layers by the migratory patterns of copepods and their predators. They can also move from surface layers to the seabed after being excreted by copepods within fecal pellets. All of these processes could potentially impact the carbon cycle and the profile of carbon deposition, thus playing a role in climate regulation. Therefore, a deeper understanding of MPs retention in copepods is crucial and should enhance our understanding of carbon cycling processes and the distribution patterns of MPs within marine environments through its future integration into modeling studies.

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INFLUENCE OF MICROPLASTIC PARTICLES ON THE GROWTH AND DEVELOPMENT OF *GONGOLARIA BARBATA,* AN IMPORTANT HABITAT-FORMING SEAWEED

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Abstract

Gongolaria barbata is a canopy-forming brown algae species that forms dense underwater forests, important habitats, nursery areas, and biodiversity hotspots in the Mediterranean Sea. This enclosed basin is also one of the marine areas with the highest levels of microplastic pollution. Due to the electrostatic attraction seaweeds attract microplastic particles that adhere to their surface. Algal forests can therefore act as a buffer zone for microplastic pollution, but at what cost? In our study, we investigated the impact of microplastic particles on the early stages and juveniles of *G. barbata* from the northern Adriatic, by monitoring in mesocosms the growth and development at different concentrations of microplastics.

Keywords: Algae, Pollution, Plastics, Adriatic Sea

Introduction: Microplastics have found their way into all world's seas and oceans and have even entered bodies of marine organisms [1]. Microplastic particles can have several adverse effects on marine life, including seaweeds, impacting its physiology and ecology [1-2]. Microplastics contains and/or can adsorb and concentrate toxic chemicals from the surrounding seawater, such as persistent organic pollutants (POPs) and heavy metals [3]. When ingested, these chemicals can be released from the microplastic and penetrate the tissues of marine organisms, causing toxicity, developmental abnormalities, and reproductive disorders [1,3]. Larger microplastic particles or fragments can cause physical damage to marine organisms upon ingestion or contact by abrasion or puncture of delicate tissues, leading to internal injuries, inflammation, and compromised immune function [3]. In seaweeds, the sorption of particles on the surface of the thallus can lead to reduced photosynthesis in the covered areas [2]. Small plastic particles cannot be removed from the oceans with current technology, so stopping pollution is a priority. However, as large amounts of microplastics are already present in the environment, it is important to investigate possible effects on different organisms. Macroalgae can serve as an important vector for the transfer of microplastic particles into the marine food chain or act as a buffer zone that binds these particles and prevents their further spread in the environment [2]. Due to electrostatic attraction between cellulose in the algal cell walls and the plastic polymer chains, microplastic particles adhere to surface of the algal thalii [5]. By serving as both a vector and a barrier, seaweeds play a dual role in microplastic pollution [6]. The relationship between seaweeds and microplastics underscores the need to understand their interactions and impacts on marine ecosystems. The aim of our study is to shed light on the influence of microplastics on the growth and development of canopy-forming macroalgae.

Materials and methods: Nine glass aquaria with UV sterilized seawater were set up in a temperature-controlled room set to 17?, with a 15:9 light/dark cycle and an intensity of 140 µmol photons. The experiment consisted of two parts. In the first part, three different treatments were investigated: a low concentration of microplastics (1mg/L), a high concentration of microplastics (20mg/L), and a control group with only sterilized seawater. Polyamide microplastic fragments, sized 8.98 ± 2.89 µm, were used. Each treatment comprised three replicates (aquaria). Within each aquarium, ten clay tiles served as growth substrata for *Gongolaria barbata* germlings. Fertile algal receptacles, collected from a donor population in Slovenian coastal waters (northern Adriatic), were placed on the tiles for 2 days and then removed. The growth and development of the young germlings were monitored over a period of 21 days. Daily, 25 germlings from a randomly chosen tile in each treatment were measured under a stereomicroscope, photographed, and examined for deformities. In the second part of the experiment, the growth and development of juvenile thalli were monitored at microplastic concentrations of 1 mg/L, 20 mg/L, and 100 mg/L. The experimental setup mirrored that of the first part, with additional 3 aquaria for the 100 mg/L concentration. Growth, development, and number of microplastic particles per square mm of algal thalli were assessed for 21 days.

Results and discussion: In the first part of the experiment, germlings subjected to treatments containing microplastics exhibited accelerated growth compared to those in microplastic-free seawater conditions (Fig. 1). Although no deformities were detected in the microplastic-treated groups, observations revealed some particles adhering to the algal surfaces. Consequently, in the second part, a third concentration of microplastics (100 mg/L) was introduced to further investigate their effects. Presently, data analysis for the second part is underway to discern any notable distinctions from the initial observations. These results are of great importance as little attention has been paid to the interactions of microplastics with benthic macroalgae and the specific role of seaweeds in the transfer of microplastics into marine food webs should also be considered in future studies.
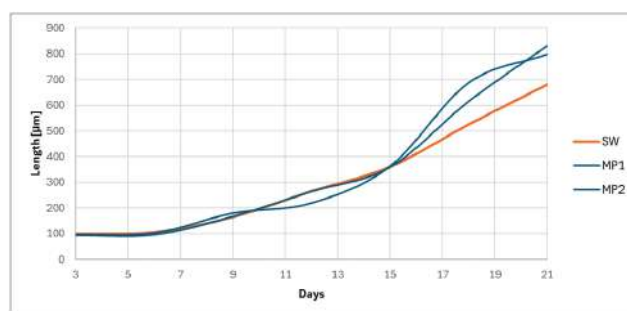

Fig. 1. Growth (average length in µm) of *Gongolaria barbata* germlings in 3 different treatments (SW – seawater, MP1 – seawater with low microplastics concentration (1mg/L), MP2 – seawater with high microplastics concentration (20mg/L) from day 3 to day 21.

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MICROPLASTIC INGESTION BY THE NORWAY LOBSTER FROM THE AEGEAN SEA

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Abstract
Ingestion of plastics has been documented in many marine organisms but information regarding their presence in deep-sea fauna is still limited. This study evaluates the presence and characteristics of microplastics (MPs) in the stomachs of *Nephrops norvegicus*, an ecological key crustacean of the Mediterranean Sea and typical inhaitant of deep-sea.

Keywords: Plastics, Aegean Sea, Crustacea

Introduction
Microplastics (MPs) are a major global concern in the marine environment. Direct MP pollution measurements in the deeper waters of the marine environment are often considered technically challenging and costly. In the Mediterranean Sea, MPs have been detected in various species such as, crustaceans and cephalopods, marine birds and fishes. The Norway lobster, *Nephrops norvegicus* (Linnaeus, 1758), has been suggested as a possible monitoring tool for the abundance of MPs within sediments and the environment [1]. The aim of this study is to investigate the occurrence, abundance and characteristics of MPs on *N. norvegicus* in a semi – enclosed Gulf of the Aegean Sea, the North Euboean Gulf.

Material and Methods
A total of 64 individuals of *N. norvegicus* were collected from the North Euboean Gulf during December of 2022. Sex, total length (TL, in mm) and stomach content weight (SW, in g) were recorded for each individual. Stomach contents were examined for MPs following the MEDSEALITTER protocol [2]. The type and color as well as length, width and area measurements of the identified MPs were carried out using Image Pro–Plus analysis software on optical stereoscope. The occurrence of MPs in our sample as well as the abundance of MPs per individual were assessed. Data were statistically analyzed using Statgraphics Centurion 19.

Results
A total of 163 MPs were found in the stomach content of 64 individuals with TL from 120 to 147 mm and a mean TL of 132,6 ± 6,5 mm. Within the examined sample, 48 individuals (75%) were found to retain at least one MPs item. The abundance ranged from 1 to 11 MPs items per individual (Fig.1) with a mean value of 2,55 MPs items per individual. The identified MPs encompassed three distinct types: fibers, fragments and entangled fiber balls. In particular, 137 fibers (84,05%), 6 fragments (3,61%) and 20 entangled fiber balls (12,05%), were recorded. Data on the occurrence and mean abundance of MPs by sex are shown in Table 1. The four predominant colors of MPs were the black (49,7%), transparent (24,3%), red (6,5%) and green (5,9,1%). The other colors were less than 3% each. Our results showed no significant relationship between the abundance of MPs and total length. Similarly, no significant relalationship was observed between the abundance of MPs and stomach content weight.
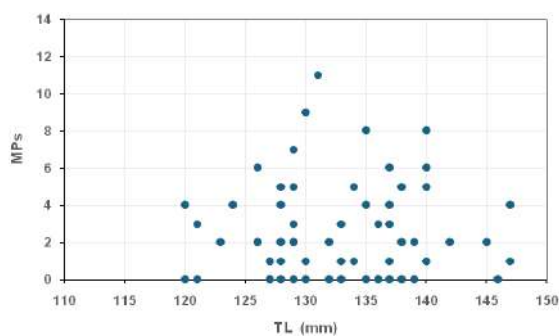

Fig. 1. Number of MPs found in the stomachs of *N. norvegicus* in relation to their total length (TL, mm).

Tab. 1. Number of *N. Norvegicus* (N), Number of MPs (N_{MPS}), Occurrence (%) and Abundance of MPs assessed in all samples and by sex

	N	N_{MPS}	Occurrence %	Abundance mean MPs/ind	Abundance max MPs/ind
Male	61	160	75,4	2,62	11
Female	3	3	66,7	1,00	2
TOTAL	64	163	75,0	2,55	11

Discussion
Our results highlight a high occurrence of MPs in the wild population of *N. norvegicus* from the Euboea Gulf (75%). However, higher levels have been reported in the Adriatic Sea and the Sardinian waters with 83% and 100% respectively [1,3]. Moreover, the relatively high mean abundance of MPs observed in *N. norvegicus* from the Euboean Gulf was lower than the abundances that have been observed in the Sardinia shores (4,75 ± 0,76/individual), in the Adriatic Sea (4,9 ± 2,4/individual), in the Balearic Sea (7,06 ± 12,01/individual) and in Barcelona coasts (12,55 ± 20,78/individual) which are highly touristic areas of the Mediterranean Sea [3,4,5]. Significant amounts of fibers and entangled fiber balls have been discovered in our samples as in earlier studies [6,7]. This fact may reflects the plastic fiber ability to be easily ingested and potentially be retained for longer period in stomach than other types of MPs. On the other hand, it could be deduced that plastic fibers predominate in sediments and surface waters in the Euboean Gulf. Based on the above results, *N. norvegicus* could be adopted as a flagship, benthic species for monitoring MPs pollution in the deep waters of the Mediterranean Sea.

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MICROPLASTIC PARTICLES IN DIFFERENT TISSUES OF EUROPEAN ANCHOVY (*ENGRAULIS ENCRASICOLUS*, LINNAEUS, 1758) FROM THE AEGEAN SEA, A PRELIMINARY REPORT

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Abstract

This study presents a preliminary assessment of microplastic presence and concentration in the gastrointestinal (GI), gonads, and muscle tissue of European anchovy in the northern Aegean region. A total of 15 individuals were sampled, revealing 127 microplastic particles in various tissues with a size range between 0.43 and 4.8 mm. Microplastics (MPs) were predominantly found in GI samples (52%), followed by gonads (39%), and to a lesser extent in muscle tissue (9%). Notably, while all GI and gonad samples contained MPs, only 53.3% of the muscle samples tested positive for microplastic occurrence. These findings underscore the need for further investigation into microplastic contamination in marine organisms, particularly in relation to potential implications for food safety and ecosystem health.

Keywords: Marine litter, Bio-indicators, Aegean Sea

Introduction The emergence of plastic pollution as a critical concern in marine environments was first underscored by scientists in the 1970s [1], emphasizing its profound impact on marine ecosystems. Since then, the study of environmental repercussions associated with plastic pollution has increased exponentially [2]. The urgency to address this issue aligns with the objectives outlined in the 2030 Agenda for Sustainable Development, specifically the goal to conserve and sustainably utilize oceans, seas, and marine resources [3]. Notably, plastic pollution endangers numerous smaller fish species, particularly filter feeders, to ingest plastic particles smaller than 5 mm, known as MPs. European anchovy, recognized as an eligible bioindicator species, holds promise for monitoring plastic waste levels within specific regions [4]. The present study aimed to investigate the occurrence and the type of microplastics identified in different tissues of European anchovy in the northern area of the Aegean Sea.

Materials and Methods The study was conducted in the northern Aegean Sea (GSA22), situated in the eastern Mediterranean Sea. 15 European anchovy individuals were obtained from the commercial catch of a local purse seine vessel in April 2024. Biological parameters were recorded for each individual, and three tissue samples (GI tract, gonads, and muscle) were collected from each, resulting in a total of 45 samples. Subsequently, the tissue samples underwent chemical digestion at 60°C for 24 hours, followed by filtration using glass microfiber paper filters. The filtered contents were dried and then examined under a stereoscopic microscope. Microplastic particles were categorized based on their shape (fiber, fragment, film) and colour (black, blue, green, yellow, red, white) and size (mm). Dissection, storage, and sample processing followed established quality assurance protocols and MP recognition was performed following the MEDSEALITTER protocol (MEDSEALITTER deliverable 4.6.1 "Final common monitoring protocol for marine litter"). Furthermore, a methodology to assess potential laboratory contamination was applied [5].

Results and Discussion Microplastics were detected in all 15 individual fish analyzed, with presence in the studied tissues in 84.4% of the samples. MP size ranged between 0.43 and 4.8 mm.

Fig. 1. Sankey diagram depicting the percentage, type and colour of microplastics isolated in each of the three types of sample tissue.

The microplastic particles identified exhibited a diverse array of shapes and colors, as illustrated in a Sankey diagram (Fig. 1). Among these, fibers constituted the majority, accounting for 61.42% of the total 127 microplastic particles. Fragments and films were less prevalent and likely originated from the breakdown of larger plastic items. The majority of fibers observed were either black (54.33%) or blue (21.26%; Fig. 1). The findings of this study confirm the presence of microplastics, particularly microfibers, in European anchovy, as stated at many recent studies [6]. Microplastic particles were detected across all examined fish tissues, with fibers being the most prevalent type, notably in black color. The accumulation of microplastics (MPs) in planktivorous fish is of particular concern because of the similar size between microplastics and planktonic species [7]. Further investigation is necessary to validate the observed quantities and FT-IR analysis is needed to evaluate the integrity of polymers structure. Continued research in this area is crucial for understanding the extent and implications of microplastic pollution in marine environments and its potential impacts.

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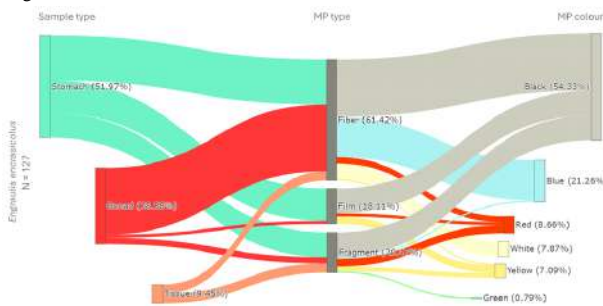
CIESM Congress Session : Biogeochemistry at the ocean/atmosphere interface

Moderator : Pasquale Castagno – Univ. of Messina, Italy

Session's Synthesis

In the session on biogeochemistry at the ocean/atmosphere interface, 4 papers presented advances in understanding and monitoring biogeochemical processes in the ocean through innovative methods, data acquisition and biogeochemical modelling. The first presentation emphasised the use of autonomous surface vehicles to measure air-sea CO_2 fluxes in different regions and seasons, highlighting the role of autonomous technologies in enhancing global carbon cycle in underrepresented regions and ecosystems. A study in the Krka River estuary (Croatia) analysed copper redox species in rainwater and estuarine water and showed the variability of copper oxidation states. Further studies could investigate the copper speciation and ecosystem health. A study in the south-eastern Mediterranean showed the role of dry aerosols leachable fluxes of atmospheric inorganic nitrogen in supporting surface primary production. These results provide insights into nutrient limitations oligotrophic systems and emphasise the need to monitor atmospheric deposition under increasing desertification and climate variability. Over the course of 15 years, a marine biogeochemical model, the Med-BGC forecasting system, has improved significantly through the use of multivariate data assimilation and advanced modelling techniques. These advances enable reliable predictions of the variability and trends of important marine variables and relevant events such as anomalous blooms. Looking ahead, the incorporation of AI-driven approaches and extended observational data networks could refine forecasting accuracy and support ecosystem management. Discussions at the end of the session emphasised the importance of interdisciplinary approaches, enhanced data sharing frameworks, and the development of predictive tools that link marine biogeochemistry, ecosystem dynamics and climate variability to better inform policy and conservation strategies.

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AIR-SEA CO₂ EXCHANGE IN THE EASTERN ATLANTIC AND THE MEDITERRANEAN SEA BASED ON AUTONOMOUS SURFACE MEASUREMENTS

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Abstract

The ATL2MED mission was a collaboration between European institutions and the American company Saildrone. Two Saildrone autonomous surface vehicles (ASVs) sailed from Cape Verde in the Atlantic Ocean to the Gulf of Trieste in the Mediterranean Sea between October 2019 and July 2020. Given the scarcity of air-sea CO2 flux measurements in the ocean, ATL2MED generated valuable surface data to study CO2 fluxes from the Atlantic to Adriatic regions through different seasons and marine ecosystems. This initiative helped to overcome the data shortage during the COVID-19 pandemic, while expanding the spatial coverage of air-sea CO2 fluxes.

Keywords: Air-sea interactions, Carbon, Adriatic Sea, Ligurian Sea

Introduction The atmospheric concentration of carbon dioxide (CO2) has surged by over 50% since the pre-industrial era, reaching presently 417.2 ppm, primarily attributed to human activities. The ocean has mitigated the impact by absorbing approximately 26% of CO2 emissions, but this absorption is leading to an acidification of the oceans, affecting marine ecosystems. In the North Atlantic, warming trends and upwelling systems influence CO2 levels. The Mediterranean Sea, a hub for tourism and maritime trade, experiences climate change effects such as temperature rise and decreased rainfall, with ocean acidification posing a threat to its biodiversity. Monitoring CO2 concentrations is crucial, and initiatives like the Integrated Carbon Observation System (ICOS) aim to provide high-quality data. However, CO2 flux measurements at the air-sea interface are limited, prompting efforts to develop sensors for autonomous in-situ measurements. A demonstration experiment (ATL2MED) involving Unmanned Surface Vehicles (USVs) aimed to examine air-sea gas exchange, addressing data gaps during the COVID-19 pandemic. This study focuses on the CO2 exchange during navigation from Atlantic Ocean to the Adriatic Sea, highlighting regional ocean features and the use of USVs as a complementary tool for validation and extending spatial coverage.

Material and methods The ATL2MED demonstration experiment was conducted in the North East Atlantic and the Mediterranean Sea from October 18, 2019, to July 17, 2020. In this study, we focused on pCO2 in seawater (pCO2sw) and air-sea CO2 flux exchange, including measurements from various fixed platforms (DYFAMED, W1M3A, E2M3A, PALOMA, and MIRAMARE), R/V Meteor, and Saildrone vehicles (SD) 1030. Ancillary oceanic data from glider transects Nice-Calvi and Bari-Dubrovnik were included. Details of the ATL2MED experiment and instruments used are provided in Skjelvan et al. (2021) and Martellucci et al. (in review). SDs measured SST, SSS, O2, pCO2sw, pCO2atm, and wind speed. Measurements were conducted hourly for pCO2sw and pCO2atm, with an uncertainty of ±5 µatm. Sensor drift due to biofouling during the 9-month experiment was corrected according to Martellucci et al. (in review). In addition to these in situ observations, a neural network trained and validated in the Mediterranean Sea (CANYON-MED; Fourrier et al., 2020) has provided new information on carbonate variables in the Ligurian Sea, validating and filling gaps in pCO2 data measured by the SD-1030 and some fixed platforms.

Results and discussion In this study, we focused on the large-scale variability of pCO2sw and CO2 flux, zooming on local events in the Ligurian and Adriatic Seas. pCO2sw is influenced by a series of processes such as primary production and respiration, air-sea gas exchange, mixing and advection of water masses. The mission results show that pCO2sw in the eastern Atlantic was lower than pCO2atm, while the situation was reversed in the Ligurian and Adriatic Seas. However, variability is high, as expected, due to the different seasons and ocean zones. The evolution of pCO2sw generally reflects variations in SST, with pCO2sw exceeding pCO2atm in summer/autumn and vice versa in winter/spring. Several factors contribute to this pattern: the effect of temperature on gas solubility, phytoplankton growth which reduces pCO2sw, seasonal stratification which traps CO2-rich water near the surface, upwelling which

brings CO2-rich water to the surface, and temperature-induced changes in carbonate chemistry. In this study, we observed that the thermal component of pCO2sw decreases with SST, while the non-thermal component increases slightly. The relationship between these processes indicates a greater influence of thermal processes on pCO2sw.
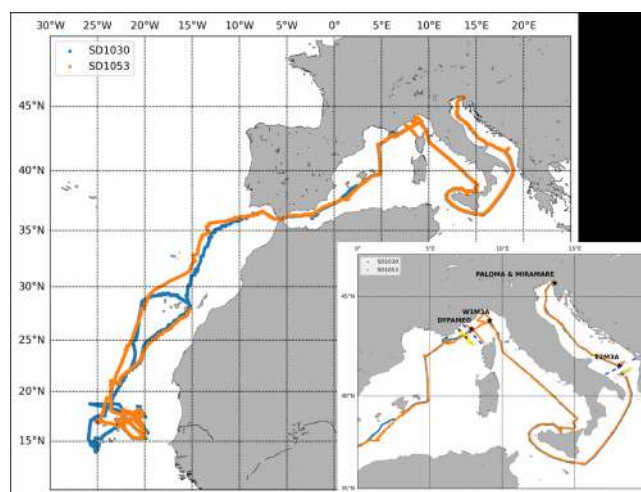

Fig. 1. Sailing drones from SAILDRONE (SD-1030, SD-1053) routes (blue and orange lines) during the ATL2MED demonstration experiment, alongside with fixed platforms (black star) and glider sections (dashed blue line) in the Ligurian and Adriatic Seas.

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COPPER REDOX SPECIATION IN RAINWATER IN COASTAL AREA: KRKA RIVER ESTUARY

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Abstract
The redox speciation of copper (Cu) was determined in rainwater samples collected from October 2023 to March 2024 at the marine research station in the Krka River estuary, Croatia. The concentrations of total dissolved copper (CuT) ranged from 5 to 300 nM, while the percentage of Cu(I) in CuT (Cu(I)/CuT) ranged from 1 to 56 %. In addition to rainwater, samples of estuarine water were also collected for Cu redox speciation. In the surface estuarine water, CuT varied between 3-10 nM, while Cu(I)/CuT varied between 40-75 %. An adapted solid-phase extraction method was used for Cu redox speciation, while Cu concentrations in the CuT, Cu(I) and Cu(II) fractions were determined using anodic stripping voltammetry. Dissolved organic carbon (DOC), pH, salinity and concentrations of chloride, sulfate, nitrate and nitrite were also analyzed.

Keywords: Trace elements, Adriatic Sea

Introduction
Copper (Cu) is an important micronutrient for living organisms and one of the most abundant trace metals in atmospheric waters [1,2]. Although redox speciation is important for understanding the biogeochemical cycling of Cu, it is often overlooked and Cu in natural waters is often discussed as CuT. Nevertheless, a significant amount of Cu(I) has already been detected in marine and estuarine waters as well as in rain and fog water. In rainwater, a Cu(I)/CuT fraction of 22-32 % has been found, contributing to the various mechanisms of photoreduction, reduction of Cu(II) by organic compounds and stabilization of Cu(I) by inorganic compounds such as sulphite (SO_3^{2-}) [3]. In sunlit surface waters of the Atlantic Ocean, the Cu(I)/CuT fraction was between 5-10 % of the CuT fraction, while in estuarine waters Cu(I)/CuT fractions of up to 80 % of the CuT fraction were measured [4,5]. The formation and stability of Cu(I) is attributed to various photochemical processes involving hydrogen peroxide, as well as to the presence of humic substances and organic compounds of biological origin [4,5].

Study site
In this work, we collected rainwater and estuarine samples at the research station in the Krka River estuary in Croatia. The Krka River (Croatia) is a medium-sized karst river with a length of 49 km, flowing into the eastern coast of the Adriatic Sea and draining carbonate soils. It is characterized by extremely low natural concentrations of trace metals. In addition, the Krka River and its estuary are characterized by lower DOC concentrations compared to other coastal areas [7]. The pristine estuary of the Krka River has been the subject of research interest for decades, although no research results on Cu redox speciation in the estuary and rainwater have yet been published. CuT concentrations in the estuary are relatively low, although they increase in summer due to Cu emissions from antifouling paint.

Methods
An adapted solid phase extraction method was used for Cu redox speciation in the samples [6]. For this purpose, a mixture of the strong Cu(I) chelator bathocuproine disulfonic acid disodium salt (BCS) and the strong Cu(II) chelator ethylenediaminetetraacetic acid disodium salt (EDTA) was added to the filtered water samples. After the addition of the reagents, the samples were passed through the columns with the Cu(I)-BCS complex retained on the column. After UV digestion of the acidified samples, Cu concentrations in the Cu(I), Cu(II) and CuT fractions were measured by anodic stripping voltammetry in differential pulse mode (ASV-DP) by standard addition method. DOC was measured by catalytic high-temperature oxidation with a carbon analyzer, while chloride, sulfate, nitrate and nitrite in rainwater were measured by ion chromatography with a conductivity detector.

Results
CuT concentrations in the estuary were from 3-10 nM, which is consistent with the relatively low Cu concentration expected off-season in the pristine Krka River estuary. In contrast, CuT concentrations in rainwater were generally higher and varied between 5-300 nM. A higher Cu(I)/CuT content of 40-75 % was found in the estuarine samples than in the rainwater samples, in which the Cu(I)/CuT content was from 1-50 %. The pH of the estuarine samples ranged from 8.09-8.17, while the pH of the rainwater samples ranged from 5.50-6.61. DOC values ranged from 0.790-1.452 mg/L in the estuarine samples and from 0.604-1.717 mg/L in the rainwater samples. A higher Cu(I)/CuT values were detected in the rainwater samples with lower DOC and lower CuT. While this may suggest that inorganic ligands play an important role in Cu(I) stabilisation in the rainwater, it is possible that concentration of Cu-binding ligands in the rainwater is not sufficient to stabilize Cu(I) in the rainwater samples with high CuT.

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COUPLED ATMOSPHERIC NUTRITION AND OCEAN PRODUCTIVITY IN THE OLIGOTROPHIC EAST MEDITERRANEAN SEA

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Abstract

This study presents the coupling between leachable fluxes of atmospheric inorganic nitrogen and phosphorus (LIN and LIP, respectively) and surface water primary production and nutrient concentrations/pool during a full annual cycle at the oligotrophic Southeastern Mediterranean Sea. It was estimated that dry aerosols leachable fluxes of LIN can support between 2-4% of the surface primary production and between 1-19% of the NO_3 concentration in the seawater mixed layer, enhanced mainly during the stratified period and dust events.

Keywords: Aerosols, Nutrients, Primary production, Atmospheric input, Mediterranean Sea

Introduction

While phytoplankton production in the oceans is primarily supported by nutrient transport via physical vertical mixing and diffusion from deep layers, external nutrients are additionally provided by atmospheric deposition. Recently is was estimated that the deposition of dust over the oceans support 4.5% of the global annual export production, but varies regionally, with some areas exhibiting substantial changes in phytoplankton biomass [1]. In this study, leaching measurements of aerosol's derived inorganic nitrogen (LIN - LNO3, LNH4) and phosphorus (LIP - LPO4) from total suspended particles in air collected between February 2018 and January 2019 were compared to contemporaneous measurements of primary production and nutrient concentrations in seawater at an offshore station in the Southeastern Mediterranean Sea (50 km off Haifa, Israel).

Results and Discussion

Nutrient leaching was conducted using SE Mediterranean prefiltered (0.2 um) aged surface seawater on 36 aerosol samples (each representing ~3 d) collected on Whatman 41 filters at Tel Shikmona, Israel (SE Mediterranean shoreline) and on 1 Saharan dust event filter collected on 8-9 January 2024 during the RV Meteor M197 cruise in the East Mediterranean Sea. The calculated atmospheric nutrient fluxes were compared to monthly measurements of primary production and nutrient concentrations at an offshore station (THEMO-2; 50 km offshore, 1500 m water depth) [2,3]. In addition, we also compared the atmospheric fluxes to particulate organic carbon (POC) fluxes measured by a sediment trap at 1300 m water depth at a nearby offshore DeepLev mooring station (50 km off Haifa, 1500 m water depth) [4].

Fig. 1. Variability of: (a) the atmospheric contribution (%) of leachable NO_3 to the concentrations of NO_3 in the mixed layer depth during February 2018 till January 2019 ([NOx]at/[NOx]sw); (b) % of calculated atmospheric LIN flux converted to PP (assuming Redfield ratios) from the measured surface water PP [2] (PP-Nat/PPsw); (c) the mixed layer depth (MLD, open boxes) [5]. Also presented (diamond) the contribution of leachable NO_3 from a Saharan Dust event (8-9 January 2024) to the NO_3 concentration in the upper mixed layer (52 m) during the M197 cruise of the RV Meteor.

The atmospheric contribution to the concentrations of nitrate in the mixed layer depth is presented in Figure 1, enhanced during stratification (~9%) as compared to mixed winter period (~2%) on average. Likewise, considering a 4 days response of the phytoplankton to external "new" nutrients we present the ratio between the calculated flux of atmospheric carbon (converting LIN to DOC assuming Redfield ratios) to the surface water primary production (Reich et al., 2022), exhibiting higher contribution during stratification (average 2.7%) compared to the mixed period (~1%) (Figure 1). The calculated average atmospheric flux converted to DOC is 6 mg organic C m^{-2} d^{-1}, similar to the average measured value of POC export at 1300 m as measured in the DeepLev station; ~7.5 mg POC m^{-2} d^{-1} [4, Alkalay et al.-submitted).

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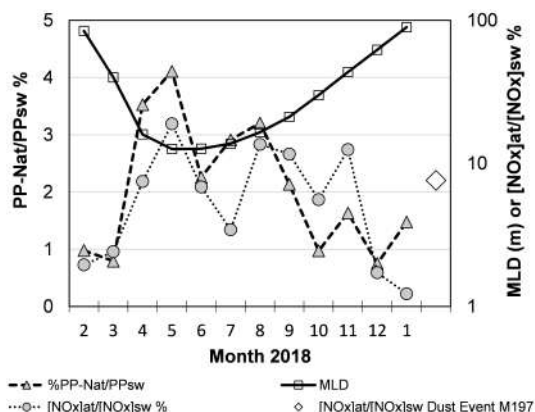
THE FIFTEEN-YEAR-LONG HISTORY OF MEDITERRANEAN SEA BIOGEOCHEMISTRY FORECASTING

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Abstract

Based on a fifteen-year-long history of marine biogeochemistry modelling, the Med-BGC forecasting system has evolved encompassing different projects and landed into the full operational EU Copernicus Marine Service. Med-BGC developments included model science achievements, such as the incorporation of the carbonate system and multispectral optics, the cutting-edge integration of multivariate and multi-platform data assimilation, and relevant technological developments supporting increased spatial resolution and updated land and ocean boundary conditions. Thanks to the continuous improvements, Med-BGC is able to operationally predict the variability and trends of key ocean variables and relevant events (e.g., anomalous blooms) with a quantified level of uncertainty.

Keywords: Models, Mediterranean Sea, Nutrients, Phytoplankton, Primary production

Operational biogeochemical modelling offers the opportunity to monitor the present state and trends of marine biogeochemistry in the Mediterranean Sea, where a fifteen-year history of achievements involved technological and scientific aspects. Beginning with the pre-operational version of the biogeochemical Med-BGC system in 2009 (Lazzari et al., 2010), Figure 1 resumes some of the major developments of the Med-BGC model and their impact on the system performances in terms of root mean square differences (RMSD) with respect to satellite chlorophyll observations. Med-BGC can predict surface chlorophyll and phytoplankton blooms three times better than ten years ago thanks to the assimilation of ocean colour observations (Teruzzi et al., 2014), upgrades in biogeochemical parameterization, increased resolution and better alignment with the physical component (Salon et al., 2019), and novel optical components (Álvarez et al., 2023).

With the step-by-step introduction of BGC-Argo float data assimilation (chlorophyll and nitrate in 2019 and oxygen in 2022; Amadio et al., 2023), the Med-BGC system has improved the ability to predict the vertical dynamics of nutrients, phytoplankton and oxygen (Figure 2). The Med-BGC system has further benefited from the inclusion of carbonate system (Cossarini et al., 2015), nutrient parametrization for phytoplankton (Lazzari et al., 2016) and improved multivariate boundary conditions (Salon et al., 2019); and it now provides predictions and uncertainty estimations for more than 20 key ocean variables including, among others, CO_2 air-sea fluxes, pH, phytoplankton functional types, primary production and zooplankton (Coppini et al., 2023). Future developments of the Med-BGC system, that will bring new technological and computational challenges, will focus on enhancing the ecosystem description (novel components for biodiversity, optics and high trophic levels), further reducing the model uncertainty (real-time land and atmospheric boundaries, and ensemble prediction and assimilation), and increasing resolution to support coastal applications.

Fig. 1. Accuracy of the chlorophyll forecasts since 2008 (RMSD between Med-BGC system and satellite chlorophyll) and main Med-BGC developments on spatial resolution (green arrows); data assimilation (BGC DA), boundary conditions (New Med-PHY BC at Gibraltar) and biogeochemical parametrization (Daily cycle in BFM, Optics). Red dots: RMSD of the operational products since November 2022 Copernicus Marine release.

Fig. 2. RMSD between Med-BGC and BGC-Argo profiles of chlorophyll, nitrate and oxygen at different development stages since 2018.

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COMITÉ 4
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Microbiologie et biotechnologie marines
Président : Monia El Bour

CIESM Congress Session : Dynamics of phytoplankton
Moderator : Silvia Casabianca – Univ. of Urbino "Carlo Bo", Italy

Session's Synthesis

During the session "Dynamics of phytoplankton", seven speakers presented their research. All the presentation were very interesting exploring different aspects of the session topic. In particular, the presentations regarded the development of a database about HAB events to better understand the biotoxin impacts on humans; the analysis of lipids production under salinity stress; the HPLC analysis of pigments for the characterization of phytoplankton communities both in a short and long time period analyzing also the impact of rivers discharge on the phytoplankton biomass; changing environmental conditions (i.e.: water temperature and stratification) linked to the presence of phytoplankton toxic species; genetic and phylogenetic analyses of halophilic microalgae leading to new species identification; the analysis of chlorophyll variation in a ten years period linked to phytoplankton phenology and bloom events. The dynamics of phytoplankton are therefore influenced by several factors, such as nutrient availability, light, temperature, ocean stratification, biological interactions, and climate change. From the session discussion, the complexity of marine ecosystems emerged highlighting the need for a multidisciplinary approach to understanding phytoplankton dynamics. Improved models combining physical, chemical, and biological factors are crucial for predicting future changes and shifts in phytoplankton populations, especially in the context of global climate change. Emerging technologies such as satellite remote sensing, autonomous systems, artificial intelligence, and molecular techniques will all help us better monitor and forecast these changes, both in environmental conditions and in phytoplankton communities. Understanding phytoplankton's future dynamics will be crucial for global climate regulation, carbon cycling and for marine ecosystem health.

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LINKING MARINE BIODIVERSITY CONSERVATION, FOOD SAFETY AND BLUE ECONOMY : A ONE HEALTH APPROACH TO ADDRESS HABS IN THE MEDITERRANEAN SEA

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Abstract

Biotoxin producing harmful algal blooms (HABs) are increasingly prevalent in the Mediterranean Sea, posing significant threats to marine life and humans. This study aims at filling gaps in the availability of consolidated data on biotoxin contamination in seafood. A database is being developed that integrates information from various sources, including the acquisition of new data, with a particular interest in emerging benthic species. To better understand the impact of biotoxins on the Mediterranean population, we use FAO FishBase to estimate seafood consumption patterns and derive population exposure to biotoxin. Moreover, in the framework of the Barcelona Convention, the creation of a collaborative Mediterranean HAB network will help assess socioeconomic impacts, prioritize threats, and facilitate more effective mitigation strategies.

Keywords: Ecotoxicology, Food webs, Phytoplankton, Mediterranean Sea, Toxic blooms

Introduction

Harmful Algal Blooms (HABs) are the naturally occurring proliferation of microscopic algae that have adverse effects on the marine environment as well as on animal and human health, constituting a One Health issue. HAB events have been significantly increasing in Mediterranean countries over the past 30 years [1]. Major events include mass mortalities of marine organisms, fisheries and beach closures, food contamination with biotoxins above safety levels and human intoxications [2]. Consumption of contaminated seafood can lead to various human illnesses, including amnesic, diarrhetic or paralytic shellfish poisoning. In a context of climate change, some species such as *Ostreopsis* or *Gambierdiscus*, common in tropical areas, are also emerging or increasing in occurrence in the Mediterranean Sea [1]. Enhancing our understanding of the transfer of biotoxins in marine food web and of the extent of seafood contamination is crucial to promote food safety, food security and sustainable economies in Mediterranean countries. This study aims to address these gaps using a transdisciplinary One Health approach, linking human, animal and environmental health. We will assess potential human exposure to biotoxins using estimates of seafood contamination and investigate the role of ecosystem health in the occurrence and transfer of biotoxins, focusing on *Ostreopsis spp.* In the framework of the Barcelona Convention, this study also includes the development of a Mediterranean network of experts dedicated to HABs.

Material and methods

Human exposure to biotoxins was assessed by the integration of data on seafood consumption and seafood contamination. Datasets were mined from the FAO-FishStat, UNESCO-HAEDAT and EU-RASFF databases, as well as national monitoring networks, bibliographic review and data from the newly-created network with Plan Bleu Regional Activity Center (RAC) of the UN Environment Program/Mediterranean Action Plan (MAP). A questionnaire was also developed and distributed to the HAB-network partners to further populate the database and prioritize issues related to HABs in the Mediterranean Sea.

New data acquisition is also being undertaken through field surveys along the French Riviera. In four sites with different ecological health status as assessed by the CARLIT index, we are combining regular sampling and in situ observation to monitor for benthic HABs and toxin occurrences. Surveys include the deployment of artificial substrates and light traps to measure *Ostreopsis* cell occurrence and benthic assemblage information. Toxin levels and transfer along the food web will be measured by mass spectrometry and bioassays.

Results and discussions

To date, our database encompasses information sourced from existing databases and close to 200 scientific publications. The majority of the publications pertain to lethal PSP and DSP toxins, predominantly detected in bivalve molluscs, with values reaching safety levels recommended by CODEX Alimentarius. The consumption estimates across the 21 Mediterranean countries (Figure 1), which are derived from fish and fisheries production, importation and exportation data from FAO-FishStat, underscore the significance of seafood as a source of protein, with values reaching 61.1 g/person/day in Spain. These data stress the potential risk of exposures to biotoxins in the absence of effective food monitoring measures. Future data analysis will deepen our understanding of the frequency of occurrence and levels of toxicity observed. Furthermore, planned toxin analyses of field samples (*Ostreopsis*) will help to clarify the role of ecosystem health in the production and transfer of toxins in the context of increasingly urbanized coasts.

The Mediterranean HAB-network being established currently includes 7 countries representing both the southern and northern Mediterranean regions. This initiative encourages trans-Mediterranean collaboration and data sharing and will enhance our understanding of HAB occurrence and impacts in the region, particularly with new data expected from the south.
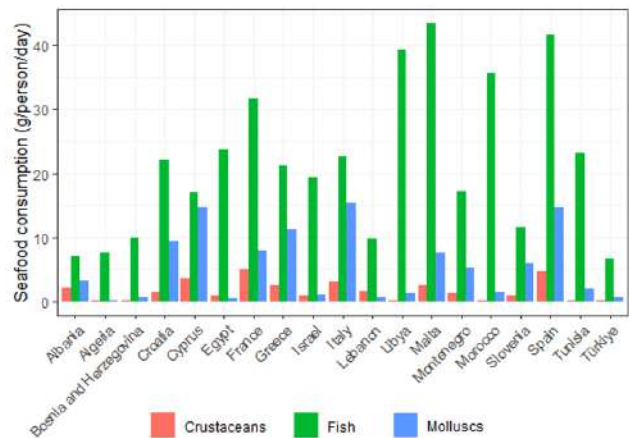

Fig. 1. Seafood consumption across Mediterranean Countries, based on FAO FishStat

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ESTUARINE PHYTOPLANKTON ACCOMODATE LIPID COMPOSITION IN RESPONSE TO SALINITY FLUCTUATIONS

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Abstract

Life in estuaries is a challenge, particularly due to changes in salinity (S). Environmental changes inevitably lead to adaptation of phytoplankton in order to survive. As membranes are the first to sense changes in the environment, we focused on understanding how phytoplankton in estuaries adapt to salinity stress through lipid remodeling. We analysed the content and composition of glycolipids and phospholipids in the subtropical, eutrophic Wenchang River Estuary (WRE) and in the temperate, pristine, mesotrophic Krka River Estuary (KRE). We found that the cellular content of the glycolipid monogalactosyldiacylglycerol (MGDG) increased at the lowest S along with the increase in MGDG unsaturation. Phospholipid (PL) content decreased in estuarine waters. The unsaturation of PL and the changes with S depend on the PL class.

Keywords: Stressors, Phytoplankton, Adriatic Sea, Organic matter

Introduction

Estuaries and coastal areas are regarded as major global hotspots for climate change. Estuaries are among the most productive environments. They get a lot of organic matter and nutrients from the mainland, which support high primary production [1]. Phytoplankton is the most important lipid producer [2]. Lipids play an important role in numerous biological processes [3]. They are excellent biogeochemical markers for tracking how marine plankton adapt to various environmental conditions. They are trophic markers in food webs and markers for identifying different sources and processes of marine organic matter [4].

Methods

We employ thin–layer chromatography–flame ionization detection and high-performance liquid chromatography (HPLC)/electrospray ionization (ESI) tandem mass spectrometry (MS/MS) to provide qualitative and quantitative lipid characterization and to monitor lipid molecular change along the salinity gradient. We performed phospholipid fatty acid profiling of two most abundant phospholipids phosphatidylcholine (PC) and phosphatidylglycerol (PG) and also of glycolipids MGDG.

Results

The contribution of MGDG to cell lipids was low in the river end members in the KRE and WRE. MGDG contribution (%) increased significantly at the lowest S compared to riverine waters and then decreased with increasing S in both estuaries (Fig. 1A). We analysed the MGDG species in detail using HPLC/MS/MS. The estuarine phytoplankton synthesised more unsaturated FA in MGDG than the freshwater phytoplankton (Fig. 1B). Cell phospholipid content is higher in the pristine KRE (Fig. 1C), which is a consequence of the more favourable N/P ratio in the KRE. Although we investigated two notably different estuaries, similarities in the phosphatidylcholine (PC) and phosphatidylglycerol (PG) number of double was observed. The highest degree of unsaturation was observed for PG in both estuaries: double bonds 1.57-2.35 and 1.50-2.57 for the KRE and WRE, respectively (Fig. 1D). The lowest double bond variability was observed for PC in both estuaries: 1.53-2.05 in the WRE and 1.56-1.79 in the KRE (Fig. 1D). in the WRE and 1.56-1.79 in the KRE (Fig. 1D).
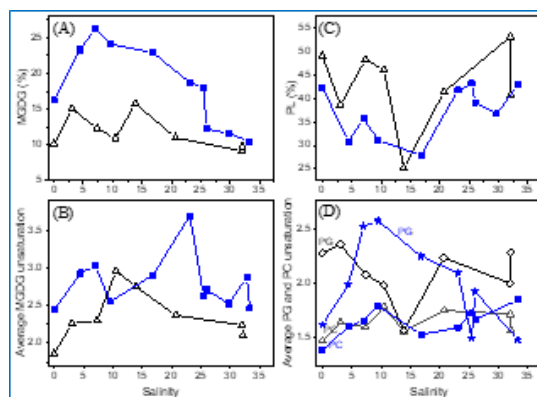

Fig. 1. (A) The contribution of MGDG to cell lipids, (B) Average MGDG unsaturation (number of double bonds, (C) The contribution of PL to cell lipids and (D) Average PC (triangle and square) and PG (rhombus and star) unsaturation along the salinity gradient in the KRE (open symbols) and WRE (full symbols).

Conclusions

Here we show a mechanism of salinity stress tolerance utilised by phytoplankton in estuaries through lipid remodelling. Acclimation involves the accumulation of unsaturated MGDG to control thylakoid membrane function and ultimately protect the photosynthetic machinery. Different PL respond differently to S fluctuations. The small change in PC unsaturation with S indicates the conservatism of cellular PC synthesis in terms of maintaining the integrity of the cell itself. The higher PG unsaturation can be explained by its role in photosynthetic electron transport in the thylakoids [5].

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SPATIAL AND SEASONAL VARIATIONS IN SOUTHERN BLACK SEA PHYTOPLANKTON SIZE CLASSES

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Abstract

This study investigates the spatial and seasonal variations in phytoplankton size classes across the southern Black Sea basin. HPLC pigment analysis of samples collected in December 2022 (winter) and June 2023 (summer) will be used to characterize phytoplankton communities. The focus will be on identifying shifts in size class distribution (pico -, nano-, microphytoplankton) between the seasons. Understanding these variations is crucial for elucidating the dynamics of primary productivity and biogeochemical cycles in the Black Sea. The short-term variability data encompassing the entire southern Black Sea basin will provide insights into potential environmental drivers influencing phytoplankton size structure. The research contributes to understanding the seasonal response of the Black Sea's phytoplankton community and its role.

Keywords: Phytoplankton, Black Sea, Primary production, Chlorophyll-A, Pigments

The Black Sea is a unique ecosystem characterized by distinct seasonal and regional variations in phytoplankton size classes, influenced by factors such as nutrient availability (riverine input, upwelling, lateral transport), temperature, and hydrodynamics [1]. The seasonal and long-term variability of phytoplankton in the Black Sea is still insufficiently studied, highlighting the need for further research in this area [2]. Climatic warming has led to changes in the Black Sea's ecological regime, affecting the distribution and dynamics of phytoplankton in the region [3]. The Black Sea experiences major phytoplankton blooms, significantly impacting the distribution of phytoplankton size classes. These findings emphasize the importance of studying the distribution of phytoplankton size classes across the Southern Black Sea in winter versus summer seasons to gain a comprehensive understanding of the unique ecological dynamics in this region.

The sampling for this study was conducted in December 2022 and June 2023 aboard the R/V Bilim-2. Filter samples were collected to analyze pigment amounts using high-performance liquid chromatography (HPLC). Subsequently, Uitz et al.'s (2006) formulas were employed to calculate phytoplankton size classes from the obtained data [4]. The use of these formulas allowed for the assessment of the vertical distribution of phytoplankton communities in the open ocean based on surface chlorophyll-a, enabling the classification of different size classes such as microphytoplankton, nanophytoplankton, and picophytoplankton [4]. Additionally, the study also considered the synoptic relationships between surface chlorophyll-a and diagnostic pigments specific to phytoplankton functional types, providing valuable insights into the seasonal variability of phytoplankton in the Black Sea [5].

The surface pigment concentration distribution was utilized to compare the seasonal and the spatial distribution of the size groups. The chlorophyll-a distribution in our study period aligns with the circulation pattern and seasonal mixing and stratification in the water column. Higher surface chlorophyll-a concentrations were observed in the December 2022 period. Micro-phytoplankton (mostly Diatom and Dinoflagellate) dominated the basin in December, with a notable presence of picoplankton, particularly concentrated in the area around 33-34 degrees East. The elevated chlorophyll-a levels near the coast between 35-40 degrees east are attributed to the accumulation of riverine input. Conversely, the June 2023 data revealed lower chlorophyll-a concentrations, with a pronounced peak near the Kizilirmak river outlet, likely influenced by nutrient transport from heavy rainfall during that period.
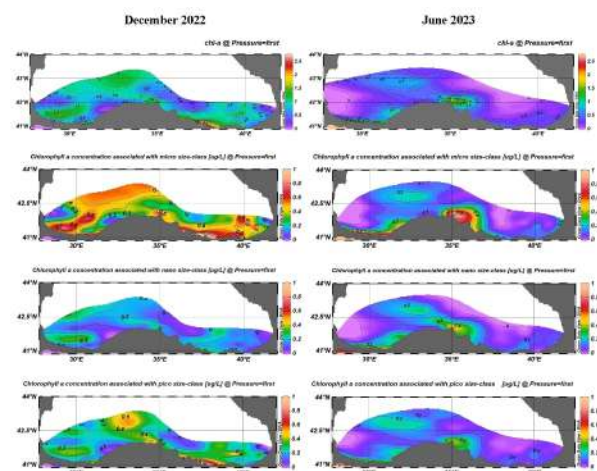
Fig. 1. The chlorophyll-a concentrations' distribution across the Southern Black Sea. The total chlorophyll-a at the top row, followed by the contribution of micro-, nano-, and picoplankton classes to the total. The left column is from the cruise of December 2022; the right column is the cruise of June 2023.

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MULTIANNUAL TRENDS IN PHYTOPLANKTON DYNAMICS IN THE NORTHERN ADRIATIC AS REFLECTED BY CHEMOTAXONOMIC PIGMENTS

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Abstract
Systematic field observations of chemotaxonomic pigments using an HPLC method encompassing a period of eleven years (1998 - 2008) were carried out on the Po River mouth – Rovinj transect in the northern Adriatic Sea to assess phytoplankton dynamics with a special emphasis on multiannual trends. A strong negative correlation between chlorophyll a and salinity in the upper layers of the water column confirmed the importance of the Po River discharge as a key factor determining phytoplankton biomass and community structure in the northern Adriatic. The trend of increasing salinity during the investigation period, which could be related to climate change, resulted in a decrease of the total phytoplankton biomass, accompanied by lower proportions of diatoms and silicoflagellates, especially in the western part of the basin.

Keywords: Phytoplankton, Adriatic Sea

Introduction. Phytoplankton dynamics as a key component of the structure and functioning of aquatic ecosystems are highly sensitive to environmental changes. Since the late 1990s, significant changes in oceanographic features have been observed in the northern Adriatic (NA), indicating possible oligotrophication of the basin [1]. In recent decades, an increase in temperature and salinity has been observed in the NA, which has been accompanied by a decrease in phytoplankton abundance and changes in phytoplankton taxonomy characterized by an increase in smaller size fractions in phytoplankton populations [2,3].

Study area and Methods. The Northern Adriatic (NA) is the northernmost and one of the most productive parts of the Mediterranean Sea. The field study was conducted in the period 1998-2008 with a monthly sampling frequency along the Po River mouth – Rovinj transect (Fig.1). The seawater samples were filtered directly on board through 0.7 mm GF/F filters, immediately frozen in liquid nitrogen and subsequently analysed for chemotaxonomic phytoplankton pigments using reversed-phase high-performance liquid chromatography [4]. The relative contribution of the different phytoplankton groups, including diatoms, dinoflagellates, Prymnesiophyceae, Cryptophyta, Chrysophyceae, green algae and cyanobacteria, to the total chlorophyll a biomass was determined from the corresponding chemotaxonomic pigment concentrations using specific biomarker pigment/chlorophyll a ratios aquired from the literature.

Results and Discussion. The photosynthetic pigments detected in the samples from NA between 1998 and 2008 showed a complex composition characterized by pronounced temporal and spatial variability. In addition to chlorophyll a, an indicator of total phytoplankton biomass, several chemotaxonomic biomarker pigments, including alloxanthin, 19´-butanoyloxyfucoxanthin, chlorophyll b, fucoxanthin, 19´-hexanoyloxyfucoxanthin, peridinin and zeaxanthin, proved to be highly relevant for the interpretation of phytoplankton dynamics. The key role of the Po River inputs for phytoplankton dynamics in the NA was revealed by the statistically significant inverse correlation between salinity and chlorophyll a concentration, especially in the western part of the basin. As a result, the spatial distribution of phytoplankton in the NA was mainly influenced by the distance from the Po River mouth, the seasonal fluctuations of river water discharge and the stratification of the water column [5], which is consistent with earlier studies of phytoplankton pigments in the NA [4].

The spatial and seasonal changes in biomass concentration were accompanied by significant changes in phytoplankton composition. The horizontal distribution of the Fp index in the NA clearly illustrates more eutrophic characteristics in the western and central part of the basin (Fp index = 0.5 – 0.8), compared to the oligotrophic character of the west Istria coastal waters (Fp index = 0.28 – 0.5) (Fig. 2). The oligotrophic state of station RV001 is mainly a consequence of the prevailing cyclonic circulation system in the NA, which flushes most of the river inputs out of the basin along the Italian coast.

Fig. 1. Map of the northern Adriatic with indicated sampling stations.
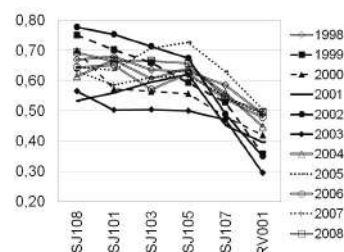

Fig. 2. Horizontal distribution of the average annual F_p index values on the Po River mouth – Rovinj transect during the period 1998-2008.

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RELATIONSHIP BETWEEN ENVIRONMENTAL FACTORS AND THE OCCURRENCE OF TOXIC BENTHIC MICROALGAE BLOOMS IN SOUTHERN MEDITERRANEAN: THE CASE OF ANNABA BAY, ALGERIA

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Abstract
In the current study, we focus on toxic benthic dinoflagellates and the relationship between their occurrence and environmental factors. Two sites were selected based on the abundance of macrophytes and their low hydrodynamics. A 20-week monitoring period in 2023 allowed us to identify the presence of two potentially toxic species: *Prorocentrum lima* and *Coolia monotis*. Our results indicate that their occurrence is associated with environmental conditions, particularly water temperature and water mass stratification.

Keywords: Blooms, Dinoflagellates, Temperature, Toxic blooms, Mediterranean Sea

Introduction
In the last decades, blooms of toxic benthic microalgae have been reported in many regions around the world [1,3]. These benthic dinoflagellates coexist in assemblages composed of the following genera: *Prorocentrum*, *Ostreopsis*, *Coolia*, and *Amphidinium* (Fig.1).

Fig. 1. Images of the two toxic dinoflagellates *Coolia* (left) and *Prorocentrum* (right) taken with an upright light microscope, Laika GR 10*100.

Material and Methods
This study focuses on the *in situ* monitoring of benthic microalgae in Annaba Bay, as well as the ecological parameters controlling the spatiotemporal variations in their abundance. Annaba Bay, located in the eastern part of the Algerian coast, receives several urban and industrial effluents from various coastal factories. The observation protocol includes three different samples: one planktonic (in the water column), one benthic (on the macrophytes), and a half-liter water sample for measuring physicochemical parameters. For the physical parameters, a HANA 9829 multiparameter device was used for *in situ* measurements of temperature, salinity, pH, and dissolved oxygen.

Results

Fig. 2. Spatiotemporal variations of *Prorocentrum lima* (bottom right) and *Coolia monotis* (top right). Spatiotemporal variations of salinity and temperature (left) in the northwestern Algerian region, specifically Annaba Bay, during the first half of 2023.

As shown in Fig. 2, *Prorocentrum lima* proliferated during the spring season, particularly in April, with a maximum density of 4249 cells.g^-1 FW. *P. lima* exhibited a wide distribution throughout the study period at temperatures ranging from 13.02 to 19.7°C and salinities between 35.6 and 37.1 PSU. Similar to *P. lima*, *Coolia monotis* was present throughout the study period from January to May. Its proliferation began at the start of the spring season, reaching a peak in April with densities exceeding 3000 cells.g^-1 FW. In comparison with other studies, *C. monotis* was found in the Gulf of Gabes during winter, spring, and occasionally summer. The distribution variation of *C. monotis* was recorded at temperatures ranging from 13.02 to 19.7°C and salinities between 35.6 and 37.1 PSU.

Discussion & Conclusion
In autumn and winter, external energy is introduced by rain and wind storms, which negatively impacts the microalgae by simplifying and reducing their structures. These conditions can also affect all epiphytic organisms. The differences in cell concentration between warm and cold months may also result from the carrying capacity of macroalgae, which varies according to hydrodynamic characteristics. The seasonality of dinoflagellate occurrence in Annaba Bay is closely linked to the dinoflagellate assemblage on macroalgae, which follows a clear seasonal pattern in response to several factors, likely the same factors that trigger the spring growth of macroalgae in the region, including increased temperature and irradiance in early spring, plus the availability of biotic substrate. This explains the monthly variations in concentration observed in our study. The presence of these harmful blooms can have adverse effects on public health. Even though the cell counts were lower than those typically observed along the northern Mediterranean coasts, regular monitoring of these benthic dinoflagellates and their emerging biotoxins should be implemented to protect human health and marine ecosystems from potential dangers.

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GENETIC DIVERSITY AND PHYLOGENY OF NEW HALOPHILIC MICROALGA STRAINS FROM REMOTE SALINE SITES

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Abstract

Fifty-two new strains of halophilic microalgae were isolated from marine solar salterns on the shores of the Mediterranean and Black seas, as well as from some inland saline lakes in Russia. The molecular phylogeny of the strains was analyzed using 18S rRNA and rbcL genes, and ITS1-5.8S-ITS2 region. *Asteromonas gracilis, Picochlorum* sp., *Tetraselmis* sp., *Dunaliella salina, D. parva,* and *D. viridis* were identified in geographically remote saline sites. The results demonstrate a considerable genetic diversity of the genus *Dunaliella* and its closest neighbours. Some of the new isolates may represent new species and even genus.

Keywords: Algae, Biodiversity, Brine pools, Black Sea, Mediterranean Sea

Hypersaline water bodies are widely distributed throughout the world, and include both talassohaline and continental environments that differ in origin and chemical composition. These hypersaline environments are inhabited by organisms adapted to high levels of salinity, including microalgae of the phylum *Chlorophyta*, which are one of the main producers of organic matter. Halophilic microalgae are biotechnologically valuable, particularly members of *Dunaliella*, which are used for the production of β-carotene, biofuel and as a recombinant protein expression system [1]. Various species of this genus have unique properties, biological characteristics and biotechnological potential. There are several taxonomic classifications of *Dunaliella* species based on their morphological, physiological and molecular features. However, none of them is reliable and accurate, and some inconsistencies exist between different classifications, leading to ambiguous taxonomy of newly described strains [2]. Thus, the diversity of the genus *Dunaliella* is currently underestimated due to insufficient sampling and a lack of comprehensive descriptions for a number of strains [3].

Using 18S rRNA, rbcL genes and ITS1-5.8S-ITS2 region sequencing we assessed the phylogenetic position and taxonomic affiliation of 52 new halophilic microalgal strains belonging to the phylum *Chlorophyta*. The strains were isolated from marine solar salterns located in the southeastern part of Italy and Portugal, the western part of Sicily, on the Black Sea coast (Crimea), as well as from inland saline lakes in various regions of Russia (Elton Lake, Sol-Iletsk Lakes, Kulunda Steppe Lakes).

Great genetic diversity has been revealed within the genus *Dunaliella*, to which most of cultures (40) belonged. Phylogenetic analysis distinguished several clades based on the ITS1-5.8S-ITS2 sequences. The first clade "*D. parva*" included two isolates from the Krasnoe Lake (Crimea) and the inland Lake Razval. Other isolates from the Razval Lake, exhibiting similar morphology (small green cells with a pointed posterior end) formed the second clade "*Dunaliella* sp. 1". The similarity of their sequences with the closest homologue, *Dunaliella pseudosalina* (KU641615), did not exceed 94.0%. The third large clade consisted of carotenogenic large-cell isolates from Krasnoe Lake (Crimea), Elton Lake, Pechatnoe Lake (Kulunda Steppe) were identified as *D. salina*. Non-carotenogenic isolates with small palmelloid cells formed the fourth clade "*Dunaliella* sp. 2". They had low similarity (92.21-94.57%) with the closest homologue, *Dunaliella* sp. (MG952974). Representatives of the fifth clade differed in nucleotide sequences from the third clade *D. salina*, and had distinctive morphological features from strains assigned to species *D. salina*. The sixth clade contained sequences of small-cell non-carotenogenic *Dunaliella* strains from Italy, Crimea and Sol-Iletsk, were identified as *D. viridis*. An additional clade consisted of four strains from Motsia saltern (Sicily), Chokrakskoye Lake (Crimea) and an ephemeral reservoir nearby Sivash Lake (Crimea). The vegetative forms of these microalgae were represented by green palmelloid and small motile cells, whereas the cysts were bright red in color. The closest homologs were the sequences of 'Halosarcinochlamys cherokeensis' (*nomen nudum*), found in Lake Tyrrell (Australia) and Salt Plains (USA, Oklahoma). The similarity with the type strains of the genus *Dunaliella* was very low: 83.96% with *Dunaliella*

tertiolecta in the ITS region and 97.44% with *Dunaliella tertiolecta* (EF473738) in the 18S gene. Therefore, these isolates were identified as *Chlamydomonadales* sp. Moreover, new cultures of halophilic microalgae *Asteromonas gracilis, Picochlorum* sp., *Tetraselmis* sp. were isolated from geographically remote saline habitats.

The obtained results revealed significant genetic diversity in the genus *Dunaliella* and its closest neighbors. Distinct clades of *D. parva, D. salina, D. viridis* included representatives from different geographic sites. Some new isolates of halophilic microalgae may represent two or more new species and even genus. Thus, careful and intensive sampling allowed a realistic assessment of the geographical distribution of known *Dunaliella* species. The results obtained expand our horizons in the modern diversity of halophilic microalgae of the *Dunaliellaceae* family, and indicate directions for further search of new biotechnologically valuable strains.

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INTERANNUAL AND SEASONAL CHLOROPHYLL VARIABILITY FROM HIGH RESOLUTION FLUORESCENCE TIME SERIES (2012-2022) AT AN ELTER SITE IN THE NORTHERN ADRIATIC SEA.

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Abstract

Continuous optical observations of chlorophyll fluorescence from August 2012 to December 2022 at the meteo-oceanographic buoy E1, located along the Emilia-Romagna coast in the Northern Adriatic Sea, were analysed. The dataset spanning a decade, consisting of 69,705 hourly in-situ derived chlorophyll fluorescence observations, was employed to examine both seasonal and non-seasonal variability in chlorophyll, along with long-term trends in phytoplankton phenology and bloom events in the Northern Adriatic Sea. E1 buoy is located in the research site 'Delta del Po and costa Romagnola', which belongs to the Italian branch of the eLTER-RI and is integrated into the Italian national project PNRR ITINERIS - Italian Integrated Environmental Research Infrastructures System.

Keywords: Monitoring, North Adriatic Sea, Blooms, Phytoplankton

Monitoring coastal marine environments is crucial for understanding ecosystem health and assessing risks to human health. Chlorophyll (Chl) serves as a key indicator of phytoplankton biomass, reflecting primary production dynamics and responding to environmental factors such as wind and nutrient transport. Various methodologies, including satellite remote sensing, sample-based laboratory analysis, and in-situ optical sensors, are employed to gather Chl data, each with distinct advantages and limitations. Variations in Chl concentrations result from natural and anthropogenic factors such as solar irradiation, nutrient inputs, carbon fluxes, and fishing. Continuous long-term observations, facilitated by autonomous monitoring platforms, are essential for investigating marine environments. This study focuses on a temporal analysis of Chl levels in the Northern Adriatic Sea (NAS) over the past decade, aiming to understand Chl concentration trends and their relationship with environmental factors. The study evaluates the reliability of optical sensor data compared to other methods and assesses seasonal variability using a ten-year dataset.

The station "E1" (44°08.58'N; 12°34.20'E) located within NAS, approximately 100 km south of the Po Delta and 7 km northeast of Rimini, is part of the research site 'Delta del Po and costa Romagnola', which belongs to the Italian branch of the eLTER-RI (Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research Infrastructure) and is integrated into the Italian national project PNRR ITINERIS - Italian Integrated Environmental Research Infrastructures System. Since 2006, an autonomous meteo-oceanographic platform, namely Buoy E1, has been deployed at this station to gather meteorological and oceanographic data. In 2012, the system underwent an upgrade with the integration of the WET Labs® ECO Triplet three-optical-sensor instrument (1). This enhancement enables the estimation of Chl, colored dissolved organic matter (CDOM), and turbidity values through fluorescence and backscattering readings. Data are collected at 60-minute intervals, with near-surface Chl data transmitted in near real-time (NRT) to the Data Centre of CNR-ISMAR in Bologna.

The dataset comprises 69,705 Chl hourly values collected between August 2012 and December 2022. The average Chl concentration is 2.8 μg L^{-1}, with a standard deviation of 4.1. Concentrations range from maximum daily average of 41.9 μg L^{-1} to values below the detection limit. Seasonal variations are characterized by two distinct phytoplankton growth periods, occurring in spring (typically March, averaging 5.3 μg L^{-1} with a standard deviation of 6.5, and May, averaging 4.5 μg L^{-1} with a standard deviation of 6.1) and winter (spanning December, averaging 3.1 μg L^{-1} with a standard deviation of 3.3, and January, averaging 4.6 μg L^{-1} with a standard deviation of 4.6). Bloom events are detected by using the net growth rate (r_t) (2), and on average, two blooms events per year were identified. Chl concentrations are higher during the winter and spring months, with average concentrations reaching 3.9 μg L^{-1}, whereas July to November values are 1.4 μg L^{-1}. The general trend of Chl concentrations is illustrated in Fig. 1.
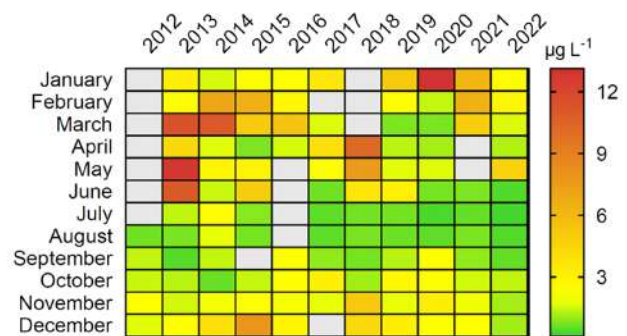

Fig. 1. Monthly Heatmap (2012-2022) of ECO Chl data. Grey color indicates missing data.

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CIESM Congress Session : Microbial Biotechnology

Moderator : Donatella de Pascale – Stazione Zoologica Anton Dohrn, Naples, Italy

Session's Synthesis

The session "Microbial Biotechnology" hosted six contributions that shed light on the complex issue of Marine Biotechnology. Microbial biotechnology is an interdisciplinary field that exploits the capabilities of microorganisms for various applications in industry and medicine, it is directly related to 8 of the 17 sustainable development goals of the United Nations.

Presentations covered several sectors of the Microbial biotechnology, starting from two talks related to the production of ectoine, a compatible solute with great potential for industrial use in food industries, from a thermoactinomycete isolated form Sfax, Tunisia. A nice discussion come up from these two talks, since they highlighted the chance to produce ectoine at very high yield in comparison to the previous methods applied.

The treatment of the environmental pollution by using microalgae is a field with significant industrial interest, this topic was covered by a talk focusing the attention on some Adriatic microalgae species, opening to a large discussion on how microalgae could be usefully used for heavy metal accumulation. Other very interesting talks covered different aspects from the microbial biotechnology, such as the role of viral community in shaping bacterial biodiversity pattern during hydrocarbon biodegradation process. The discovery of two bacteriophages with specificity against *Thalassolituus oleivorans* suggests an important role of viral communities in hydrocarbon biodegradation process.

Of great interest also the research focused on the antimicrobial activity discovered from two cnidarians and their symbionts that could open at potential pharmaceutical applications, while the last talk focused the attention on electrokinetic for the treatment of environmental pollution as a pivotal strategy for the environmental decontamination. Microbial biotechnology is the application of biotechnology principles and techniques to the study and utilization of microorganisms and their products. It involves the use of bacteria, fungi, and other microorganisms to perform various tasks that are beneficial to human health, industry, and the environment. Much work has been done but much remains to be done to have a complete application of microorganisms in different sectors.

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ANTIMICROBIAL ACTIVITY AND ENZYMATIC POTENTIAL OF BACTERIAL EPIBIONTS ISOLATED FROM *PHYLLORHIZA PUNCTATA* AND *RHIZOSTOMA PULMO*

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Abstract

The two cnidarians *Rhizostoma pulmo* and *Phyllorhiza punctata*, exhibit close symbiotic relationships with micro-epibionts producing a wide range of bioactive molecules. In the present study we investigated the microbial community of the two cnidarian species and their antimicrobial potential, exo-enzyme production, antibiotic sensitivity, bio-surfactant and EPS production.

Keywords: Cnidaria, Microbiota, Antibiotics, Gulf of Tunis, Gulf of Gabes

Introduction

Phyllorhiza punctata and *Rhizostoma pulmo,* are two distinct species of jellyfish from the order of Rhizostomeae within the class Scyphozoa. *Phyllorhiza punctata*, is an invasive species introduced in the Eastern-Mediterranean Sea in the 1990s from the Eastern-southern-central coast in Australia [1]. *Rhizostoma pulmo* is native to the Mediterranean Sea and the north eastern Atlantic Ocean [2]. The present study focused on the antimicrobial and enzymatic properties of bacterial microbiota of jellyfish to exlpore the potential of bioactive compounds.

Materials and method

The isolation and characterization of epibiotic bacteria from different organs of jellyfish were followed by the analysis of antimicrobial potential. Agar disc diffusion assay was used to screen both the antibiotic sensitivity and antimicrobial production. All strains were also examined for exo-enzymes production in different appropriate solid mediums. To screen exo-polysaccharide (EPS) production, strains were grown in a modified TSA agar medium containing 5% of selected carbon source and the quantitative drop-collapse test was performed in the 96-microwell to test the bio-surfactant production by the strains.

Results

A total of 15 Gram-bacteria isolates from *Phyllorhiza punctata* and 5 isolates from *Rhizostoma pulmo* were characterized and identified. The agar overlay inhibition method revealed an antagonistic potential for 19 isolates with a large spectrum of inhibition against the pathogen microbial species (*Escherchia coli, Candida albicans, Vibrio anguillarum, Vibrio alginolyticus, Pseudomonas fluorescens, Pseudomonas aeruginosa, Salmonella typhymurium* and *Staphylococcus aureus*). Besides, these isolates produced various extracellular hydrolytic enzymes including: chitinase, hemolysins, lecithinase, gelatinase, amylase, lipase, and cellulase (Figure 1). The proportion of isolates sensitive to the antibiotics tested ranged from 0% to 100%. Most of the Gram-negative bacterial isolates showed significant bio-surfactant and EPS production.

Conclusion

This study underscores the importance of further investigating the potential of these Gram-negative epibionts as a source of novel bioactive substances, with potential applications in various industries.

Figure1: Enzymatic production profile of the different isolates

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ECONOMIC PRODUCTION OF ECTOINE BY *PALUDIFILUM HALOPHILUM* USING A MINERAL CULTURE MEDIUM AND NON-STERILE FERMENTATION CONDITIONS

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Abstract

The aim of this study was to explore the potential of *P. halophilum* to produce ectoine under submerged non-sterile fermentation conditions. A mineral Sea-Water (SW) medium composed of 10 g/L glucose, 3.2 g/L ammonium chloride and 100 g/L NaCl was used and the cultivation parameters such as Dry Cell Weight (DCW), pH, glucose consumption were determined. At shake-flask level, the non-sterile medium resulted in ectoine cellular content of 240 mg/gDCW, similar to that in sterile one. Moreover, the enumeration of halophilic and non-halophilic contaminants over the 6-day culture period revealed minimal fluctuations, indicating effective control measures against contaminants.

Keywords: Bacteria, Biotechnologies, Mediterranean Sea

Introduction

Ectoine, a compatible solute with diverse industrial applications, has garnered significant attention for its potential in various fields, including pharmaceuticals, cosmetics and agriculture [1,2,3].
Commercially, ectoine is often produced by large-scale microbial fermentation. However, the conventional sterile fermentation processes used for ectoine production usually entail substantial costs associated with sterilization, thereby posing economic challenges for large-scale production. In response to these limitations, alternative cultivation methods have emerged, aiming to harness the robustness of halophile and halotolerant microorganisms under non-sterile conditions [4].
In a previous study, *P. halophilum*, a high-salt tolerant thermo-actinomycete isolated from the solar saltern of Sfax (Tunisia), was reported to be a promising host for ectoine production in sterile conditions [5].
In the present study, the efficacy of non-sterile submerged fermentation of ectoine was evaluated for the first time using the saltern-derived *P. halophilum*. After optimization of fermentation conditions in shake flasks, the ectoine production performance was further improved in open non-sterile batch and fed-batch fermentation in a 7L bioreactor.

Materials and methods

Shake-flasks fermentation conditions: A loopful of fresh mycelium of *P. halophilum* from a 7-day-old colony on ISP2 agar was scraped and inoculated in 5 mL preculture broth. After 3 days of culture at 40 °C with an agitation speed of 200 rpm, the total seed culture was transferred to 250 mL non-baffled flasks containing 50 mL of the same preculture broth and incubated at 40 °C. After 26-28 h of growth, 2.5 ml of the second seed culture was transferred to 250 mL non-baffled flasks containing 50 mL of sterile or non-sterile SW growth medium. All fermentations lasted for 6 days and samples were periodically taken for pH monitoring, quantification of mycelial biomass, residual glucose, and cellular ectoine content. Contaminants were also periodically evaluated on LB agar plates spread with 100 μl of non-diluted culture broth.

Non-sterile batch and fed-batch fermentation in a 7 L bioreactor: For open non-sterile batch and fed-batch fermentation, mycelial cells were grown in a non-sterile 7-L bioreactor (Infors-HT, Bottmingen, Switzerland). A 4 L non-sterile SW medium supplemented with 3.2 g/L NH_4Cl, and 10 g/L glucose was used as an initial medium for fermentation. The fermentation proceeded until the glucose concentration decreased to below 1 g/L. Then, a calculated amount of fresh medium (composed of glucose, NH_4Cl and oligo-elemnts) was fed into the bioreactor to increase the glucose concentration to around 10 g/L. Samples were taken at 24-h intervals to determine DCW, residual glucose, residual ammonia-nitrogen (NH_4^+-N) and ectoine content.

Results and discussion

Our studies showed comparable growth kinetics, glucose consumption, and ectoine production in sterile and non-sterile fermentation conditions. The maximum DCW of 5.78 g/L was obtained at 144 h with non-sterile fermentation of the strain *P. halophilum*, while DCW observed with sterile medium was 4.82 g/L simultaneously. It was also evident that at a temperature of 40°C and a salinity of 10%, the SW medium could inhibit the growth of most non-halophilic and halophilic contaminants, and the number of cells was approximately maintained at 11 CFU/mL and 113 CFU/mL, respectively. Batch and fed-batch non-sterile fermentation in a 7 L bioreactor showed efficient utilization of resources for *P. halophilum* cultivation. The stepwise addition of fresh non-sterile medium maintained favorable growth conditions, as evidenced by the monitored parameters such as DCW, residual glucose, and ectoine content. Under these open non-sterile conditions, a stable process leading to 9-10 g/L of DCW containing 210-250 mg ectoine/gDCW was obtained after 196 h of growth. At last, with the combination of the non-sterile open fed-batch fermentation process for lower energy consumption, and the utilization of low-cost mineral medium, *P. halophilum* can be exploited beneficially in the cost-effective production of ectoine for anti-age cosmetic purposes.

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SUSTAINABILITY OF THE MICROALGAE BASED WASTEWATER TREATMENT: CASE STUDY OF THREE ADRIATIC SPECIES

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Abstract
There is a wide consensus that microalgae are god candidates for more sustainable wastewater treatment, sequestering at the same time atmospheric carbon, and producing valuable biomass. However, some industrial wastewaters, such as petroleum refinery wastewater, represent a challenge due to the presence of toxic and growth inhibiting substances. Three marine microalgae species: *Pseudochloris wilhelmii, Nannochloropsis gaditana* and *Synechococcus* sp. were tested for the efficiency and economic sustainability of nitrogen removal from the oil refinery wastewater.

Keywords: Algae, Carbon, Biomass, Adriatic Sea

Introduction - There are few autotrophic organisms capable to thrive under the presence of oil derived toxic compounds. Previous studies have found the picoeukaryote algae *P. wilhelmii* and *N. gaditana* to be promising candidates due to fast growth and good tolerance for high concentrations of NH_4^+, NO_3^- and hydrocarbons [1;2]. In addition, both algae are rich in lipids with high proportion of unsaturated fatty acids, offering a wide variety of applications from biodiesel production to pharmacy and nutraceutics. Along with striving for clean energy, there is a serious need for the secure and clean fresh water resources. In order to achieve higher productivity and efficient toxicants removal, more and more interest is paid to cyanobacteria, small autotrophic prokaryotes, capable of fast growth and high nutrient uptake efficiency [3]. Cyanobacteria possess significant amounts of phycocyanin, lipids and carbohydrates, and are easily genetically manipulated and metabolically engineered [4]. Herein we compared the capacity of the *P. wilhelmii, N. gaditana* and *Synechococcus* sp. to sequester inorganic C, store it into the biomass and efficiently remove N from toxic, heavily polluted wastewater (WW).

Materials and Methods - Algae cultures were obtained from the SAG culture collection. The experiments were performed in 2.6L reactors with SCADA controlled light, temperature and air:CO_2 inflow. Cultures were grown in the oil refinery WW at 19 psu. Growth was observed as OD_{690}, whereas intracellular C, N and lipids were measured on GCMS. N and P were measured spectrophotometrically. A simple model developed by [5] was applied to enable the prediction of biomass values in continuous operation from kinetic growth parameters obtained in batch experiment.

Results - During exponential phase growth rate nitrogen and carbon incorporation were similar in all three cultures (Fig. 1a and 1b). After exhaustion of dissolved inorganic N (DIN) after day 4-5, intracellular C accumulation continued to the end of experiment. The highest N-demand, and consequently the lowest C:N ratio was observed in *Synechococcus* sp (Fig.1c) resulting in the lowest specific DIN uptake rate of 0.531 mmol/ (gday) and the lowest lipid content (Table 1). In the late exponential and stationary phase similarly high intracellular accumulation of C compared to N was observed for *P. wilhelmii* and *N. gaditana,* reaching C:N stoichiometric ratios 18-22 mol/mol.

Discussion - *N. gaditana* demonstrated highest specific growth rate, as well as the highest lipid, and overall biomass yield, along with the lowest required retention time for the removal of nitrogen. These qualities classify *N. gaditana* as the most promising analyzed species for the valuable biomass production and WW remediation. However, there is considerable concern regarding low level of toxicity reduction in the WW. On the other hand, *P. wilhelmii* demonstrated the highest efficiency in nitrogen removal and toxicity reduction. Both algae are promising candidates for carbon capture, storage and reuse technologies development, as well as for the innovative, more sustainable and cost effective WW remediation approaches in the future.
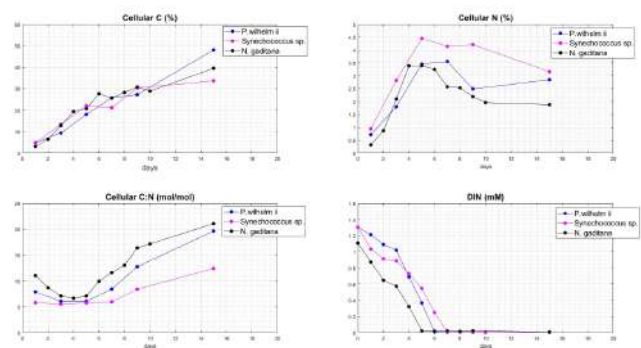

Fig. 1. N and C dynamics in *P. wilhelmii, N. gaditana* and *Synechococcus* sp. grown on oil refinery WW. The highest growth rate and lipid productivity were observed by *N. gaditana* (Table 1.). In spite of the apparently slower growth rate (0.432 g/gday), and lower final lipid content (26.30 mg/Lday) *P. wilhelmii* reached the highest volumetric productivity and the highest rate of WW toxicity removal (76.5 %).

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Tab. 1. Summary of the observed growth indices and wastewater treatment potential in exerimental cultures.

	Maximum specific growth rate g/g(day)	Maximum specific DIN uptake rate mmol/(gday)	Maximum volumetric productivity mg/(L day)	Hedraulic retension time day	Final content % d w	Lipid productivity mg/(L day)	Toxicity reduction %	WW treatment cost reduction n/(year)
P. wilhelmii	0.432	0.195	83.9	2.38	28	26.30	76.5	998.893.8
Synechococcus sp	0.336	0.531	71.0	3.52	21	14.91	12.4	802.728.14
N. gaditana	0.578	0.698	79.6	1.73	37	29.45	51.0	1.112.660.0

THE ROLE OF THE MARINE VIRAL COMMUNITY IN SHAPING BACTERIAL BIODIVERSITY PATTERNS DURING HYDROCARBON BIODEGRADATION PROCESSES

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Abstract

This paper presents, for the first time, the role of the viral community in the dynamic of bacterial communities during hydrocarbon biodegradation. In particular, we have identified two bacteriophages with specificity against a hydrocarbonoclastic bacterium, *Thalassolituus oleivorans*, in the early stage of the process. This discovery suggests that the viral lysis occurring at the early stage of the natural biodegradation processes could have a consequential transfer of carbon, nutrients, and energy throughout the entire ecosystem.

Keywords: Biotechnologies, Bacteria, Restoration, Pollution, Messina Strait

et al. : Amalfitano S.[1], Smedile F.[3], Yakimov M.M. [3]

Introduction

Obligate Marine Hydrocarbonoclastic Bacteria have been described at specific stages of the biodegradation process in the marine environment [1]. Among the factors influencing biodegradation efficiency, the impact of viruses remains poorly understood. Indeed, high densities of bacteria and phages in reactors containing seawater and hydrocarbons were observed. Moreover, the increased number of bacteriophages in Deepwater Horizon oil plume samples suggested a phage-mediated biomass turnover. Recent studies have indicated varying abundance levels, with *Alcanivorax borkumensis* predominating over *Thalassolituus oleivorans* [2]. This study aimed to ascertain whether this phenomenon could be attributed to bacteriophage-mediated regulation of *Thalassolituus oleivorans* growth.

Material and methods

Sampling was conducted within the port of Messina (38° 19' 24" N, 15° 56' 82" E), which is impacted by hydrocarbon pollution. Natural samples were utilized to establish a microcosm, consisting of 250 ml of ONR7a and 750 ml of the natural sample supplemented with 0.4% diesel as a sole carbon source. The microcosm was maintained at 20°C. Sampling occurred at several time points over a month, including the starting point (T0) and after 7, 14, and 32 days. Biomass was harvested via centrifugation, and total DNA was extracted using the MasterPure Complete DNA/RNA Kit (Epicenter), followed by PCR amplification of the 16S rRNA genes from the total DNA. Sequences were analyzed using NGS. For flow cytometry analysis, aliquots were collected, filtered at 0.1 and 0.22 µm, and fixed in glutaraldehyde. Plaque assays were conducted, with aliquots of the microcosm sample filtered through 0.1 or 0.22 µm filters. This was followed by incubation of the viral eluate with *Alcanivorax borkumensis* or *Thalassolituus oleivorans* cultures and plating on ONR7A solid medium.

Results and discussion

Molecular analyses of the microbial community revealed a distinct succession pattern in microcosm samples compared to the natural sample, indicative of substrate selectivity. Notably, alkane-degrading strains were dominant in the early sampling times, particularly *Alcanivorax* sp., comprising up to 60% of the diversity pattern. Conversely, aromatic hydrocarbon-degrading strains exhibited increased relative densities at t32d. The Oceanobacter group, inclusive of *Thalassolituus*, displayed a notable decline from t7d to t32d, with *Thalassolituus* registering low and diminishing percentages from t7d to t14d, finally becoming undetectable at t32d. Flow cytometry analysis estimated approximately 10^9 bacteria/ml and substantially lower virus-like particle abundance, indicating a potential interaction between bacterial and viral communities, with bacterial abundance declining post-day 7 while viral abundance increased post-day 14. Lysis plaques were observed exclusively in *T. oleivorans*, while *A. borkumensis* was not affected by the viral action. DNA sequencing of lysis plaque identified contigs traceable to genomes of *Thalassolituus oleivorans* MIL-1, alongside contigs attributed to three bacteriophages, including one corresponding to the *T. oleivorans* MIL-1 prophage, a second contig

identical to a phage for 85% of the genome shows 95.7% homology to the C5a phage of *Pseudoalteromonas*, and finally the last one belonging to a phage that shows no homology to known phage genomes. The observed lysis plaques in *T. oleivorans* could be attributed to one or both of the last two identified phages. In conclusion, considering the consistent presence of T. oleivorans at low levels and its susceptibility to lysis when exposed to the viral eluate, it could be assumed a regulatory role of the viral community on the regulation of relative densities of *T. oleivorans*. Further investigations are in progress to elucidate the infection dynamics of *T. oleivorans* and its impact on modulating oil biodegradation processes and to isolate and sequence the genomes of the identified phages.

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ECTOINE PRODUCTION BY *PALUDIFILUM HALOPHILUM*, A HALOPHILIC THERMOACTINOMYCETE ISOLATED FROM THE SOLAR SALTERN OF SFAX, TUNISIA

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Abstract

The aim of this study was to produce ectoine by *P. halophilum* using a low-cost mineral medium. It was found that ammonium chloride, gave the best combination with glucose to maximize the biomass yield and mycelial ectoine content. A maximum biomass concentration of 3.07 g/L with an ectoine content of 104.9 mg/gDCW was attained in shake flasks using a C/N ratio of 5, and initial glucose concentration of 10 g/L. Furtheremore, pulsed fed-batch fermentation conducted in a 7-L bioreactor gave the final cell concentration of 8.9 g/L with an ectoine content of 243 mg/g DCW.

Keywords: Bacteria, Mediterranean Sea

Introduction

Ectoine is one of the best well-known extremolytes produced by halophiles for hypersalinity resistance [1,2]. Due to its excellent moisturizing power, protective and stabilizing cell properties, ectoine is widely exploited as an ingredient in the cosmetic and pharmaceutical industries [3]. Commercially, ectoine is often produced by large-scale microbial fermentation. Recently, *Paludifilum halophilum*, a high-salt tolerant thermoactinomycete isolated from the solar saltern of Sfax (Tunisia), was reported to be a promising host for ectoine production in mineral Sea Water medium (SW), because of its being a natural ectoine producer from glucose and sodium aspartate harboring the ectABC cluster in its genome [4]. in this study, we tried to reduce cost of the medium by finding a cheaper alternative for sodium aspartate, and to improve the productivity of the process by understanding the interplay between nitrogen and carbon sources, in batch flask cultures, and in a 7-L bioreactor under two-pulsed fed-batch fermentation strategy.

Materials and methods

Standard culture conditions for ectoine production in shake flasks : A loopful of fresh mycelium of *P. halophilum* from a 7 days old colony on ISP2 agar was scraped and inoculated in 5 mL preculture broth. After 3 days of culture at 40 °C with an agitation speed of 200 rpm, the total seed culture was transferred to 250 mL non-baffled flasks containing 50 mL of the same preculture broth and incubated at 40 °C. After 26-28 h of growth, 2.5 ml of the second seed culture were transferred to 250 mL non-baffled flasks containing 50 mL of SW ectoine production broth, and samples were removed periodically to assess growth, ectoine content and residual glucose and nitrogen.

Pulse fed batch fermentation in a 7 L bioreactor : For pulse fed-batch fermentation, mycelial cells were grown in a 7-L bioreactor (Infors-HT, Bottmingen, Switzerland). A 4 L SW medium supplemented with 3.2 g/L NH_4Cl, and 10 g/L glucose was used as an initial medium for fermentation.The fermentation was allowed to proceed until the glucose concentration decreased to below 1 g/L. Then, calculated amount of fresh medium (composed of glucose, NH_4Cl and oligoelemnts) was fed into the bioreactor to increase the glucose concentration to around 10 g/L and attain a C/N of 5. Samples were taken at 24-h intervals for the determination of dry cell weight (DCW), residual glucose, residual ammonia-nitrogen ($NH4^+$-N) and ectoines contents.

Results and discussion

Effect of nitrogen sources and C/N ratio on growth and ectoine production : Three low-cost mineral nitrogen sources were compared with sodium aspartate for their effects on biomass and ectoines production. Results showed that in the presence of aspartate, the intracellular content of ectoines reaches its maximum value of 136.4 mg/g DCW, followed by urea (84.26 mg/g DCW), ammonium chloride (82.2 mg/g DCW), and finally ammonium sulfate (8.86 mg/g DCW). However, the content of extracellular ectoines was maximal on ammonium chloride and reached 0.35 mg/mL.Therefore, ammonium chloride was chosen as the nitrogen source in place of sodium aspartate and used for subsequent experiments.Growth of the bacterium at three different C/N ratios was also tested and revealed that the ectoine content of 104.9 mg/g DCW was maximal at C/N ratio 5.

Glucose-pulsed fed batch fermentation in a 7 L bioreactor : In order to scale-up the cultures to higher cell densities, a fed-batch cultivation was performed in a 7 L bioreactor with 4 L culture volume. It was found that in the first batch, the biomass concentration increase slowly reaching 5.69 g/L after 162 h of fermentation. During this period glucose concentration drops from 9.3 g/l to 0.9 g/L and N-NH3 from 0.93 g/L to 0.16 g/L. Following the first and the second glucose feeding, the dry mycelial cell weight, intracellular ectoine concentration, and extracellular ectoine accumulation were improved to 8.9 g/L, 2.1 g/L and 0.35 g/L, respectively. The ectoine content of the mycelial biomass was 243 mg/gDCW and ectoine productivity was 0.216 g/(L·j).

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SEA WATER INJECTION COUPLED WITH ELECTROKINETIC AS EFFICIENT APPROACH FOR ANOXIC MARINE SEDIMENT RECOVERY.

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Abstract

This paper presents, the cumulative effect of in situ oxygen production through seawater electrolysis and seawater injection on the bioremediation of anoxic marine sediments contaminated with organic matter. Several parameters were evaluated: i) nutrient concentration; ii) extracellular enzymatic activities (β-d-glucosidase and aminopeptidase); iii) total microbial biodiversity. These parameters were compared under different conditions, highlighting the positive effect of both electrokinetics coupled with seawater injection and seawater injection alone on the recovery of anoxic sediments.

Keywords: Anoxia, Microbiota, Organic matter, Mediterranean Sea

Oxygen availability in sediments is a critical factor in bioremediation processes, as its absence slows down biodegradation and leads to the production of toxic metabolites such as H_2S, CO_2 and CH_4, causing environmental problems on a large scale. Electrokinetic remediation and artificial oxygenation of sediments have shown promise as an in situ bioremediation approach by increasing the self-cleaning capacity of sediments through native microbial bioremediation by enhancing oxygenation of sediments [1-3]. In this study, we compared the effects of direct seawater injection (WI) into the sediment and coupled with water electrolysis (E-WI) to enhance the bioremediation process compared to untreated anoxic sediment. Natural coastal sediments (150 kg) were enriched with fish pellets (150 gr), covered with seawater and allowed to mature until anoxic conditions were reached (at ~20°C). Samples were taken (time 0) and the sediments were distributed in three glass tanks of 40 L (50 kg each). Tanks 1 (E-WI) and 2 (WI) were equipped with a 450L/h centrifugal pump and a PVC piping system mounted to obtain a water circulation of ~3L/min in the sediment (Fig. 1). In tank 1, two graphite electrodes (rode shape 30 cm x 10 mm) acting as anode (O) and a stainless steel wire mesh of 40 x 35 cm acting as cathode (H) were placed vertically in the sediment at a distance of about 30 cm and an electric current of 2A at 4V was applied continuously for 30 days.

Fig. 1. CHNS concentration, Enzymatic Activities and schematic apparatus

Both WI and E-WI proved to be valid methods to remove organic matter from the sediment, with a significant decrease in both C-H-N-S from the treated sediment (CHNS-O Elemental Analyzer-Thermo Fisher Scientific, Flash EA 1112). Interestingly, microbial-mediated extracellular enzyme activities, see [4] for methodology, showed a significant increase in both MUF-glu and Leu-MCA under seawater injection WI condition, while a marked decrease in enzyme activities was observed near the anode electrode in the E-WI. This is probably due to excessive concentrations of oxygen or the presence of chlorine-derived compound as a side reaction of seawater electrolysis. After one month of treatment, the electrokinetic process was stopped in the E-WI tank, while the water pumps were left active in both WI and E-WI for another month. At the end of the experiments, the value of both MUF-glu and Leu-MCA increase slightly also in E-WI, although never reaching the value found in the WI treatment, demonstrating a sluggish recovery of microbial activities. Total microbial biodiversity, monitored by V3-V4 hyper-variable regions of the prokaryotic SSU rRNA gene [5], showed an important effect of WI and E-WI

treatments. In the tank equipped with E-WI, in the region near the anode we did not detect 16s RNA sequences useful for analysis, whereas at the cathode, where H_2 is actively produced during electrolysis, an important component of Campylobacteria, mainly Sulfurimonas, already detected in the control anoxic sediment, found affordable conditions to thrive (Fig. 2).

Fig. 2. UNIFRAC diversity (weighed analysis) and phylum distribution among treated V1 (E-WI), V2 (WI), control sediments.

After electrical deactivation, microbial communities recovered and WI and E-WI tanks converge towards a more homogeneous microbialstructure. Overall, this study demonstrates the potential of seawater injection alone and coupled with electrokinetics for the recovery of anoxic sediments, while also emphasizing the need for further investigation and caution in large-scale applications in marine environments.

Other coators involved in this project: Gina La Spada[1], Maurizio Catalfamo[2] ,Susanna Maisano[3], Michail M Yakimov[1] 3- Institute for advanced energy technologies, National Research Council (ITAE.CNR) Italy

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COMITÉ 5

Ecosystèmes marins et ressources vivantes

Présidents : Hichem Kara et Simone Panigada

CIESM Congress Session : Ocean biogeochemistry in the coastal areas
Moderators : Nigar Alkan / Ali Alkan – Karadeniz Technical Univ., Turkey

Session's Synthesis

Coastal ocean biogeochemistry is the study of how chemical elements and compounds, particularly carbon, nitrogen, phosphorus, and oxygen, circulate in the marine environment and how these cycles are affected by biological, geological, and physical processes. Coastal areas are dynamic regions where the land, ocean, and atmosphere interact, resulting in biogeochemical hotspots due to high biological production, nutrients inputs, and human activity. Coastal biogeochemistry research is crucial for understanding the impact of climate change, pollution, and human activities on marine ecosystems, as well as sustainable resource management. Today's most pressing issues include nutrient cycling dynamics, pollution and biogeochemical response, the impact of ocean acidification, the impact of coastal development, blue carbon dynamics, monitoring and modeling, data integration and fusion, sediment-water interactions, microplastics/additives and biogeochemistry. In this session, eight presentations were made covering the interaction of rivers, coastal lagoons and the ocean, the spread of industrial discharges in the marine environment, the effects of TCE contamination in the coastal environment, the determination of domestic wastewater discharge-related loads and future scenarios, and studies aimed at understanding marine dynamics in the Mediterranean and the Black Sea. Discussions focused on the subjects and suggestions listed below after the presentations.

1) Meteorological data and physical, chemical, and biological processes are closely related, and combining their evaluation will yield more accurate findings.

2) To more clearly describe how pollutants and climate change affect marine ecosystems, long-term research is required.

3) Using CRM and interlaboratory comparisons to increase the reliability of the analytical results from the research would be crucial.

4) In order to manage coastal areas sustainably, authorized institutions should gather wastewater discharge data sensitively and create standard procedures and methods for monitoring marine ecosystems.

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INTERPLAY OF MASS DYNAMIC EXCHANGES BETWEEN RIA FORMOSA COASTAL LAGOON AND THE ATLANTIC, IN SW EUROPE

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Abstract

The aim of this study was to understand the exchanges between the productive coastal lagoon Ria Formosa (SW Europe) and the ocean. Exchanges of water, nutrients, chlorophyll-a and suspended solids between the main inlets (Faro-Olhão inlet-BFO, Armona inlet-BAR and Ancão inlet-BAN) and the adjacent ocean were estimated along complete semi-diurnal tidal cycles, under extreme tidal ranges and different seasonal and environmental / oceanographic conditions. The BFO was the most important in terms of exchange, maximised during spring tides, with the lowest exchanges during the summer campaign. The data show the strong link between physical and biogeochemical processes, with meteorological/oceanographic factors superimposed on the tidal influence. Ria Formosa fertilizes but is also fertilized by the adjacent ocean under upwelling events.

Keywords: Coastal processes, Chlorophyll-A, Lagoons, Nutrients, Gulf of Cadiz

Coastal lagoons and coastal oceans are tightly coupled ecosystems, and understanding their coupling is fundamental to understanding the feedbacks and interactions between terrestrial and marine cycles that play an important role in the fluxes of water, nutrients and organisms. Nevertheless, and despite the progress and increase in observational programmes on coastal processes, the quantification of mass fluxes through these interconnected systems, allowing an assessment of the biogeochemical processes and water exchange, remains poorly studied. In Ria Formosa lagoon, Portugal a multi-inlet system in southwestern Europe (Fig. 1), water quality and mass exchange are mainly determined by tidal interaction with the ocean and internal circulation. However, understanding and quantification of the mass balance of nutrients, chlorophyll-a and suspended solids that control biological productivity are still limited, particularly at the main sector of Ria Formosa, from where ca. 90% of the total tidal prism of the entire lagoon is exchanged (1). To fil the gap of knowledge, the main objectives of the present study are: i) to understand the role of the mass exchange of nutrients, chlorophyll-a (as a proxy for phytoplankton growth) and suspended solids through the interconnectivity of the western sector of Ria Formosa (BFO, BAR and BAN) with the adjacent ocean during the most productive seasons (Spring and Autumn) under extreme fortnightly tidal range (neap tides versus spring tides) and ii) the seasonality of these exchanges at the main inlet of this sector, during spring tides. To that _in-situ_ and remote sensing observations have been carried out, together with 16 field surveys. Ria Formosa is a shallow coastal lagoon (ca.100 km^2, 55 km long; Fig. 1) on the south coast of Portugal, with reduced freshwater contribution.

Fig. 1. Ria Formosa lagoon location

At the three inlets of the western sector six campaigns was conducted in the Autumn of 2011, three in spring tide and three in neap tide, like the other six taken in the following Spring 2012. Four additional campaigns were taken at BFO in summer and winter in spring tides and in Autumn 2012, in spring and neap tides. The discharge was calculated through the integration of the product between the velocity component normal to cross-section and the corresponding cross-sectional area. The transport of nutrients, suspended solids and Chl-a was calculated hourly over the entire tidal cycle, multiplying the discharge by the cross-sectional average concentration. Finally, the tidal prisms and the net transport of nutrients, suspended solids and Chl-a were obtained by integrating the hourly transport values in the time domain over the entire tidal cycle. Data indicate that exchanges in the Ria Formosa follow the sequence

BFO>BAR>>BAN, intensified during spring tides. The magnitude is influenced by tidal, meteorological, oceanographic and biological processes. Extreme meteorological events (rainfall, upwelling, dry summers) dominate mass exchanges at BFO over the tides. In the winter survey, following a period of rainfall, there was a net export of water and all compounds except nitrate and phosphate, which were still imported due to weak upwelling. Autumn 2012 was characterised by increased nitrate import at BFO (1.3 tonnes) due to a strong upwelling event (Fig. 2).
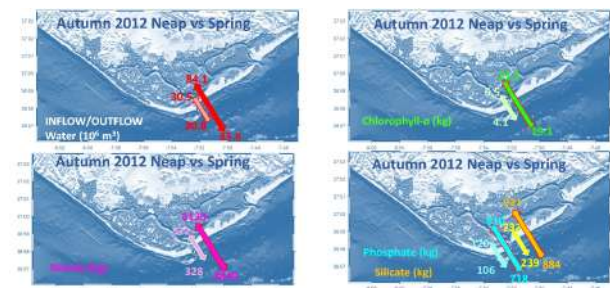

Fig. 2. Transport of water, chlorophyll-a, nitrate, phosphate and silicate (in kg) exchanged between BFO (Faro-Olhão; see Fig 1 for location) and the adjacent ocean in Autumn 2012 during ebbing and flooding phases along a complete neap (9 October; smallest arrows) and spring cycle (16 October; larger arrows).

The summer survey showed the lowest ebb and flood exchanges, but there was a global supply of compounds from Ria Formosa to the adjacent ocean, enhancing coastal productivity, especially at a time when these waters are typically oligotrophic. The Spring campaign showed increased mass exchange, capturing a phytoplankton bloom with significant chlorophyll a and nitrate import. However, there was an export of ammonium and suspended solids, with fertilisation of the adjacent ocean supporting its biological productivity, highlighting the role of Ria Formosa. Accurate estimation of mass exchange is crucial for understanding current conditions and predicting long-term trends in coastal systems such as Ria Formosa.

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SPECTROSCOPIC AND ELECTROCHEMICAL CHARACTERIZATION OF COPPER COMPLEXES WITH BATHOCUPROINE DISULPHONATE (BCS) AND HISTIDINE

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Abstract

Copper (Cu) is a micronutrient required for phytoplankton growth but may be toxic at elevated concentrations. Understanding Cu speciation and redox transformations is important for evaluating the potential effects of Cu toxicity in the aquatic environment. The spectroscopic and electrochemical analysis was conducted to study the behaviour of histidine, BCS and Cu(II)/Cu(I) in the water solution, with different times of exposure to the solar simulator. The Cu(II) reduction occurs after exposure of Cu(II)HIS2 to solar simulator light, and the reaction is of second order with respect to Cu(I)BCS2.

Keywords: Electrochemistry, Trace elements, Adriatic Sea, Chemical speciation

Copper (Cu) is an important bioessential trace element in the marine environment, acting as an essential micronutrient for phytoplankton growth. However, at high intracellular concentrations, Cu becomes toxic and affects both planktonic abundance and diversity in coastal waters. The bioavailability and toxicity of Cu in aquatic environments are governed by its speciation. It was found that Cu chemical speciation is controlled by complexation reactions with organic ligands that bind > 99% of the total dissolved Cu [2]. Toxicity can occur at free metal ion concentrations as low as 10^{-12} M, however, some organisms can counteract the negative effects of high free Cu concentrations by producing organic ligands that complex Cu and reduce the concentration of bioavailable Cu in the environment [3]. Because Cu(II) is thermodynamically favoured in oxygenated waters, Cu(I) has generally been neglected in speciation models. Yet it has been estimated that 10% of the total dissolved copper in surface waters is present as Cu(I), stabilized by chloride ions or thiol ligands [4]. The reduction of Cu(II) to Cu(I) in seawater is governed by various photochemical and thermochemical processes [5].

To study the redox transformations of Cu and investigate the role of organic ligands in Cu(II) reduction, a multi-method approach was applied, including electrochemical analysis and UV-Vis spectroscopy. Solutions containing Cu(II) and organic ligands were analysed under different conditions, e.g., different molar ratios and with/without exposure to solar simulator light. The electrochemical behaviour of histidine, BCS and Cu(II)/Cu(I) in the sodium chloride electrolyte was analysed using cathodic stripping voltammetry and hanging mercury drop electrode (HMDE). Experiments were performed using the μ-Autolab (Eco Chemie, Netherlands) controlled by NOVA 2.1 software in a three-electrode cell (VA 663 Stand; Metrohm, X) (HDME as working electrode, Pt wire as counter electrode, Ag/AgCl electrode as reference electrode). Electrolyte solutions (0.55 mol dm^{-3} NaCl) were buffered at a pH of ~8.2 by borate buffer with a final concentration of 0.01 mol dm^{-3}. The UV-Vis absorption spectra were recorded on an Analytik Jena SPECORD 200 PLUS spectrophotometer (quartz cuvettes, path length 10 cm) in the wavelength range of 350-850 nm. Measurements were performed in water solutions at pH=8.6 (±0.05). A solar simulator (Ossila) was used to evaluate the influence of UV irradiation on the formation of metal-ligand complexes.

The obtained spectra (Fig. 1) and voltammograms show that with increasing exposure time to the solar simulator light, there is a decrease in absorbance at 630 nm as well as a decrease in voltammetric peak at -0.2 V (vs Ag/AgCl) which corresponds to Cu(II)His2. At the same time, there is an increase in absorbance at 487 nm, and also an increase in voltammetric wave characteristic for Cu(I) BCS2. The results suggest that Cu(II) reduction occurs after exposure of Cu(II) HIS2 to solar light, and the reaction mechanism is ligand-to-metal charge transfer. The kinetics of the reaction is of second order with respect to Cu(I) BCS2.

These findings are important considering the recent work by Moriyasu and Moffett [6], where it has been suggested that total dissolved Cu comprises kinetically labile Cu and inert Cu pools. After exposure to solar irradiation, inert Cu becomes labile, which is probably more biologically available. Understanding the partitioning between labile and inert Cu is crucial for assessing the potential effects of Cu toxicity on marine ecosystems, and solar irradiation most certainly plays a significant role in the bioavailability of Cu. In future work, experiments will be carried out with other biologically important Cu (II) ligands, e.g. methionine, and the impact of chloride concentrations will be assessed, as it is known that chloride stabilises Cu(I) in the water solution.
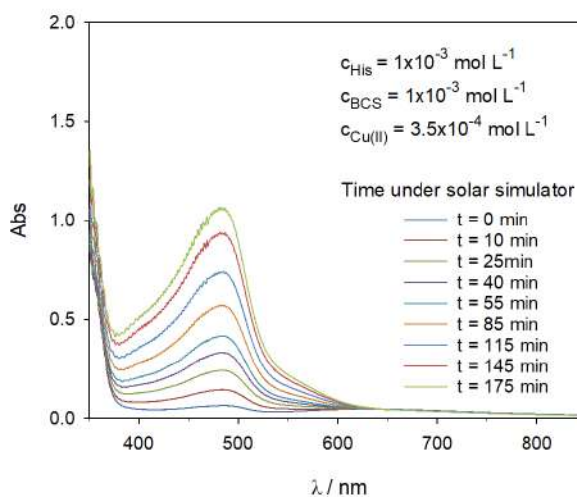

Fig. 1. The UV-Vis spectra of water solution of Cu(II), histidine and BCS exposed to solar simulator light.

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CARBONATE GEOCHEMISTRY AND FLUXES DELIVERED BY ISONZO AND TIMAVO RIVERS INTO THE NORTH-EASTERN ADRIATIC SEA

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Abstract
The Gulf of Trieste (GoT) receives alkalinity rich waters transported by rivers and submarine springs draining carbonate watersheds from the surrounding Karst. In this study, two major rivers discharging into the GoT (Isonzo and Timavo) were sampled monthly for 15 months to investigate the dynamics of the CO_2 system at the sea-river interface. The two rivers are characterised by highly different carbonate systems and Mg/Ca molar ratio, possibly due to the origin and characteristics of the two catchment basins. Both rivers resulted major contributors to the CO_2 system and to the total alkalinity discharged into the GoT.

The carbon is transferred by the rivers under inorganic and organic (dissolved and particulate) fractions, influencing the carbonate system in coastal areas. The Gulf of Trieste (GoT) in the northeast Adriatic Sea (NAd) is a semi-enclosed basin catching rivers and submarine springs which drain carbonate watersheds. This notably contributes to increase alkalinity, which reaches higher values than in the rest of the Mediterranean Sea [1]. The aim of this study is to investigate and characterise the CO_2 system of two major rivers influencing the GoT, the Isonzo (Soca) and Timavo (Reka) Rivers, which were monthly monitored at 3 sites from September 2021 to December 2022. The sampling stations were located at Pieris (ISO) for Isonzo, and at San Giovanni di Duino (TIM) and Aurisina spring (AUR) for Timavo. Several physical and chemical parameters were monitored including temperature, pH, electrical conductivity, total alkalinity (AT), Ca, Mg, Sr and δ^{13}C-DIC. The carbonate system (pCO_2, TCO_2) was calculated from AT and pH. Principal component analysis (PCA) was applied to evaluate relationships between the three sampling sites and variables (Fig. 1). Isonzo (ISO) and Timavo (TIM and AUR) were completely resolved on the model first axis. The water collected at the station ISO was characterised by the highest Mg/Ca molar ratio (0.29±0.03 for ISO; 0.17±0.04 for TIM and 0.08±0.02 for AUR), δ^{13}C-DIC (-8.6±0.8‰ for ISO and -13.2±0.4‰ and -11.5±0.8‰ respectively for AUR and TIM) and pH (7.93±0.25 ISO; 7.28±0.25 TIM; 7.05±0.14 AUR). The water samples collected at the stations TIM and AUR were instead correlated to TCO_2, pCO_2 and AT. The main differences between TIM and AUR were based on the Sr content (Sr/Ca molar ratio was highest in TIM 4.05±1.41) and on the elevated CO_2 that characterised the water of AUR. To such extent, the highest AT level was observed in AUR (4.63±0.28 mmol kg^{-1} AUR; with 3.89±0.26 and 3.06±0.32 mmol kg^{-1} detected in TIM and ISO respectively), as well as the maximum of pCO_2 (24.18±7.8x10^3 µatm vs 12.3±5.4x10^3 µatm and 2.29±1.62x10^3 µatm respectively in TIM and ISO) and TCO_2 (5.83±0.54 mmol kg^{-1} in AUR; 4.5±0.5 mmol kg^{-1} in TIM and 3.16±0.38 mmol kg^{-1} for ISO).

The Mg/Ca ratio is highly influenced by the geological composition of riverbeds and the main rock weathering processes. According to [2] a Mg/Ca ratio of 0.33 indicates the dissolution of similar amounts of dolomite and Ca carbonates, consistently with the geological composition of the Isonzo drainage basin. Timavo sites showed lower Mg/Ca ratio as the weathering of Ca carbonates prevailed in its course. The higher δ^{13}C-DIC and pH values observed at ISO could be due to the surface course of this river, which allows degassing and release of CO_2 over its course [3]. The other CO_2 system parameters, which differentiated ISO from TIM and AUR, suggest a high dissolution of carbonates from rocks that increased the CO_2 content of Timavo freshwater with subsequent lowering of pH. Interestingly, AUR, which was sampled directly at the spring, showed higher content of pCO_2, TCO_2 and AT and lower pH than TIM, which is consistent with results from other karstic rivers [3]. The Isonzo delivered, in 2022, 4.59 Gmol yr^{-1} of AT and 4.59 G mol C yr^{-1} of TCO_2,while, in the same time frame, the Timavo released 2.75 Gmol yr^{-1} of AT and 3.25 Gmol C yr^{-1} of TCO_2. If these data are compared with previous observations (2007-2010) the values are 50% less abundant, mainly due to the reduced freshwater discharge of the two rivers in 2022 compared to the previous period. The annual discharge of the two rivers accounts for ~3.6 % of the total AT released from rivers flowing into the NAd and about ~3.7 % of TCO_2 as estimated by [1]. Our results suggest that both Isonzo and Timavo make an important contribution to the CO_2 system in the GoT. Given the large differences in CO_2 content and cation composition found for the two rivers, further efforts are needed to investigate the effects of such different inputs during runoff events and their impact on the carbonate system of the GoT.

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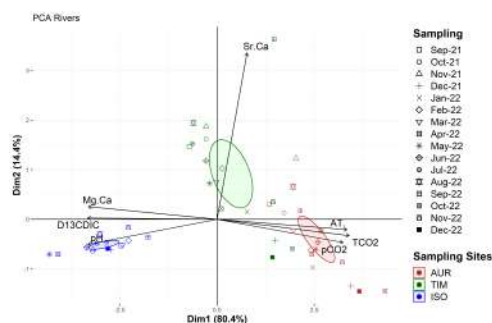
Fig. 1. Principal Component Analysis (PCA) for the three sampling sites.

BAYER EFFLUENT DISCHARGE OF THE GARDANNE ALUMINA PLANT IN THE MEDITERRANEAN SEA: MIXING WITH SEAWATER, PARTICLES FORMATION YIELD AND TRACE METALS BEHAVIOUR

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Abstract

At the end of 2015, bauxite residues discharged into the Mediterranean Sea from the Gardanne alumina plant were officially replaced by a high-pH, high-metals-content effluent, raising new concerns about its impact on the marine environment. We investigated in late 2016 the effluent dilution in seawater and the fate of particles and concretions forming at the outfall (324m depth), primarily composed of hydrotalcite. We questioned the fate of these particles regarding their non-stability and their dispersion in seawater. The issue of the potential release of metals (especially Al) contained in hydrotalcite being at the heart of many interrogations. These findings are crucial for understanding the environmental implications of industrial discharge and guiding regulatory measures to mitigate its impact.

Keywords: Metals, Mediterranean Sea, Trace elements

Aim of the work

Starting 2016, bauxite residus (wastes) from the Gardanne alumina plant discharged in the Mediterranean Sea (Marseille area; south of France) evolved into a high-pH (12.5), high-metals-content clarified Bayer effluent. Regulatory authorities expressed particular concerns about the fate of the effluent at sea, including the formation of concretions and particles when it mixes with seawater. They also emphasized the importance to monitor Al, V, and As (the elements most concentrated in the effluent) in the chemical plume created by this discharge. In the context of the monitoring of the Gadanne effluent in the marine environment we investigated in late 2016 the effluent dilution in seawater and the fate of particles forming at the outfall, primarily composed of hydrotalcite [1; 2].

Results

We estimated that the effluent contribution would be detected in the seawater up to 0.003 % for Al (dilution factor of around 3×10^4), 2.4 % for V and 10 % for As. The effluent impact on metals concentration was visible starting 200 m depth for Al, but it was essentially salient and restricted in the 10 upper meters above the outfall for Al, V, As and the other metals studied. Regarding the *in situ* formation of precipitates in the zone where the effluent mixes with seawater, we estimated their formation yield. Results indicated that on average 1L of effluent can form 2.5 g of dry particles (around 25 g wet). Al, V and As were mainly associated to the largest fraction (53% of the sample weight) of particles, corresponding to diameters between 15 and 63 µm and settling rate of around 88 m d^{-1}. It was roughly estimated that these particles would sink to bottom in around 1 day or would be dispersed within a 5 to 9 km radius on the seafloor around the outfall. Precipitation experiments revealed that Al was very rapidly (in less than 5 minutes) and totally transferred from the dissolved to particulate fraction (hydrotalcite formation) when the effluent mixes with seawater, in contrast to V which remained entirely in the dissolved fraction. Dissolution experiments also revealed that Al was one of the first element to be released in seawater. For the other elements, precipitation and dissolution rates were depending on the effluent/particles vs. seawater ratio and duration of the experiment.

Discussion

We questioned the fate of hydrotalcite particles regarding their non-stability and dispersion in seawater. The issue of the potential release of metals contained in hydrotalcite being at the heart of many interrogations, especially in the context of the effluent pH and metals concentration reductions done in 2019 by the company to comply with environmental regulations. This was achieved by installing a CO_2 treatment plant. These new conditions will stop the formation and then destabilise the concretions. The dynamics of metals in such processes remain complex.

Conclusions

While our investigations revealed that in late 2016 the effluent's contribution to seawater was mostly concentrated in the 10m above the outfall (324m depth), first results from monitoring metal concentrations in the water column surrounding the outfall revealed between 2016 and 2021 increasing Al and other metals concentrations starting 200 m depth. A very recent work has been carried out at sea in February 2024 to determine the possible origin of these increases in the water column with regard to an effluent whose concentrations have been in compliance with regulations for several years.
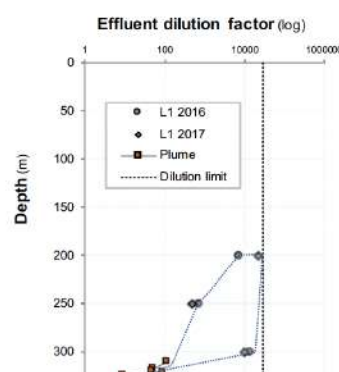

Fig. 1. Effluent dilution factor profile in the plume and water column above the outfall (station L1; 2016 and 2017 cruises) next to the dilution limit below which we can consider that it was not possible to detect the effluent contribution in the water samples.

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CONTRIBUTION TO THE ASSESSMENT OF TCE CONTAMINATION IN COASTAL ECOSYSTEMS OF THE PROVENCE-ALPES-CÔTE D'AZUR REGION

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Abstract

Technology Critical Elements (TCE) is an emerging family of contaminants. They are increasingly used in fields requiring advanced technologies. Limited data are available about their impact on marine ecosystems, particularly close to urban and industrial areas. The objective of this project is to provide an assessment of TCE contamination in coastal environments. The study was carried out on the coastline of the Provence-Alpes-Côte d'Azur (PACA, France) region. Samples were analysed using triple Quadrupole Inductively Coupled Plasma Mass Spectrometry (ICP-QQQ-MS) (CCEM, Nantes) for Rare Earth Analysis. Platinum concentrations were determined using Adsorptive cathodic Stripping Voltammetry (AdSV) (MIO, Toulon).

Keywords: Trace elements, Mediterranean Sea, Coastal waters

Technology Critical Elements (TCE) is an emerging family of contaminants including: Rare Earth Elements (REE); Platinum Group Elements (PGE); and "non-traditional" metals and metalloids. These elements have unique physico-chemical properties (ductility, conductivity, fluorescence) [1]. They are increasingly used in advanced technologies fields such as electronics, pharmaceuticals, and renewable energies. Despite their growing use, limited data exist regarding their impact on marine ecosystems, particularly in urban and industrial areas. This knowledge gap comes from the complexity of their analysis and their low concentrations in natural environments. Advances in chemical analysis enable to meet this challenge. Recent studies have shown that the biogeochemical cycles of TCEs can be disrupted by their increasing introduction into the environment [2][3]. The objective of this project is to provide an assessment of TCE contamination in coastal environments.

The study area corresponds to the coastline of the Provence-Alpes-Côte d'Azur (PACA, France) region. Results comes from an analysis of surface sediment samples collected during previous campaigns (SUCHIMED, CARTOCHIM). Given the wide variety of elements within the TCE family, this project focused on rare earths and platinum.Samples were analysed using triple Quadrupole Inductively Coupled Plasma Mass Spectrometry (ICP-QQQ-MS) (CCEM, Nantes) to obtain Rare Earth concentrations measurements. Platinum concentrations were determined using Adsorptive cathodic Stripping Voltammetry (AdSV) (MIO, Toulon).

This presentation offers an initial distribution of TCE contamination along the PACA region coastline. REE distribution has been normalised to PAAS. Profiles obtained from SUCHIMED 2021 samples shows a general convex profile with medium REE (fig.1).

This enrichment (between Nd and Ho) is due to element scavenging during exposure to sea water [4]. This phenomenon of preferential adsorptive of MREE into the crystal lattice of phosphates [4]; together with the absence of other enrichment, leads us to believe that REE measured in our sediment have a geological origin. The variations between REE profiles measured at different stations can be correlated to the nature of the origin rock. These measurements have enabled us to map coastal REE profiles along the PACA region coastline as a function of terrigenous inputs and the geological nature of the leached rock.

Platinum's results showed a sharp divergence in concentration depending on the study site. Higher concentrations are revealed in coastal areas near urban areas or rivers rich in anthropogenic inputs. We presume these increases are linked to anthropogenic activity.

This study has enabled us to make an initial assessment of TCE concentrations along the PACA region coastline. The next stage of this project will focus on measuring platinum and rare earth concentrations in samples from different compartments of the marine environment (seawater, sediment, living matter). These measurements will enable us to establish an initial distribution diagram for these elements in the coastal environment.

In parallel, we are working on new methods for normalizing REE data obtained in these different matrices. More appropriate normalization tools will enable us to study these profiles more accurately and precisely.

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Fig. 1. Rare-earth distributions (PAAS-normalized) obtained for SUCHIMED's stations.

ESTIMATION OF POLLUTANT AND NUTRIENT LOADS FROM DOMESTIC WASTEWATER DISCHARGES OF TURKISH COASTAL CITIES TO AEGEAN AND MEDITERRANEAN SEAS AND FUTURE SCENARIOS

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Abstract

The study presents an estimation of pollutant (biological oxygen demand (BOD) and suspended solids (SS)) and nutrient (nitrogen and phosphorus) loads from the domestic wastewaters discharged directly to the Aegean Sea and the Mediterranean Sea from the coastal provinces in Turkey. Current national statistical database (TUIK) including population, degree of the treatment, wastewater flowrate per capita was used for the estimation and pollutant loads per capita were assumed based on the degree of the treatment. The results showed that about 2.2 million cubic meter of municipal wastewater is discharged directly to the seas, causing annual loads of 8.5 kton BOD, 13.4 kton SS, 9.8 ktons N and 1.8 ktons P. Finally, modification of the plants to advanced levels with nutrient removal were assessed in terms of their positive effect.

Keywords: Sewage pollution, Aegean Sea, Mediterranean Sea, Nutrients, Pollution

Introduction - Approximately 21 million people live in the Aegean and Mediterranean regions of Turkey. These regions are extremely important for Türkiye not only in terms of industry and agriculture, but also due to their high tourism potential. According to 2023 data, approximately 30 million local and foreign tourists visited the Mediterranean Region, while the number of tourists visited the Aegean Region was approximately 15 million [1]. Due to both the people living in densely populated coastal provinces such as Izmir and Antalya and the high tourist population during the tourism season, large amounts of domestic wastewater are discharged into the Aegean and Mediterranean Seas, causing some pollution problems in the seas. In this study, pollutant and nutrient loads from domestic wastewater discharged directly from coastal provinces of Aegean and Mediterranean regions were estimated. Scenarios for future revision of treatment facilities and increasing treatment levels were evaluated and the possible effects of these improvements on the seas were examined.

Methodology - In the study, the current populations of the provinces and districts on the Aegean and Mediterranean coasts were taken from the TÜIK database [2]. Per capita wastewater production rates and sewage service population rates for the provinces were also obtained from TÜIK Geographic Statistics Portal and municipal wastewater statistics. Pollutant loads per capita were taken as 35, 55, 11 and 1.5 g/person/day for BOD, AKM, total nitrogen (N) and total phosphorus (P), respectively, taking into account the values given for Turkey in the Wastewater Treatment Facilities Design Guide [3]. The removal efficiencies of these parameters in treatment plants are according to the treatment levels in domestic wastewater treatment plants [4]. The treatment levels and discharge points of domestic wastewater treatment facilities in the provinces and districts on the Aegean and Mediterranean coasts were taken from the 2021 Provincial Environmental Status Reports prepared by the Provincial Environmental Directorates for these provinces and the treatment facility statistics of the relevant municipalities [5].

Results and discussion - According to population data, the population living on the Aegean and Mediterranean coasts, whose domestic wastewater is treated by classical biological treatment or by advanced treatment systems with nutrient removal and then discharged directly into the sea, is around 9.3 million, 58% of which is in the Aegean region and 42% in the Mediterranean region. The amount of domestic wastewater discharged into the seas in this way is approximately 2.2 million m³/day, 54% of which is directly discharged to the Mediterranean Sea (1.17 million m³/day) and 46% to the Aegean Sea (1 million m³/day). The amounts of pollutant and nutrient loads discharged into the seas by domestic wastewater discharge with treatment level percentages are given in Fig. 1. Fig. 1 shows that the majority of domestic wastewater discharged into the sea is treated in advanced biological treatment facilities with nutrient removal systems. The percentage of advanced treatment is lower in the Mediterranean Region. Figure 1 shows that the majority of domestic wastewater discharged into the sea is treated in advanced biological treatment facilities with nutrient removal systems. The percentage of advanced treatment is lower in the Mediterranean Region. Within the scope of the study, the scenario including the

case that all treatment facilities are modified to advanced treatment systems was also examined. In such a scenario, nitrogen and phosphorus loads are expected to decrease by 62% and 43% respectively. In this regard, it has been stated that modifying existing classical biological systems to advanced treatments will cause a significant reduction in the nutrient loads.
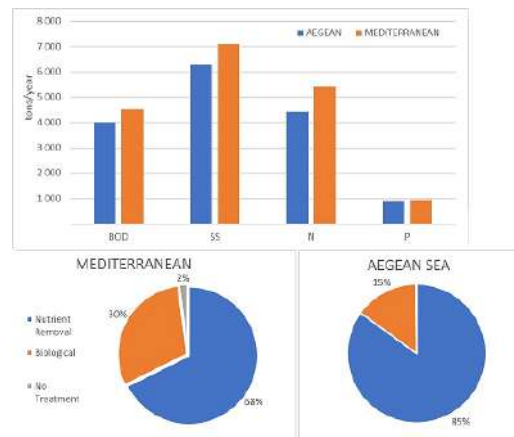

Fig. 1. Pollutant and Nutrient Loads Discharged into the Seas by Domestic Wastewater Discharge and Treatment Level Percentages

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LIFE ADVECTED IN OLIGOTROPHIC WATERS: RESULTS OF THE PIONEER CRUISE

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Abstract

This study assesses marine community production in the oligotrophic waters of the Ionian Sea, based on data collected by a BioGeoChemical-Argo (BGC-Argo) autonomous profiling float. During late autumn, nutrient-rich waters from the Sicilian coastal upwelling are carried eastward by the Atlantic-Ionian stream. Subsequently, they are directed by mesoscale eddies towards the inner regions of the Ionian Sea. Both observed data and numerical predictions indicate a significant influx of particles and chlorophyll, nurturing life in these oligotrophic environments. This study highlights the potential of BGC-Argo floats in revealing the sustainability of life in stratified oligotrophic systems, which are prevalent features across the global ocean.

Keywords: Mesoscale phenomena, Ionian Sea, Chlorophyll-A

Introduction. The Ionian Sea (IS) is classified as oligotrophic, with the Deep Chlorophyll Maximum (DCM) persisting at depth throughout the year. This system exemplifies the oligotrophic DCM type, akin to the subtropical South Pacific Ocean gyre [1]. Coastal upwelling from the Sicilian coast supported by the Atlantic-Ionian Stram (AIS) lead cold, biologically active waters to move eastward [2]. This process fosters long-distance particle transport, featuring cold, chlorophyll-rich filaments in the central IS.

Fig. 1. Horizontal (a) and vertical (b) sections of daily averaged mass concentration of chlorophyll from CMS on Nov. 27th, 2023. The dashed line indicates the transect shown in (b), black dots depict the BGC-Float trajectory, the white dot in (a) and line in (b) denote the float's position on Nov. 27th, 2023. Interpolated spatial evolution of (c) mass concentration of chlorophyll and (d) optical backscatter collected by the float from Nov. 21th to Dec. 20th, 2023. Black dots in (c) and (d) indicate the euphotic depth derived from simultaneous PAR measurements along BGC-Float profiles.

Material and methods. We analyzed data measured by an ISMAR-CNR's BGC-Argo float (WMO 2903797) deployed on the 20th of November 2023 (Fig. 1a), during the PIONEER Cruise from the CNR's R/V "Gaia Blu". Around solar noon (black dots in Fig 1a), the float autonomously measures 0-2000 m daily profiles of the following Essential Ocean, Climate and Biological Variables: temperature, salinity, pressure, oxygen, chlorophyll (Fig 1c), optical backscatter (Fig 1d), dissolved organic matter, downwelling irradiance, particle size distribution and zooplankton taxonomy. Quality controlled data have been obtained from Global Data Assembly Centre [3]. To gain a comprehensive understanding of the observed physical and biological processes, we used three-dimensional fields of temperature, salinity, velocity and mass concentration of chlorophyll from Mediterranean Copernicus Marine Service (CMS) [4,5].

Results. Merging observed and numerical data, we found that the dynamics of a chlorophyll filament (Fig. 1b) transported by the AIS is strongly influenced by the presence of mesoscale eddies. Before the filament reaches the float, numerical predictions clearly show that the Atlantic-Ionian Stream is forced to meander northward, propagating between two mesoscale eddies with opposite vorticity. This causes surface convergence and in turns, an intensification of the cold filament [6]. The consequent increase in downward vertical fluxes leads nutrients to move partially away from the biologically active euphotic zone. When the float encounters the filament, along the water column abrupt changes in the bio-geochemical features occur, as confirmed by the significant increase in chlorophyll and backscattering observed for about 150 m along the water column (Figs. 1 c, d from x=50 km) . The interplay between the filament and the mesoscale dynamics facilitates the influx of particle-rich waters into the oligotrophic environment. However, the intensification of the filament leads to an escalation in downwelling, promoting nutrient dispersion.

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BLACK SEA BASIN-WIDE EXPEDITIONS WITH R/V BILIM-2 IN 2022 AND 2023: FIRST RESULTS OF A NOVEL, INTEGRATED SMART MONITORING APPROACH

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Abstract
We present the most recent findings on the Black Sea's biogeochemical structure, which were revealed as part of regular basin-wide research expeditions by R/V Bilim-2 in 2022 and 2023, conducted within the framework of Turkish national programs and supported by the European Horizon 2020-funded ARSINOE and BRIDGE-BS multi-national projects. We used CTD hydrocasts and bottle samplings to measure dissolved oxygen, nutrients, alkalinity, pCO2 and pH, dissolved manganese, and hydrogen sulfide; among many other physical, biogeochemical and biological oceanographic parameters. Results are currently being fed to 3D models for ecosystem state prediction and also shared with a diverse set of stakeholders to better tackle Black Sea challenges in the frame of climate warming and anthropogenic multiple stressors.

Keywords: Anoxic basin, Black Sea, Redox, Management, Nutrients

The Strategic Research and Innovation (SRIA) of the Black Sea, launched in 2019 as a result of the common effort of Black Sea countries and the European Commission, set out a vision for a healthy, resilient and productive Black Sea by 2030 [1]. Projects are now actively implementing the SRIA, and among these the Horizon 2020-funded ARSINOE and BRIDGE-BS projects develop a pioneering case-study based approach in the Black Sea. Both projects aim to develop in a complementary manner the predictive tools and capabilities necessary to understand and predict the impacts of climate-driven and anthropogenic multi-stressors on the services stemming from Black Sea ecosystems. The key component of this approach is the program including basin-wide research cruises and samplings on the pre-identified case study or pilot sites in the Black Sea.

Basin wide stations network grids were chosen to represent basic dynamics, like coastal offshore exchange and understand climate change related alterations (Fig.1). Besides physical-chemical parameters, temperature, salinity, depth, relative fluorescence of chlorophyll-a, turbidity, oxygen concentration, and photosynthetically active radiation were measured in situ. Discrete water samples were collected from key vertical density layers. In selected case study sites using smart sampling techniques were deployed in addition to water column measurements. A towed instrument (ScanFish) was used and the surface sampling was done every 30 minutes (~3.5 nautical miles resolution) as the Scanfish was underway. Other ship-mounted underway systems included an ADCP, thermo-salinograph, fluorimeter. In addition, pH and pCO2 sensors fed by continuous seawater pumping were used for in-situ physical and chemical measurements while the ship was transiting between stations.

The results of our basin-wide expeditions in the Black Sea revealed that, in particular, the oxygen and sulfide gradients exhibit a considerable degree of resilience in comparison to the early 2000s [2]. Despite the fact that the average sigma-thetas at the lower end of the oxycline varied from 16.0 to 16.2, which was lower than the lowest end of historical datasets spanning decades, we found evidence of winter mixing and oxygen injection across density layers as a result of our investigation. In a similar vein, the onset density of hydrogen sulfide was discovered to be between 16.2 and 16.4, which agrees with historical distributions [3]. On the other hand, we demonstrate that the reported long-term rise in the oxycline [4] appears to have stabilized over the course of the past 20 years, and there is no indication of an upward increase in the density layer of sulfide onset. This is despite the fact that warming in the surface and deeper layers is still occurring. On the basis of this, it appears that redox processes exert a major control on oxygen dynamics, rather than warming, and are principally driven by the biogeochemical dynamics of iron and manganese. In order to study these redox reactions in detail, in-situ voltammetry was also performed during hydrocasts with a newly developed miniaturized autonomous underwater electrochemical analyzer.

Additional continuing work on three-dimensional coupled physical-biogeochemical modeling and resilience assessments will further support the historical interpretation of the ecosystem state assessment reported here and inform better marine ecosystem management strategies in the Black Sea region.

Fig. 1. Red lines indicate the tracks occupied by R/V Bilim-2 Station grid used in the expedition. Black dots represent the sampling points planned by all partners in the BRIDGE-BS project.

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Session's Synthesis

The moderator, F. Fiorentino, introduced the session "Insight on Biodiversity I" by recalling some aspects he considered relevant in the light of his experience as fisheries ecologist. Since the current human capacity to exploit natural resources and transform natural environments, which has never been achieved in the history of the planet (the Antropocene era), he highlighted the need to: i) study the spatial pattern of biodiversity in terms of α, β and γ diversity; (ii) characterise this spatial pattern in relation to the main ecosystem services provided (regulating, provisioning, cultural and supporting services); (iii) investigate the connectivity pattern between different biodiversity patches; (iv) monitor the impact of the use of biodiversity in terms of taxonomic, functional and structural responses to human pressures under climate change; v) improve the integration of empirical approaches and modelling to better understand biodiversity dynamics under climatic and anthropogenic drivers and to inform sustainable management of marine ecosystems; vi) adopt a spatial-based management approach to optimise the allocation of ecosystem services provided by biodiversity and to ensure its sustainable use and conservation. Eight presentations were made. Five contributions dealt with benthic biodiversity (N. de la Ballina, A. Delliou Valentini, S. Diez Gonzales, M. Muscat and B. Ozturk), highlighting the importance of knowledge of its spatial pattern as a prerequisite for effective conservation. Three presentations dealt with planktonic biodiversity (I. Alvarez Ellacuria, C. Bordehore and M. Mucko), providing further evidence of the key role of environmental parameters, such as depth and sea water temperature and salinity, on the qualitative and quantitative composition of planktonic communities. Due to time constraints, questions and comments were postponed to the poster session scheduled for the following day.

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TRACKING PELAGIC DIVERSITY ALONG TIME

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Abstract

The inherent dynamism of the pelagic habitat makes it challenging to study changes in the ecosystem over time. Most fish species coincide in the water column during their early planktonic stages. We used this early stages to explore the diversity of the pelagic habitat along time and also performed Generalized Additive Models (GAMs) to analyse the non linear influence of the environment on the calculated diversity. Results highlighted two main components of the environment impacting pelagic diversity: depth (static component) and salinity (dynamic component). Bioregions were defined using the environmental indicators. The composition of the associated larval fish communities was significantly different among bioregions. The identified components can be used as indicators of pelagic diversity in the area for further monitoring purposes.

Keywords: Fishes, Larvae, Pelagic, Biodiversity, North-Western Medite

Introduction - Studying diversity of early life stages is a potential tool to assess the status of pelagic habitats since almost all marine organisms form part of the plankton at some point in their life (i.e. egg and/or larva), regardless of their adult habitat, being highly dependent on environmental conditions for survival. The waters surrounding the Balearic Islands (NW Mediterranean) is a major summer spawning area for a wide variety of species inhabiting coastal, pelagic, and benthic habitats as adults. The species coexistence is enhanced by the very particular mesoscale hydrodynamic features characterizing the area.

Materials and methods - We identified a total of 135 species and analysed the relative composition of fish larvae communities inhabiting the area across a 5-year series (2012-2016). The Shannon diversity index was selected as the most suitable for characterizing diversity in an area where very few species (8) account for 95% of larval abundance. Spatially, diversity was higher near the coast but also exhibited high peaks in open waters during summer every year. The functional response of biodiversity indices to the environment was analysed through Generalized Additive Models (GAMs) [1]. Depth, location, temperature and salinity in the mixed layer depth were considered. Bioregions for each significant variable were then defined as regions with similar spatial and temporal functional response. Subsequently, SIMPER analyses (percentage of Similarity, [2]) were performed to detect if larval fish communities associated to each of the bioregions were significantly different among them.

Results - Our results show biodiversity changes with depth and salinity (used as a proxy for water masses in the area). Communities at stations with depths greater than 650 m were different from those at shallower depths by a 73% (Simper results >70% consider differences among communities are significant) (Fig. 1).

Fig. 1. Left: Bioregions according to depth. Isoline at 650 meters that separates the bioregions identified after analyzing the partial effect of depth on the Shannon diversity index.; Right: Shannon diversity index. Isoline at a value of 1.5 to emphasize the relationship with depth characterizing the identified bioregions.

In the shallow bioregion, the species that contribute the most to the characterization and differentiation of the bioregions are coastal species such as anchovy (*Engraulis encrasisolus*), damselfish (*Chromis chromis*), and the Mediterranean rainbow wrasse (*Coris julis*), among others. The species characterizing the deep bioregion are those of mesopelagic adults including species such as lanternfish (Cera*toscopelus maderensis, Hygophum spp.,*

Lampanyctus spp., etc.) and bristlemouths (*Cyclothone pygmaea* and *Cyclothone braueri*). Salinity is a dynamic variable and each sampling station may present different salinity values compared to previous or subsequent years (Fig.2). Along the salinity front, associated with the dynamics of water masses in the area, specifically at the value of 37.7, diversity varied. Two bioregions based on the salinity of the mixing layer, showed differences between groups (SIMPER analysis 72.5%).
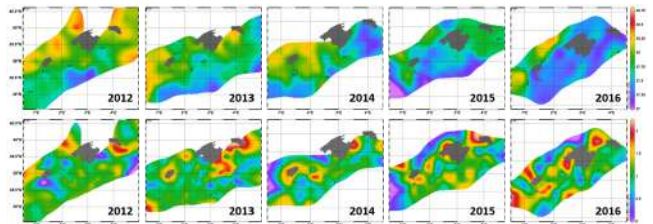

Fig. 2. Up: Bioregions according to salinity in the mixed layer. Isoline at 37.7 that separates the bioregions identified after analyzing the partial effect of salinity in the mixed layer on the Shannon diversity index.; Down: observed yearly Shannon index. Isoline at a value of 1 to emphasize the relationship with salinity in the mixed layer characterizing the identified bioregions.

In this case, species of large pelagics and mesopelagics characterize the community of the bioregion with the low salinity characteristic of the new Atlantic water, from more open sea. Coastal species and those of small resident pelagics were characteristic of the resident Atlantic waters (*Sardinella aurita* and *Trachurus trachurus*) and characterize the community of saline waters. The bathymetric gradient is a static feature defining oceanic habitats [3], therefore consistently shapes diversity (e.g. similar effect of depth in biodiversity along years) with higher diversity in coastal areas. In contrast, frontal areas are dynamic features associated to different patterns of biodiversity. Future observations of different values of both depth and salinity indicators may be related to differences in the environmental state of the pelagic habitat. *Tunibal survey has been co-funded by the European Union through the European Maritime Fisheries and Aquaculture Fund (EMFAF) within the National Program of collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.*

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INSIGHTS INTO JELLYFISH ABUNDANCE FROM FISHERIES SURVEY DATA (MEDITS)

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Abstract

The MEDITS_ES_2023 survey's inclusion of jellyfish captures crucial data on their distribution and abundance, with jellyfish found in nearly 70% of trawls. Analyzing trawls from the Spanish Mediterranean, this study quantifies jellyfish contributions to total biomass of trawls and assesses their potential ecological significance in the benthos, supporting their systematic monitoring in marine surveys.

Keywords: Western Mediterranea, Fisheries, Trawl surveys, Zooplankton

The necessity of integrating jellyfish data into marine surveys has become increasingly apparent, as blooms have been reported to grow in size, frequency, duration, and geographic extent, impacting human activities and marine ecosystems worldwide [1,2]. The impacts of jellyfish encompass several sectors, including tourism, fisheries, aquaculture, energy production, and ecosystem food webs. Incorporating jellyfish within the systematic marine surveys of the Mediterranean International Trawl Survey (MEDITS) program addresses a significant gap in our understanding of marine ecosystems and the role jellyfish play. Jellyfish, often viewed merely as a nuisance due to their stinging capabilities and potential to clog fishing nets, play an essential role in marine environments. They serve as indicators of ecological shifts, contribute to oceanic structure, and function, and influence trophic dynamics [3,4]. This study aims to leverage the comprehensive data collected during the MEDITS campaign to analyze jellyfish abundance and distribution patterns, highlighting their ecological significance and the implications for marine conservation and management.

The MEDITS_ES_2023 campaign, conducted aboard the research vessel B/O Miguel Oliver, covered the Geographical Sub-Area 6 (GSA-6) along the northern Spanish coast. Employing a stratified random sampling design, the survey targeted trawlable grounds from the continental shelf to the upper slope (30-800 meters depth). Trawling was conducted using the GOC-73 nets. Data on environmental parameters, including temperature, salinity, and depth, were collected using a CTD SBE-37. The biological sampling focused on a comprehensive suite of species, now expanded to include jellyfish, aligning with MEDITS and PNDB protocols.

Data from 120 trawls were analyzed, where a total of 347 species were recorded, and for the first time jellyfish. The two jellyfish species that appeared were *Pelagia noctiluca* and *Chrysaora hysoscella*. The trawls, conducted across various depths with an average of 188 meters (ranging from 35 to 730 meters), covered an average distance of 4,282 meters and filtered approximately 208,420.54 cubic meters of seawater. These efforts resulted in an average density of 100,837.55 individuals per km^2 and a biomass of 974.38 kg/km^2. As for the jellyfish in the trawls, an average biomass of 0.46 kg per trawl, with observed values ranging from 0 to a maximum of 23.58 kg. The abundance of jellyfish averaged 56 individuals per trawl, with a variation from 0 up to 5,447 individuals. The contribution of jellyfish biomass to the whole trawl had an average of 1.2%, with a minimum and maximum of 0 to 55.3%, respectively. With only 37 trawls coming out with no jellyfish. While jellyfish accounted for an average of 1.2% of the total biomass in trawls, their incidence in 83 out of 120 hauls—nearly 70%—highlights their pervasive distribution and potentia influence on marine ecosystems. The study also underlines the importance of random sampling and not just targeted sampling. Although these jellyfish are pelagic, a great number were caught with a demersawl trawl, hinting towards the fact that they may have an ecological significance in prey finding in the benthos, or they are part of 'JellyFalls'.

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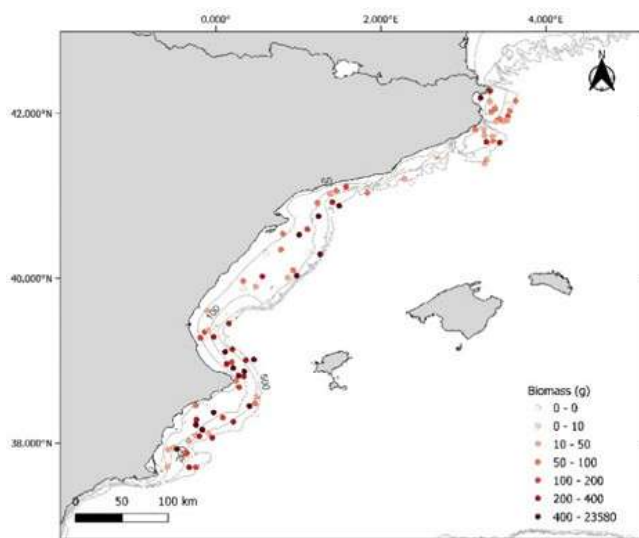
Fig. 1. A map with the 120 trawls performed from the 2023 MEDITS campaign. Data show is biomass in grams per trawl.

LARGE SCALE CHARACTERIZATION OF INFRALITTORAL MEGA-INVERTEBRATE ASSEMBLAGES OF SPANISH WESTERN MEDITERRANEAN SEA THROUGH UNDERWATER VISUAL CENSUS

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Abstract

The characterization of benthic communities is useful to evaluate the state of marine environmental health to aid marine management measures. Despite the multitude of studies regarding this subject they are fragmented and not standardized, whereas policy markers need large scale and coherent information of marine communities. Here we present a characterization of mega-invertebrates of the infralittoral rocky bottoms along Spanish Western Mediterranean Coast. To conduct this type of survey over such a large area, underwater visual census was conducted in 113 stations between depths of 5-18 meters. In total 262 species were found from nine different phyla. The most common species were *Crambe crambe* and *Myriapora truncata*. Moreover, it is worthed to note that the endemic *Cladocora caespitosa* was most frequently found in marine reserves.

Keywords: Western Mediterranea, Biodiversity, Zoobenthos, Rocky shores, Marine reserves

Introduction

The Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC 2008) aims to achieve Good Environmental Status (GES) of the European Union's marine waters, defining a basis upon which each EU Member state is required to develop an evaluation and management plan to improve the marine environmental status. Monitoring Programs of the infralittoral rocky domain were implemented by the Spanish government on the period 2020-2023, with the aim to characterize benthic assemblages along the Levantine-Balearic Marine subdivision (LEBA) in the Western Mediterranean.Results of the characterization of the infralittoral mega-invertebrate communities are presented.

Methods

The study was conducted in the Spanish Western Mediterranean Coast, including the Balearic Islands, along which a total of 113 survey stations were censed. The survey was restricted to infralittoral rocky bottoms between 5 and 18 m depth, where underwater visual censuses were conducted by scuba divers. At each station, mega-invertebrate species (>1 cm) were censed along four transect, by placing 25 quadrats (50 cm × 50 cm) 2 m apart from each other at every transect. For every quadrat, the species of mega-invertebrates were identified and their abundance was noted. In the case of the sessile organisms, the percentage of cover for each species was also recorded.

Results and Discussion

A total of 262 invertebrate taxa belonging to nine phyla were identified. The relative abundances of the 262 megabenthic species identified show that the most abundant are sponges (34.88%), bryozoans (23.46%), annelids (12.73%), echinoderms (10.17%), cnidarians (8.49%), ascidians (5.95%), molluscs (3.25%), crustaceans (0.96%) and platyhelminthes (0.11%) (Figure 1). *Crambe crambe*, *Myriapora truncata*, *Chondrosia reniformis* and *Paracentrotus lividus*, identified as the most frequent infralittoral species in the Western Mediterranean, were found in more than 30% of the locations.

Fig. 1. Relative proportions of mega-invertebrate phyla identified along Spanish Western Mediterranean Coast (LEBA subdivision).

It should be noted that among these frequent species there is also *Cladocora caespitosa*, the only endemic zooxanthellate coral with reef-building capacity in the Mediterranean Sea (Kersting & Linares 2012). This species is included in the IUCN Red List, due to population decline and vulnerability (Kersting et al., 2022). Results show that *C. caespitosa* was most abundant in the Special Area of Conservation Cap Martinet, Columbretes Islands Marine Reserve and North-east Coast of Ibiza-Tagomago Marine Reserve (Figure 2), highlighting the important function of the marine protection to achieve or maintain a GES.

Fig. 2. Distribution of *Cladocora caespitosa* recorded along Levantine-Balearic Marine subdivision (LEBA).

Infralittoral rocky reefs are among the most productive and diverse coastal environments (Bevilacqua et al., 2021). Their complexity and associated species contribute to the functioning of marine ecosystems and are, therefore, crucial for the provision of marine goods and services (Boero et al., 2019). Altogether, the present study could contribute to better understanding main infralittoral megabenthic invertebrate assemblages and the distribution of endangered species which could be key to develop suitable conservation and management actions.

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DIVERSITY OF BENTHIC FORAMINIFERA FROM SUBLITTORAL SEDIMENTS IN THERMAIKOS GULF (NORTH AEGEAN SEA) WITH NEW MEDITERRANEAN RECORDS

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Abstract

A benthic foraminifera survey from soft-substrata assemblages in Thermaikos Gulf revealed the presence of 169 species classified to 81 genera, 55 families and 9 orders. *Virgulinella fragilis*, *Bulimina biserialis*, *Patellina elaborata*, *Ptychomiliola costifera*, *Quinqueloculina latidentella* and *Siphonaperta arenata* constitutes first Mediterranean records, while another nine species are new records for the Hellenic Seas. Two NIS species, *Mimosina affinis* and *Pyrgo denticulata,* were detected. These results highlight the increased diversity of foraminifera in Thermaikos Gulf.

Introduction

Benthic foraminifera are among the most prominent meiofaunal taxa in marine ecosystems. The scientific interest on their diversity and distribution is increasing, with many studies reporting their applicability as environmental and climate change indicators. Although, foraminifera have been studied in the Mediterranean relevant data are limited for the Aegean [1]. The Aegean constitute a hot-spot area of climate change as seawater is warming in higher rate, which, in combination with the opening of Suez Canal, facilitates the intrusion and settlement of non-indigenous species (NIS) of tropical affinity. The present study aims to assess the diversity of living foraminifera in the poorly known area of Thermaikos Gulf (north Aegean).

Material and methods

Thermaikos Gulf (TG) is a semi-enclosed embayment of the NW basin of the Aegean with shallow bathymetry (<40m depth), sustaining urban coastal regions and preserved natural areas. Samplings were carried out at three sites: S1, central TG ($40^0$33'7,20"N 22°51'14,40"E, 25m), S2 inner TG ($40^0$37'4,80"N 22°56'31,20"E, 13m) and S3, fringe zone of central to outer TG ($40^0$27'43,20"N 22°49'15,60"E, 30m). Thirty meiofaunal samples were seasonally collected from 2018 to 2020 with a VanVeen grab; surficial material (top 1cm) was taken from the grab with a Bowser corer and preserved in 70% ethanol solution containing 2gr/l rose Bengal under the standardized FOBIMO protocol [2]. Muddy substrates prevailed in S1 & S3, which are influenced by waste disposal pipes; at S2 the sea bottom is covered by sandy muds.

Results- Discussion

Overall, 10,523 individuals were collected identified to 169 species classified to 81 genera, 55 families and 9 orders. In total, 1,540 specimens were alive (14.6%) identified to 116 species. Hyaline taxa prevailed in alive foraminiferal assemblages (S1:64.92%, S2:44.98%, S3:50.70%) represented by *Bulimina*, *Ammonia*, *Nonionoides*, *Nonionella*, *Bolivina* and *Hopkinsina*. The contribution of agglutinated forms was also significant (S1: 24.76%, S2: 44.95%, S3: 30.04%) with the prevalence of *Eggereloides*, *Textularia* and *Reophax*. Porcelaneous foraminifera were rare, represented mainly by *Quinqueloculina*, *Adelosina* and *Miliolinella*. Six species constitute first records for the Mediterranean Sea, whereas another nine are first records for the Hellenic Seas (Table 1, Figure 1).The NIS *Mimosina affinis* of Indo-Pacific origin is reported for the first time from the eastern Mediterranean, whereas the NIS *Pyrgo denticulata* for the Greek Aegean Sea. The presence of alive specimens of *Adelosina carinata-striata* document its occurrence in the regional biota [3]. The reported *Cymbaloporetta* sp.1 is considered as cryptogenic [3]; genetic analysis will clarify its origin.The presented results highlight the increased diversity of foraminifera in TG, which seems to be higher than previous studies from the same geographic sector [6,10], reveal new Mediterranean records, and underly the need of systematic research on benthic foraminifera applying standardized methods.

Fig. 1. SEM images 1. *Textularia earlandi* 100μm; 2. *Patellina elaborata* 100μm; 3-4. *Cornuspirella diffusa* 100μm & 200μm; 5. *Adelosina carinata-striata* 100μm; 6. *Ptychomiliola costifera* 200μm; 7. *Pyrgo denticulata* 100μm; 8. *Quinqueloculina latidentella* 50μm; 9. *Spiroloculina terquemiana* 100μm; 10. *Siphonaperta arenata* 50μm; 11. *Bulimina biserialis* 100μm; 12. *Mimosina affinis* 50μm; 13. *Glabratella hexacamerata* 50μm; 14. Cymbaloporetta sp.1 200μm; 15. Hopkinsina pacifica 50μm; 16. Virgulinella fragilis 100μm; 17. Robertinoides pumilum 50μm.

Tab. 1. New foraminifera records from the Aegean Sea. Station, Number of specimens per station (N), Origin and geographical Distribution: Pacific Ocean (PAC), Atlantic Ocean (ATL), West Mediterranean (WM), Adriatic Sea (ADR), Sea of Marmara (MAR), Indo-Pacific (IP), Aegean Sea Turkish coast TUR-AEG

Species	Station	N	Origin	Distribution
Textularia earlandi Parker, 1952*	S1/S2/S3	13/6/11	ATL	ATL, PAC, ADR, WM, MAR
Patellina elaborata Mc Culloch, 1977**	S2	1	IP	PAC
Cornuspirella diffusa (Heron- Allen & Earland, 1913) *	S1/S3	29/6	IP	INDO-PAC, ATL, MED
Adelosina carinata-striata (Wiesner, 1912) *	S3	11	M	ADR
Ptychomiliola costifera (Cushman, 1917) **	S3	1	IP	IP, ATL
Pyrgo denticulata (Brady, 1884) *	S1/S2/S3	1/3/2	IP	IP, ATL,TUR-AEG
Quinqueloculina latidentella Loeblich & Tappan 1994**	S1/S2/S3	3/1/2	IP	IP, ATL
Spiroloculina terquemiana Fornasini, 1900*	S1/S3	4/7	M	ADR
Siphonaperta arenata (Said, 1949) **	S1	1	IP	IP, ATL
Bulimina biserialis Millett, 1900**	S1/S2/S3	6/3/1	IP	PAC
Mimosina affinis (Millett, 1900) *	S3	2	IP	PAC, ADR,
Glabratella hexacamerata Seiglie & Bermudez, 1965*	S3	3	IP	PAC, ATL, WM, ADR
Hopkinsina pacifica Cushman, 1933*	S1/S2	42/38	PAC	ATL, IP, TUR-AEG
Virgulinella fragilis Grindell & Collen, 1976**	S1/S2/S3	9/8/2	IP	IP
Robertinoides pumilum Hoglund, 1947*	S1	1	ATL	ATL, WM

** first Mediterranean records, *first records from the Greek Aegean Sea.

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CHARACTERIZATION OF INFRALITTORAL ROCKY HABITATS PRESENT IN THE WESTERN MEDITERRANEAN SEA LEVANTINO-BALEAR MARINE REPORTING UNIT.

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Abstract

Conservation of marine habitats is key to sustain the ecosystem services and ecosystem resilience. Because of this, the EU Habitats Directive targets key habitats and species to protect. In this context, under the category of Reefs (Habitat 1170) are included a plethora of different habitats. In this study the characterization of the habitats in the infralittoral rocky bottoms of the Spanish western Mediterranean coast was carried out through underwater visual census and multivariate clustering analysis. Results indicate the presence of 18 habitats: 11 characterized by photophilic algae and 7 darker habitats characterized by invertebrates. Furthermore, a series of key rarer habitats were found.

Keywords: Bio-indicators, Habitat, Marine reserves, Infralittoral, Mediterranean Sea

Introduction. As part of the Marine Strategy Framework Directive (MSFD) (2008/56/EC), each European Union member state is required to evaluate and to develop a management plan to improve their marine environmental status. Reef habitats (1170) are protected under the EU Directive on the conservation of Habitats, Flora and Fauna (92/43/EEC; Community 2010). Under the definition of "1170 Reefs", a whole set of complex and diverse hard-bottom habitats are included, these can be either biogenic concretions or geogenic origin. The Characterization of the habitats, benthic community and how they change along their domain is useful to define their ecological status and how they are affected by human activities . For this purpose, Spanish government implemented MSFD Monitoring Programs of the infralittoral rocky domain by means of underwater visual census. From 2020 to 2023, sampling stations were evaluated along the entire MSFD western Mediterranean, the Levantino-Balear (LEBA) Marine Reporting Units (MRU). Results of the characterization of the infralittoral rocky habitats of the demarcation Levantino-Balear are presented.

Methods. The study was conducted in the Spanish Western Mediterranean Coast, including the Balearic Islands, along which a total of 113 survey stations were censed. The survey was restricted to infralittoral rocky bottoms between 5 and 18 m depth, where underwater visual censuses (UVC) were conducted by scuba divers. At each location 4 x 50 m transects were performed. Macroalgal assemblages were characterized by the contact-point methodology, while mega-invertebrate species (>1 cm) were censed by means of quadrat sampling, using a frame of 50 cm x 50 cm, placed 2 m apart from each other at every transect. The characterization of macroalgae and megabenthic invertebrate assemblages was used to identify infralittoral rocky habitats through multivariate clustering analyses (SIMPROF and SIMPER) using the software PRIMERv6. The SIMPROF was used to identify the existence of groups among the stations, while the SIMPER routine, using the SIMPROF factor was used to identify the species that were contributing up to the 90% of the similarity within each SIMPROF group.

Results and Discussion. Eighteen different habitats were identified. The eleven photophilic infralittoral rocky habitats identified were mainly defined by macroalgae, while seven sciaphilic or semi-sciaphilic habitats were mainly defined by megabenthic invertebrates, and the majority of them were located in enclaves such as vertical and overhanging bedrocks or crevices. The distribution of the different habitats indicates that the most represented algal communities of the photophilic rock infralittoral correspond to habitats without Fucoids species with a high presence of species of the order Dyctiotales, located in 41% of the sampled stations, followed by the habitat without Fucoids species with algae of the family Corallinaceae (29%). In the third place, being present in 16% of the sampled stations, were Fucoids habitats, corresponding to *Cystoseira* spp. (sensu lato) and *Sargassum* spp. as community-structuring genera. The aforementioned Fucoids habitats are considered of great interest due to their high ecological value and environmental sensitivity (Sales, 2009). In this context, there are other habitats of high ecological value but with a lower percentage of representation in the study area, such as the habitats without Fucoids and with *Halopteris* spp. (*H. scoparia* and *H. filicina*) or the habitat of *Dictyopteris polipodioides*, identified in a smaller proportion, 5% and 7% of the stations sampled respectively. There are other habitats that do not exceed 9% of the sampled stations, being considered habitats of minority representation in the MRU.

As for the darker areas of the photophilic community, the most represented habitat corresponds to the invertebrates dominated habitat with *Myriapora truncata* identified in 54% of the stations, most of them located in the central to southern part of the MRU, both on the peninsular and insular coast (including some stations in Columbretes Islands, Mallorca and Ibiza). This was followed by the habitat dominated by massive sponges, which represents 24% of the sampled stations occupying a wider geographical range, distributed throughout the entire demarcation. The remaining 22% of the sampled stations is made up of 5 habitats, 4 of which are dominated by Anthozoans, which are worth to note, despite their scarce frequency, because of their high ecological importance. For example, the habitat defined by *Cladocora caespitosa*, the only endemic zooxanthellate coral in the Mediterranean with reef-forming capacity in existence (Morri et al. 1994), was recorded in Ibiza and Mallorca (present in 4% of stations); and the one defined by *Caryophyllia inornata* and *Balanophyllia europaea* (also with 4% frequency) recorded in Mallorca, the Columbretes Islands and Alicante. In addition, the barren habitat was found in sheltered shallow rock dominated by *Oculina patagonica* (3% frequency), was located at two stations in Almería. O.patagonica presents characteristics of opportunistic species, as it colonises both natural and artificial habitats along the southeastern coast of the Iberian Peninsula (Serrano et al., 2013) and shows invasive behaviour, as it prevents the establishment of local communities by rapidly colonising rocky substrates(Serrano et al., 2012; 2013). In addition, the increase in temperature favours the spread of this species, so it is considered of interest to monitor the evolution of its geographical distribution in relation to the influence of climate change. Finally, the habitat dominated by *Parazoanthus axinellae* (2% of frequency) was recorded at two stations in Alicante.

Altogether, the present study could contribute to a better understanding of the main infralittoral photophilic algae and megabenthic invertebrate assemblages and the distribution of sensitive habitats that could be key to develop suitable conservation and management actions.

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PLANKTON COMMUNITY COMPOSITION IN SOUTH ADRIATIC SEA DURING SUMMER STRATIFICATION PERIOD

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Abstract

A two-week survey during the summer stratification period was conducted at one station in Lastovo Island Archipelago, South Adriatic Sea. A detailed insight into the plankton community composition in deep chlorophyll maximum and surface layer was elucidated with eDNA metabarcoding of both 16S rRNA and 18S rRNA genes covering bacterioplankton and eukaryotes. Contribution of dominant plankton taxa in size-fractions and depth layers is discussed.

Keywords: Plankton, Stratification, Metagenomics, South Adriatic Sea

Introduction

Oligotrophic South Adriatic Sea is characterized by low overall nutrient concentrations with especial phosphorus limitations, low primary production, and intense summer stratification. These conditions contribute to dominance of mixotrophic and heterotrophic organisms of small cell sizes (pico- to nano-) adjusted to decomposing roles in water column microbial loop [1]. This study focuses on intense plankton sampling experiment through two-week survey with the special focus on plankton size fractions, depth, and different approach in bioinformatic pipeline to estimate amount of Metazoa sequences in smaller fractions.

Methods

Total of 24 seawater samples of surface and deep chlorophyl maximum (DCM) layer for eDNA retrieval and subsequent metabarcoding analysis were collected and processed as described in [1, 2 and references therein].

Results and Discussion

Overall plankton community composition and contribution within size-fractions is shown in Figure 1 A, B and C. Whitin 18S rRNA dataset, Dinoflagellata and Metazoa comprised most of the community (36.35% and 27.60%, respectively), followed by Gyrista (8.33%), Fungi (4.45%), Ciliophora, Chlorophyta and Haptophyta (all 4%, respectively) (Figure 1A). Further on, highest relative abundances of Metazoa are present in micro fraction (48.39%), while lowest in pico fraction (17.77%) and most of metazoan sequences belong to class Copepoda (Figure 1A) which is congruent with high number of copepods found in zooplankton net samples at Lastovo Island [1]. When Metazoa are excluded from dataset, dinoflagellates act as ubiquitous dominant group (Figure 1B).

Fig. 1. Community composition with relative abundance of taxa (on left) and rPCA analysis plots for three analysed datasets (on right). A&D: 18S with Metazoa, B&E 18S without Metazoa, C&F 16S dataset.

Within nano- fraction dominant classes are *Dinophyceae* (Gymnodiniales and Peridiniales) and Syndiniales, while ratio between *Dinophyceae* and Syndiniales shifts in favour to parasitic Syndiniales Groups I and II in pico- fraction (Figure 1B), once more proving small cell size in oligotrophic environment combined with parasitic heterotrophic lifestyle is gold standard for low productive area

[3]. Most contributing primary producers in 18S dataset were *Pelagophyceae* (10%) and *Mamiellophyceae* (5.57%) within pico- fraction and *Prymnesiophyceae* within nano- and micro- fraction (7.97% and 2%, respectively, Figure 1B), however due to low number of PPE cells found in flow cytometry, primary production is mostly driven by Cyanobacteria [1]. Bacteria are comprised from Gammaproteobacteia (from 30.64% in nano- to 51.84% in micro- fraction), Alphaproteobacteria (most abundant in pico- fraction, 32%), Bacteroidota, Verrucomicrobiota and Cyanobacteria (most abundant in pico- fraction, 8.45%), Figure 1C.

Tab. 1. Beta diversity values calculated with robust Aitchison's index and tested with PERMANOVA for three datasets. *significant **strongly significant.*

Sample groups β diversity	18S rRNA With Metazoa		18S rRNA Without Metazoa		16S rRNA Bacteria	
	Robust Aitchison's index, PERMANOVA pairwise test					
	p-value	q-value	p-value	q-value	p-value	q-value
Fraction						
Group1 vs. Group2						
MICRO vs. NANO	0.056	0.084	0.262	0.262	0.001**	0.003**
MICRO vs. PICO	0.005**	0.010*	0.027*	0.040*	0.002**	0.003*
NANO vs. PICO	0.350	0.350	0.001**	0.003**	0.529	0.529
Depth						
Group1 vs. Group2						
SURFACE vs. DCM	0.001**	0.001**	0.001**	0.001**	0.001**	0.001**

Differentiation of two depth layers is significant in all datasets (Figure 1 D, E and F; Table 1) and within 18S datasets with Metazoa is driven with ratio of *Ostreococcus* and *Pelagomonas* vs. copepods (Figure 1D). When Metazoa are excluded, differentiation of layers do primary producers and parasitic Syndiniales: Pelagophyceae, Mamiellophyceae and Syndiniales in DCM, while heterotrophs/mixotrophs thrived in surface layer (Figure 1E). Bacterial taxa contributing most to surface layers are from genera *Alteromonas* and *Pseudomonas*, proven potential pathogens on zooplankton cells and important chemoheterotrophs, while Cyanobacteria (among others) contribute to DCM (Figure 1F).

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MACROFAUNAL ASSEMBLAGES ASSOCIATED WITH *POSIDONIA OCEANICA* BANQUETTES IN THE MALTESE ISLANDS

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Abstract

The macrofauna associated with *Posidonia oceanica* banquettes on groomed and ungroomed sandy beaches in Malta were assessed in autumn 2023 and winter 2024. Samples of the banquettes were collected using a 5 L PVC corer. Results indicated that the seagrass banquettes on ungroomed beaches had a higher total abundance and number of species compared to banquettes of the same seagrass on groomed beaches. Moreover, on ungroomed beaches, both total abundance and number of species were higher in autumn than in winter, whereas on groomed beaches both attributes were higher in winter. The present results highlight the impact of grooming of sandy beaches on the macrofaunal assemblages associated with *P. oceanica* banquettes.

Keywords: Crustacea, Habitat, Posidonia, Supralittoral, Mediterranean Sea

Introduction

Posidonia oceanica meadows serve as an important habitat for many marine species in the Mediterranean [1]. Leaf litter and other material released by the seagrass and deposited on beaches form 'banquettes', which have important physical interactions with the environment, including protecting the sandy beaches against erosion, while they also serve as a habitat for several macroinvertebrate species [2]. In the Maltese Islands, *P. oceanica* banquettes are removed (a process known as 'grooming') from the more popular, larger, sandy beaches in spring of each year since bathers prefer sand without seaweed on the surface, while they are left in place on the smaller, less popular, beaches [3]. The main aim of the present study was to compare attributes of the macroinvertebrate assemblages associated with *P. oceanica* banquettes on groomed and ungroomed beaches in Malta.

Materials and Method

A PVC corer, having a diameter of 19 cm and a height of 17.7cm, was used to collect *P. oceanica* banquette material in autumn 2023 and winter 2024 from three ungroomed beaches: Xatt l-Ahmar, Ramla tal-Qortin and Qalet Marku, and two groomed beaches: White Tower Bay and Mellieha Bay (Figure 1). No banquettes were present at the two ungroomed beaches in autumn. Two replicate samples were collected from the Supralittoral Zone adjacent mean sea level from each of two different points on each beach. After collection, samples were preserved in 70% ethanol, and later sorted manually to separate out the macroinvertebrates, which were identified to species level and enumerated.

Fig. 1. Map of the Maltese islands showing the study localities

Results and Discussion

A total of 7180 macroinvertebrate individuals were collected from ungroomed beaches, compared to 180 collected from groomed beaches. Results indicated that mean number of species per core was higher at ungroomed beaches compared to ones that were groomed, with Xatt l-Ahmar having the highest mean value (Figure 2). At ungroomed beaches, mean number of species was higher during autumn; on the other hand, values of this attribute were higher during winter at groomed beaches. Values of mean total abundance per core were also higher at ungroomed beaches. Values of mean total abundance were greater during autumn at ungroomed beaches. At the groomed beaches, values of mean total abundance were greater during winter. The higher values of number of species and total abundance at groomed beaches during winter resulted from the small size of banquettes present in autumn, since most of the material would have been removed during summer. On the other hand, seagrass banquettes are not removed at the ungroomed beaches, which therefore support undisturbed banquettes that retain the associated macroinvertebrate assemblages. Therefore, ungroomed beaches support seagrass banquettes that support a higher diversity and abundance of macroinvertebrates.
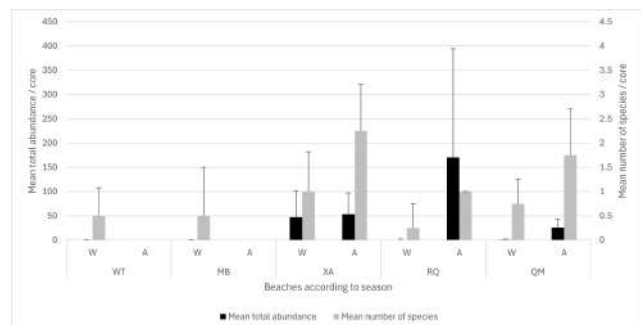

Fig. 2. Mean total abundance/core (+ SD) and mean number of species/core (+ SD) recorded from the *Posidonia oceanica* banquettes collected in autumn 2023 (A) and winter 2024 (W) from the 5 study localities. White Tower Bay (WT) and Mellieha Bay (MB) are groomed beaches; Xatt l-Ahmar (XA), Ramla tal-Qortin (RQ) and Qalet Marku (QM) are ungroomed beaches

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A STUDY ON SOME BANKS IN THE NORTH AEGEAN SEA

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Abstract

The Aegean Sea has several banks what makes it very important for benthic biodiversity. However, the studies on these banks are limited. In May and September 2022 and 2023, surveys were conducted in the North Aegean Sea to better understand high sea marine biodiversity and coralligenous habitats which are marine key habitats in the Mediterranean Sea. Macrobenthic samples collected at four high sea banks included a total of 28 species: five fish, nine crustacean, nine mollusc, four echinoderm and one Brachiopoda species. These banks should be protected due to its rich biodiversity and vulnerable coralligenous habitats, especially against bottom trawling.

Keywords: Biodiversity, Conservation, MPAs, Open sea, Aegean Sea

The Aegean Sea has several banks what makes it very important for benthic biodiversity. However, the studies on these banks are limited. The first data on the benthos at some banks in the Aegean Sea were published by Kisseleva (1983), who studied macrobenthos at three banks in the Aegean Sea and their comparative characteristics. Apart from this, some floral and faunal benthic communities have been the subject in the subsequent studies (Topaloglu et al. 2010). Aktan (2012) studied to the knowledge on Coralline algae which are the major coralligenous builders in the Johnson Bank.

The aim of this study, therefore, is to elucidate the biological richness and main threats of the banks in offshore areas of the Aegean Sea.

In May and September 2022 and 2023, surveys was conducted in the Aegean Sea to better understand high sea marine biodiversity and coralligenous habitats which are marine key habitats in the Mediterranean Sea. Four high sea banks in the Aegean Sea (Figure 1: Sinaya Bank at 72 m depth, Johnston Bank at 41 m depth surrounded by depths of 300-500 m, Brooker Bank at 110 m depth, and Mansell Bank at 80 m depth surrounded by depths of 500-800 m) were surveyed with the reseach vessael Yunus-S. The samples were taken by dredging with 2 knot speed during 10 minutes. The samples were counted, identified and fixed.

Fig. 1. Map of the sampling stations at high sea banks in the Aegean Sea

A total of 28 species were identified, including five fish, nine crustacean, nine mollusc, four echinoderm and one Brachiopoda species, in the samples collected at the banks (Table 1). These banks have large amounts of coralligenous communities. Coralligenous formations are important habitats for many fish, molluscs and crustaceans, equivalent to kelp forests in the oceans or seagrass beds in the coastal waters of the Mediterranean. They also serve as shelters for juveniles of many commercial species which are under fishing pressure, thus contribute greatly to the recruitment of valuable stocks. These areas are unique habitats of the Aegean Sea in terms of size and species richness, but despite their ecological and economic importance, there is no conservation measure for them at present. This is particularly concerned for bottom trawling.

Tab. 1. List of macrobenthic species found at the high sea banks in the Aegean Sea

Taxonomic group	Species	St1	St2	St3	St4
Brachiopod	*Megerlia* sp.				√
Arthropod	*Alpheus glaber*	√			√
	Ebalia sp.	√	√		
	Inachus dortonesis	√	√	√	
	Inachus phalangium		√		√
	Macropodia rostrata	√		√	
	Munida rugosa				√
	Macropipus tuberculatus				√
	Parthenopoides massena	√			√
	Ebalia cranchii	√			√
Mollusc	*Hiatella rugosa*	√	√		
	Bolma rugosa		√		
	Modiolula phaseolina	√	√	√	
	Vexillum savignyi				√
	Vexillum tricolor	√	√	√	
	Antalis inaequicostata		√		√
	Diodora graeca	√			
	Diodora gibberula		√	√	
	Pseudamussium clavatum				√
Echinoderm	*Echinus melo*		√		
	Cidaris cidaris	√	√	√	√
	Asterina gibbosa		√		√
	Ophiothrix fragilis	√		√	
Fish	*Serranus cabrilla*	√	√		
	Phycis blennoides			√	√
	Gaidropsarus biscayensis		√	√	
	Macroramphosus scolopax		√		√
	Arnoglossus laterna	√		√	

Öztürk (2009) have presented some proposals on marine protected areas in the high seas of the Aegean Sea including the Johnston, Broker and Stoker Banks in the Aegean Sea to ensure protection of marine biodiversity according to the criteria in the Convention of Biological Diversity. The present study confirms the ecological importance of these banks, which needs particular attention for the overall protection of marine biodiversity in the Aegean Sea. Türkiye and Greece should cooperate as two coastal states to protect these vulnerable habitats.

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CIESM Congress Session : Insight on marine Biodiversity II
Moderator : Patrick J. Schembri – Univ. of Malta

Session's Synthesis

The session explored diverse aspects of the biology, behaviour, habitat roles, and geographic distribution of Mediterranean species, with implications for marine biodiversity and ecosystem management. Studies on the locomotion of the bivalve *Arca noae*, showed that smaller individuals (<20 mm) were more mobile than larger ones, which exhibited reduced movement rates. Research on the coralline alga *Lithothamnion* cf. *valens*, a foundation species in rhodolith beds of the Menorca Channel highlighted their critical role in providing structural complexity to these key marine habitats. A rare finding of blanket octopus *Tremoctopus* sp. in the southern Adriatic Sea provided new morphological insights into this elusive species. Long-term analysis in the Strait of Sicily revealed a decline in the population of the crinoid *Leptometra phalangium*, likely driven by climate change rather than reduced fishing activity, underscoring its ecological importance in high-productivity areas. Additionally, the first recorded sighting of the puffer fish *Lagocephalus lagocephalus* off the west coast of Algeria added to the understanding of this species' distribution in the Atlantic-Mediterranean region.

The discussion which followed these presentations addressed the bimodal depth distribution of the crinoid *Leptometra phalangium*. While most records aligned with its typical depth range, a second peak was observed at significantly greater depths. Participants speculated that warming seas might be driving cold-adapted species to deeper waters, but this hypothesis does not account for the absence of records in the intermediate depth range between the shallow and deep-water populations. Another possibility raised was that the observed distribution pattern could be influenced by habitat preferences. Reference was made to a recent study that modelled the effects of ocean warming on this species, highlighting the need for further research into both *L. phalangium* and other species potentially impacted by changing ocean temperatures. The session also included discussion on the seasonality of *Lagocephalus lagocephalus* sightings, with records from Algeria predominantly in autumn and those from the Central Mediterranean in winter, suggesting a potential link between its distribution and colder seasons.

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LOCOMOTION OF NOAH'S ASK SHELL *ARCA NOAE* LINNAEUS, 1758 IN LABORATORY CONDITIONS

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Abstract

Noah's ark shell, *Arca noae* is mediterranean species with some interest for fisheries, as well as for aquaculture diversification. Locomotion of shellfish is studied in this article under laboratory conditions. Animals were divided into 4 categories of shell length: < 20 mm SL ; 20-40 mm SL; 40-60 mm SL and > 60 mm SL. Measurements showed fastest and highest rate of locomotion on smallest shellfish (< 20 mm SL: 3740 ± 2762 mm 48h^{-1}), while lowest locomotion was noted in size category 20-40 mm SL (59 ± 17 mm 48h^{-1}). Highest locomotion in mm hr^{-1} was noted in size category < 20 mm SL ($77,91 \pm 57,54$ mm hr^{-1}), while lowest locomotion rate was for larger shellfish 40-60 mm SL ($1,22 \pm 0,35$ mm hr^{-1}).

Keywords: Bivalves, Adriatic Sea

Introduction

Locomotion in shellfish is well documented and there are basically two types: heavier, attached species discard the byssus and drag themselves with their muscular foot, while lighter ones, like Chlamys, Lima and Pecten species propel themselves by ejecting water from the intervalvar space using adductor muscles and "jet" around. Morton and Peharda (2008) showed that both young and adults can move up to 20 cm and attach themselves with byssus after one to two days. Aggregation of A. noae, whether by migration of adults, or by simultaneous settlement of larvae may serve purpose in protection from the predation (Peharda and Onofri, 2000; Peharda et al., 2003,). Huang et al. (2008) investigated locomotion in Tridacna squamosa and Jennings and Hunt (2009) measured dispersal of juvenile Mya arenaria, Mercenaria mercenaria and Gemma gemma. Ansell (1967), documented jumping and other locomotion types in Cardium echinatum, Laevicardium crassum and Cardium edule. Amyot and Downing (1997) worked on seasonal variations in vertical and horizontal movement of freshwater shellfish Elliptio complanata.

Material and methods

Individuals of Arca noae were collected in Mali Ston Bay (south-eastern Adriatic). Bivalves acclimated to the ambient aquarium conditions (salinity 37 ± 1.0 psu, temperature 20 ± 1 °C) for seven days prior to the experiment. Four size groups of shellfish: < 20 mm SL; 20-40 mm SL; 40-60 mm SL; > 60 mm SL were formed and from each group 4 individuals were placed in the experiment in rectangular container with volume of 48l. Water was aerated for normoxic conditions (75-100% sat.). Graph paper was placed under the container and photo was taken every 5 minutes. The experiment lasted for 48 hours. ImageJ was used for image analysis with tracker plugin. The result was corresponding position of ellipsoid centroid for each individual in time frames.

Results and discussion

Size category comparison showed (nested ANOVA; $F = 191,2584$, $p < 0,001$) largest influence to the locomotion speed and rate, with smaller shellfish moving further and faster than larger (Fig. 1).

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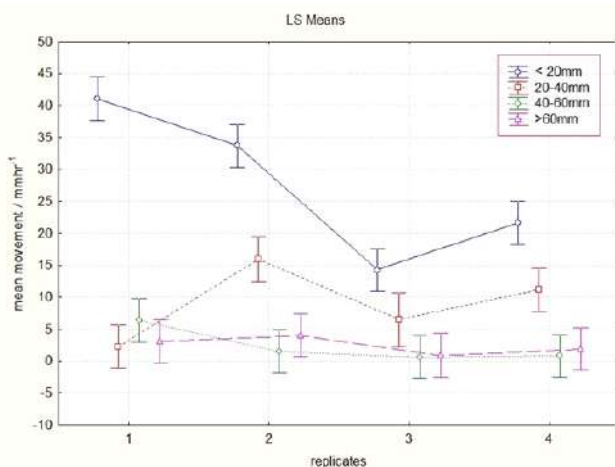
Fig. 1. LS means of movement of shellfish in experiment.

LITHOTHAMNION CF. VALENS: FOUNDATION SPECIES THAT PROVIDES THE MOST THREE-DIMENSIONAL STRUCTURE IN THE RHODOLITH BEDS OF THE MENORCA CHANNEL.

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Abstract

Rhodolith beds are important marine habitats harboring diverse assemblages of flora and fauna in the Mediterranean Sea. This study aimed to assess the taxonomic and molecular identification of the morphospecies that provides the highest structural complexity to the Menorca Channel rhodolith beds.

Keywords: Algae, Mediterranean Sea, Biodiversity, Conservation

Introduction

Rhodolith beds (RBs) are formed by free-living red coralline algae and are found in the mesophotic zone of the Mediterranean, making them largely unexplored. Mediterranean RBs, declared as habitats of special interest under the Marine Strategy Framework Directive (MSFD, 2008/56/EC) host a diverse range of rhodolith-forming species [1][2][3], not just the two species protected by the Habitats Directive (92/43/EEC), *Phymatolithon calcareum* and *Lithothamnion corallioides*. The Menorca Channel RBs in particular exhibit a great variety of morphologies that form extensive and heterogeneous biogenic habitats [4]. Despite only these two species are protected in the directives, there are many other ecologically important species in the Mediterranean RBs. The Mediterranean endemic *Lithothamnion valens* is known to be the dominant species in the Punta de la Mona bed where their presence increases with depth [3]. This species is also abundant in deep RBs found in Italy [2] and in Balearic Islands [5]. In the study by Cabrito et al. (2024), different proportions of morphospecies were found depending on the sampled area of the channel. Overall, morphotype A showed a decline from the more sheltered zones to the more exposed ones. Additionally, this morphotype was found to provide one of the highest levels of three-dimensional structure and thus greater interstitial space among branched forms, contributing ecological value to the rhodolith beds in the area and increasing their complexity. In this study, we attempt to elucidate the taxonomic and molecular identification of this morphotype A.

Materials and Methods

This study examines rhodoliths from the Menorca Channel (3°45' E, 39°75' N) [5]. Collections were obtained using a naturalist dredge in 2022. Scanning electron microscopy was performed for morphological identifications. Specimens were cleaned for DNA extraction. The *psbA* locus was amplified using the primer pair psbA-F1/psbA-R1 and the thermal profile used by [6] Peña et al. (2015). Sequences were assembled, aligned, and trimmed using MEGA v.6, and phylogenetic relationships were inferred using maximum likelihood under a generalized time-reversible GTR+F model for 500 standard bootstraps.

Results

The morphological characters observed match with those described for *Lithothamnion valens* in [7]. Although no asexual or sexual conceptacles were observed in the SEM, they could be partially seen under the magnifying glass (Fig.1). Furthermore, the peculiar shape of the epithelial cells and numerous cell fusions were observed (Fig.1). Molecular results for *psbA* have ruled out the possibility that the specimens belong to another known and sequenced *Lithothamnion* species in the Mediterranean, suggesting the identification of *Lithothamnion cf. valens*, for which there are currently no genetic sequences available in the databases. The identification of morphotype A fits with the findings of other authors, who observed an increase in the distribution of *L. valens* in the Mediterranean in deep RBs [3]. These results also coincide with those of Farriols et al., 2022 [8] who observed a better state and development in specimens identified as *L. valens* in the Menorca Channel.

Taking into account the ecological importance due to the three-dimensional structure that morphology A brings to the RBs of the Menorca Channel [4], *L. valens* should be considered as one of the species of special interest for protection in the Mediterranean RBs.
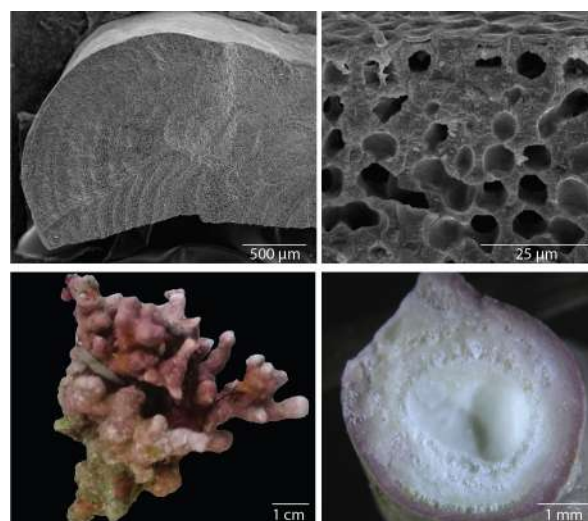

Fig. 1. Top-left: calcified bands. Top-right: cell fusions. Down-left: whole individual. Down-right: conceptacles.

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OCCURRENCE AND ABUNDANCE OF THE CRINOID *LEPTOMETRA PHALANGIUM* (ECHINODERMATA: CRINOIDEA) IN THE STRAIT OF SICILY

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Abstract

The crinoid *Leptometra phalangium* is recognised as an indicator of areas of high biological productivity, providing essential habitat for juveniles and spawners of several commercial species. To study some aspects of the population dynamics of this crinoid in the Strait of Sicily (GSA 16) from 2008 to 2021, we analysed time series of occurrence and abundance indices from the MEDITS trawl survey. *L. phalangium* showed a wide distribution between 19 and 799 m depth. The species was most frequent between depths of 50-150 m and 600-700 m, with the former showing the highest abundance. There was a significant decrease in both occurrence and abundance of the species in the study area. This pattern may be due to climate-related changes rather than fishing activity, which has decreased significantly over the same period.

Keywords: Sicily Channel, Echinodermata, Time series, Trawl surveys, Warming

Leptometra phalangium (Müller, 1841) is a crinoid that indicates highly productive marine areas capable of supporting large fish and crustacean biomasses [1]. This study reports the bathymetric distribution of the species and evaluates its temporal trends off the southern coast of Sicily (GSA 16) using occurrence and density data collected during the bottom trawl survey MEDITS from 2008 to 2021. *L. phalangium* was found at depths ranging from 19 to 799 m, being most frequent between 50-150 m and 600-700 m. The highest abundance occurred on the continental shelf, between 50-150 m, corresponding to the offshore detritic biocoenosis (DL) facies on the shelf break area.

The temporal pattern, evaluated using the classical monotonic Pearson correlation coefficient, showed a significant decrease in the percentage of occurrence, as well as in the number and weight indices (Fig. 1).
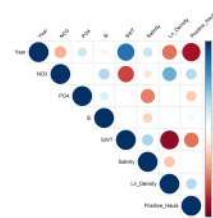

Fig. 2. Correlation matrix between abiotic variables from [2] and abundance and occurrence of *L. phalangium* on the shelf in the GSA 16. Positive correlations are shown in blue and negative correlations in red with size of circles proportional to the correlation strength.

Fig. 1. Temporal pattern of *L. phalangium* off the southern coast of Sicily (GSA 16). Significant decreasing monotonic trends were found for occurrence (as % of positive hauls; r=-0.8371, p<0.0005; right axis), biomass/km^2 (ln(g+1); r=-0.8770, p<0.0005; right axis), number/km^2 (ln (no+1); left axis); r=-0.7905, p<0.0005).

The change in the occurrence and abundance of *L. phalangium*, could signal a variation in the productivity of fishery resources in the Strait of Sicily. Exploring patterns of ecological factors (sea water temperature, SWT in °C, salinity, S in psu, and nutrients as NO_3, PO_4, Si in µmolL-1), reported by [2], and abundance (ln_nkm^{-2}) and occurrence (% of positive hauls) of the species on the shelf from 2010 to 2021, a significant negative correlation between abundance and SWT was found (Fig.2). The effects of environmental factors (pH and NO_3) on the abundance of the sea cucumber *Parastichopus regalis* (Cuvier, 1817) in the Strait of Sicily have recently been reported by [3].

Although the vulnerability of crinoids to trawling is known [4], in the studied case the concurrent downward trend of the trawling fleet in the area [5] suggests that the observed decline in species may be due to ecological factors rather than fishing impacts.

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NEW FINDING OF RARE BLANKET OCTOPUS, *TREMOCTOPUS SP.* DELLE CHIAJE, 1830 IN SOUTHERN ADRIATIC

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Abstract

Finding of several females of blanket octopus, *Tremoctopus sp.* delle Chiaje, 1830, is described in this paper. June 14. 2023., during early morning hours (03:46) appr. Dozen of small octopus individuals were noted at sea surface while performing regular plankton sampling (project), two of which were captured and analyzed in the laboratory. Subsequent morphological and meristic analysis is given for this unusual female sighting of this very rare species.

Keywords: Cephalopods, Pelagic, South Adriatic Sea

Introduction

Genus *Tremoctopus* delle Chiaje, 1830, a cosmopolitan, pelagic genus that exhibits extreme sexual dimorphism, where the females are several orders of magnitude larger that its males. In the Mediterranean it is mostly found as stranded specimens, or as a stomach content of a predator (2., 3.,6.). The aim of this paper is to record and describe morphologically this find from the southern Adriatic sea.

Materials and methods

During night sampling of marine plankton in southern Adriatic basin (41°36'56.60"N and 17 °50'17.85"E, depth 1200m, Figure 1), several octopi, 12 in total were observed under floodlight at the surface. Two of the individuals were caught with small sac and placed in seawater for observation. The specimen were brought alive to the laboratory and later preserved in 2,5% seawater formaldehyde for measurements. Basic meristic measurements were taken, animals were weighted and photodocumented in the laboratory. Wild Heerbrugg stereomicroscope with measuring attachment was used for analysis and measurement. Water physical and chemical parameters of seawater were also recorded.

Results and discussion

After examination under the stereomicroscope, specimen were identified as juvenile female development stage III of *Tremoctopus sp.* (7.) (Figure 2a). ML was measured as 11,7 and 13.4mm and BW was 1,28 and 1,81g respectively. Arm formula was 1:2:4:3. Arm 1 is typical of stage III, with round filament at the tip, the interbrachial membrane terminates just at the filament in round, spatulate manner (Figure 2b). Extensive interbrachial membrane between arms I and II, two pairs of water pores were located dorsally and ventraly on the head (Figure 2c). On arms I and II several portions of attached tentacles were found, possibly siphonophoran attached to suckers (Figure 2d). These presumably are used for defence (4., 7.). Along *T. violaceus*, in the Mediterranean there is present *T. gracilis* (Souleyet, 1852), which was usualy misinterpreted as *T. violaceus* (1., 5.), therefore, subsequent DNA analysis of the samples is warranted for full identification of this find.
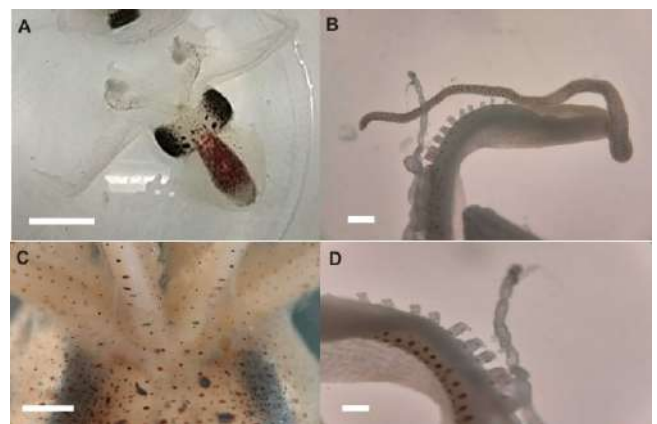

Fig. 2. Female *Tremoctopus sp.* From south Adriatic. A.: Live specimen, ML=13,4mm, scale bar 10mm. B.: detail of arm I right, scale bar 1mm. C.: Dorsal water pores, scale bar 1mm. D.: Detail of siphonophoran tentacles attached to the suckers of the arm I left, scale bar 1mm.

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Fig. 1. Map with finding location.

FIRST RECORD OF THE OCEANIC PUFFER *LAGOCEPHALUS LAGOCEPHALUS* (LINNAEUS, 1758) ON THE WEST COAST OF ALGERIA (MOSTAGANEM)

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Abstract

Lagocephalus lagocephalus (Linnaeus, 1758) is an Atlantic-Mediterranean species. It is distinguished by a white ventral face with spines and a dark grey to blue dorsal face. An individual of *L. lagocephalus* was captured by trawling at "Salamandre harbor" (Mostaganem, Algeria) in November 2023. The in-depth morphological description allowed us to identify and report it for the first time on the west coast of Algeria. Keywords: new records, fish, *Lagocephalus lagocephalus*, Herculean species, Algerian basin.

Keywords: Fishes, Algerian Sea

Introduction

The Tetraodontidae family consists of 33 genera. The distribution of their species extends across the tropical and subtropical zones of the Atlantic, Indian and Pacific oceans [1]. This family includes fish with the ability to inflate themselves under stress, becoming entangled in fishing nets. This behavior has earned them the nickname "pufferfish" [2]. Their flesh exhibits toxicity due to the presence of a potent neurotoxins (tetrodotoxin), *which is found in their skin,* liver, gonads, and viscera [3]. *Lagocephalus lagocephalus* has been reported occasionally in the Mediterranean (Adriatic Sea [4], Italy [5] and Syria [6]) and herein for the first time in Algeria (present work).

Material and methods

The specimen provided by the commercial fishermen on 19 November 2023 at "Salamandre Harbor" (35°55'18.71"N / 0°03'29.54"E) was identified according to descriptions by Whitehead et al. [7]. Morphometric measurements were carried out.

Results and Discussion

The specimen is male. The head and upper body (which has no bony plates) are grey-blue. The sides are silver presenting two distinct lateral lines with a narrow caudal peduncle; the ventral side is white with small spines that run from the chin to the anus. We noted two nostrils with developed papillae on each side of the snout (Fig. 1) unlike to *Lagocephalus sceleratus* reported on the Algerian coast in 2015 [8]. All measurements are presented in Table 1.

Tab. 1. Measurements on *L. lagocephalus*.

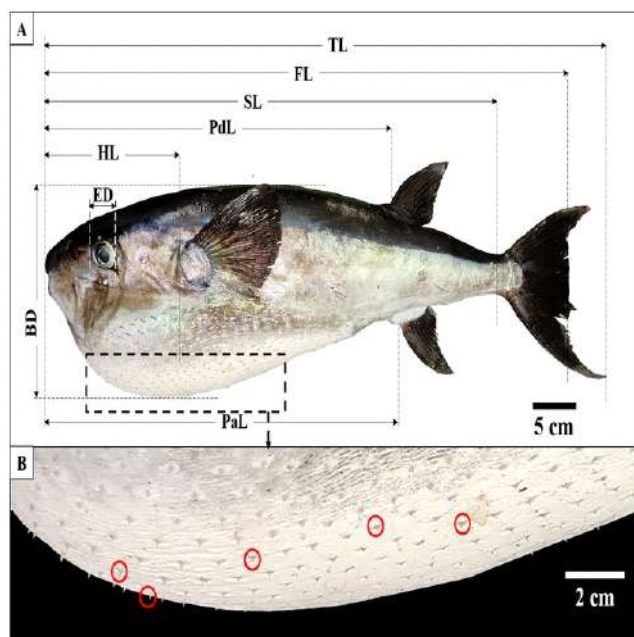| weight	2571g
Total length (TL)	64,7 cm
Fork length (FL)	58,2 cm
Standard length (SL)	50,3 cm
Body depth (BD)	16,0 cm
Body width (BW)	07,4 cm
Head length (HL)	15,5 cm
Eye diameter (ED)	02,2 cm
Pre-dorsal length (PdL)	38,6 cm
Pre-anal length (PaL)	42,9 cm

Fig. 1. **A-** External morphology of *L. lagocephalus* found at "Salamandre Harbor". **B-** spines on the ventral side (red circles).

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CIESM Congress Session : Zooplankton Research
Moderator : Anna Schroeder – ISMAR-CNR, Venice, Italy

Session's Synthesis

The "Zooplankton Research" session provided new insights into the dynamic roles and adaptations of zooplankton in the Mediterranean Sea. The eight presentations covered a range of studies, mostly in the Adriatic Sea, from examining vertical distribution patterns to assessing the impacts of environmental stressors and invasion pathways. This session provided new insights into the dynamic roles and adaptations of zooplankton in the Mediterranean Sea.

The vertical distribution of hydromedusae in the southern Adriatic (1) highlighted how seasonal shifts, such as deep winter convection, increased their abundance at 200-600m, in contrast to late-spring stratification. Similarly, stable hydrographic conditions in Adriatic waters below 100m (4) helped maintaining a consistent euphausiid community composition year-round, while a study on copepods (6) revealed day-night shifts in vertical migration and diversity, with notable increased epipelagic nighttime abundance.

Several presentations focused on specific taxa and their ecological adaptations. Research on *Paracalanus* species (5) used metabarcoding to map cryptic species distribution in the North Adriatic, advancing prior methods that relied on individual sequencing. Another study examined the non-indigenous copepod *Pseudodiaptomus marinus* (7), shedding light on its ecological traits and spread in the Mediterranean coasts. In the Levantine basin (8), a new, and rare, zooplankton dataset underscored the region's vulnerability to warming and Indo-Pacific species introductions.

Environmental influences on zooplankton were also addressed by the detection of zooplankton cysts in Ionian Sea sediments (2) revealing confinement-driven cyst richness, contrasting with active plankton stages and enhancing our understanding of coastal plankton dynamics. In Sfax, Tunisia (3), high trace metal concentrations were linked to pollution sources, with varying copepod abundance across zones signaling ecosystem resilience differences.

Together, these presentations - integrating both classical and innovative molecular approaches - enriched our understanding of Mediterranean zooplankton, reflecting the region's complex and evolving ecosystem, while highlighting zooplankton migration patterns, resilience, and the broader environmental pressures shaping this vital marine community.

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HYDROMEDUSAE VERTICAL DISTRIBUTION IN THE OPEN SOUTHERN ADRIATIC SEA (NE MEDITERRANEAN) UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

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Abstract
Vertical distribution of the hydromedusae community was investigated in the open southern Adriatic by analyzing zooplankton samples taken from the surface down to1200 m depth in February and June 2021. The impact of a deep winter vertical convection on hydromedusae was clearly visible in deeper layers, between 200 and 600 m depth where their abundance was from 1.5 to 4 times higher than in late spring when pronounced thermal stratification was observed.

Keywords: Zooplankton , Water convection, Open sea, Adriatic Sea

Introduction
The Adriatic Sea is a semi-enclosed basin in the northeastern Mediterranean. Its deeper southern part is characterized by the circular, 1243-m deep South Adriatic Pit (SAP) and it is one of three sites of open-sea deep convection in the Mediterranean Sea. Adriatic ecosystems are influenced by the regular exchange of water with the Eastern Mediterranean through the Strait of Otranto. Levantine Intermediate Water (LIW) and Ionian Surface Water (ISW) flow into the Adriatic along the sea's eastern border. When more saline water (LIW) is exposed to winter episodes of cold, dry northerly winds (Bura), conditions are favourable for deep convection event (1). In this study, we compared vertical distribution of hydromedusae community in the deep open southern Adriatic under two different environmental conditions. Special attention was paid on the impact of winter convection event on hydromedusae distribution and abundance.

Methods
The oceanographic and zooplankton sampling was conducted during the two research cruises in the SAP (42°37'21'N, 18°06'05'E): in February and June 2021. Vertical profiles of temeperature, salinity and chlorophyll *a* (Chl-*a*)-fluorescence were taken by CTD multi-probe (SBE 911plus, Sea-Bird Electronics Inc.). Zooplankton samples were collected by vertical tows using the Nansen opening–closing net (250-μm mesh) at eight depth intervals (see Figs.1, 2), from surface to 1200 m. Hydromedusae were counted and identified with an Olympus stereomicroscope SZX9.

Results and discussion
The February cruise took place after strong Bora wind episodes (gusts surpassing 50 m/s) and consequently substantial winter heat loss (temperature below 0°C) at the air-sea interface. In the intermediate layer, the inflow of saline water, LIW (> 38.9) was recorded, which, in addition to the stated weather condition, leads to the strong vertical mixing event. As a consequence the water column was well mixed (till 600 m depth) with uniform thermal and salinity conditions with an average of 14.17±0.03 °C and 38.86±0.03, respectively. In late spring cruise, temperature (max. 21.33°C) and salinity (max. 39.03) decreased gradually from the surface to the deeper layers. A typical seasonal thermocline was present in the upper 10 m and 20 m, respectively. Deep Chl *a* maxima (0.79 mg/m3) was recorded at 65 m in June 2021.This could be related to the phytoplankton bloom enhanced by nutrient input into euphotic zone due to episodes of winter mixing phase (1). Hydromedusae abundances were ranged from 0.10 to 5.60 ind./10m^3 in February 2021 and from 0.15 to 17.20 ind./10m^3 in June 2021 (Figs.1, 2). During the convection time in February, abundance of hydromedusae was low in the upper layers, but from 200 to 600 m, it was 1.6 to 4.2 times higher than in June. In addition, an unusual vertical distribution (from surface till 600 m depth) for epipelagic species *Rhopalonema velatum* occurred (Fig. 1). Similar vertical distribution of mesozooplankton during winter vertical mixing was occurred in winter 2008 in the open southern Adriatic (2). In June, when strong thermal stratification was observed, increase of hydromedusea abundance (~17 ind./10m^3) in the epipelagic layer was registered (Fig. 2). Also, in the same layer high Chl *a* and consequently high abundance of copepods (unpublished data), the main food for hydromedusae, was recorded. Future work that documents the impact of convective events such as that described herein will further enhance understanding of contribution of all gelatinous zooplankton to vertical carbon transport from the surface ocean to the deep sea.
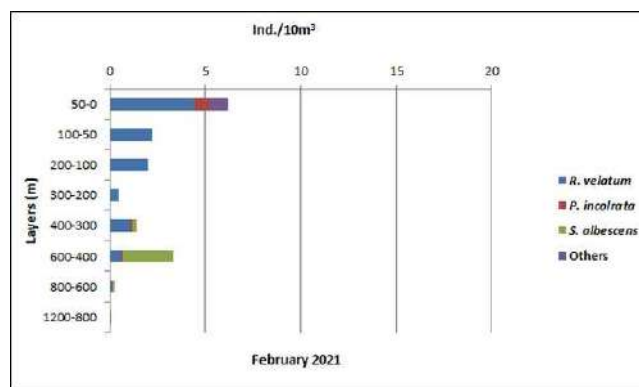
Fig. 1. Vertical distribution of hydromedusea (ind./10^3) in February 2021.
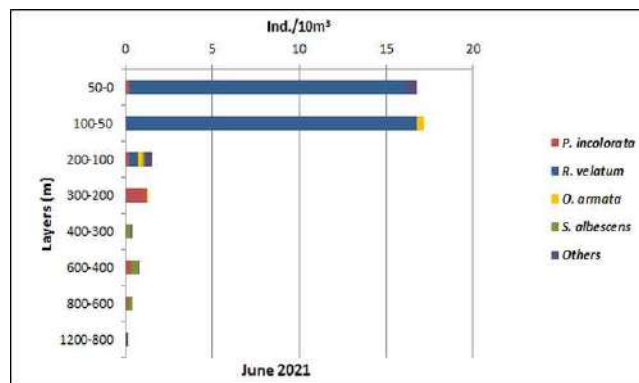

Fig. 2. Vertical distribution of hydromedusea (ind./10^3) in June 2021.

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PLANKTON CYSTS IN SURFACE SEDIMENTS OF THE TARANTO SEA SYSTEM (SOUTHERN ITALY)

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Abstract

The presence of resting stages (cysts) produced by plankton has been studied in the sediments of Taranto Sea System (north Ionian Sea). The taxa richness of cysts in sediments grew accordingly with the confinement degree from the open sea to the most confined part of the system. Such a growth of cyst richness in the sediments showed a trend exactly opposed to that of active stages in the plankton. The consideration of the resting community in the sediments evidently offers a more complete knowledge of plankton dynamics in such a marine coastal environment.

Keywords: Coastal systems, Plankton, Benthic-pelagic coup, Ionian Sea

Introduction

Many plankton species produce resting stages (cysts) that sink and accumulate in bottom sediments of coastal confined areas [1]. Cysts can rest in the sediments also for long periods, ensuring the persistence of the species in the environment, although linked to an intermittent active presence. The active plankton, characteristically, show a species richness diminishing from open sea to more confined areas [2,3]. Species able to produce cysts, and linked to the resting strategy, are predicted to grow along the same gradient. The aim of this work was to establish for the first time if the species richness of the active plankton of confined environments [2] is also paralleled by the distribution of cyst richness in the sediments.

Study area and Methods

The Taranto Sea System is made of 4 basins (G, MG, MPI, MPII) aligned along a progressive confinement degree from the open sea (G) at S-W, to an actually confined area (MPII), at N-E. The Mar Piccolo is a quasi-enclosed area with shallow depths (max 13 m) and a limited water circulation. The sampling of surface sediments was carried out in Autumn 2015 at three sites in each basin and/or confinement condition (Fig. 1).

Fig. 1. Map of the study area. The position of the 12 sampling stations is indicated in the 4 sites shaping the Taranto Sea System.

The collected sediment samples were analyzed under LM. Univariate and multivariate analyses of the collected data were performed using PRIMER v.6 (Primer-E Ltd., Plymouth, UK) to obtain statistical comparisons between sites.

Results and Discussion

A total of 103 cyst morphotypes were identified, deriving from a single date collection of surface sediments at 12 points of the Taranto Sea System. Most of the taxa (68) were recognized as Dinophyta. The abundances varied between 430±163 to 4,451±3,320 cysts g^{-1} at GB and MPIB respectively. And the taxa richness was also sensibly different from 41 to 71 morphotypes in G and MPII respectively (Fig. 2).
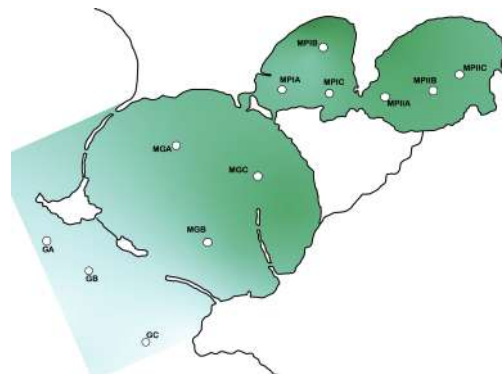

Fig. 2. Distribution of resting stages in sediments of the studied area. Intensity of color corresponds to morphotypes (taxa) richness.

The highest value of dissimilarity was registered between G and MPII (49.84%). The taxa that mostly contributed to differentiate G and MPII were Copepoda Acartiidae and Dinophyta _Scrippsiella precaria_. The growth of taxa richness in the sediments was in accordance with the increase of the confinement degree, showing a trend exactly opposed to that of active stages in the plankton [2]. This result is probably due to the necessity, enhanced in most confined areas, for plankton species to produce cysts, not so necessary in undisturbed open sea. This datum also sustains the existence of a biodiversity sheltered (as cysts in the sediments), and only intermittently expressed (in the plankton), in confined systems, where only a small part of the existing species can play an active role, in the water column, in each time of the year, and the most of biodiversity is waiting in the sediment for their favorable moment. The present investigation, although based on a single date (November 2015), gave a total species richness higher than in a previous study [4] (based on samples collected in MPI but in different seasons) where 91 cyst morphotypes were reported. This difference could even be higher if more than a single date can be considered.

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ETAT DE LA SALUBRITÉ DES EAUX CÔTIÈRES DE LA ZONE DE SFAX ET DE GHANNOUCH (TUNISIE) VIA UNE ANALYSE PHYSICO-CHIMIQUE ET ZOOPLANCTONIQUE

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Abstract

Les concentrations en métaux traces ont été mesurées dans l'eau de surface de la CS (S 1-10) et CN (stations 11-20) de Sfax et la GA (stations 21-30) en Octobre et Novembre 2014. Les ETMs sont classés suivant ce gradient Ni>Pb>Fe>Cu>Cr>Zn>Mn>Co>Cd. Ces éléments, à l'exception de Fe et Mn, ont dépassé la limite de sécurité des critères de qualité de l'eau. Ni et le Co sont issus de la SIAPE et la STEP (S1, CS) alors que Cd, Mn, Cr et Pb dérivent du port de pêche de Sfax (S9, CS). O. nana, E. acutifrons et A. clausi diffèrent considérablement en abondance entre ces trois zones sous des degrés de pollution contrastés. Les trois écosystèmes peuvent donc être classés en fonction de leur degré de résistance aux intrants anthropiques en fonction des résultats physico-chimiques et de la diversité des espèces comme suit: CS>GA>CN.

Keywords: Pollution, Mediterranean Sea, Plankton, Copepoda, Trace elements

Introduction

Le golfe de Gabès est soumis à diverses activités humaines [1] [2] [3]. La surveillance de la qualité de l'environnement peut se faire suivant deux approches complémentaires : la détection des polluants et leur quantification (i) et l'évaluation des effets des polluants sur les organismes vivants, soit au niveau des individus, soit au niveau des populations et/ou des communautés (ii) [4].

Matériel & Méthodes

Les concentrations en métaux traces ont été mesurées dans l'eau de surface de 30 stations appartenant à trois zones côtières le long du golfe de Gabes, c'est-à-dire la CS (stations 1-10) et CN (stations 11-20) de Sfax et la GA (stations 21-30) en Octobre et Novembre 2014 (Fig. 1).

Fig. 1. Site d'étude et des stations d'échantillonnage dans le golfe de Gabes.

Résultats & Discussion

Les éléments traces métalliques sont classés suivant ce gradient Ni>Pb>Fe>Cu>Cr>Zn>Mn>Co>Cd. Ces éléments, à l'exception de Fe et Mn, ont dépassé la limite de sécurité des critères de qualité de l'eau. Les CS, CN et GA devraient être considérées comme des zones relativement polluées par des métaux (Zn, Ni, Pb, Co, Cr, Cd et Cu). Les principales sources de la pollution de l'eau de mer par le Ni et le Co sont la SIAPE et la STEP à proximité de la station 1. Alors que le port de pêche de Sfax, situé sur la côte sud (station 9) est la deuxième source en Cd, Mn, Cr et Pb. L'étude de la faunule copépodique a montré que l'abondance relative, la diversité et la richesse spécifique des Oithonidae sont les indicateurs les plus pertinents de la pollution anthropique. *Oithona nana*, *Euterpina acutifrons* et *Acartia clausi* diffèrent considérablement en abondance entre ces trois zones sous des degrés de pollution contrastés. Les trois écosystèmes peuvent donc être classés en fonction de leur degré de résistance aux intrants anthropiques en fonction des résultats physico-chimiques et de la diversité des espèces comme suit: CS>GA>CN.

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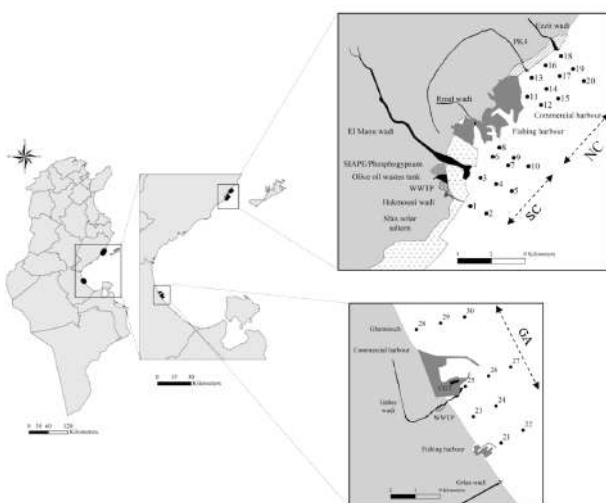
ANNUAL TREND IN SPECIES COMPOSITION OF *PARACALANUS* POPULATIONS IN THE NORTH ADRIATIC UNVEILED BY METABARCODING

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Abstract
The genus *Paracalanus* comprises multiple very similar or cryptic species. Advancements in genetic methods have revealed that the distribution of *Paracalanus* species differs markedly from previous assumptions. Previous research relied on sequencing individual animals to assess species distribution. With the arrival of metabarcoding methods, monitoring of these hard-to-identify species has become feasible. We present, for the first time, the annual dynamics of *Paracalanus* species in the North Adriatic, revealed using the COI metabarcoding approach with monthly samplings.

Keywords: Copepoda, Adriatic Sea, Zooplankton , Biodiversity

Introduction

Species of the genus *Paracalanus* are notoriously difficult to distinguish due to minute differences in exopodite morphology. Recently, the distribution of *Paracalanus* species in the Mediterranean has been elucidated using genetic and morphological approaches [1]. It has been shown that in the Adriatic, there are three *Paracalanus* species, with *Paracalanus quasimodo* as the dominant species. The study by Kasapidis *et* al. [1] only sampled the Gulf of Trieste in April 2014 and November 2015, revealing very different compositions of *Paracalanus* species in each sample indicating large seasonal variation. Due to the limited sampling, the yearly dynamics of *Paracalanus* species in the North Adriatic remained unknown. To investigate the annual dynamics of *Paracalanus* species composition in the North Adriatic, we collected monthly zooplankton samples from March 2021 to February 2022, employing a metabarcoding approach.

Materials and methods

The zooplankton samples were collected in the North Adriatic monthly, from March 2021 to February 2022, at RV001 station (45°04'48"N, 13°36'36"E), a coastal station near the town of Rovinj. The zooplankton samples were collected using a 200-µm Nansen net with a 0.25 m^2 mouth opening, employing vertical tows from the bottom to the surface and preserved in ethanol. For Illumina COI metabarcoding, we utilized the primer pair mlCOIintF (Leray et al., 2013) and jgHCO2198 (Geller et al., 2013), which amplify a 300 bp-long COI fragment. The obtained sequences were processed and assigned to species using Mothur software.
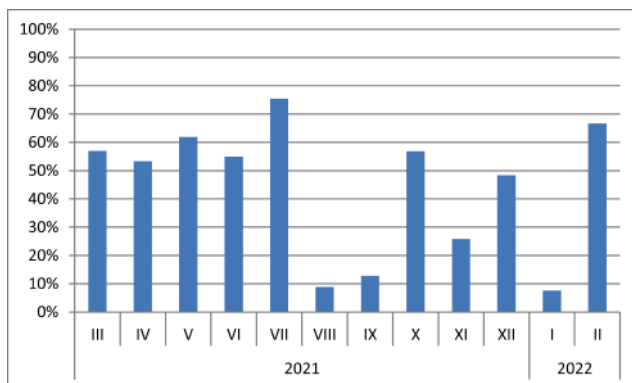

Fig. 1. Percentage of *Paracalanus* sequences in total copepod sequences.

Results and Discussion

The percentage of *Paracalanus* sequences in total copepod sequences varied from 9% to 75% (Figure 1). We detected five *Paracalanus* species in the North Adriatic using the metabarcoding approach: *Paracalanus indicus*, *P. nanus*, *P. parvus*, *P. quasimodo*, and *P.* sp. F (Figure 2). These results reveal two different patterns of relative abundance of *Paracalanus* species. *Paracalanus parvus* dominates from February to June, while *Paracalanus quasimodo* is dominant from July to January.
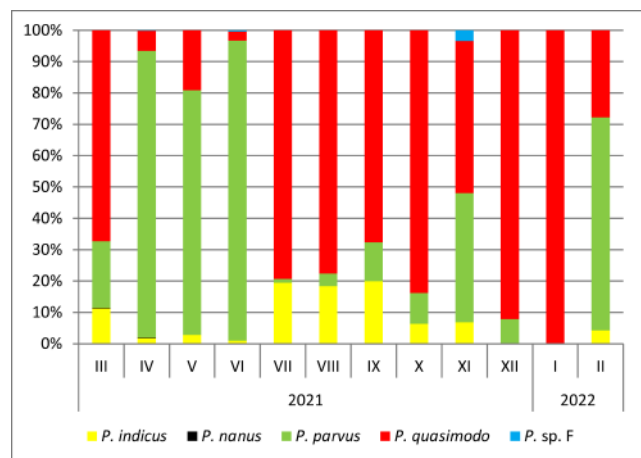

Fig. 2. Relative abundance of *Paracalanus* species based on relative contribution of sequences obained by COI metabarcoding.

Paracalanus indicus is most abundant from July to September, contributing nearly 20% to the total *Paracalanus* population. *Paracalanus nanus* was present only in March, April, and September, consistently in very low numbers, with a maximum of 0.2% in March. Despite primarily being found in the Atlantic and western Mediterranean, we detected *Paracalanus* sp. F [1,2] in small numbers in the North Adriatic during April, June, and November. Its maximum relative abundance of 3.5% occurred in November. Our results demonstrate the necessity of year-round sampling to properly assess species distribution and diversity, given the seasonal patterns exhibited by many zooplankton species. The metabarcoding approach is likely to significantly enhance our understanding of the distribution and occurrence of hard-to-identify and cryptic species.

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DIEL VERTICAL DISTRIBUTION OF COPEPOD COMMUNITIES IN THE OPEN SOUTHERN ADRIATIC SEA: ABUNDANCE AND DIVERSITY PATTERNS

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Abstract

The diel vertical distribution of copepod communities was investigated in the open southern Adriatic by analyzing zooplankton samples collected from June 2020 to September 2023. A significant increase in abundance, especially of calanoids, was detected in the epipelagic layer during the night. Day-night differences in diversity and number of taxa were also found, with the average number of taxa gradually decreasing from the surface to the lower layers during the night, while higher diversity and more copepod taxa were present in the middle layers during the day. <\/div>

Keywords: Biodiversity, Adriatic Sea, Zooplankton , North-Eastern Medite, Vertical migration

Introduction - In the marine environment, copepods have successfully colonized the entire marine realm, with their vertical distribution depending on a variety of factors: biological and physical features, cyclonic circulation, different behaviours (diel, ontogenic and seasonal migrations), etc. Through their vertical migration, copepods play an important role in the vertical transport of organic carbon to deeper waters, and thus in the buffering of global climate change. By feeding near the surface and then fasting at depth, where they continue to defecate, respire and excrete, migrating zooplankton remove carbon and nitrogen from the surface and release them at depth (1). Their high energy content also makes them an important food source for fish larvae and other organisms. The aim of this work is to compare their communities and investigate their diel vertical habitat selection in a 1243-m deep South Adriatic Pit.

Methods - The research was conducted on nine cruises on a seasonal basis between June 2020 and September 2023 at a fixed station in the middle of the southern Adriatic Sea. Temperature, salinity and Chl-a fluorescence in the water column were measured with a CTD probe to describe environmental characteristics. A total of 136 zooplankton samples were collected from the surface to a depth of 1200 m using an opening-closing Nansen net (250 μm mesh size) at eight depth intervals. Qualitative-quantitative analyses of copepods were performed with an Olympus SZX16 stereomicroscope. Aspects of species diversity were assessed using the Shannon-Wiener index (H') (2).

Results and discussion - The environmental data showed a clear seasonal cycle, mainly determined by winter mixing conditions and a summer warming with a stratification period from June to October in the upper 50 m depth. The profiles showed good aeration in all seasons with generally higher Chl-a concentrations in the upper 80 m. The vertical distribution of copepods showed higher total abundances in the upper 100 m at night, while during the daylight the majority of copepod populations were concentrated in the 200-300 m layer (Figure 1). This mostly applies to calanoids, which were generally the most numerous copepod group, comprising on average 63% of the total copepod abundances. The family Oithonidae inhabited the upper layers, especially during the day, when they outnumbered the Calanoids in the subsurface layer. While Oncaeida and Mormonilloida showed a relatively uniform vertical distribution through the water column, Corycaeide were more abundant in the upper layers. The order Harpacticoida and the less abundant Cyclopoid families Lubockiidae and Saphirinidae did not contribute significantly to the total copepod numbers. A total of 109 copepod taxa were identified. During the night, The average number of taxa gradually decreased from the surface to the lower layers, while higher diversity and more copepod taxa were present in the middle layers during the day (Figure 2). Low species diversity was observed below 600 m depth, in the layers where progressive disappearance of some mesopelagic species is evident. Elucidating the finer temporal dynamics of vertical distribution will provide better insight into the seasonal vertical distribution of copepods under different hydrographic conditions. In addition, future work highlighting information on the vertical behavior of copepods at the species level, considering the variability of their body sizes, trophic levels and life histories, will further improve the understanding of vertical carbon flux in this highly dynamic area.
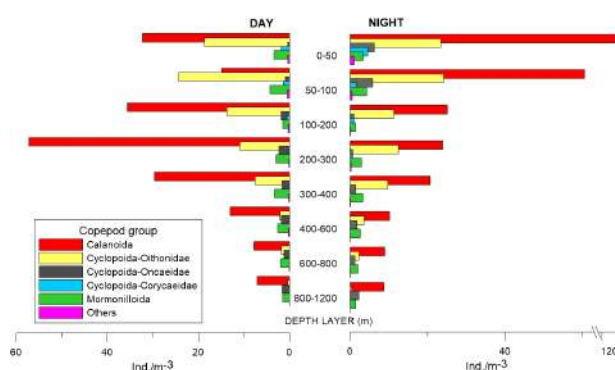

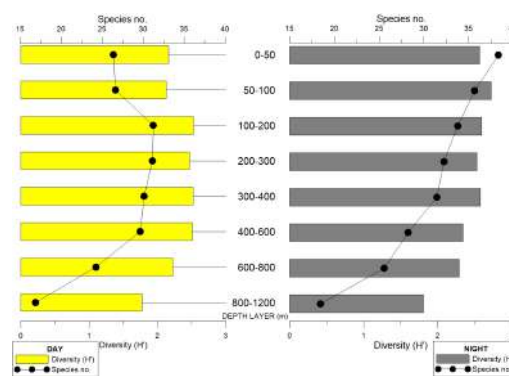Fig. 1. Day-night vertical distribution of copepod abundance.

Fig. 2. Day-night vertical distribution of copepod diversity.

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FIRST INSIGHT ON MOLECULAR IDENTIFICATION AND NYCTHEMERAL VERTICAL DISTRIBUTION OF *PSEUDODIAPTOMUS MARINUS* (COPEPODA: CALANOIDA) IN ITALIAN WATERS.

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Abstract

The non-indigenous copepod *Pseudodiaptomus marinus* is being increasingly recorded in numerous sites along the Mediterranean coasts. In this contribution, the first results collected in the framework of the PIRATES project (Pseudodiaptomus marinus bIo-ecological tRAits through mulTidisciplinary approachES) shed new light on key ecological traits of this species, allowing a better understanding of the mechanisms supporting its spreading.

Keywords: Gulf of Napoli, Adriatic Sea, Alien species, NIS, Zooplankton

Over the past 17 years, the calanoid hyperbentic copepod *Pseudodiaptomus marinus* Sato, 1913, native to Indo Pacific area, has been spreading rapidly throughout European waters [1-3]. Since 2007, confirmed occurrences have been documented in Italian waters, and *P. marinus* has been recorded also in the Tyrrhenian Sea (e.g., Gulf of Naples) and in the Adriatic Sea (e.g., Gulf of Trieste). Species-specific physiological, behavioural and genetic traits (e.g., euryhalinity, eurythermicity, behavioural plasticity, occurrence of different morphs) confer on *P. marinus* the ability to settle down in sites characterised by different biotic and abiotic conditions. As a consequence of its wide adaptability, *P. marinus* is considered a species of potential concern, and has been included in early warning lists of non-indigenous species (NIS) in several Countries. Nevertheless no targeted monitoring is presently carried on.

The fast expansion of this NIS has motivated the new project PIRATES (Pseudodiaptomus marinus bIo-ecological tRAits through mulTidisciplinary approachES), funded by the Italian Ministry of University and Research (PRIN 2022). In detail, PIRATES will integrate: 1) microscale observations of the 3D swimming behavior of *P. marinus* under definite stressors; 2) genetic diversity of specimens from different sampling sites; 3) *in situ* investigations on its seasonality and 4) its nycthemeral vertical distribution. Each line of investigation will shed light on target traits, while their merging will define the broader ecological role and potential of this species. Two key areas will be investigated: the Gulf of Naples and the Gulf of Trieste. Here we present the first results related to objectives 2 and 4 of the project.

Individuals from both sites were morphologically identified and investigated using the mitochondrial gene cytochrome c oxidase I (COI), marker of reference for copepods [4]. The results showed that *P. marinus* forms a separate clade compared to other *Pseudodiaptomus* species, and that different haplotypes can be distinguished in the two investigated regions, pointing at different routes of introduction and donor areas.

In December 2023, in the Gulf of Trieste (LTER_EU_IT_056) zooplankton samples were collected four times between dawn and one hour after dusk, by vertical tow of a WP2 net (200 micron mesh) from 3 m above the bottom to surface. *P. marinus* showed clear nycthemeral pattern and its abundance varied from a minimum of 0.92 ind. m^3 at noon (11.40 A.M.) to a maximum of 66.46 ind. m^3 after sunset (5.40 P.M).

On a broader perspective, the framework emerging around *P. marinus* will yield new insight into the mechanisms potentially adoptable by other non-indigenous species, boosting the awareness of invasion ecology in aquatic ecosystems.

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NEW ZOOPLANKTON DATASETS OF SOUTH LEBANON: PRELIMINARY RESULTS AND FIRST RECORDS.

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Abstract
The Levantine basin of the Mediterranean Sea is the first to be affected by sea warming and non-indigenous species arrival from the Indo-Pacific region. This notwithstanding, Levantine zooplankton inventories lack recent datasets. The present study, although limited to a single date - November 2022 - reports on representatives of two families and one subclass of Crustacea as new records for the Levantine basin.

Keywords: Plankton, Levantine Basin, Biodiversity

Introduction. The Levantine basin of the Mediterranean Sea has a negative water balance, with evaporation exceeding the freshwater supply (1). Especially, the abiotic conditions make the Levantine basin the first to suffer the warming climate and establishment of new thermophilic Non-Indigenous species (NIS) coming from the Red Sea (2;3). Marine biodiversity and NISs have been mainly studied in benthos (4;5), and zooplankton species lists need to be updated, relying upon the last sampling session in 2007 (6). The aim of the present study is to provide updated data on zooplankton in Lebanese waters. **Methods.** Sampling was conducted in November 2022 within the framework of the project *Blue Tyre - Local Partnership for Sustainable Marine and Coastal Development* (AID 012314/01/6), in three sites off the coast of Tyre (Lebanon). Each site was sampled with three vertical tows (each tow is a replicate) in water column of 30 m using a 200 µm mesh sized plankton net. Each sample was fixed (80% EtOH) and stored in the *Blue Tyre Project* inventory (Department of Biological and Environmental Sciences and Technologies of the University of Salento, Lecce, Italy). Samples were analysed under a compound microscope and specimens were preliminary identified to the LPT (Lowest Possible Taxon). Taxonomic abundances per sample were normalized to taxon per m^{-3} to allow a comparison with previous literature on Lebanese zooplankton communities. **Results.** The analysis of the collected material allowed us to obtain a provisional checklist of 84 taxa. The most represented taxon was Copepoda (Crustacea) (35 taxa, mainly identified to Family level), particularly Calanoida (17 Families). Calanoida was also the most abundant taxon, with 116.7 - 407.7 specimens per m^3. The most abundant copepod family was Clausocalanidae (Calanoida), followed by Oithonidae (Cyclopoida), and *Evadne* spp. (Branchiopoda, Onchyopoda) (Fig.1).
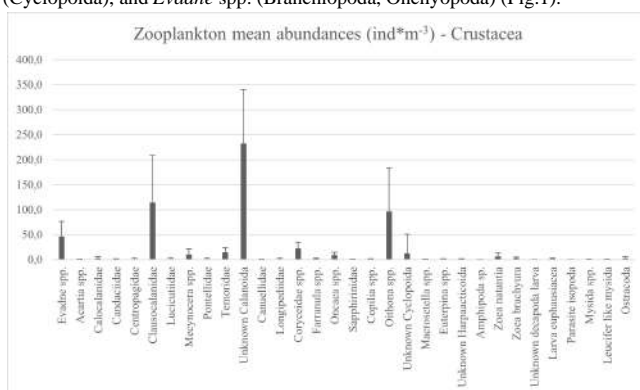

Fig. 1. Mean abundances of the identified Crustacea in the nine samples, expressed in individuals per cube meters.

In terms of rare taxa, Canuellidae and Longipediidae nauplii (Copepoda, Harpacticoida), were reported for the first time in Lebanese plankton, together with Y-nauplii (Thecostraca, Facetotecta) that represent a novelty for the whole Levantine Basin. **Discussion and Conclusion.** The results of the study revealed significant differences from previous research (Autumnal data set) in both abundances and taxonomic presence provided by (7), who collected zooplankton in a nearby area of South Lebanon, and by (6,8), who provided most of the available data for Lebanese zooplankton. In previous studies (6,8), Copepoda were dominated by *Paracalanus parvus*, *P. crassirostris*, and *Acartia discaudata*, while all November 2022 samples showed a dominance of the family Clausocalanidae, 10 times more abundant than Paracalanidae. The revised checklist of the whole Lebanese plankton (6) describes the Autumn as a prolongation of the Summer season in hydrologic and planktonic point of view, with remarkable abundances of Hydromedusa, Siphonophora, Polychaeta larvae, Appendicularia, Cirripedia larvae and Radiolaria, with presence of *Leucifer* mysis (year peak), and dense macroscopic aggregations of Ctenophora. All these taxa were found in November 2022 too, with *Leucifer* mysis reflecting what already described by (6). Canuellidae and Longipedidae (nauplii), were found for the first time. The forementioned taxa show shapes and features already detectable in nauplii, allowing the first record of two Copepoda families in Lebanese waters. On the other hand, Y-Nauplii (Facetotecta) have been poorly studied worldwide due to unavailability of the adult stage and only few authors provided literature on their taxonomy (see 9, and references therein). Their finding in November 2022 not only allows a first record in the whole Levantine Basin, but their future identification will add more clarity on this poorly known taxon. The future taxonomic identification to species level of all the collected sample will provide new data on Eastern Mediterranean, with particular attention on NIS of Lessepsian origin and eventual description of new taxa.

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ICHTHYOPLANKTON ASSEMBLAGE IN THE CHANNEL AREAS OF EASTERN ADRIATIC SEA

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Abstract
From March to September 2023, ichthyoplankton sampling occurred in the eastern Adriatic channel area. A total of 1059 fish early life stages were isolated, with 87% successfully identified, encompassing 34 fish species. Anchovy dominated the collected ichthyoplankton (43.4%), alongside notable proportions of sardines, sprats, and round sardinella. Monthly observations indicated higher ichthyoplankton presence during the summer months. No significant linear correlation between abiotic and biotic parameters was found, except a negative correlation between sardine early life stages abundance and sea temperature.

Keywords: Ichthyoplankton, Larvae, Adriatic Sea, Mediterranean Sea

Introduction
Studying ichthyoplankton occurrence and assemblage helps us to understand adult population patterns and identify spawning and nursery grounds, crucial for resource management. In the face of climate change threats, scientists seek reliable indicators like ichthyoplankton assemblages to monitor and predict ecosystem changes long-term [1]. The majority of Adriatic fish stocks are currently overexploited or in overexploitation [2], there is an evident imperative for this kind of analysis that should bring us closer to better managing this ecosystem.

Materials and methods
In the channel area of the eastern Adriatic Sea (Fig. 1) monthly ichthyoplankton samples were collected from March 2023 till September 2023, except in May, by standard vertical plankton tows using a WP2 sampler (mouth opening, 0.255 m^2; mesh size, 0.200 mm) and preserved in 10% formaldehyde.
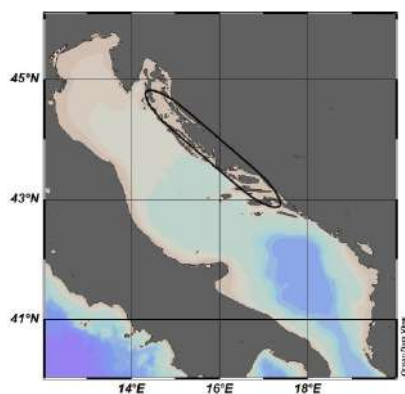

Fig. 1. Study area (circulated)

In the laboratory, ichthyoplankton were isolated under the binocular and identified according to their morphological characteristics. The sea surface temperature and salinity (mean value obtained for the first 10 m depth) were measured at each station using a CTD probe to analyse the possible correlation between abiotic and biotic parameters.

Results and discussion
From the collected ichthyoplankton samples (N=72), 1059 early developmental stages (311 eggs and 748 larvae) were isolated, representing both pelagic and demersal fish species. According to their morphological characteristics, we identified the early life stages of 34 fish species, while 13% of ichthyoplankton remained unidentified. Anchovy early life stages dominated quantitatively (43.4%) during the entire research period. Following anchovies, sardines (10.8%), sprats (8.7%), and round sardinella (6.9%) constituted significant proportions in the overall sample, while all other species were below 6% (ranging from 0.2% to 5.6%). All collected early life stages belonged to species whose spawning in this part of the Adriatic and Mediterranean occurs during the warmer part of the year (spring-summer; [3]). Sardines eggs and larvae were recorded during March and April, after which anchovy early life stages dominated the samples until the end of the research period which is in line with [4]. In general, the abundance of all collected ichthyoplankton at positive stations ranged from 8 to 888 early life stages of fish/m², with an average value of 176.3±182.6 early life stages of fish/m². Monthly observations indicated a higher representation of ichthyoplankton during the summer months, specifically from June to August (Fig. 2).
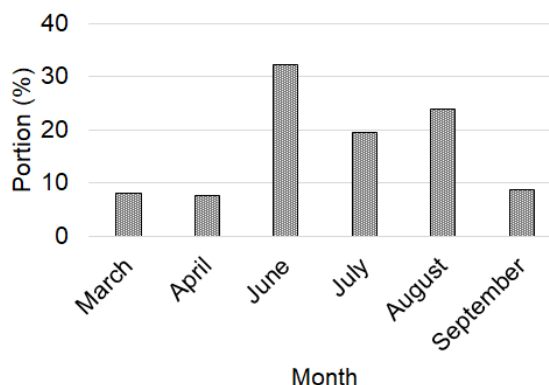

Fig. 2. Monthly ichthyoplankton abundances oscillation in the channel areas of investigation, March – September 2023

Linear correlation analysis between measured abiotic (sea temperature, salinity) and biotic parameters (abundance of anchovy, sardine, and overall fish early life stages) revealed a significant negative correlation between sardine eggs and larvae with sea temperature (R=-0.946). Other correlations were not statistically significant.

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STYLOCHEIRON ABBREVIATUM G.O. SARS, 1883.: LARVAL POPULATION DYNAMICS IN THE DEEP ADRIATIC WITH NEW INSIGHTS INTO THE DEVELOPMENTAL CYCLE

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Abstract

The study was conducted in the deep southern Adriatic Sea during four seasons. The results of the measurement of hydrographic parameters confirmed that the annual temperature fluctuations were limited to the surface layer down to a depth of 100 meters, while the salinity fluctuations were low throughout the water column. The presence of such stable hydrographic conditions contributes to the relatively constant composition of the euphausiid community. These results relate to the seasonal distribution and abundance of the euphausiid larvae *Stylocheiron abbreviatum* G.O. Sars, 1883., which are representative of the open southern Adriatic. During the identification of the species, slight deviations from the previously known keys for the developmental stages were found, so that we introduce their addition for this species.

Keywords: Zooplankton , Adriatic Sea

Material and methods

Zooplankton was sampled at a single station (41°44' N 17°52' E) at 1200 m depth in the southern Adriatic Sea during four seasons. Thirty-five sample series were collected with an opening and closing Nansen net (200 μm mesh size, 113 cm diameter) at standard oceanographic depth intervals. The average towing speed of all trawls was 0.5 m s−1. The samples were preserved in a 4% formalin-saltwater solution buffered with $CaCO_3$. In winter and spring, the average temperature dropped from less than 16°C at the surface to 13°C at the bottom. In summer and autumn, the temperature was higher: 23.5°C at the surface and 15°C below 50 m. Salinity was higher in winter (38.50 at the surface and 38.98 at 400 m depth) and spring (38.4 to 39.06 at 200 m depth), with little variation in summer (38.6 at the surface to 38.5 at the bottom) and autumn (38.7 to 38.8). Chlorophyll levels (0.85 ml/L) were higher in the surface layer in winter and 0.83 ml/L between 50-100 m in summer.

Results

The larval development of euphausiids is considered to be the longest and most complex in the entire class of Malacostraca [2]. Euphausiids go through 7 stages of development: egg, pseudonauplium, metanauplium, nauplii, calyptopis, furcilia and postlarvae. The phases are divided into stages that normally correspond to the period between two coats. In this study, we analysed the calyptopis and furcilias of *Stylocheiron abbreviatum*. Calyptopis were found in all seasons. In winter, their numbers were low, while they increased during the rest of the year, reaching the highest average values in autumn. In winter, they were recorded in the column from 50 to 1200 m, but not with an abundance of more than 4 ind. 100 m^{-3}. In April, calyptopis were found in all layers except at the surface, with a maximum of 34 ind. 100 m^{-3} in the 100 to 200 m layer. Corresponding to the warm season, larger aggregations were found in deeper layers. In the summer months, the highest value of 32 ind. 100^{-3} m was measured in the 200 to 400 m layer. In autumn, they were only found between 200 m and 600 m depth with a maximum of 37 ind. 100 m^{-3}. Furcilia of *S. abbreviatum* were found in samples from all seasons. The lowest abundance was found in winter. An increase in abundance followed in spring with the highest value for this annual cycle. Summer was characterised by a decrease in the number of furcilia, which continued in autumn. Higher values of *S. abbreviatum* furcilia were always found in layers up to 100 m depth, and single individuals were found down to the lowest layer. The highest number of 32 individuals was found in winter. 100 m^{-3}. A clear maximum of 371 ind. 100 m^{-3} was recorded in April. In June, the highest number was 158 ind. 100 m^{-3} in the 15 to 50 m layer and 140 ind. 100^{-3} in the 50 to 100 m layer. In July, the numbers are lower and part of the population sinks below 200 meters. In autumn, there are again strong concentrations in the surface layer with a maximum of 53 ind. 100 m^{-3}. During the identification of the species, slight deviations from the previously known keys for the developmental stages were found, so that we bring their addition for the species *Stylocheiron abbreviatum* G.O. Sars, 1883 (Tab. 1).

Tab. 1. Analysed developmental stages and phases of *Stylocheron abbreviatum*. Newly found stages are marked with an asterisk (*).

Phase	Pleopods - number and setation (')	Stage	Telson and lateral spines (t-terminal, l-posterolateral)
Calyptopis		Ca I	6t+3l
		Ca II	6t+3l
		Ca III	7t+3l
Furcilias	0	F I 0	7t+3l
	1	F I 1	7t+3l
	2	F I 2 (*)	7t+3l
	5	F I 5 (*)	7t+3l
	1'	F II 1'+2	7t+3l
	2'+3	F II 2'+3 (*)	7t+3l
	3'+2	F II 3'+2	7t+3l
	5'	F III 5t+2l	5t+2l
	5'	F III 1t+2l	1t+2l

Three newly described stages of the furcilia phase: F I 2, F I 5, F II 2' + 3. The method of development of pleopods and spines on the telzone was used to determine the developmental stages [1].

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CIESM Congress Session : Biology and Ecology of Marine Resources I
Moderator : Fabio Badalamenti – IAS-CNR, Palermo, Italy

Session's Synthesis

During the session "Biology and Ecology of Marine Resources I", eight oral contributions were presented, all focused on the collection of what can be defined as "Essential Information for Fisheries and Aquaculture". This baseline data - ranging from organism morphology, age determination and growth rates to reproductive biology and diet - serves as the foundation for understanding fish population dynamics and supporting effective management strategies. The focus on essential information highlights both the current research gaps in certain Mediterranean regions and the fundamental role these data play in improving ecosystem and fisheries models, especially in areas where precise, localised data are lacking. It was recognised during the session's discussions that the collection of these essential data can have a profound impact on improving the understanding of fish populations and ecosystem dynamics, ultimately leading to better fisheries and aquaculture management. Specifically, these parameters allow fisheries scientists to build models that predict population trends, assess the sustainability of fishing practices, and guide regulations that maintain fish stocks at sustainable levels while supporting the improvement and monitoring of aquaculture activities. The more data researchers collect, the more they can identify relationships between variables - such as environmental factors, physiological traits and species interactions. These insights may facilitate the discovery of hitherto unknown phenomena and promote a more profound comprehension of ecosystems, fisheries dynamics and biodiversity. Such comprehensive knowledge may facilitate the development of new innovations in the fields of management, conservation, and scientific methodology.

However, it was also noted that ecosystem and management modelling could be carried out in areas where basic information is limited, using data from more thoroughly studied regions as a proxy. Although this approach may be necessary, it can reduce the accuracy of models in reflecting the unique dynamics of these areas. Consequently, there is a need to expand research efforts in all regions of the Mediterranean to improve the reliability of models to support effective management of marine resources.

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ANALYSE COMPARATIVE DE LA BIOLOGIE DE DEUX ESPÈCES D'ATHERINES DU COMPLEXE D'ESPÈCES *ATHERINA BOYERI* DANS LE GOLFE D'ANNABA.

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Abstract

Une comparaison basée sur différents paramètres biologiques a été réalisée au niveau du golfe d'Annaba à l'Est algérien de deux espèces d'atherines; ponctuée (*Atherina punctata*) et non ponctuée (*Atherina boyeri*) appartenant au complexe d'espèces *Atherina boyeri*.

Keywords: Algerian Basin, Population Dynamics, Reproduction, Teleostei, Growth

Introduction

Les athérines sont des petits poissons téléostéens vivant dans les zones côtières, les estuaires et les lagunes, allant des lacs d'eau douce aux lacs hyper-salés. *Atherina boyeri* est considérée comme un complexe taxonomique, divisé par certains auteurs en trois espèces ou sous-espèces [1-4], deux formes marines et une autre lagunaire, Malgré la variabilité morpho-anatomique des deux espèces marines, leur systématique est encore débattue. La raison de cette situation est la rareté des éléments séparant les deux espèces. L'objectif de cette étude, est de comparer quelques paramètres biologiques via l'analyse de la reproduction et de la croissance des deux atherines marines, ponctuée (*Atherina punctata*) et non ponctuée (*Atherina boyeri*).

Matériels et Méthodes

L'échantillonnage mensuel a été réalisé à l'aide d'une senne de plage d'une maille de 4 mm, entre Février 2017 et Février 2018 dans le golfe d'Annaba à l'Est algérien. L'étude est fondée sur un ensemble de 4270 individus dont 2735 *A. punctata* (64.28% de femelles et 35.72% de mâles) 2.9cm<Lt<10.7cm, 0.17g<Pt< 12.2g. et 1535 *A. boyeri* (63.71% de femelles et 36.29% de males) 2.5cm<Lt<13.1cm, 0.007g<Pt<14.8g.

Résultats

L'étude du cycle sexuel révèle que la période de reproduction d' *A. punctata* s'établie entre Janvier et Juin et pour *A. boyeri* elle est décalée et débute en Février pour s'achever en Juillet. La taille à la première maturité sexuelle (L50) d'*A. punctata* est estimée à 6,8 cm TL pour les femelles et à 6.3 cm TL pour les mâles et pour *A. boyeri* : $L50_F$ = 7,9 cm, $L50_M$ = 7,5cm. La croissance pondérale des deux atherines (*A. punctata* et *A. boyeri*) est caractérisée par une allométrie majorante (Fig. 1, 2). L'étude de la sex-ratio a montré que les femelles sont toujours plus nombreuses que les mâles pour les deux espèces. Quatre groupes d'âge ont été observés chez *A. boyeri* (mâles et femelles) et cinq groupes d'âge pour *A. punctata*, les deux sexes confondus. La fonction de von Bertalanffy associée aux données de taille à l'âge rétrocalculé pour *A. punctata* est la suivante : $Lt = 14.18 [1 - e^{-0.119 (t + 1.764)}]$ pour les femelles, $Lt = 11.75 [1 - e^{-0.173 (t + 1.271)}]$ pour les mâles. Pour *A. boyeri* : $Lt_F = 10.36 [1 - e^{-0.224 (t + 1.026)}]$, $Lt_M = 9.87 [1 - e^{-0.390 (t + 0.573)}]$.

Discussion

Selon les résultats obtenus et en utilisant différents outils de comparaison, *Atherina punctata* et *Atherina boyeri* présentent des différences distinctives, non seulement dans leur morphologie mais également sur plusieurs aspects de leur biologie. Ceci fournit un élément supplémentaire pour soutenir la reconnaissance de leur classification en tant qu'espèces distinctes.
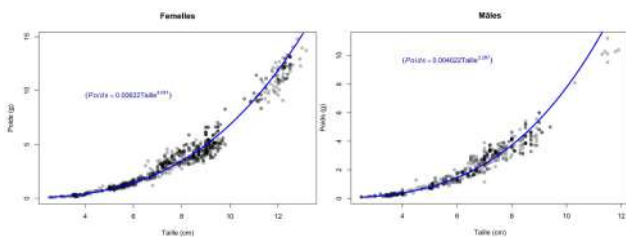

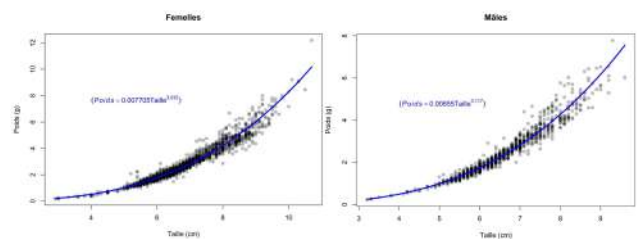Fig. 1. La relation taille-poids chez la population d'*Atherina boyeri* du golfe d'Annaba.

Fig. 2. La relation taille-poids chez la population d'*Atherina punctata* du golfe d'Annaba.

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GROWTH FEATURES OF WILD AND FARMED MUSSELS (*MYTILUS GALLOPROVINCIALIS*) IN THE ADRIATIC SEA - PRELIMINARY RESULTS

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Abstract

Mussels (*Mytilus galloprovincialis* Lamark, 1819) from three Adriatic coastal areas and six sites in Italy were analyzed to assess morphological features and quality in wild and farmed populations. Condition Index (CI) and weight percentages of meat, shell, and water were calculated for each site. In two areas, farmed mussels had higher CI and meat percentages compared to wild ones, while the shell-to-total weight (SW/TW) relationship varied significantly across the sites.

Keywords: Bivalves, Aquaculture, Artificial reefs, Growth, Adriatic Sea

Introduction

Mussels are crucial to Italian shellfish production, primarily sourced from aquaculture in lagoons and the open sea [1], with some from wild populations in the central and northern Adriatic Sea. Recently, both farmed and wild mussels have experienced decreased meat content and increased shell fragility, negatively impacting their quality and market value. Given the static nature of farming techniques and similar issues in wild populations, recent environmental factors are likely causing these impacts. This paper outlines initial findings from research focused on identifying key environmental factors influencing both farmed and wild mussel populations analysing the biological and skeletal properties of mussels, in relation to physical, biochemical, and biological features of the water column.

Material and Methods

Investigations were carried out at three Adriatic coast locations in Italy—Emilia Romagna (Rimini, RN), Marche (Senigallia, SG), and Abruzzo (Giulianova, GN). In March 2024, two samples of mussels were collected from both an artificial reef (AR) and a longline mussel farm (MF) at each area, at depths of 11-14m. Measurements were taken on approximately 250 specimens per sample, including Total shell Length (TL), Total Weight (TW), and various other metrics for mussels longer than 25mm. The Condition Index (CI) [2] was calculated, and statistical tests (Mann-Whitney-Wilcoxon Test) were performed to identify differences among size classes across the six sites. Additionally, relationships between TL, TW, and shell weight (SW) were analyzed using regression models, factoring in the site-specific variations. Lastly, the composition percentages of meat, shell, and water relative to the total weight were determined for each site.

Results and Conclusions

All samples showed seed presence, likely settled early in 2024, with similar modal classes (6-10 mm TL; Table 1). Intermediate settlements from fall 2023 (modal classes of 38-42 mm TL), were observed at RN and SG MFs and GN AR. The largest individuals were primarily found at ARs, mainly at SG AR. TL/TW relationship (Table 1) did not differ across sites (p>0.05), whereas a significant variability was observed for SW/TW relationships (P<0.05) with the RN wild population showing a higher SW (41%). Farmed mussels generally exhibited a higher condition index (CI) than wild ones, particularly in specific size classes at GN (50-59 mm TL) and RN (60-69 mm, 70-79 mm TL). Due to a lack of size overlap between the farm and reef, comparisons at SN were infeasible. These findings suggest that the strategic positioning of longline farms, which likely benefits from consistent nutrient flow, impacts mussel quality, supporting the hypothesis with higher meat percentages noted in RN and SG farms (44% and 48%, respectively). Initial data show variations in mussel populations across different areas and between wild and farmed groups within the same area. Notably, farmed mussels at two sites have higher edible content, consistent with previous findings along the Adriatic coast [3]. Further sampling and detailed analysis will enable to further investigate potential structural differences and their causes.

Acknowledgements

Tab. 1. Biological parameters of mussels. Number of observation, a and b coefficients and r^2 are reported for the Relationships TL/TW and SW/TW. TW = total weight; TL = total length; SW = shell weight; MF = mussel farming; AR = artificial reef.

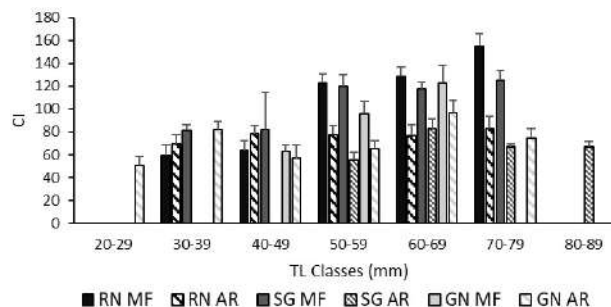|		Rimini MF	Rimini AR	Senigallia MF	Senigallia AR	Giulianova MF	Giulianova AR
	No observations	276	267	251	250	250	221
	TW (g)	3060	2090	2479	5484	2163	2409
	TL Range (mm)	3-75	4-81	2-72	3-92	3-63	3-75
	modal classes (mm)	8; 42; 60	8; 50	8; 38; 58	8; 72	6; 50	10; 38; 58
TL/TW Regr.Param.	No observations	276	267	251	250	250	221
	a	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	b	2.7841	2.6890	2.7247	2.7696	2.7893	2.7684
	r^2	0.9914	0.9750	0.9867	0.9865	0.9794	0.9850
SW/TW Regr.Param.	No observations	75	67	46	50	50	67
	a	0.2865	0.371	0.3393	0.2616	0.3183	0.2663
	b	0.7996	0.3401	0.3042	2.419	0.2519	0.9355
	r^2	0.9294	0.9197	0.8614	0.7088	0.7722	0.9021

Fig. 1. Condition Index (CI ± se) obtained for the 6 mussel samples. RN = Rimini; SG = Senigallia; GN = Giulianova; MF = mussel farming; AR = artificial reef.

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AGE AND GROWTH PROPERTIES OF THE MEDITERRANEAN SLIMEHEAD (*HOPLOSTETHUS MEDITERRANEUS* CUVIER, 1829) INHABITING NORTH-EASTERN MEDITERRANEAN

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Abstract

In this study, a total of 432 specimens of *Hoplostethus mediterraneus* was captured by commercial trawler from northeast Mediterranean. The total length ranged from 6.4 to 17.6 cm in females and from 6.5 to 18.6 cm in males. Growth parameters of the von Bertalanffy growth function were L∞=23.57 cm, K= 0.1409 year-1, t_0= -1.675 years in females and L∞= 22.67 cm, K= 0.1596 year-1, t_0= -1.1423 years in males. The growth performance index was 1.900 for all individuals.

Keywords: Population Dynamics, Fisheries, Fishes, Growth, Eastern Mediterranea

Introduction

Hoplostethus mediterraneus (Mediterranean slimehead) is one of bathypelagic fish species inhabiting near the bottom at depths 100-1408 m [1]. This species is widely distributed in the Mediterranean Sea, including the Atlantic Ocean from the British Isles to South Africa, Indian Ocean and New Zealand [2]. There are only two study on the length-weight relationships and otolith morphometry of *H. mediterraneus* [3, 4]. Therefore, this study provides the first information on the age and growth of the this species in the North-eastern Mediterranean Sea (Türkiye).

Material and methods

A total of 432 individuals (167 females and 265 males) of *H. mediterraneus* were captured with a commercial bottom trawler at depth of 230-410 m off the Iskenderun Bay. Total length (TL) and total weight (TW) were measured to the nearest mm and 0.01g respectively. A total 376 Sagittal otoliths were read as whole and one opaque zone with one transparent zone considered as annual growth (Figure 1). Growth parameters was estimated using the von Bertalanffy growth equations [5] and growth performance index (φ') [6].

Fig. 1. Otolith of *H. mediterraneus* with four rings and a total length of 14.6 cm.

Results and discussion

Minimum-maximum length and weight of caught fishes were determined as 6.4-17.6 cm and 3.4-77.92 g for females and 6.5-16.8 cm and 3.4-66.88 g for males respectively. The maximum age recorded, based on otolith reading, was seven years for a female individual of TL of 17.6 cm, while males reached a maximum age of 6 years (TL=16.8 cm). The parameters of the von Bertalanffy growth function for all individuals were: L∞=23.15 cm, K = 0.1483 year-1, t_0= -1.563 years, whereas for the two sexes separately were estimated as: L∞=23.57 cm, K= 0.1409 year-1, t_0= -1.675 years, and L∞= 22.67 cm, K= 0.1596 year-1, t_0= -1.1423 years, for females and males respectively. The growth performance index was 1.900 for all individuals.

Tab. 1. The von Bertalanffy growth parameters ve growth performance values of *Hoplostethus mediterraneus* inhabiting north Eastern Mediterranean

Sexes	N	L∞(cm)	k (year^{-1})	to (year)	Φ'
Female	167	23.574	0.1409	-1.675	1.894
Male	265	22.670	0.1596	-1.423	1.913
All	432	23.153	0.1483	-1.563	1.900

The estimates of the asymptotic length were lower than those reported by Anastasopoulou [7], D'Onghia et al. [8] and Vitale et al. [9] in the Mediterranean Sea. This could indicate differences in the growth performance among the different populations, although the different modelling approaches could also have caused the divergence of the estimates. Von Bertalanffy growth parameters (Table 1) showed that this species has slow growth rate, such several deep water species.

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MORPHOLOGICAL DIFFERENTIATION OF THE SARDINE *SARDINA PILCHARDUS* FROM THE NORTH AFRICAN COAST

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Abstract

L'analyse de la morphologie somatique de *S. pilchardus* a révélé deux groupes significativement distincts : le premier comprenant les individus de Jijel, et le deuxième regroupe la population du golfe d'Annaba et de Tunis. D'autre part, l'analyse discriminante réalisé sur les coordonnés procrustes de la forme du corps permet une meilleure différenciation, et a permis de différencier les trois groupes.

Keywords: Fishes, Biometrics, Algerian Sea

Introduction

S. pilchardus (Walbaum, 1792) est une espèce de poisson pélagique côtier à croissance rapide et de courte durée de vie [1], largement répartie dans la mer Méditerranée et le long de l'Atlantique NE, des mers Celtiques et du Nord jusqu'en Mauritanie et au Sénégal [2]. Parmi toutes les méthodes d'identification des stocks disponibles, l'analyse des caractères morphométriques est l'une des plus couramment utilisées. Dans cette étude nous utilisons la forme du corps et les caractères métriques comme outils de discrimination de différentes populations de *S. pilchardus* en Méditerranée.

Matériels et méthodes

Pour l'étude de la morphologie somatique, 204 individus provenant de trois localités, le golfe d'Annaba (N=129 ; $10,85 \leq Lt \leq 22,58$cm), Jijel (N=61 ; $11,32 \leq Lt \leq 18,64$cm) et de Tunis : (N=39 ; $13 \leq Lt \leq 16,32$ cm), ont été décrit utilisant 9 paramètres métriques. Une analyse discriminante a été réalisée utilisant ces paramètres, et une analyse par validation croisée (Jackknife) a été utilisée pour évaluer la qualité et validité de la discrimination. Une classification hiérarchique (méthode de Ward) permettant d'observer la similarité selon le site d'étude, a été réalisée avec le package FactoMineR avec le logiciel R®. Concernant la morpho-géométrie du corps, l'analyse a été réalisée sur les mêmes individus, ces derniers ont été numérisés à l'aide d'un appareil photo à haute définition. Utilisant le logiciel TpsDig2, douze landmarks ont été sélectionnés de manière à intégrer la forme générale du corps. Une analyse canonique de la variance (CVA), ainsi qu'une analyse discriminante sur les coordonnés procrustes de chaque groupe d'individus a été réalisée avec le logiciel MorphoJ V1.06d.

Résultats

Le test statistique F de Fisher montre que toutes les variables sont discriminantes pourvu que les valeurs de signification enregistrées soient inférieures au seuil de 5%. Ainsi, la classification des échantillons (fig. 1) donne un bon degré de fiabilité. Le pourcentage des individus totaux bien classes est de 73,7%. Le pourcentage des individus les mieux classes sont de 100 % pour les spécimens de *S. pilchardus* de Jijel, suivie par ceux du golfe d'Annaba (76,47 %), puis ceux de Tunis (57,89%).
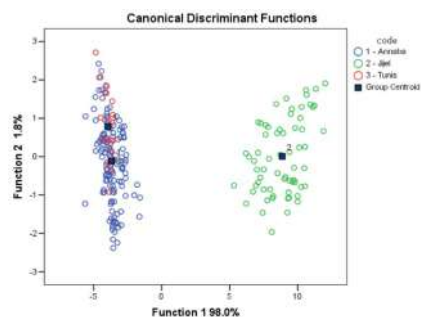

D'autre part, l'analyse discriminante deux à deux réalisée sur les coordonnés procrustes de la forme du corps permet une meilleure différenciation, et a permis d'identifier trois groupes distincts, avec un taux de reclassement de 100% en comparant les individus d'Annaba avec ceux de Jijel ou de Tunis. Le taux de reclassement en comparant les individus provenant de Jijel avec ceux de Tunis est de 86,36% pour la population de Jijel et 66,66% pour celle de Tunis.

Discussion

Les résultats obtenus utilisant la morphologie somatique et la morpho-géométrie du corps, vont dans le même sens et mettent en évidence une variation intra-spécifique. Cette variation morphologique a été observé sur les côtes atlantiques marocaines, utilisant la morphométrie [3, 4] ou encore la forme des otolithes [5,6] et peut être expliquée par des facteurs environnementaux ou la disponibilité alimentaire ou encore la croissance de ces poissons. Cette étude souligne aussi le fait que la morphologie somatique et la forme du corps peuvent être utilisées avec succès pour l'identification des stocks de *S. pilchardus*, son utilisation étant facile, relativement rapide, et peu coûteuse comparée à d'autres méthodes.

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Fig. 1. Représentation graphique de l'analyse discriminante comparant les trois populations de *S. pilchardus* utilisant les caractères métriques.

AGE AND GROWTH PARAMETERS OF MUGILIDAE SPECIES (*MUGIL CEPHALUS* AND *CHELON RAMADA*) FROM SIDI SAAD RESERVOIR

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Abstract

This study aims to compare age and growth parameters of *Mugil cephalus* (Linnaeus, 1758) and *Chelon ramada* (Risso,1810) from Sidi Saad Reservoir in Tunisia for one year (from January to December 2016). A total of 204 specimens of *Mugil cephalus* and 530 specimens of *Chelon ramada* were subjected to biological analysis. The ages of *M. cephalus* and *C. ramada* were determined from measurements of scales. The total length weight (W) relationship was estimated at $W = 0.0081 \times TL^{3.07}$ for *M. cephalus* and $W = 0.0105 \times TL^{2.9644}$ for *C. ramada*. A total of 10 age classes are observed for *M. cephalus*, versus only 8 for *C. ramada*. The parameters of Von Bertalanffy growth were estimated for two species : $L\infty = 77.87$ cm, $K = 0.1147$ a-1, $t_0 = -2.41$ for *Mugil cephalus* and as $L\infty = 52.01$ cm, $K = 0.1782$ a-1, $t_0 = -1.41$ for *Chelon ramada*.

Keywords: Fisheries, Tunisian Plateau, Growth

Introduction - In Tunisia, the exploitation of reservoir of fishing dates back to the 1960s. This activity was initiated through the rearing of certain dam reservoirs of Mugilidae fry and their exploitation of fishing [1]. The good growth observed in the introduced Mugilidae species revealed that dam lakes may represent a significant potential for fish production [2]. Thus, knowledge of the biology of these species is essential for the management of these fisheries. This study provides preliminary information on the age and growth of the *Mugil cephalus* and *Chelon ramada* fish in Sidi Saad Reservoir. Knowledge of these parameters contributes to the proper estimation of this resource and the management of the fishery for a sustainable development.

Material and methods - Mugilidae species were collected using gillnets from Sidi Saad reservoir (Fig. 1). Samples were directly carried to Marine Biology Lab. The total length (TL), measured to the nearest millimeter and weights (total weight WT, eviscerated weight We and gonad weight Wg) were measured using a toploading digital scale (precision of 0.01g).
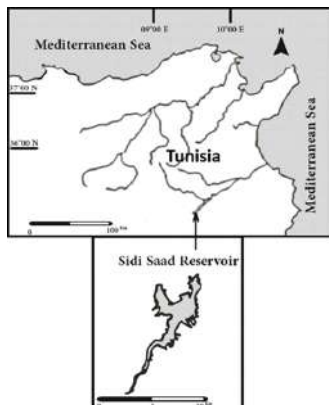

Fig. 1. Geographical position of Sidi Saad Reservoir (Tunisia).

For age estimation, scales were taken from above the lateral line, behind the pectoral fin individuals. They were cleaned with water and examined under the stereo binocular microscope. The von Bertalanffy growth curve was fitted to data of the resulting age-length of through Marquardt's algorithm for nonlinear least squares parameter estimation. The FSAS program was used to estimate the parameters of the Von Bertalanffy growth equation [3]: $Lt = L\infty (1 - e^{-k(t-t_0)})$; $Wt = W\infty [1 - K(t - t_0)]^b$ where Lt = the predicted fork length at age t, $L\infty$ = the mean asymptotic fork length, K: the growth constant (year-1), and t_0: the theoretical age at which the fish would have been zero length, Wt is the weight of the fish at age t and $W\infty$ is the asymptotic weight [4].

Results and Discussion - The Von Bertalanffy growth equations fitted to fish length are:

• For *Mugil cephalus*: $TL = 84.03 (1- e^{-0.1012(t + 2.64)})$ for females; $TL = 72.64 (1- e^{-0.1291(t + 2.18)})$ for males and $TL = 77.87 (1- e^{-0.1147(t +2.41)})$ for combined sexes
• For *Chelon ramada*: $TL = 53.13 (1- e^{-0.1733(t + 1.42)})$ for females; $TL = 50.93 (1- e^{-0.1830(t + 1.4)})$ for males and $TL = 52.01 (1- e^{-0.1782(t +1.41)})$ for combined sexes. The growth in weight described by the Von Bertalanffy equation for females, males and combined sexes is presented respectively below:
• For *Mugil cephalus*: $W = 6685.02 (1- e^{-0.1012(t + 2.64)})^{3.09}$; $W = 3927.63 (1- e^{-0.1291(t + 2.18)})^{2.99}$; $W = 5142.91 (1- e^{-0.1147(t +2.41)})^{3.07}$.
• For *Chelon ramada*: $W = 1348.13 (1- e^{-0.1733(t + 1.42)})^{2.95}$; $W = 1222.63.63 (1- e^{-0.1830(t + 1.4)})^{2.98}$; $W = 1283.39 (1- e^{-0.1782(t +1.41)})^{2.96}$.

M. cephalus has a higher growth potential than that of *C. ramada* which has a relatively slow growth. By comparing our results with those found by authors who worked on Mugilidae outside dams, we can say that growth in freshwater is faster for *Mugil cephalus*. A similar result was found by [5], reporting that the fathead grey mullet reaches an overall weight twice that of the thinlip grey mullet in a freshwater lake. [6] indicated that mullets living in coastal ponds and estuaries generally grow faster than in the open sea.

Conclusion - Our finding gives new insight on the growth parameters of two freshwater species (*Mugil Cephalus* and *Chelon ramada*) harvested from a Tunisian reservoir. This work will be needed for future stock evaluation, management and preservation.

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MEDITERRANEAN MUSSEL *MYTILUS GALLOPROVINCIALIS* VALVE GAPING BEHAVIOUR AS A PROXY OF FAVOURABLE ENVIRONMENTAL CONDITIONS

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Abstract

Mussel valve movement (gaping) is widely recognized as an integrative measure of physiological functions such as respiration, feeding and excretion, which can change under stressful conditions in response to a deteriorating environment and pollution. Using a valve gaping monitoring system (VGMM) based on an Arduino microcontroller platform and Hall sensors, we monitored valve gaping (VG) of six mussels during acclimatisation to laboratory conditions for 4 days. By analysis of VG results it was possible to determine the mussel's normal daily rhythm, > 70 % time filtrating with the valve open > 50 % and 1-5 resting periods with the valve open < 30 %. Achieved results contribute the present knowledge of normal mussel VG behaviour under favourable environmental conditions needed for further field and laboratory experimental work.

Keywords: Bivalves, Adriatic Sea, Behaviour, Pollution, Monitoring

Introduction - The mussel *Mytilus galloprovincialis* Lamarck, 1819 is an important commercial mariculture species and a powerful bioindicator commonly used to monitor marine pollution in coastal and estuarine areas [1,2]. More recently, behavioural markers have been used to assess changes in mussel and ecosystem health in response to various threats and as part of biological early warning systems (BEWS) [3]. Mussel valve movement (gaping) is widely recognised as an integrative measure of physiological functions such as respiration, feeding and excretion, which can change under stressful conditions in response to a deteriorating environment and as a defensive response to external stimuli such as touch or shading or the sudden approach of a predator [4]. In this preliminary study, we observed the valve gaping of 6 mussels for four days to extend the current knowledge of the normal VG behaviour of mussels under favourable environmental conditions.

Materials and Methods - Under laboratory conditions (40 L tanks with aeration and seawater flow), 6 acclimatised mussels (5 cm in size) were connected to the Valve Gaping Mussel Monitor (VGMM). The VG was measured using Hall sensors and magnets attached to the mussel shells, which were connected to the Arduino Uno microcontroller and a notebook. We tested measurement frequencies of 0.5, 1.0 and 2.0 Hz for the VG assessment of the mussels to avoid processing and analysing huge data sets (43,200; 86,400; 172,800 measurements per mussel/day). Since the opening/closing of the mussel valves is a slow physiological process, we chose a frequency of 0.5 Hz as it was satisfactory to record and analyse all valve movements. The Hall sensor output is proportional to the magnetic field strength, but because of the small differences in sensor and magnet position, including the mussel shell size (different valve gape), each sensor output was normalised by subtracting the minimum value to obtain the value of zero for a closed mussel shell, and at the end of the experiment, the maximum VG value was used as 100 % open mussel shell.

Results and Discussion - The mussels were monitored for 4 days to determine normal valve gaping (VG) behaviour as an indicator of their normal filtration and resting activity. We chose a line graph of shell opening (0 - 100 %) during each day (Fig. 1 A) and a bar graph of the cumulative daily VG occurrence of the mussels (24 h, 0:00 - 24:00 h) (Fig. 1B) as the most appropriate representation of the mussels' VG behaviour. We found that each mussel has its own VG behaviour pattern and repeats the same resting and filtration periods on each day of VG monitoring. The mussels used have a good condition index (meat yield, 21.3 %) and good fitness (SOS-test LT50, 9.3 days), so we can conclude that the mussel that has more resting and fewer filtration periods with VG > 30 % has better vitality and/or the environmental conditions (e.g. food supply) are more favourable. The valve closures (resting periods) were not synchronised in the six mussels, indicating that they were not controlled by a common stressor. Cameau et al. [4] described a similar normal *M. galloprovincialis* valve gaping behaviour with maximum valve gape opening at night and minimum opening during the day. They show that mussel aquaculture rafts in favourable Galician waters rarely close valves during a 10-day VG monitoring period (2.55 % daily occurrence). In our mussels, the valves (VG < 30 %) were open on average 23.19 % of the time during the 24-hour period.
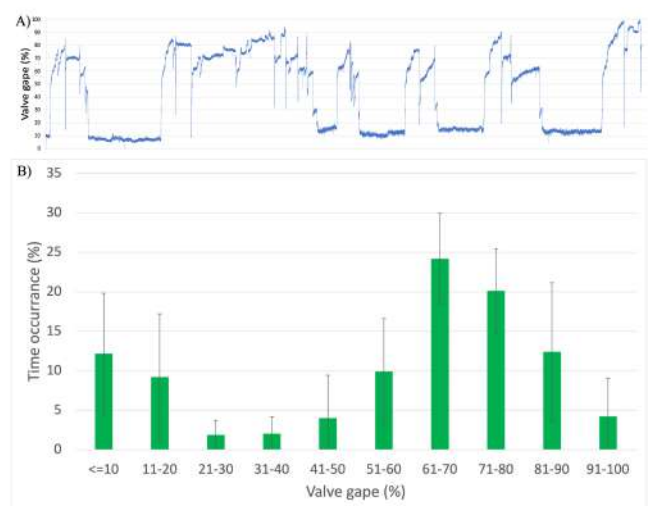

Fig. 1. A) Representative mussel valve gaping behaviour under the favourable environmental conditions (0:00 - 24:00 h) and B) Average percent time occurrence of cumulative daily mussel valve gaping (24 h) with standard deviations.

Conclusion - The normal VG behaviour with circadian diurnal rhythm described in this study for *M. galloprovincialis* corresponds to the general behaviour of filter-feeding mussels under optimal and undisturbed conditions. The average temporal occurrence of mussel valve gaping (filtration proxy) shows a typical binomial distribution that can be described by a polynomial regression.

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GROWTH PARAMETERS OF ATLANTIC MACKEREL (*SCOMBER SCOMBRUS*, LINEAUS, 1758) IN NORTH AEGEAN SEA (E. MEDITERRANEAN).

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Abstract

This study examines the growth patterns of 115 Atlantic mackerels (*Scomber scombrus*, Linnaeus, 1758), consisting of 50 males and 65 females, captured in 2023 by the commercial fleet along the North Aegean coast (GSA22). Age determination was conducted by analyzing annual growth rings on otoliths extracted from 106 individuals. The observed mackerels exhibited lengths ranging from 205 to 315 mm (average of 248 mm) and ages spanning from 0 to 4 years (with mean lengths at ages 0 – 4 being 212, 221, 254, 269, and 297 mm, respectively). Analysis of the length-weight relationship indicated a positive allometric growth trend (b > 3.0). These findings contribute valuable insights into the growth characteristics of Atlantic mackerel within a relatively understudied region of its European habitat range.

Keywords: Fisheries, Aegean Sea, Growth

Introduction - Atlantic mackerel (*Scomber scombrus*) is a key pelagic species found in the northern Atlantic and Mediterranean waters, playing a critical role in the economies of European coastal states. This study concentrates on the northern Aegean Sea, a heavily exploited area within the Mediterranean. We seek to investigate the length-weight relationship (LWR), of Atlantic mackerel in this region.In fisheries biology, LWRs serve as critical tools for estimating weight and biomass based solely on length measurements, providing insights into individual condition and enabling comparisons of species growth across diverse regions [1]. Despite the extensive history of fishing in the Mediterranean, research on the Atlantic mackerel population here remains relatively limited compared to other marine ecosystems [2]. Therefore, understanding these biological parameters is essential for effective management and conservation of this important fishery resource.

Materials and Methods - The study area was the northern area of the Aegean Sea. Samples were collected during 2023 from three separate commercial catches, in Martch, August and November. All samples were randomly selected, obtained fresh and subsequently processed in the laboratory for biological analysis. For each fish, all nessessary biological parameters were recorded. Age was determined from sagittal otoliths following the procedures and criteria described by ICES [3] assuming to be 1st of January as the date of birth, and annual rings as every translucent growth band followed by an opaque. The LWR was determined by fitting an exponential model: $W=aL^b$ to the dataset. The parameters *a* (representing the initial condition factor) and *b* (indicating the allometric coefficient) of the LWR were estimated through linear regression analysis using the least-squares approach.

Results and Discussion - The length distribution ranged from 205 to 315 mm, with an average length of 248 mm. Approximately 74% of the individuals measured between 235 and 275 mm in length. Notably, our sample primarily consisted of fish from commercial catch, thus we observed a limited presence of very small or large individuals.

The relationship between length and weight of *S. scombrus* was analyzed based on total length measurements (fig. 2). Overall, the intercept value was a=0.0022 and the exponent b (3.4201) was found to be greater than 3, indicating a positive allometric pattern of growth, as pointed by relevant literature [4,5].
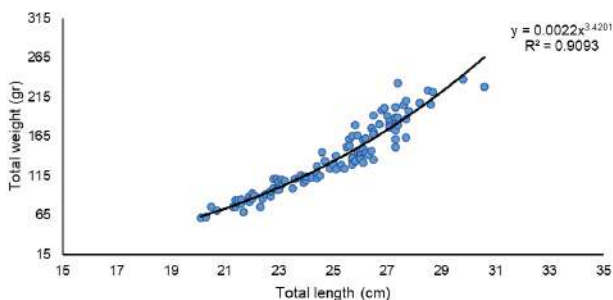

Fig. 1. Length-Weight Relationship of Atlantic mackerel in the North Aegean in the frame of the present study.

Table 1 displays the length distributions and counts of 106 individuals divided across five different age groups (0-4), along with the mean length observed at each age. The results of this study could be particularly valuable for fisheries managers given the current lack of efficient information on the local population of Atlantic mackerel. Additionally, they could aid fisheries scientists in future stock assessment studies, thereby supporting sustainable management efforts for commercially important pelagic fish species within GFCM Area GSA 22.

Length (mm)	Age groups				
	0	1	2	3	4
205	1	3			
215		6			
225	1	9			
235		10	4		
245		3	10	1	
255			8		
265			18	10	
275			6	9	
285			1	5	
295				1	1
305					1
315					1
n	2	31	47	26	3
Mean length (mm)	212	220	254	269	297

Fig. 2. Length distributions, number of individuals by age group, and mean length at age of *S.scombrus* in the North Aegean.

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AGE ESTIMATION OF THE EUROPEAN HAKE *MERLUCCIUS MERLUCCIUS* CAPTURED IN THE NORTHEASTERN OF ALGERIA

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Abstract

Our choice was on a demersal species (the European hake *Merluccius merluccius*) of an important economic value. The sampling was carried out during a year on a total of 662 individuals captured in the Northeastern of Algeria. Results were surprising; indeed, growth patterns were clear and did not need a prior treatment. The otolith reading of specimens provide a success rate of 90.82%. The total length was between 11 to 46.6 cm for ages ranging from 0+ to 7 years. This work contributed to a better understanding of the growth dynamics of the *M. merluccius* population on the Algerian coast, which is of great importance for the management and conservation of this essential resource.

Keywords: Conservation, Fishes, Growth, Stock assessment, Algerian Sea

Introduction

This difficulty in interpreting the otoliths is an important problem in the field (Morales-Nin et Moranta, 2004) mainly due to the otolith shape and the formation of annual/intermediate rings or the prolonged spawning period. The age estimation the European hake is based on the interpretation of the growth rings in the otoliths, which presents an unusual complexity that has been widely reported in the literature (Piñeiro and Saínza, 2003). Currently, the otolith approach is the only internationally recognized method for accurately estimating the age of *M. merluccius*.

Material & methods

A total of 662 of European hake specimens were collected from commercial landings between January 2021 to December 2021(12 months) in the southern Mediterranean Sea (El Kala Coast, Annaba Gulf and Skikda Gulf – East of Algeria) (Figure 1). For each specimen, total length "Lt" (cm), total weight "Wt" (g). The otoliths are cleaned mechanically and air-dried at room temperature, stored in labeled microtubes (Eppendorf*) for later examination, and kept in a cool, dark place. The clarity of the growth marks on the otoliths of the captured fish allowed direct interpretation without prior preparation using an Olympus stereo microscope under reflected light on a dark background. The assessment of their age was made by counting the growth rings using the formula (Panfili et al., 2002): Age (Month) = 12 * N+ (ranK C−ranK B) N: the number of rings; § rank C: the month of capture; § rank B: the date of birth (which is taken to be 1st January). The age-length key was obtained for males, females, immatures and the total population; the mean length in each age class was calculated (Panfili et al., 2002).

Results

Reading the otoliths of specimens caught on the east Algerian coast gave a success rate of 90.82%; the total length was found to be between 11 and 46.6 cm for ages ranging from 0+ to 7 years. The key length-age is summarized in the table 1. Here, the von Bertalanffy equation is expressed as follows (Figure 2):

Total population $Lt=47.25(1-e-0.33(t-(-0.35))$ Female $Lt=50.95(1-e-0.31(t-(-0.34))$ Male $Lt=40.29(1-e-0.46(t-(t-(-0.48))$ The asymptotic total length of females is higher than that of males, but the opposite phenomenon is observed for the growth coefficient (K). Immature fish show a very fast growth, with a k of around 0.77. The observation of the otolith edge nature (opaque or hyaline edge) highlighted that the most opaque margins were observed in cold period, whereas translucent margins were noted in warm period (Figure 3).

Tab. 1. Age-length key of *M. merluccius* captured in the east coast of Algeria (IM: Immature, F: Female, M: Male, ID: Indeterminate).

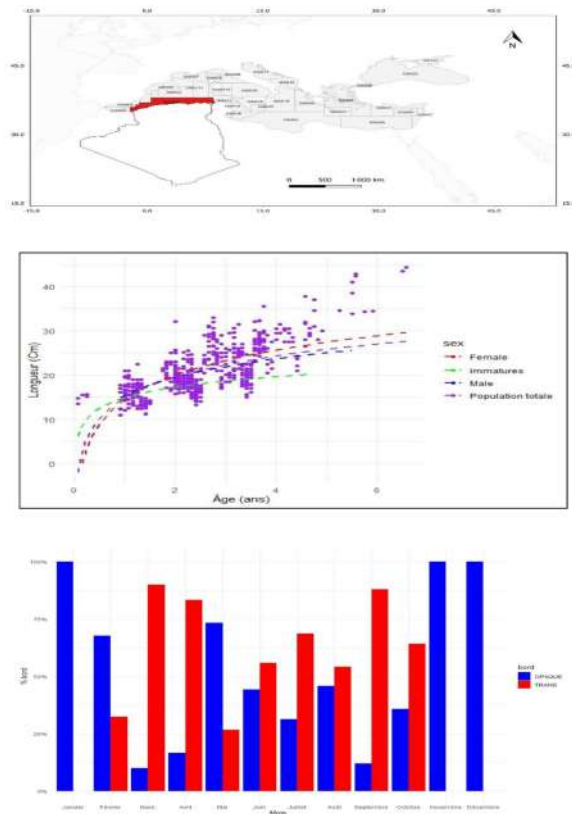| Classes of age	0-1				1-2				2-3				3-4				4-5				5-6				6-7		
Sex	IM	F	M	ID	IM	F	M	ID	IM	F	M	ID	IM	F	M	ID	IM	F	M	ID	IM	F	M	ID	IM	F	M
Length (cm)																											
[11-16[	44	40	8		59	25	3		1																		
[16-21[	9	30	29		78	75	4		2	8	3		3														
[21-26[	2	9	1		12	52	19	9	3	20	5	5	3						2								
[26-31[			9		1	10	2	6		19	7	4	13	5	1		2	3					1				
[31-36[						1				3	2		2	1			4				2						
[36-41[													1				2										
[41-46[													2				1				2				2		

Fig. 1. Top: Geographical sub-area GSA 04 (red color) involved in this study; Middle: Growth curve for *M. merluccius* caught on the east coast of Algeria; Bottom: Opaque and translucent edges of otoliths.

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CIESM Congress Session : Biology and Ecology of Marine Resources II
Moderator : Francesco Paolo Mancuso – Univ. of Palermo, Italy

Session's Synthesis

The session "Biology & Ecology of Marine Resources II" provided a platform to eight contributions that shed light into the complex dynamics of Mediterranean marine ecosystems, including genetic studies of commercially important species to ecosystem-level analyses. It covered issues related to genetics of octopus populations, fish migration, and climate change consequences. It gave much importance to fisheries management and conservation with different research in the analysis of the European hake nursery regions in the Strait of Sicily and an examination of trawling fleet captures along the Spanish Mediterranean coast. This has turned the genetics part of marine resource management into a hot topic; hence, extensive studies have been carried out on the population structure of *Octopus vulgaris* and DNA identification of a single species in the eastern Mediterranean. The genetics part of marine resource management has become a critical subject, as is shown through the extensive study of *Octopus vulgaris* population structure and DNA identification of a single species in the eastern Mediterranean. Methodological development was marked, with presentations showing the complementarities taken from traditional morphological methodologies together with the most advanced molecular techniques. Interest in long-term monitoring was underlined by studies of interannual fluctuations in fish populations, in particular those involving *Boops boops*, which gave possible signs of climate change consequences in the Mediterranean area. These have attracted much interest on the spatial distribution and population dynamics of many species, including research into depth-related patterns in the distribution of *Spicara flexuosum*, and details on the complexity of European eel migration pathways. These findings underlined both the interplay of Mediterranean marine ecosystems and, simultaneously, a need for regionally coordinated research activities. Some of the recurring themes then noticed included population structure and reproductive biology, as noticed with the extensive study on the otolith features of *Diplodus annularis* and studies on the sex ratio for a variety of species. These researches have provided the significant insight into life cycle strategies and their implications for resource management. After the presentations, constructive discussions followed. The discussions brought into focus the importance of coordination in research at many dimensions and disciplines in confronting the multi-faceted challenges facing Mediterranean marine resources. The session underlined the collaborative spirit of marine research in showcasing vibrant Mediterranean marine science and a forum such as CIESM for expanding our understanding of marine ecosystems.

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GENETIC DIVERSITY OF THE COMMON OCTOPUS, *OCTOPUS VULGARIS* IN THE MEDITERRANEAN SEA AS REVEALED BY THE MICROSATELLITE MARKERS

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Abstract

In this study, we investigated population structure and genetic diversity of *Octopus vulgaris* in the Mediterranean Sea, focusing our attention on the Siculo-Tunisian Strait. A total of 275 individuals from eight localities in the West and Central Mediterranean basins were analyzed for five polymorphic microsatellite loci. The overall genetic divergence (Fst = 0,0105 P<0,001) indicated a significant genetic structuring in the study area. The differentiation and sub-structuring detected among Mediterranean samples provides important information for fisheries management of *O. vulgaris*.

Keywords: Genetics, Sicily Channel

Introduction

The common octopus *Octopus vulgaris* Cuvier 1797 is a benthic cephalopod of commercial interest distributed in the whole Mediterranean Sea, Atlantic Ocean and NW Pacific [1]. As regards the genetic structure of the common octopus in the Mediterranean region, previous investigations based on allozymes [2] and the mitochondrial region *COIII* and *COI* [3, 4] rejected the hypothesis of a single panmictic unit within the Mediterranean Sea, being present a clear genetic break between the western and eastern basins. The microsatellite analysis by Cabranes et al. [5] of *O. vulgaris* collected around the Iberian Peninsula and Canary Islands found significant genetic structure, which was consistent with the isolation by distance pattern. The aim of this study was to compare the levels of genetic diversity of *O. vulgaris* samples collected from different areas of the Mediterranean Sea and to define the pattern of population genetic structure in relation to the hydrographical and biogeographical barrier (the Siculo-Tunisian Strait). To accomplish this aim we genotyped individuals of *O. vulgaris*, collected in 8 localities in the western and central Mediterranean Sea, for five microsatellite loci.

Material and Methods

Samples of *O. vulgaris* were collected from eight Mediterranean localities. From each animal, a tissue sample of about 30 mg was excised from mantle or tentacles and stored in absolute ethanol at -20°C until DNA extraction. Genomic DNA was isolated using the Qiagen DNeasy tissue kit. All eight samples were screened for variation at five polymorphic microsatellite loci (Oct3, Oct6, Ov8, Ov10, and Ov12) previously characterized for O. vulgaris by [6]. PCR reactions were carried out in a total volume of 20 ml. Amplification products were resolved on an ABI PRISM 3100 Genetic Analyser, and analysed using GeneMapper v.3.5 software. The software Micro-Checker 2.2.3 was used to identify possible genotyping errors within the microsatellite dataset by performing 1000 randomizations. The program GENETIX software was used to calculate global Fst and pairwise Fst values among all populations. Statistical significance was determined using 10,000 permutations.

Results and Discussion

A High level of genetic diversity was revealed with the five microsatellite loci. The mean number of alleles per locus ranges between 10,4 and 24 and unbiased heterozygosity exceeding 0.845. Global Fst value was highly significant (Fst = 0,0105 P<0,001) indicating differentiation among Mediterranean samples of *Octopus vulgaris*. After Bonferroni adjustment, significant pairwise Fst values were obtained between western and central Mediterranean samples as well as within central basin (Table 1). Finally, our analysis of population structure in the Mediterranean Sea based on microsatellite markers agrees with the analysis previously conducted using mitochondrial DNA in detecting sub-structuring among Mediterranean populations, which can be used as guidelines for a fisheries management perspective.

Tab. 1. Pairwise Fst values among samples. Significant values after Bonferroni adjustment are in bold.

Fst	Sete	North Tunisia	Sicile	Coastal Kerkennah	Deep Kerkennah	Zarzis	Libya
North Tunisia	0.0165	-					
Sicile	0.0112	0.0119	-				
Coastal Kerkennah	**0.0410**	0.0061	**0.0221**	-			
Deep Kerkennah	0.0164	0.0037	**0.0111**	0.0071	-		
Zarzis	**0.0449**	**0.0123**	**0.0333**	0.0093	**0.0110**	-	
Libya	0.0224	0.0076	0.0054	0.0135	-0.0012	0.0117	-
Malta	0.0066	0.0068	0.0020	**0.0204**	0.0004	**0.0255**	0.0028

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IDENTIFICATION OF NURSERIES OF EUROPEAN HAKE (*M. MERLUCCIUS*) AND ENVIRONMENTAL CORRELATES IN THE STRAIT OF SICILY

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Abstract
Improving exploitation patterns in multispecies fisheries requires protecting nursery areas to reduce mortality on early life stages of commercial species. European hake (*M. merluccius*) is an important fishery resource in the Strait of Sicily. While Fishery Restricted Areas to protect hake nurseries have already been implemented in the northern sector, similar information and measures are missing in the southern sector. Analyzing 6 years of data (1997-2004) from 1348 stations, we identified high-recruit density areas that could serve as potential nurseries. The relationships between the recruit density index and abiotic features were investigated, revealing an overlooked bell-shaped relationship with sea surface height, an indicator of cyclonic vortexes. This suggests its influence on the nursery distribution and hake recruitment success.

Keywords: Habitat, Sicily Channel, Management, Fisheries, Fishes

One of the effective management measures for modifying exploitation patterns and achieving the sustainable use of fishery resources is the reduction of fishing pressure on the recruitment [1]. In multispecies fisheries, where the adoption of selective multi-species gear is difficult, Fishery Restricted Areas (FRAs) can be implimented and located in essential fish habitat of early recruits of commercial species where specific abiotic and biotic features promote their growth and survival [1]. The European hake (*M. merluccius*; HKE) is a necto-benthonic predator, with continuous recruitment, and one of the main commercial species for fishery in the Mediterranean Sea. In the Strait of Sicily (SoS), the HKE fishing mortality corresponds to Maximum Sustainable Yield (MSY) value after decades of overfishing status, while the stock spawning biomass remained below the MSY threshold [2]. Early HKE recruits (i.e, young of the year, below 15 cm of total length [3]) are exposed to bycatch in bottom trawling, targeting deep water rose shrimp (*P. longirostris*; DPS) in the SoS [4]. Three FRAs were established in the northern SoS, encompassing the persistent nurseries of both HKE and DPS (GFCM/40/2016/4). In this work, we investigated the persistence of high-density index of early HKE recruits across a wide area, extending to the southern SoS and up to 30 nautical miles from the Tunisian coast. We analyzed data by kriging with depth from 1348 hauls obtained from autumn surveys between 1997-2004, excluding 1999 and 2002, as part of GRUND survey.
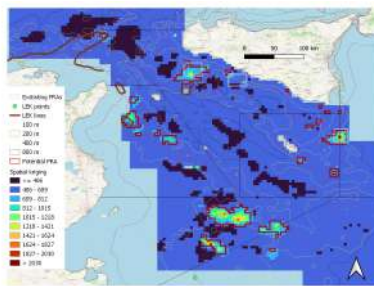

Fig. 1. Spatial interpolation of recruit density index and contouring by hotspot analysis. Local Ecological Knowledge (LEK) from fishers on hake nurseries occurrence is overlaid.

This allowed to identify uncharted persistent nurseries in the southern sector of SoS, eligible as FRAs as planned by the GFCM management plan in the SoS (Art. 30 - GFCM/45/2022/4).Hotspot analysis from mean annual kriging outputs allowed to distinguish two important areas for HKE recruitment off the Africa coast, supported by the fisher's local ecological knowledge (Figure 1). One of the newly found nurseries in the southern SoS was also confirmed by a recent fishery-independent survey in 2019 [5]. Additionally, we explored the relationship between recruit density index and some abiotic features. Not only we were able to confirm the strong role of sea bottom temperature, bathymetry, rugosity and slope [3],[4] but also

revealed an overlooked bell-shaped relationship with sea surface height (SSH), showing its peak around - 0.4 meters (Figure 2).
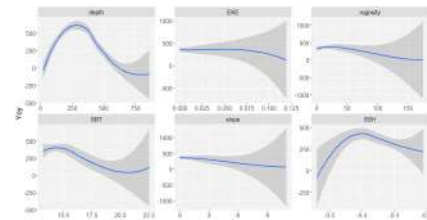

Fig. 2. Smoothing LOESS function between recruit density index and abiotic factors: bathymetry (depth), eddy kinetic energy (EKE), rugosity, sea bottom temperature (SBT), slope, sea surface height (SSH).

The range of the SSH indicates the occurrence of cyclonic vortexes that are known to create favorable food availability for the HKE recruits [6]. Seasonal and permanent cyclonic vortexes in the SoS [7], seem to play a crucial role in the identified high-recruit-density areas. Further investigations need to be focused on the inclusion of sea surface height in species distribution model and on the contribution of its variation to the distribution of those species recruits with a pelagic dispersal phase. The understanding of this patterns could improve the fishery managment quantify the role of existing FRA across the years and improving the identification of new FRA in the SoS.

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SEASONAL MAPPING OF THE TRAWLING FLEET CAPTURES ALONG THE SPANISH MEDITERRANEAN COAST: COMPOSITION BY SPECIES AND POPULATION STRATA

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Abstract

In the Mediterranean Sea, intensive bottom trawling activity has resulted in an overexploited state of some demersal stocks. Since 2020, and within the EU multiannual plan (EUMAP), specific measures have been implemented to restore these stocks. This study focuses on the spatio-temporal trends of commercial catches along the Western Spanish Mediterranean. Our results may contribute to a better understanding of the catch composition by fishing grounds and fishing strategies as well as provide insights into the spatio-temporal dynamics of catches obtained from the bottom trawl fleet and their landings, considering biomass and economic importance.

Keywords: Fisheries, Demersal, Western Mediterranea

Introduction

Bottom trawling is one of the most important fisheries in the Western Mediterranean, as it produces the highest seafood biomass and highest economic revenue [1]. However, this resource extraction may lead to overexploitation and depletion of fish stocks [2]. To mitigate the effects of fishing activity on the marine environment in the Western Mediterranean, a Multiannual Plan for demersal fishing (EUMAP, EU Reg 2019/1241) was implemented in 2020. This plan focuses on fishing being environmentally, socially and economically sustainable in the long-term. Among other technical measures, EUMAP mentions area closures and an effort reduction up to 40%. Despite the evident multispecific nature of bottom trawling, EUMAP establishes five main target species based on their importance, both in terms of biomass and economic benefit: *Aristeus antennatus* (ARA), *Parapenaeus longirostris* (DPS), *Merluccius merluccius* (HKE), *Mullus* spp. (MUX) and *Nephrops norvegicus* (NEP). This analysis enables the identification and characterization of the main fishing strategies of the Spanish trawling fleet and allows the analysis of spatio-temporal trends of commercial catches and economic benefit.

Material and methods

This study integrated data from vessel monitoring systems (VMS) and sales notes. These data were combined to geolocate the captures at fishing ground level, calculate catches per unit of effort (CPUE), determine fishing ground profit (in € per day), and analyze fishing strategies through clustering captured species.

Results and discussion

Our outcomes show that effort reduction does not lead necessarily to a reduction in CPUE of target species. Similarly, fishing strategies confirm the great variety of species in the catches across all GSAs, highly dependent of the specific bathymetric, as expected. *A. antennatus,* a fishing strategy of a mainly monospecific nature, predominates in the deeper fishing grounds, whilst in the shelf, a greater variety of captured species is present [3]. Regarding profitability, these deeper grounds are the most lucrative, as the catch species (*A. antennatus, N. norvegicus, P. longirostris)*are highly valued [4]. Overall, EUMAP measures reduce fishing effort, thereby alleviating pressure on marine environment. However, the heterogeneity of bottom trawling captures should be considered for any improvement on the management of these fisheries. Finally, these results provide insights into the detailed spatio-temporal dynamics of demersal communities exploited by bottom trawling, generating scientific knowledge for better implementation of technical measures at a smaller spatial scale.
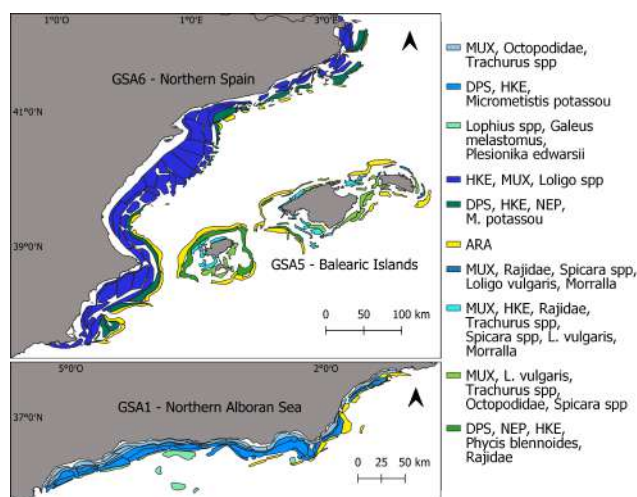
Fig. 1. Spanish GSAs 1, 5 and 6 fishing strategies determined by clusters

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INVESTIGATION OF GSA 22 SOLE STOCK FOR EVIDENCE OF *SOLEA AEGYPTIACA* (CHABANAUD, 1927) VIA DNA

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Abstract

This study investigated the genetic and morphological characteristics of flatfish species in the Thracian Sea, focusing on distinguishing between common sole (*Solea solea*) and Egyptian sole (*Solea aegyptiaca*). A total of 209 specimens were analyzed, with 32 selected for molecular analysis based on morphological features. Polymerase Chain Reaction (PCR) targeting the cytochrome b gene confirmed all specimens as common soles. EcoRV restriction enzyme digestion further validated species identity, revealing specific DNA fragments unique to common sole. Notably, Egyptian sole was absent in our samples, challenging reliance on morphological criteria for species differentiation in this region. These findings emphasize the importance of genetic techniques for accurate species identification and management.

Keywords: Aegean Sea, Fisheries, Genetics

Introduction

In the Mediterranean basin, the common sole (*Solea solea*, Linnaeus, 1758) stands out as one of the most economically significant flatfish species [1]. Alongside this species exists the less common Egyptian sole (*Solea aegyptiaca*, Chabanaud, 1927), which was considered a subspecies of the common sole, *Solea vulgaris*, at the past, due to their similar external morphology [2]. A distinctive morphological feature widely used to differentiate between these two species is the presence or absence of a membrane connecting the caudal fin to the last dorsal and anal fin rays [1,3]. Genetic analysis, however, employing molecular markers offers a more precise and reliable method for distinguishing between these species [4]. The common sole is classified as a priority species within Geographical Sub Area (GSA) 22 under the Greek Data Collection Reference Framework (DCRF). Potential misidentification and oversight of the occurrence of Egyptian sole in this region could lead to inaccuracies in data, with significant implications for the sustainable management of these species. This study aims to validate the use of the aforementioned morphological criterion and investigate the presence of Egyptian sole in the study area.

Materials and Methods

A total of 209 specimens were obtained from 11 different commercial catches in the Thracian Sea during 2020. Upon recording all biological parameters for each specimen, 32 individuals (15.31% of the total annual sample) displaying evidence of a gap (reduced joining membrane) on both sides of the caudal peduncle were selected for molecular analysis (Fig. 1), specifically Restriction Fragment Length Analysis (RFLP) targeting the cytochrome b gene.

Fig. 1. Picture of a sole specimen from the studied sample. Clearly discernible the reduced joining membrane before the caudal fin.

Genomic DNA extraction was performed on these selected individuals using the Chelex 100 DNA extraction method as described by Estoup et al. (1996) [5]. Approximately 20 mg of tissue was placed in 500 µl of a 10% Chelex solution supplemented with 7 µl of proteinase. The mixture was incubated at 55 °C for 75 minutes with periodic vortexing every 15 minutes. Subsequently, the vials were heated to 95 °C for 10 minutes to complete the extraction process. A fragment of the cytochrome b gene (cytb) was amplified following the protocol outlined by Boukouvala [4]. PCR products were then subjected to digestion using EcoRV (Minotech, Heraklion, Greece) according to the manufacturer's instructions. The resulting EcoRV-digested fragments were analyzed by agarose gel electrophoresis (1.5%) and visualized through ethidium bromide staining for further molecular characterization.

Results and Discussion

The polymerase chain reaction (PCR) successfully amplified a 1141 bp fragment of the cytochrome b (cytb) gene. Subsequent digestion of PCR products with the EcoRV restriction enzyme yielded specific DNA fragments characteristic of common sole, consisting of two distinct fragments measuring 413 bp and 728 bp. These fragments serve as reliable markers distinguishing common sole from other members of the Soleidae family [4]. Based on these genetic analyses, all specimens examined in this study were confirmed to be common sole. Our findings indicate the absence of Egyptian sole in the Thracian Sea, challenging the utility of the membrane morphology as a distinguishing feature between these two species. The genetic data provide robust evidence supporting the sole presence of *S. solea* in this region, highlighting the limitations of relying solely on external morphological characteristics for species identification and management.

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MORPHOLOGICAL AND MORPHOMETRIC FEATURES OF THE SACCULAR OTOLITHS IN THE ANNULAR SEABREAM, *DIPLODUS ANNULARIS* (FAMILY SPARIDAE)

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Abstract

Sagittal otoliths of the annular seabream, *Diplodus annularis* (family Sparidae) were analysed using descriptive morphological characters and morphometric indices. In general, otolith shape varied from pentagonal to oval, with the irregular margins. Antirostrum was poorly defined, regardless of the size and sex of the fish. All relationships between the morphometric parameters of the otoliths (length, width and mass) and the body size (total length and weight) of the annular seabream were described using a simple linear model. Otolith length proved to be the best predictor of both total length and weight of the investigated seabream. When analysed by sex, the results for males differed from these, and the strongest relationship to fish weight was shown by otolith width.

Keywords: Biometrics, Adriatic Sea, Fishes

Introduction

Otoliths are one of the most useful and important biological structures of fish in diverse studies. Their numerous practical applications are known, which are not limited only to ichthyology. Thus, for example, saccular otoliths (*sagittae*), which have accretionary growth and species-specific morphology, serve as a powerful tool in fish ageing, ecomorphological, taxonomic, phylogenetic, palaeoichthyological and dietary studies [1,2]. Research on the feeding ecology of piscivorous predators highlight the importance of describing and knowing the morphological and morphometric features of the otoliths. If we add to this the determination of the relationship between fish size and otolith morphometrics, it is possible to determine otolith measures from fish size or the other way around and such data can provide information on the size, mass and energetic content of the fish prey. Therefore, the aim of this study was to investigate otolith morphology and morphometry of the common coastal sparid species, *Diplodus annularis*, that is also important prey of many marine fishes, and to test relationships between fish size and various otolith measures.

Materials and Methods

Samples of the annular seabream were collected in the coastal shallow waters in the eastern Adriatic Sea (Zadar area), using gillnets, in February and March 2020. During the study period, a total of 115 *Diplodus annularis* adults were caught. After their capture, each fish was measured to the nearest 0.1 cm total length (TL), and weighted (W) to the nearest 0.1 g. Sex was determined by macroscopic analysis of the gonads and sagittal otolith pairs were removed, cleaned and stored dry for later examination. Length frequency distributions of females and males were compared using the Kolmogorov-Smirnov two-sample test. Otoliths were photographed using a stereo microscope with an Olympus DP-25 digital camera attached. Otolith length (OL) and width (OW) were measured to the nearest 0.001 mm using Olympus cell^A Imaging Software. Otolith mass (OM) was weighed to the nearest 0.001 g. Differences between left and right otoliths were tested by paired t-test while ANCOVA was used to test for differences in otolith measures between females and males, considering fish length as a covariate. Otoliths were described using the generally accepted terminology [3]. Relationships between fish total length and weight and all otolith morphometrics were constructed using the linear model.

Results and Discussion

Total length of all sampled fish ranged from 14.2 to 18.5 cm (mean TL ± SD = 16.3 ± 0.93 cm). The sample consisted of 80 females (69.6%), 21 males (18.3%) and 14 individuals of indeterminate sex (12.1%). Total length of females and males ranged from 14.2 to 18.5 cm and from 15.1 to 18.5 cm, respectively. The Kolmogorov-Smirnov two-sample test did not show significant difference between length frequency distributions of females and males (P > 0.05). Otoliths of *Diplodus annularis* are pentagonal to oval, with broad and blunt rostrum and poorly defined antirostrum. The *sulcus acusticus* is quite deep, located near the midline of the otoliths. The *ostium* and *cauda* are clearly differentiated and have a different shape, with the *ostium* being slightly shorter than the *cauda*. The funnel-shaped *ostium* opens wide on the anterior part, while the *cauda*, which is tubular, does not reach the posterior edge of the otolith. No significant differences in morphometric measures were found between left and right otoliths (paired t-test, P > 0.05 for all measures) and between females and males (ANCOVA, P > 0.05 for all measures), so data were pooled and mean values for each otolith pair were used in analyses (Table 1).

Tab. 1. Range of otolith measures (OL=otolith length, OW=otolith width, OM=otolith mass) and their mean values with standard deviation (SD).

Otolith measures	Range	Mean ± SD
OL (mm)	5.084 – 6.884	6.028 ± 0.320
OW (mm)	2.996 – 4.307	3.609 ± 0.201
OM (g)	0.016 – 0.039	0.025 ± 0.004

A linear model described relationships between fish total length and weight and otolith length, width and mass. The highest correlation was found between fish weight and otolith length for the whole sample. When the results are analysed regarding the sex, the best predictor of fish weight differed for males (Table 2).

Tab. 2. Parameters of the linear regression between fish total length (TL) and weight (W) and otolith morphometrics (OL=otolith length, OW=otolith width, OM=otolith mass) for all individuals, females and males (a=regression slope; b=intercept value; R^2=coefficient of determination).

Relationships	All individuals			Females			Males		
	a	b	R^2	a	b	R^2	a	b	R^2
TL vs. OL	222.4	2407.7	0.416	217.7	2472.0	0.420	221.0	2586.0	0.539
TL vs. OW	108.5	1841.7	0.252	98.9	2000.4	0.187	113.2	1785.8	0.490
TL vs. OM	0.002	-0.01	0.301	0.002	-0.01	0.289	0.003	-0.02	0.341
W vs. OL	15.0	4876.5	0.432	15.7	4808.2	0.434	12.7	5190.9	0.472
W vs. OW	7.7	3020.9	0.286	7.9	3002.8	0.235	6.8	3101.8	0.477
W vs. OM	0.0002	0.01	0.298	0.0002	0.01	0.305	0.0001	0.02	0.256

The ability to identify species using sagittal morphological and morphometric features has already been proved for teleosts [1], to which our results strongly contribute and therefore they can be helpful in studying feeding ecology of fish predators, for the adequate identification of fish prey and estimation the prey size or mass.

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DISTRIBUTION, SEX RATIO AND LENGTH-WEIGHT RELATIONSHIP OF *SPICARA FLEXUOSUM* RAFINESQUE 1810, IN THE EASTERN PART OF THE NORTHERN AND CENTRAL ADRIATIC SEA

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Abstract

Samples of *Spicara flexuosum* were collected in the eastern part of the Northern and Central Adriatic Sea during fishery–biological survey MEDITS held annually in the spring-summer period from 1996 to 2022. The species was found at depths between 23 and 230 m. Abundance and biomass indices had the highest mean values at 10–50 m depth stratum (554.05 N/km^2 and 14.87 kg/km^2) and decreased with depth. The species had the highest density in the coastal channel areas of the Northern and Central Adriatic and along the western side of the Istria peninsula. The sex ratio (m/f) was 0.43 and the total length of the sex conversion was 14 cm. The length–weight relationship showed a positive allometry (b=3.2198).

Keywords: Fishes, Demersal, Distribution coeffic, Teleostei, Adriatic Sea

Introduction: *Spicara flexuosum* Rafinesque, 1810 (Teleostei: Sparidae) is a demersal fish species distributed in the Mediterranean and Black Sea, and the Eastern Atlantic [1]. The three species of the genus *Spicara* inhabiting Adriatic Sea (*S. flexuosum*, *S. maena* and *S. smaris*) are of commercial interest, with mean annual catches of 113 t in Croatian territorial waters. Previous studies, primarily from the Mediterranean Sea, are focused on the genetics and biometry of this species, nutrition, growth and the length-weight relationships (see in [2]). However, studies in the Adriatic Sea are still scarce. In order to enhance the present knowledge on *S. flexuosum*, this study provides the insight into distribution patterns, length-weight relationship, sex ratio and length of sex conversion in the eastern Adriatic Sea.

Materials and methods: Samples of *S. flexuosum* were collected during the Mediterranean International Bottom Trawl Survey (MEDITS) [3].) which is performed annually, in the spring-summer periodfrom 1996 to 2022. In total, 14384 individuals of *S. flexuosum* were caught during the surveys, and the data were used to analyse the distribution patterns, length-frequency distribution, sex ratio and length of sex conversion. A subsample of 198 specimens was used for calculation of the length-weight relationship. Total length (TL; precision 0.1 cm) and weight (BW; precision 0.01 g) were measured and sex was determined following the MEDITS protocol [3]. Depth and spatial distributions were presented with abundance and biomass indices (N/km^2, kg/km^2) obtained using the "swept area" method [4]. Maps of the spatial distribution were created using GIS techniques (Geographical Information Systems) and displayed using ArcView GIS software [5]. Length-weight relationship was calculated using the formula BW = a * TL^b [4]. The length of sex change was calculated using the logistic curve method [6].

Results and discussion: Specimens of *S. flexuosum* were found in the depth range from 21 to 230 m. The highest abundances were recorded in shallow waters, at depth stratum 10-50 m (554.05 N/km^2, 14.87 kg/km^2). Values were slightly lower at stratum 50-100 m (521.58 N/km^2, 13.79 kg/km^2), while at depts 100-200 m mean abundance and biomass indices drastically decreased (49.83 N/km^2, 1.25 kg/km^2). At depths over 200 m the species was found only sporadically (0.17 N/km^2, 0.01 kg/km^2). Similar distribution was previously noted in the Adriatic [1], while in some other areas of the Mediterranean the species was not found deeper than 130 m [6]. In the eastern Adriatic Sea, the highest abundances were recorded in channel areas of the Northern and Central Adriatic, and along the western side of the Istria peninsula (Fig. 1). The total length (TL) of all measured specimens ranged between 9.0 and 20.0 cm. The average length of males was 13.3 cm and of females 12.9 cm. In this study females were dominant in the sample (m/f = 0.43), similarly to the previous studies in the Mediterranean [7]. *S. flexuosum* is a protogynous hermaphrodite, and according to the existing data for the Adriatic Sea, sex change occurs at TL 12-14 cm [1]. Our results showed that this change occurs at TL 14 cm. In the subsample of 198 individuals, TL ranged from 8.3 to 17.3 cm with mean 14.13±2.02 cm. The body weight (BW) varied from 4.88 to 56.76 g, with a mean 30.79±12.80 g. The formula obtained for the length-weight relationship is: BW = 3*10^{-6} * TL^{3,2198}, and it revealed that the species has a positive allometric growth. This refers only to females, as males were not present in the subsample.
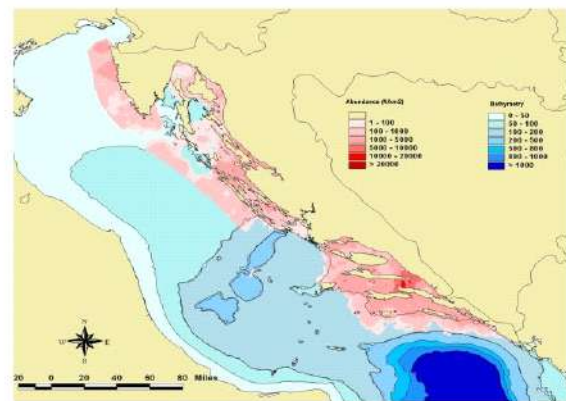

Fig. 1. Distribution of *Spicara flexuosum* in the eastern part of the Northern and Central Adriatic Sea in the spring-summer period (MEDITS 1996-2022)

It was previously found that b was 3.0367 in the eastern Adriatic [8]. In some parts of Turkish waters, and in Greek waters, the growth also showed the positive allometry [2,7]. In some studies in the Mediterranean and Black Sea, authors reported negative allometric or isometric growth for this species (FishBase). These differences are not surprising as length-weight relationships depend on a number of factors such as area of sampling, sex, season, sample size and composition, environmental factors and availability of food [2,8].

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PRELIMINARY OBSERVATIONS REGARDING THE HYPOTHETICAL MIGRATORY PATHWAY OF EUROPEAN EELS FROM THE EASTERN MEDITTERRANEAN TO THE SARGASSO SEA

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Abstract
Over the years, several attempts have been made to document the European eel migratory routes. This study reveals that the eel's breeding migration from Vistonida Lake is facilitated by the primary currents of the Aegean Sea. The early release of the 10 transmitters can be attributed to natural mortality (predation) or not (capture), as well as an accidental event.

Keywords: Migration, Aegean Sea, Spawning

Introduction

Since 2009 in Europe, several attempts have been made to record the reproductive migration of European eel *Anguilla anguilla* (Linnaeus, 1758) to the Sargasso Sea, using satellite devices (GPS) (see Durif et al. 2021). The first attempt to trace the migration routes of eels from Lake Vistonida, located in the Eastern Mediterranean, to the Sargasso Sea was made in 2018 (Aarestrup et al. 2019), although detailed results were not obtained. The objective of this study is to uncover the potential migratory routes of eels from Lake Vistonida to the Sargasso Sea.

Materials and Methods

The satellite devices used in this study were Microwave Telemetry X-Tags, attached to the backs of eels and are battery powered. As soon as the tags are released, they start transmitting the collected data (temperature, depth, etc.). In this study, 12 silver eels, which were captured in Lake Vistonida in January 2024 during their reproductive migration. Before tagging, the eels were anesthetized using a 1% alcohol solution of Eugenol (1.5 ml/10 ml water). Measurements of the total body length and weight, as well as fin length and eye diameters, were recorded. After tagging, the eels were kept in a tank for one day until fully recovered, then, they were released into Vistonida Bay, at a depth of 5 m.

Results and Discussion

The primary data from tags indicate that 10 eels started their migration, as signals were transmitted from various areas of the Aegean and Eastern Mediterranean. It seems that the migration of 8 individuals halted across the Aegean Sea, while 2 individuals spotted in the Eastern Mediterranean. The individual that traveled the farthest distance into E. Mediterranean took about two months to cover that distance (Table 1), approximately 900 km in straight line.

Tab. 1. Summary table of the collected data by the transmitters.

TAGs	Date of Tagging	Date of Received Signal	Longitude	Latitude	Travel Duration (Months)	Transmission area
Sat1	2/2/2024	24/3/2024	23.47209	39.47609	1	Northeast of Volos
Sat2	2/2/2024	26/3/2024	23.9781	39.76577	1	Northeast of Chalkidiki
Sat3	2/2/2024	28/3/2024	24.09038	39.91369	1	West of Limnos
Sat4	2/2/2024	2/4/2024	24.85142	38.29458	2	North-east of Evia
Sat5	2/2/2024	7/4/2024	23.74853	39.78554	2	North of Chalkidiki
Sat6	2/2/2024	25/3/2024	23.46779	39.95977	1	East of Chalkidiki
Sat7	2/2/2024	10/4/2024	24.00445	39.14403	2	North of Alonissos
Sat8	2/2/2024	11/4/2024	26.04219	34.47835	2	South-east of Crete
Sat9	2/2/2024	11/4/2024	20.71789	34.26904	2	East Mediterranean
Sat10	2/2/2024	26/3/2024	24.83094	40.92792	1	Caught by Fisherman

According to Table I, regarding the course of the eels within the Aegean Sea, it is evident that the relationship between distance and duration of the migration route is not proportional. Some individuals took fewer days to travel a longer or nearly equal distance compared to others. The early release of the 10 transmitters can be attributed to natural mortality or mortality by predation, as well as an accidental event that could lead to the release of the transmitter.

The comparison of the results of this study with those of 2018 indicates that eels from Lake Vistonida likely follow a path that is assisted by the main currents of the Aegean Sea (Figure 1).
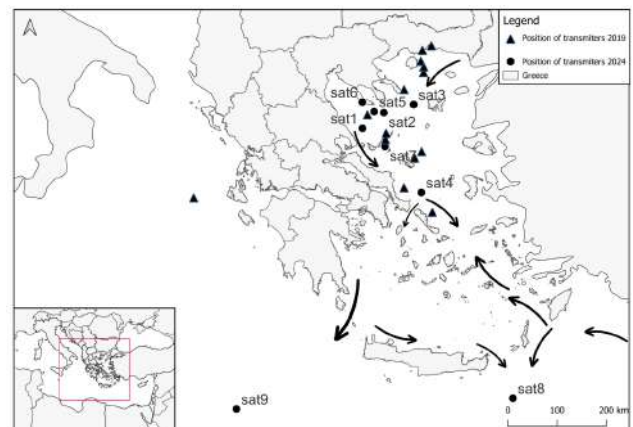

Fig. 1. Map of Aegean and Ionian Sea, showing the position of the individual tagged eels. Triangles indicate the study of 2019 and ircles the study of 2024. Black arrows represent the main currents of the Aegean Sea.

Once the data from all the transmitters are collected, they will be decoded and analyzed, to confirm or refute the hypotheses of this study.

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INTERANNUAL VARIATION (2018-2022) OF ABUNDANCE, BIOLOGY AND SPATIAL DISTRIBUTION OF THE BOGUE, *BOOPS BOOPS* (LINNAEUS, 1758) IN THE NW MEDITERRANEAN SEA.

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Abstract

Bogue abundance and biological parameters have been analyzed based on data collected in the 2018-2022 MEDiterranean International Acoustic Survey (MEDIAS) carried out in July in two different areas of the NW Mediterranean (Northern Spain, GSA06 and Northern Alboran Sea, GSA01). Bogue presented a patchy distribution in GSA06, while in GSA01 its distribution was continous. Bogue condition factor resulted higher in GSA01 than in GSA06. The sex inversion length did not show a clear interannual trend, however the proportion of females showed a decreasing trend in both areas. This fact, according to the literature, would be related to an increase in temperature in the area, so this study not only provided novel information about a little-known species, also opens new areas of research on the role of bogue as climate change sentinel.

Keywords: Acoustics, Fishes, Pelagic, North-Western Medite

Introduction

Bogue is a marine semi-pelagic, gregarious, gonochoric protogynous hermaphroditic Sparidae specie [1]. It distributes in the Eastern Atlantic and throughout the Mediterranean including the Black Sea [2]. Its commercial interest is limited in the NW Mediterranean, being mainly discarded by the purse seine fleet. However, it is ecologically relevant since it is part of the coastal pelagic fish community. Besides, bogue, as sex-reversed fish, could act as climate change sentinel. The purpose of this study is to provide new information about the species, especially that related to the interannual change of its biological parameters (sex ratio and sex inversion length) closely linked to changes in temperature in the ocean [3].

Material and Methods

The analyzed data were collected in July over the continental shelf (from 30 to 200 m depth) of two NW Mediterranean areas, Northern Spain (GSA06) and Northern Alboran Sea (GSA01), during the MEDIAS Survey (2018-2022). Bogue total abundance (individual/nm^2) obtained from processing of acoustic data and biological data (length, weight and sex) were employed to determinate the abundance trend, the spatial distribution and the main biological parameters (female proportion as F/(F+M)); the sex inversion length (length at which 50% of individual are female) and condition factor, (kn)) of the species in the two study areas. Statistical analyses were carried out using R and ArcMap 10.8.2 software was used to infer the spatial distribution of the species.

Results and discussion

Bogue in the NW Mediterranean aggregated in shallow sandy bottoms (less than 100 m depth) mainly in Northern Alboran Sea, especially in Almeria and Malaga Bays. Secondary aggregation areas were detected in Northern Spain, especially in Barcelona, and from Alicante to Murcia (Fig.1). Total abundance showed an increasing trend in Northern Spain but a decreasing one in Northern Alboran Sea. However, individuals' density (total abundance divided by the GSA area) resulted higher in GSA01 than in GSA06 (p-value<0,05). For both GSAs, the proportion of females (Fig.2a) decreased; according to [3] increasing sea temperature could lead to diminishing in females proportion. The sex inversion length remained stable, between 16-19 cm. Regarding condition factor, significant differences were not found for all sexes between GSAs (Fig2.b), but females presented a negative trend for the two study areas. This study, opens new lines of research on the role that bogue plays in the coastal pelagic ecosystem and in the future of the blue economy since consumption habits are changing and it can become a commercially interesting species.
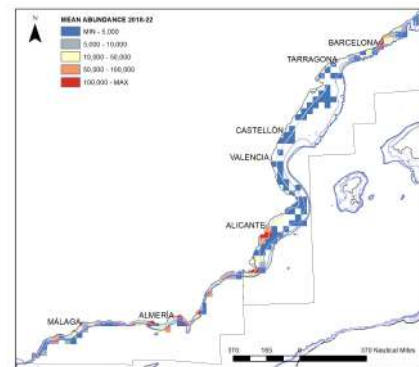

Fig. 1. Bogue spatial distribution calculated using data from the MEDIAS survey (2018-2022) in the NW Mediterranean.

Fig. 2. Temporal trends of the bogue biological parameters calculated using data from MEDIAS survey (2018-2022); a) Proportion of females and b) condition factor in GSA06 and GSA01.

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CIESM Congress Session : Ocean and Human / Animal Health
Moderator : Fabio Marino – Univ. of Messina, Italy

Session's Synthesis

The session "Ocean and Human /Animal Health" started in perfect time as planned. It was a well participated session with several contributions in different specific fields of the main topic. Most of the oral speakers were dealing with parasites of fish and mollusk and their ecological role as bioindicators, their zoonotic potential and their presence and distribution in different areas of the Mediterranean basin, to understand the health status of wild and farmed marine organisms, such as fish and mollusks. Microbiologists, ecologists, zoologists and pathologists were involved too with interesting oral presentations. Other contributions regarded sea urchins used as an animal model to study microplastic embryotoxicity, the evaluation of environmental stressors on annelid populations, the spreading of antibiotic phenomena in the sea, as well as the possibility to find microbial contaminations dispersed via aerosol in the atmosphere. The discussion was made at the end of the session with different questions from the chairmen as well as from attendants which appreciated the multidisciplinary approach of the session. The questions raised were related to the impact of pollutants, pathogens, plastics and other stressors on human/animal health, how they are very often related among them and how global change and particularly global warming is worsening the general situation in the Mediterranean sea. Other questions were related to the methodologies applied. The future perspective is to reinforce such a multidisciplinary towards the creation of a net of differently skilled researchers to provide a wider spectrum of knowledges and could read them together by a holistic approach, that is the One Health approach.

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DIVERSITÉ DES PARASITES DE LA SEICHE COMMUNE *SEPIA OFFICINALIS* DES CÔTES TUNISIENNES

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Abstract

Les céphalopodes [3] jouent un rôle important dans les réseaux alimentaires marins comme prédateurs actifs d'un large spectre d'espèces et comme proies pour de nombreux vertébrés marins. Ils sont des hôtes intermédiaires et définitifs dans de nombreux cycles biologiques. Par conséquent, ils peuvent héberger une grande variété d'espèces de parasites appartenant aussi bien aux protistes qu'aux métazoaires [4]. L'étude des parasites d'une des espèces la plus pêchée en Tunisie la seiche *Sepia officinalis* nous a permis de rencontrer des espèces appartenant à divers groupes : copépodes, cestodes, myxosporidies, des nématodes, etc. Ils ont été prélevés au niveau des branchies, des gonades, du manteau et des viscères de seiches provenants du nord (Golfe de Tunis, Lac sud de Tunis, Lagune de Bizerte) et du sud (Golfe de Gabès) de la Tunisie.

Keywords: Biodiversity, Cephalopods, Systematics, Parasitism, Mediterranean Sea

Matériel et méthodes

L'identification de ces parasites a été faite dans un premier temps, par l'utilisation de M. photonique et dans un second temps par le M. électronique et ceci pour étudier la morphologie des différentes formes parasitaires (Adultes, larves, kystes). D'autre part, le poids et la taille des différents spécimens sont notés à chaque prélèvement afin de permettre l'étude des impacts de ces parasites sur l'embonpoint de leurs hôtes. L'étude écologique des parasites est réalisé par le suivi des variations des indices parasitaires (Prévalence, intensité moyenne et abondance relative) en fonction des sites mais également des saisons. L'identification moléculaire de certaines espèces, essentiellement les formes larvaires de nématodes [8], des cestodes [1] et des protistes [2; 5] a été effectuée ainsi que l'analyse statistique des paramètres quantitatifs du parasitisme.

Résultats

L'étude parasitologique des espèces sauvages de céphalopodes peuvent contribuer à connaitre leurs parasitofaunes afin d'identifier des maladies causées par ces parasites dans les futures fermes aquacoles à grande échelle et à la surveillance et la gestion de ces espèces chez leur hôtes en élevage. Les parasites rencontrés sur la seiche *Sepia officinalis* appartiennent à divers groupe systématiques: Des Copépodes [7], des larves de Cestodes [6], des Protozoaires [2], des larves de Nématodes [2;8] et un Acantocéphales (voir Fig.1 & Fig.2).
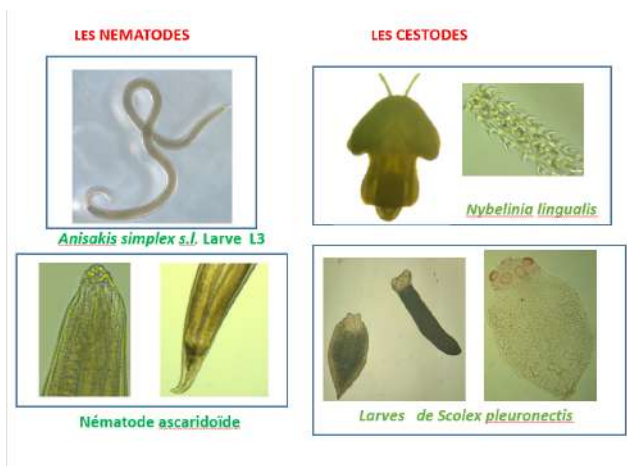

Fig. 2. Larves de nématodes (gauche) et larves de cestodes parasites du tractus digestif (droite).

Fig. 1. Copépode parasite des branchies (gauche). Kystes de protozoaires parasites des voies digestives (droite).

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ECTOPARASITES OF THE PAINTED COMBER *SERRANUS SCRIBA* (LINNAEUS, 1758) FROM TWO LOCALITIES (GULF OF TUNIS AND BIZERTE BAY) IN THE TUNISIAN WATERS

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Abstract

The study of ectoparasitic species of *S. scriba* allowed us to identify one Monogenean species namely *Protolamelodiscus serranelli*, one Isopoda (*Gnathia* sp) and three Copepod species (*Lernanthropus scribae*, *Anchistrotos laqueus* and *Caligus tunisiensis* which is a new species for Science). The sampling area and season showed significant variation of parasitological parameters and *Gnathia* sp. was the predominant parasite. Most parasites appear in spring and summer. The variation of the parasitological parameters depends on biotic and abiotic factors of hosts' habitat and seasons.

Keywords: Parasitism, Fishes, Mediterranean Sea, Teleostei, Copepoda

Introduction - The painted comber, *Serranus scriba* (Osteichthyes, Serranidae) is considered as one of the most commercial fish in Mediterranean water. However, investigations into its parasites in Tunisian coasts are rare. Thus, the aim of this study is to provide new data on the ectoparasitic species that infest this host species in two localities of the Northern Tunisian waters and to verify if the parasitological parameters may show a variation depending on seasons within and between the different localities.

Materials and methods - 240 specimens of *S. scriba* were collected between March 2020 and February 2021 from local fishermen from two localities in Tunisian coasts: 120 specimens from Bizerte Bay and 120 specimens from Gulf of Tunis. Fish samples were measured, weighed and examined for parasites under stereomicroscope. The collected parasites were isolated and stored in 70% ethanol. The parasite (Copepoda, Isopoda and Monogenean species) identification was carried out based on the keys of [1], [2] and [3]. In this study, prevalence (P%), average infection intensity (MI) and mean abundance (MA) were evaluated as described by [4]. Comparisons of prevalence and average intensity of parasite infection among seasons and localities were performed, using separate chi-square randomization tests for prevalence. On the other hand, the test of Wilcoxon Mann-Whitney (2 samples) was considered for intensities noticed at different localities. All the statistical tests were performed at the significance level of 5%.

Results - Five ectoparasitic species were identified : one monogenean *Protolamellodiscus serranelli*, the isopod *Gnathia* sp. and three copepods : *Caligus tunisiensis*, *Lernanthropus scribae* and *Anchistrotos laqueus*. The statistical analysis indicated that the mean intensity of ectoparasites in painted comber was significantly higher in the Gulf of Tunis (MI=8.2). *P. serranelli* were located exclusively on the gills of 20 painted comber individuals from the Gulf of Tunis. This monogenean presented the highest prevalence in the summer period (P=23.5%) and the highest intensity of infection in autumn (MI=2.8). *Gnathia* sp. showed more considerable prevalence and average intensity in the Gulf of Tunis (P=58.3% and MI=9.3, respectively). In the same locality, the parasitological parameters of gnathiids were highest during summer (P=72%; MI=3.3) which is significantly different from the winter values (P=40%; MI=2.9). In spring and summer, significant variability in the mean intensity between both localities was recorded. Painted comber individuals caught in the Bay of Bizerte were hosting more parasites of *L. scribae*, compared to all the other copepod parasites. This copepod was more prevalent in spring/summer showing its highest values (P=47.2% and P=40%, respectively), whereas the maximum infection intensity (MI=2.9) was observed in spring. Prevalence was as well highest in spring in the Gulf of Tunis (P=35.8%) and significantly different from winter (P=12.6%). The gill parasite *A. laqueus* was also recorded in both sampling areas with a maximum prevalence in the Gulf of Tunis (P=25%) and low mean intensity (MI=1.4). The ecological parameters were variable, but no significance was detected among seasons for this parasite.

Tab. 1. Prevalence P(%), mean intensity (MI ± SD), and mean abundance (MA ± SD)of ectoparasites in *Serranus scriba* from localities in Tunisia (Bay of Bizerte and Gulf of Tunis) from March 2020 to February 2021.

IF: infested fish; EF: examined fish; *Level of significance with *P*<0.05 between localities; similar letters indicate no significant differences at *P*>0.05 between seasons.

Discussion and conclusion - Gnathiids are known for their role as temporary fish ectoparasites during the larval stages and as vectors for a fish blood parasite. These common larvae could conclude to the death of the fish by a double parasitic impact; mechanical lesions on the gills, skin, and buccal cavity, along with a possible occurrence of hematophagy. In the current survey *A. laqueus* is the only copepod detected from both areas with no significant differences in variations regarding the parasitological parameters between localities and seasons. In this study, *P. serranelli* was only found on the painted comber from the Gulf of Tunis. This small monogenean was more common in the spring/summer period. Indeed, Diplectanid monogeneans parasites of wild serranid fishes show seasonal fluctuations increasing with high water temperatures during spring and decreasing when temperatures declined in autumn and winter.

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OCCURRENCE AND DISTRIBUTION OF ANTIBIOTIC RESISTANT BACTERIA IN THE SYRACUSE GULF (ITALY)

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Abstract
A seasonal (summer and winter) survey on the occurrence and distribution of antibiotic resistant bacteria (ARB) in the waters and sediments of the Syracuse Gulf (Ionian Sea) was carried out in order to assess potential risks for human and animal health. Fifty strains of heterotrophic bacteria were isolated and screened for their susceptibility profiles to a range of different antibiotic molecules. Multiple ARB were detected, especially in the sediments, where their percentage was significantly higher than in water. Conversely, no statistically significant differences were detected in relation to the season.

Keywords: Bacteria, Ionian Sea, Pollution, Antibiotics

Introduction - Antimicrobial resistance (AMR) mostly due to the misuse/massive use of antimicrobials is recognized as an emerging threat to human and animal health and a major global challenge for the next decade [1]. Nevertheless, to date very little information is available on the spread of this phenomenon in Mediterranean coastal ecosystems [2], where multiple impacts from anthropic activities may cause both sanitary and chemical risks [3]. Furthermore, many toxic compounds (i.e. antibiotics) can accumulate in sediments, altering the natural microbiota and its biogeochemical functions [4]. Only few studies have addressed this research topic in pelagic and benthic domains simultaneously [5]. As a contribute to fill this knowledge gap, the occurrence and distribution of ARB were studied in the water and sediments of the Syracuse Gulf (Ionian Sea) during summer and winter seasons.

Materials and methods - The Syracuse Gulf is a coastal Mediterranean area where maritime traffic, fish farming and recreational activities take place [6]. Four stations were studied, two affected by maritime and mariculture activities (stations 1 and 4, respectively), one receiving the Anapo-Cyane freshwater inputs (station 3) and one marine station serving as a control (station 6).

Fig. 1. Location of the sampling sites.

During August 2019 and March 2020, surface seawater samples were collected through Niskin bottles, while surface sediment samples were collected from stations 1 and 4 using a van-Veen grab. One hundred microliters of each water sample were directly spread on duplicate Marine agar plates, while one gram of sample was serially diluted in sterile seawater and the supernatant treated as the water samples. After incubation for 7 days at 22°C, heterotrophic bacterial strains (n=50) were isolated and screened for susceptibility to 7 antibiotics (Oxoid): ampicillin (AMP, 10 μg) and fosfomycin (FOS, 50 μg), ciprofloxacin (CIP, 5 μg) and sulphamethoxazole+trimethoprim (SXT, 25 μg), eythromycin (ERY, 15 μg), chloramphenicol (C, 30 μg) and tetracycline (TE, 30 μg) by disk diffusion method. All isolates were identified using API20E (Biomérieux) strips.

Results and Discussion - ARB were detected both in water and sediments, but in these latter the percentage of ARB was significantly (P<0.05) higher than in waters (Fig.2), confirming the role of sediments as reservoirs of antibiotic resistance, as reported in other Mediterranean sites [5]. In winter, the number of ARB increased too, although not significantly. Resistance was mostly observed against FOS and AMP, followed by C, TE and ERY.

Fig. 2. Antibiotic susceptibility profiles of the bacterial strains.

Most of the isolates were identified as *Vibrio alginolyticus* (52%), *V. fluvialis* (18%), followed by *Pseudomonas aeruginosa* (20%); *Escherichia coli* (5%) and *Enterobacter cloacae* (5%) were isolated from sediments. The widespread occurrence of ARB underlined potential sanitary risks for environmental health, stressing the need for ARB monitoring plans and remediation measures in this fragile coastal Mediterranean environment.

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ROLE OF PLASTIC LITTER IN FACILITATING THE SPREAD OF ANTIBIOTIC RESISTANCE AND VIRULENCE DETERMINANTS.

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Abstract
This paper aims to contribute to understanding of the role of the marine environment in the evolution of pathogenic bacteria and to assess the risk to human health posed by the presence of harmful vectors in coastal waters, particularly considering the rapidly increasing anthropogenic impact on marine ecosystems. Specifically, we analyzed the role of different matrices in facilitating the spread of antibiotic resistance (AR) and virulence (VIR) determinants. Mechanisms of artificially induced conjugation and transformation were monitored in sediments and plastics through the detection of AR transconjugants in microcosms.

Keywords: Antibiotics, Metagenomics, Plastics, Bacteria, Messina Strait

Introduction

The rapidly increasing anthropogenic impact on marine ecosystems is particularly evident in coastal waters, where effluents from hospitals, aquaculture farms, and human settlements play a crucial role in the distribution of pathogens and their vectors, significantly contributing to the emergence of infectious diseases. Of particular concern is the potential role of marine plastic debris in the persistence and dispersal of potentially pathogenic microorganisms [1]. These matrices facilitate biofilm formation, thereby promoting genomic exchange within microbial communities and leading to the spread of AR and VIR genes. In this scenario, horizontal gene transfer (HGT) plays a central role in pathogen evolution. HGT events can occur between pathogenic and harmless bacteria, favoring the selection of new pathotypes that can act as environmental reservoirs of AR and VIR traits. This study aims to identify the HGT events and environmental settings that may favor the emergence and spread of VIR and AR bacteria through the study of the transferability of selected sequences.

Material and methods

The methodology employed aimed to assess the structure of microbial communities that preferentially colonize different substrates: sediments and two types of low-density polyethylene, virgin (V_LDPE) and weathered (W_LDPE). Seawater and sediment samples were collected from a coastal site in the Strait of Messina, which is exposed to various anthropogenic inputs such as fishing, maritime traffic and recreational craft. These samples were utilized to establish microcosms to study preferential colonization on each substrate. The microcosms were maintained at 20°C for 3 months. A portion of the biofilm from each substrate was collected for metagenomic analysis, while the remainder was exposed to the synthetic plasmid pUT mini-Tn5 sm/sp [2] to observe the specific development of competence within the bacterial community. To induce HGT events within the microbial communities in the microcosms, the colonized biofilm was further stimulated by the addition of streptomycin and spectinomycin at concentrations of 10, 20, and 20 mg ml^{-1} at 72, 96, and 120 hours after inoculation of the pUT vector, respectively. Two distinct methods were applied: i) metagenomics to investigate the structure of the microbial community colonizing the matrices; ii) cultivation to identify transformants in media supplemented with antibiotics.

Results and discussion

Molecular analysis of the colonized matrices revealed a significantly higher biodiversity in sediments compared to plastics. The microbial community on the plastic substrates was dominated by Proteobacteria, which constituted over 75% of the total microbial community. In sediments, prevalent ASVs were associated with the _Cytophaga_ and _Capnocytophaga_ genera (4.1% and 3.6%, respectively). Traits attributed to hydrocarbon-degrading bacteria were only detected on the plastic substrate and were more abundant in the V_LDPE, such as _Alcanivorax_ (3% in V_LDPE, 0.5% in W_LDPE) and _Marinobacter_ (2.7% in V_LDPE, 2.1% in W_LDPE). Before and 48 h after the exposure to the pUT vector, the biofilms were scrubbed and inoculated on antibiotics-supplemented medium. V_LDPE biofilm did not exhibit any isolates, while the biofilm settled on the W_LDPE and the sediments showed AR-resistant strains at T_0, with almost all of these belong to _Bacillus_ genus. An exception was _Arenibacter latericius_, isolated from sediments. Accordingly, the phenotypic characteristics of species belonging to the _Arenibacter_ genus exhibited a diverse array of antibiotic resistance [3]. A comparison of the settled biofilm before and after the addition of pUT revealed that the isolates obtained were different both in the sediments and W_LDPE. Notably, W_LDPE competent isolates include _Priestia megaterium_, a bacterium with potential applications in the biotechnological field [4], which carries 33 genes involved in the mediation of competence. Finally, the biofilm was scrubbed and inoculated on antibiotics-supplemented medium after the addition of increasing concentrations of streptomycin and spectinomycin, highlighting significant difference in the phylogeny of the transformants detected on the plastic substrates, where _Muricauda_ was the most represented. Previous studies have identified strains belonging to the genus _Muricauda_ in the enrichment of ARB, particularly MARB, on the surface of microplastics in a mariculture system [5].

Conclusion

The results obtained from colonised matrices demonstrate a clear contrast in microbial biodiversity between sediments and plastic substrates. The exposure of biofilms to the synthetic plasmid provided insights into the AR of the microorganisms present. While the biofilm on V_LDPE did not yield isolates, indicating a possible lack of microbial activity or colonization, the biofilm on W_LDPE and sediments demonstrated the presence of AR-resistant strains. The diversity of isolates obtained from colonised matrices suggests that different substrates may facilitate different potential for facilitating HGT processes in the marine environment. In conclusion, these results emphasise the significance of considering substrate characteristics when evaluating the potential for AR dissemination in marine ecosystems. These findings contribute to our understanding of microbial dynamics and the dissemination of AR in marine ecosystems. They highlight the complex interplay between substrates, microbial communities, and genetic exchange processes.

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MOLECULAR DESCRIPTION AND IMPACT OF *PHILOMETRA OBLADAE* ON *OBLADA MELANURA* JUVENILE SPECIMENS FROM THE TYRRHENIAN SEA

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Abstract

Oblada melanura (L., 1758) is a common seawater species present in the Mediterranean Sea. In 2023, during a dive along the Sicilian coast, some *O. melanura* showed an abnormal swimming behaviour, as fast and uncoordinated directional changes. Four fish found dead, were collected for necropsy. Macroscopically, some fish had shown an evident celomic distention. Two *O. melanura* celomic cavities were seen to be filled with nematodes and two showed celomic cavities filled with fluid containing degraded nematodes and larvae. Morphological keys allowed to identify all parasites as *Philometra obladae*. Studies are in progress to better describe the dynamics and the epidemiology of *Ph. obladae* infection in wild *O. melanura*, considering parasite development, as well as the involvement of intermediate hosts and the description of male specimens

Keywords: Parasitism, Fish behaviour, Mediterranean Sea

Introduction

Saddled seabream (*Oblada melanura,* L. 1758) is a seawater species belonging to the family Sparidae. It is a common opportunistic predator, present both in the Mediterranean Sea, and in oceans. Nematodes belonging to the genus *Philometra* Costa, 1845 include species parasitizing freshwater, brackish and seawater teleosts worldwide. Female specimens are bigger than males, from a few centimeters up to 1 m in total length, while males are usually between 2 and 4 mm. Between spring and summer, from late May to the end of June, females of *Philometra* spp. leave the host through tissues, usually in the proximity of the anus; after body penetration, the hypotonic effect of the surrounding water causes the immediate release of the free first-stage larvae. To date, no data on abnormal fish behaviour have been reported. The aim of the present study was to describe the abnormal swimming pattern due to the infection supported by *Ph. obladae* in juvenile *O. melanura*, also adding the first molecular description of this species.

Material and methods

In July 2023, during a dive off the coast of the Province of Messina, Tyrrhenian Sea, some *O. melanura* were observed showing abnormal swimming patterns. Moreover, two dead specimens were found on the sea bottom. Due to this observation, monthly monitoring from July to October was carried out, also using a digital camera. In August, another two dead fish were found in the same area. All samples were transferred to the laboratory for necropsy and parasitological examination. Fish coelomic cavities were inspected for parasites. All retrieved nematodes were isolated under a stereomicroscope, then stored in 70% ethanol and frozen at -80 °C. For morphological assessment, nematodes were diaphanized in glycerin and observed under a light microscope. Genomic DNA from four specimens was extracted. Then, two molecular markers for phylogenetic analyses, the small ribosomal subunit (18S rDNA) and the mitochondrial cytochrome c oxidase 1 (COI), were amplified by polymerase chain reaction (PCR). The 18S and cox1 sequences obtained from the isolates were aligned with available nucleotide sequences of *Philometra* sp. using the MUSCLE algorithm and further used for phylogenetic analyses.

Results and conclusion

The four dead *O. melanura* specimens were estimated as <1 year. During examination of the coelomic cavity, two fish showed total cranial dislocation of the internal organs, due to the presence of five gravid female nematodes macroscopically attributable to the family Philometridae. In the other two fish, the celomic topography was respected, appearing to be filled by fluid. Analysis of the fluid allowed to find degraded *Ph. obladae* females and larvae in the celomic cavity (Fig.1). Morphological evaluation of all parasitic stages found and analysed, compared to the data in the key and the original description by Moravec et al. [1], allowed the identification of both adults and larvae as *Philometra obladae.* All the isolates showed positive amplification for 18S and cox1 genes. Partial sequences of 18S (823 bp) and cox1 (292 bp) obtained for *Ph. obladae* were identical among isolates and the representative DNA sequences were submitted to GenBank. Our study provides new data on the abnormal swimming pattern caused by

Philometridae nematodes in wild fish. The atypical behaviour of infected *O. melanura* observed during the diving activities, mainly considering the presence of an operator, confirms the significant impact of high parasitic infection on fish health status. Our results also confirm the absence of male specimens in the studied area during the summer, highlighting the necessity to plan other samplings in late spring, in accordance with the data reported by Gaglio et al. [2]. More studies are necessary to better explain the occurrence of *Ph. obladae* infection in *O. melanura*, as well as its epidemiology, molecular evaluation and male specimen description. Epidemiological and phylogenetic studies are in progress to improve knowledge on *Ph. obladae* in *O. melanura* from the same area, where this species is one of the most appreciated by consumers.

Fig. 1. *Oblada melanura* collected off the Tyrrhenian Sea. **A** *Philometra obladae* gravid within the celomic cavity of *O. melanura* (arrows); **B** Uterus of *Ph. obladae* showing first-stage larvae (arrows) and eggs (circle).

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WHAT COULD THE OCCURRENCE OF *PRODISTOMUM POLONII* IN MADEIRA ISLAND REVEAL ABOUT THE CONNECTIVITY BETWEEN THE MEDITERRANEAN AND THE ATLANTIC ?

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Abstract

The blue jack mackerel, *Trachurus picturatus*, is a highly consumed pelagic fish in both Mediterranean and Atlantic waters. The present study aims to investigate the digenean parasite species present in fish samples captured off Madeira Island. In 2018, a total of 122 fish samples were collected and examined. Fifteen specimens of *Prodistomum polonii* were found in the intestine of *T. picturatus*, indicating low infestation rates. This discovery may be linked to transoceanic connectivity. Negative correlations between parasite abundance and fish size were observed, likely attributable to the dietary preferences of the host.

Keywords: Fishes, Parasitism, Warming, Mediterranean Sea, North Atlantic

During 2018, 122 fish of *Trachurus picturatus* (Bowdich, 1825), were collected from a local fish market from Madeira Island in the Eastern Central Atlantic. Fish samples were weighed and measured (Total weight (g)= 85.31± 69.59; Total length (cm)= 20.30 ± 5.07). Viscera were removed, placed in Petri dishes, and examined for the presence of digenean parasites under a stereomicroscope. All the collected parasites were isolated, counted, and preserved in 70% ethanol. The parasitological indices of the parasites were determined according to [1]. Correlations between fish size and parasite abundance were analyzed by using the Spearman rank correlation test.

Fifteen specimens of the digenean species *Prodistomum polonii* (Molin, 1859) [3] were collected from the intestine of 12 *T. picturatus* samples (Figure 1). This trematode species has been reported previously on *T. picturatus* only from the French part of the Mediterranean Sea (Corsica) [2]. However, previous studies mentioned its occurrence in its congeners *T. trachurus* and *T. mediterraneus* mainly from the Mediterranean but also from the North East Atlantic (Bay of Biscay, Celtic Sea, and the Norwegian part of the Norwegian Sea) [8]. The present investigation is the first report of *P. polonii* in the Central Atlantic (Madeira).

Previous studies have been conducted on the parasite fauna of *T. picturatus* from off Madeira Island without mentioning any infestation with the digenean *P. polonii* [4-6].

The occurrence of this parasite may give rise to several hypotheses mainly associated with connectivity, such as its potential introduction via the horizontal migration of infested *Trachurus* fishes from the Mediterranean. Moreover, it could be linked to the potential colonization of the primary intermediate host within the region over recent years, possibly attributable to ecosystem disturbances and the effects of global warming.
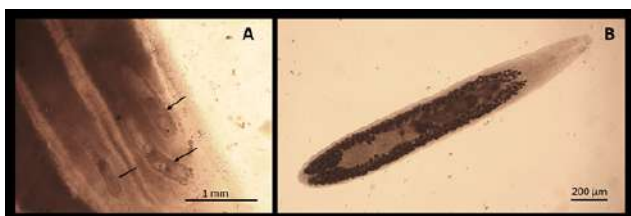

Fig. 1. Collected *Prodistomum polonii* from *T. picturatus*. A: 3 specimens located in the host intestine (Arrows); B: One parasite specimen (In vivo).

The parasitological indices (Prevalence P = 9.8%; mean Intensity mI = 1.3 ± 0.9; and mean Abundance mA = 0.12 ± 0.46) showed low infestation of *P. polonii*. The Spearman rank correlation test indicates that the parasite abundance was negatively correlated with fish size (Total length (P = 0.002; rho = -0.276) and Total weight (P = 0.002; rho = -0.28)) (Figure 2). Indeed, parasitic infestation varies according to the diet of each size class [4-5]. Furthermore, gastropods are the first intermediate host of lepocreadid digeneans [3] and constitute one of the main prey items of small horse mackerel in Madeira Island [7].
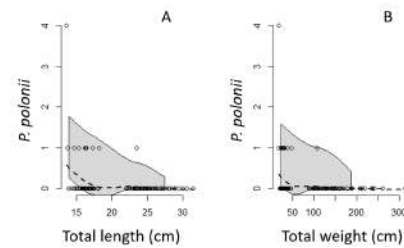

Fig. 2. Negative correlations between *Prodistomum polonii* abundance and host features caught from Madeira Island. A: Total length; B: Total weight.

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ANTAGONISM OF ANTI-INFLAMMATORY DRUG INDOMETHACIN TO POLYMETHYLMETHACRYLATE MICROPLASTIC EMBRYOTOXICITY AND OXIDATIVE STRESS IN SEA URCHIN *PARACENTROTUS LIVIDUS*

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Abstract

Co-exposure of urchin *Paracentrotus lividus* embryos to 10 µm polymethylmethacrylate (PMMA) particles and the anti-inflammatory drug indomethacin was investigated. Though accumulation of microplastic was observed in larvae, significant developmental anomalies were not recorded after exposure to the two toxicants (individually or combined). However, 1 mg L^{-1} PMMA significantly increased reactive oxygen species (ROS) levels in comparison to controls while co-exposure to 10 or 100 µM indomethacim reduced ROS to control levels or lower, respectively. Similarly, increasing quantity of indomethacin added to PMMA significantly reduced lipid peroxidation levels to below those of controls. Thus adsorption of organic pollutants to microplastics does not necessarily cause increased negative effects on marine organisms due to antagonistic effects.

Keywords: Adsorption, Echinodermata, Ecotoxicology, Larvae, North Adriatic Sea

Introduction. Large quantities of microplastics present in wastewater streams eventually reach coastal waters where they can negatively impact on marine organisms [1]. While much research has focused on polystyrene microparticles, less attention has been paid to those of polymethylmethacrylate (PMMA), even though they have been shown to accumulate in fish while other microplastics were absent [2], and can be selectively internalised and cause developmental damage in early life stages of sea urchins [3]. Furthermore, their hydrophobicity enhances the ability to act as a vector for other organic pollutants which may lead to additive or synergistic effects resulting in greater toxicity to organisms. Among the wide range of pharmaceuticals concomitantly present in wastewaters, the non-steroidal anti-inflammatory drug indomethacin [4] is oftentimes found and the nature of their interaction can have important implications for biota. Due to indomethacin's anti-inflammatory properties, we hypothesise that it can mitigate PMMA-derived oxidative stress in urchin embryonic development and lead to a reduction in developmental defects. To test this, we report on the exposure of zygotes to PMMA and indomethacin, individually and in combination, and determine reactive oxygen species (ROS) and lipid peroxidation (LPO), as well as developmental anomalies in the larvae.

Methods. Urchin zygotes were exposed to 10 µm diameter PMMA (1 mg L^{-1}) and indomethacin (0.1-100 µM), individually and in combination, for 72 h upon which plutei were scored for developmental defects. Total ROS was determined by incubating plutei with dichlorofluorescin diacetate, homogenising in Tris HCl and recording fluorescence at 540 nm (excitation at 485 nm). For LPO determination, plutei were homogenised in TRIS-EDTA-Triton X buffer, followed by reaction in trichloroacetic acid, butylated hydroxytoluene and thiobarbituric acid at 95°C for 60 min. LPO levels were determined by measuring absorbance at 530 nm. Protein concentration was determined by Bradford assay. Results were analysed by parametric or non-parametric one-way ANOVA. Differences were considered significant at *p<0.05, **p<0.01.

Results. Control samples showed 94% normally developed larvae while the various treatments with PMMA or indomethacin, individually or in combination, showed normal larvae in the range 90-95%. Co-exposure to PMMA and 100µM indomethacin gave a somewhat reduced number of normal larvae (84%). Total ROS in control, solvent-controlled (DMSO) and indomethacin -treated plutei, in the range 16-30 nmol-DCF mg^{-1}, were not significantly different (Figure 1). However, PMMA caused a significant increase in ROS to 70 nmol-DCF mg^{-1} which was reduced to the level of the control when 10 µM indomethacin was added, and even further with addition of 100 µM indomethacin (8 nmol-DCF mg^{-1}). As a measure of LPO, the generation of thiobarbituric acid reactive substances (TBARS) in indomethacin treated plutei ranged between 1.2-1.6 nmol-MDA mg^{-1} and 0.8 nmol-MDA mg^{-1} for PMMA. Co-exposure to PMMA with 10 and 100 µM indomethacin gave similar values to these (1.3 and 0.9 nmol-MDA mg^{-1}, respectively) which were not significantly different. These data indicate that 10 µm PMMA and 10-100 µM indomethacin do not cause significant developmental defects or LPO in urchin embryos, individually or combined. However, the microplastic causes a significant increase in ROS which is mitigated when indomethacin is co-present.

Conclusion. These data indicate that organic pollutants adsorbed to PMMA microplastics do not necessarily represent an increased danger to marine organisms due to antagonistic toxicity mitigation.

Fig. 1. Dichlorofluorescein concentration in larvae treated with PMMA (PM) and indomethacin (Indo) at concentrations indicated as L (low, 10 µM) or H (high, 100 µM). Negative (Control) and solvent (DMSO) controls indicated.

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ATMOSPHERIC TRANSPORT OF VIABLE AEROSOL-BORNE MICROBIAL CELLS OVER THE EASTERN MEDITERRANEAN SEA

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Abstract
We investigated the viability of airborne prokaryotes over the eastern Mediterranean Sea. Airborne prokaryotes in sea-spray contained 5-34% of viable cells (median 21%), with an apparent E-W gradient between Cyprus/Crete (~10%) westwards to Sicily (~25%). Aerosols at ~20 m above the sea surface, reflecting cells with longer atmospheric transport, displayed a patchier distribution, with higher microbial viability in easternmost locations south of Cyprus and west of Crete (~25%).

Keywords: Aerosols, Mediterranean Sea, Bacteria

Introduction
Aerosol particles contain different microorganisms originating from land or the ocean. The residence time of airborne microbes in the air may reach ~7 days, thus enabling them to cross-continents and oceans in a relatively short time [1]. During atmospheric transport, aerosols/dust undergo a series of evaporative and rehydration processes that may potentially affect their viability and/or ability to become active once deposited on land/ocean [2]. Here, we report the percent viability of airborne prokaryotic cells (bacteria, archaea and cyanobacteria) across the eastern Mediterranean Sea during the RV Meteor (cruise M197) on January 2024.

Methods
Aerosols were collected every ~10 h into sterile seawater using a low-volume sampler located ~20 m above sea level (BioSpot-VIVAS Sampler), as well as samples collected during 6 h interval by a custom-made sea-spray bubbling system (e.g. Rastelli et al., 2017) with surface seawater inflow. Viable airborne microbes were analyzed using LIVE/DEAD staining via flow cytometry. The results are compared to surface seawater, rainwater and a continuous monitoring station at the northern Israeli coast.

Results and discussion
Microbes in sea-spray collected by the bubbler contained 5-34% (median 21%) of viable cells (Figs 1&2). An apparent E-W gradient was observed, with generally low microbial viability recorded between Cyprus and Crete (~10% of all airborne cells), and higher values recorded from Crete to Sicily (~25%) (Fig 1A). Aerosols at ~20 m above the sea surface, which represents the contribution of airborne cells with a longer atmospheric transport, showed a more patchy spatial distribution, likely attributed to the air mass trajectories and aerosol loads (Fig 1B). A higher airborne microbial viability was observed in the easternmost locations south of Cyprus and west if Crete (~25%) (Fig 1B). For comparison, airborne microbial samples collected in 2023 at a coastal station using the BioSpot-VIVAS sampler located at the easternmost Mediterranean coast ~20 m above the sea level exhibited similar percent viability values as found in the offshore locations (median 18%) (Fig 2). Differently, the percent of viable cells in rainwater or in surface seawater is typically higher, with median viability of 31-35% of all collected cells (Fig 2).

Conclusions
Our results provide the first baseline of viable airborne microbial cells over the eastern Mediterranean Sea. We surmise that these results will enable a better parameterization of model simulations of viable bacterial deposition over the oceans, especially in oligotrophic provinces, enriched in dust and anthropogenic aerosols, such as the eastern Mediterranean Sea.

Fig. 1. Spatial distribution of viable airborne microbial cells over the Eastern Mediterranean Sea in January 2024 using a custom-made 'bubbler' system located ~3 m above sea level (A), and a low-volume BioSpot-VIVAS sampler that condensate sea-spray located ~20 m above sea level (B).

Fig. 2. Whiskers plots showing the percent of viable airborne microbial cells at offshore sites (using VIVAS and bubbler systems, n=53 and 28, respectively), rainwater (n=8) and at a coastal site (using BioSpot-VIVAS sampler, n=18), as well as the percent of viable microbial cells in surface seawater (n=11) at the eastern Mediterranean Sea. The line within the boxes shows the median values.

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ASSESSMENT OF THE HEALTH STATUS OF THE CLAM *CHAMELEA GALLINA* ALONG A LATITUDINAL GRADIENT IN THE ADRIATIC SEA

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Abstract
Chamelea gallina is an infaunal mollusk widely distributed in the sandy bottoms of the Mediterranean Sea. It is an important economic resource for fishing in the Adriatic Sea, despite the coastal areas where it inhabits being heavily threatened by climate change and anthropogenic disturbances. Indeed, variations in river discharge and modifications in oceanographic characteristics can lead to changes in the structure of marine ecosystems. Understanding the impact of seasonal river runoff variations on clam health is crucial. The welfare of clams was examined through two physiological indices: survival in air and condition index. While the condition index was consistent across the study sites, the survival in air varied significantly.

Keywords: Bivalves, River input, Adriatic Sea

Introduction
The Adriatic Sea is a continental basin within the Eastern Mediterranean, located between the Italian peninsula and the Croatian coast. The northern part of the basin, characterized by shallow waters, is affected by strong river runoff. The Adriatic coastal environment hosts benthic communities of considerable importance, among which commercially relevant species such as the bivalve *Chamelea gallina* (Linnaeus, 1758). Along the Italian Adriatic coast, the clam *C. gallina* is a valuable resource, with a high market price. A recent study on natural populations of *C. gallina* along the Adriatic's latitudinal gradient linked the presence of the Po River in the northern Adriatic to fluctuations in environmental parameters, in particular salinity and chlorophyll concentration, which seem to negatively influence the growth of *C. gallina* [1]. However, data on the direct impact of river runoff on the bivalve health status in the Adriatic Sea are still lacking.

Materials and Methods
Specimens of *C. gallina* were sampled from Chioggia (CH), Goro (GO), and San Benedetto del Tronto (SB) in the summer of 2023. The condition index was calculated for samples from CH and SB. Clams were opened and all soft tissue was removed. The shells and soft parts were dried for 48h at 50°C and then weighed. Condition index was calculated according to Walne, 1976 [2]. The survival in air test was performed on clams from CH, GO and SB. During the test clams were placed within a plastic box at a constant temperature of ~16°C and ~100% humidity. Clams' mortality, temperature, and humidity inside the boxes were checked daily, and animals were considered to be dead when their valves gaped and failed to close when the clam was physically stimulated.

Results and Discussion
Preliminary results showed a similar value of the condition index for CH and SB while the survival in air test differed significantly among the three sites. As it can been seen from the survival curves (Fig.1), the survival time seems to be longer for GO, then for CH and at last for SB. This could be due to the greater adaptation of clams from GO to environmental stress. However, comparing these data with those collected during the winter period and implementing study sites along the latitudinal gradient will further help explore this aspect.

Fig. 1. Survival curves obtained with the Keplan-Meier test (Keplan & Meier, 1958 [3]).

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CIESM Congress Session : Research towards sustainable fisheries
Moderator : Beatriz Morales-Nin – IMEDEA, Balearic Islands, Spain

Session's Synthesis

Fishing has induced serial depletions, long masked by improved technology, geographic expansion and exploitation of previously spurned species lower in the food web. Failure to implement adequate measures threaten the contribution of the sector to food security. Future fisheries must operate on principles that minimize impacts on marine life, adapt to climate change and allow regeneration of depleted biodiversity, while supporting and enhancing the health, wellbeing and resilience of people and communities.

To ensure the blue food security a series of challenges were identified by Morales-Nin et al. (2024. Challenges on Blue Food Provision.

Frontiers in Sustainability. DOI 10.3389/focsu.2024.1271783) envisaging the needs to achieve the UN Strategic Goals. These Goals have been addressed at CIESM sessions thanks to CIESM interdisciplinary approach. Regarding Session 29, two of the challenges were addressed: Challenge 5, "New smart technological solutions and crossovers", with four presentations, and Challenge 7, "New management measures", also with four presentations. The joint discussion among participants and presenters highlighted great interest in the following topics: the economic viability of changing fish boxes to reduce plastic contamination, methodological procedures for determining ghost fishing, management measures, new approaches to assess unreported catches, and how environmental conditions influence fishing effort.

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GHOST GEAR IN THE GULF OF GABÈS (TUNISIA): THE URGENT NEED FOR A CONSERVATION CODE OF CONDUCT

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Abstract

Goal 14 of the Sustainable Development Goals (SDGs) requires all countries to significantly reduce marine debris of all kinds by 2025. Despite the fact that Abandoned, Lost, or Discarded Fishing Gears (ALDFG) is recognised as the most harmful form of aquatic litter, the scale of the problem along the Tunisian coastline is still largely unknown. However, a new study provides a comprehensive insight into an alarming environmental problem in the Gulf of Gabès (Ghaouar et al., 2024). In this study, we present key principles that could be considered in a code of conduct, based on the results of our previous study of ALDFGs in the Gulf of Gabès and the scoping review, to propose our draft Code of Conduct, developed as part of the Life Med Turtles project to mitigate this phenomenon.

Keywords: Marine policy, Gulf of Gabes, Plastics, Pollution, Conservation

1. Ghost Gear in the Gulf of Gabès: The call for a social standard

Ghost gear (ALDFG), which refers to lost, abandoned, or discarded fishing gear, is a significant problem globally, causing harm to marine life, ecosystems, and posing challenges for fisheries management. The Gulf of Gabès (GSA 14) is the most important marine fishing area in Tunisia and an important marine biodiversity hotspot of regional significance. Although ALDFG is recognized as the most harmful form of aquatic litter, the scale of the problem along the Tunisian coastline is still unknown. The first study of ALDFGs in the Gulf of Gabès was carried out under the framework of Life MedTurtles Project and provided a comprehensive insight into an alarming environmental problem in this area and highlights the urgent need for a code of conduct [1].

2. Towards a code of conduct for ghost gear management in Tunisia

Article 1: nature and scope of the code
This Code is prepared as part of Life Med Turtles Project. It is adapted to the Gulf of Gabès off Tunisia and is directed maily toward the conservation status of the Mediterranean populations of sea turtle by reducing the impact of ghost gears on sea turtle populations.

Article 2: objectives of the code
i. Establish principles, in accordance with the relevant international guidelines, for the conservation of sea turtles' population by reducing the impact of ghost gears on turtles in the Gulf of Gabès;
ii. Provide standards of conduct for all stakeholders involved in the fisheries sector in Tunisia.

Article 3: Global Ghost Gear Initiatives
– GGGI is the world's largest cross-sectoral alliance dedicated to solving the problem of ghost gear globally.GGGI stated in its 2018 Annual Report that ghost gear is the most harmful form of marine debris.
– There is a strong need for multi-stakeholder research into the extent of the waste fishing gear problem in all regions worldwide.

Article 4: Life Med Turtles' code of conduct for the management of ghost gears in the Gulf of Gabès area (Tunisia)

4.1 Involvement of fishers
– Data collection campaign from fishermen about ghost gear concentration in the Gulf of Gabès was conducted via questionnaires. A hot spot map for ghost gears in the Gulf of Gabès was developed to help identify locations of priority where ghost gear removal activities should be conducted (Fig. 1).
– Diving campaigns are being organized by Life Med Turtles project to collect and remove ghost gears from identified hotspot areas and specific collection bins set up for removed ghost gears at different ports of the Gulf of Gabès.
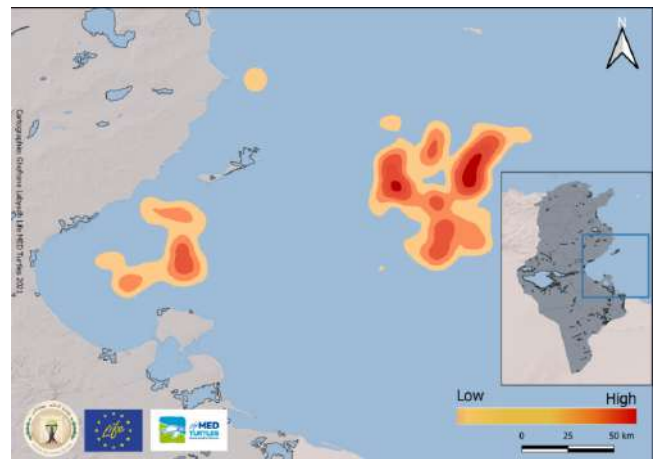

Fig. 1. ALDFGs distribution in the Gulf of Gabès.

4.2 Expected from the government
– Tunisia needs to move beyond a reactive approach and adopt a policy geared towards anticipating marine ecological disasters.
– The development of national capacities to respond to ghost gear pollution within the framework of national emergency plans is a prerequisite

4.3. Involvement of fishing gears manufactures
– Designing gear that is traceable through proper marking of key components (ropes, net panels, traps, and tracking buoys).
– Supporting efforts to eliminate ghost gear from our oceans by joining the Global Ghost Gear Initiative

Article 5: Recommendations and next steps
– Policy development is a critical aspect of addressing the issue of ghost gear in the Gulf of Gabès.
– Significant efforts should be made to develop educational programs to raise awareness among fishers, consumers, and the general public about the importance of responsible fishing practices.
– It is essential to established connection between government agencies, fishing communities, NGOs, academia, and international organizations engaged in marine conservation and fisheries management.

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QUANTIFYING UNREPORTED CATCHES SUBJECT TO FISHERY REGULATIONS

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Abstract

Unreported catches can have a significant impact in fish stock assessment. In this study, we propose a statistical tool aimed to estimate unreported catches of Mediterranean albacore subject to daily bag-limits imposed in the fishery regulations of recreational fishing tournaments held in the Balearic Sea.

Introduction. The underreporting of catches can affect many fisheries worldwide and bias the sustainable management of fish stocks [1,2,3]. For instance, this issue was considered a source of uncertainty in the latest assessment of the Mediterranean albacore stock (_Thunnus alalunga_), where one source of catch data was recreational fishing tournaments conducted in the Balearic Sea (Western Mediterranean) [4]. Since 2006, a daily bag-limit (DBL) has been imposed in these tournament regulations, which restricts the catches to a maximum of 20 individuals allowed to be landed. Thus, we formulate that this limitation can be a bias because a boat reaching DBL before the time limit may continue to fish up to the limit, potentially replacing smaller catches with larger ones. Consequently, the actual number of fish caught may exceed the reported catches when the DBL is reached.

Material and methods. Catches and weights per fishing trip were collected from recreational fishing tournaments conducted from 2006 to 2018. The fishing trip was the combination of boat and date, then, a total of 978 fishing trips were registered. We propose a Bayesian prediction model based on the difference between the weights of the sample (the fish reported at the end of the tournament) and the weight distribution of all the catchable fishes. In this model, any fish included in the final reported set by a fishing trip reaching the DBL at the end of the tournament (with weights X) will be a random sample from the weight distribution of all catchable fish from those fishing trips that do not reach the DBL (W). However, X is truncated by a lower limit (low), which is expected to increase with the number of additional fish caught over DBL. Finally, a new number of total fishes caught in a fishing trip is obtained, from which the new number of albacores is estimated from the empirical proportion of number of albacores < low over the total of fish < low. Non-normality was observed on W; therefore, a simulation exercise was computed in order to confirm that such a small normality departure, addressed through a Box-Cox transformation (Fig. 1A), does not bias the estimation of the new number of albacores (Fig. 1B).

Results. A total of 42 fishing trips were registered reaching the DBL since 2006. Finally, 94 albacores were added to the actually reported number of albacores.

Discussion. The DBL is large enough to allow for a precise estimation of the weight mean and variance of the fish reported at the end of the tournament. The W for any given year can be precisely described by the hundreds of fish coming from trips in which DBL was not reached. In our case, the number of additional captures seems small. However, in cases where the DBL is small, the number of additional captures is high, the weight distribution is poorly known or has low variance, and thus, the loss of precision can become relevant leading to uncertainties in the estimations of unreported catches.

Fig. 1. A) Weight distribution of all the fishes by species in a given year. B) Estimated number of albacores through the Bayesian prediction model on a simulated fishing trip exceeding the DBL.

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EXPLORING THE EFFECT OF T90 CODEND ON THE ELASMOBRANCHS CATCH RATES DURING BOTTOM TRAWL CRUSTACEAN FISHERIES

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Abstract

In 2020, during a bottom trawl selectivity survey targeting the deep water rose shrimp, the catch rates of elasmobranchs were compared between a 50 mm T90 codend (test) and a typical commercial trawl net (control). For the purpose of this study, the data from 24 hauls (12 control and 12 test) were used to assess for the first time the effect of a T90 codend on the catch rates of the elasmobranchs. The results highlighted the positive effect of the test gear in reducing the catch rates of elasmobranchs. In the near future more efforts should be carried out testing the T90 codend in different fishing grounds and seasons.

Keywords: Fisheries, Sicily Channel, Elasmobranchii

Elasmobranchs, because of their singular life-history traits (low fecundity, delayed sexual maturity, long lifespan, low growth rates), are thought to be particularly vulnerable to the impact of fishing pressure [1,2]. In recent years, a decline in these stocks, except for some species [3], has also been evidenced in several areas of the Mediterranean characterised by high fishing pressure and poor selectivity of the gear [4]. In particular, although the bottom trawl fishery is considered one of the most impactful fishing techniques, few attempts have been made to reduce the bycatch of the elasmobranchs [5-7]. For the purpose of the present study, the data from a bottom trawl selectivity survey with *Parapenaeus longirostris* (Lucas, 1846) as a target species, was opportunistically used to assess the effect of the T90 codend, a diamond mesh rotated 90 degrees, on the elasmobranchs catch rates. In December 2020, a 3-day selectivity campaign was conducted with three trawlers, 4 hauls per vessel each day based at the Mazara del Vallo harbour (Strait of Sicily – Central Mediterranean). One of them used a commercial gear as a control, one a 50 mm T90 codend and another one a sorting grid [8]. Every vessel carried out 4 hauls a day for a total of 36 hauls over the survey. However, for the purpose of the present study, we compared the catch per unit effort (CPUE) of elasmobranchs by haul, expressed as kg per hour, of the control and the 50 mm T90 codend (i.e. 24 hauls). Two elasmobranch species were caught with T90 codend (*Torpedo marmorata* and *Raja clavata*) and two with the control net (*Torpedo marmorata* and *Scyliorhinus canicula*). The CPUEs in weight were compared using the Mann-Whitney test pointing out statistically differences between gears. In particular, higher CPUEs were recorded in the control compared to the T90 codend (p-value < 0.05; figure 1). The present work highlighted as the T90 codend could be a suitable solution to mitigate the impact of the bottom trawl fisheries on the juvenile of this vulnerable taxon.

However, in the near future the effect of the T90 codend needs to be better evaluated also taking into account different fishing grounds/areas and seasons. Finally, since some species of elasmobranchs have a commercial value, the right balance should be struck between the ecological (reduction of juveniles in the catch) and the economic point of view (loss of commercial species and larger individuals).

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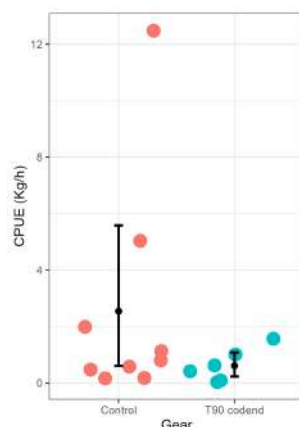
Fig. 1. Catch per Unit Effort (CPUE) of elasmobranchs caught during the survey expressed as Kg/h in each haul (coloured dots). The black dots are mean values; the bars are confidence intervals.

COST-BENEFIT ANALYSIS OF THE USE OF ECO (REUSABLE AND RECYCLABLE) BOXES FOR THE TRANSPORT OF FISH

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Abstract

The environmental sustainability of fishing activities is a critical issue given the significant impact fishing can have on marine ecosystems. Innovation in fishing gear, equipment and techniques can help reduce environmental impacts and improve the sustainability of fishing activities. The extended use of polystyrene in the fishing sector (e.g. boxes for the transport of fish) has become increasingly evident in the last decade, and, because of its null biodegradability, it is posing serious threats to marine life. Alternative solutions are finding space as the polypropylene boxes, that, being reusable and completely recyclable, seem to provide the greatest benefits in terms of environmental sustainability but are also very promising in economic terms, allowing fishing enterprises to reduce operational costs.

Keywords: Economic valuation, Adriatic Sea, Plastics, Fisheries, Marine litter

Polystyrene foam (EPS), more commonly known as polystyrene, is extensively used in the fishing sector, being the basic material for the production of the most commonly used fish storage and transport boxes in Italian fishing ports but it is also one of the most common components of marine litter, both at sea and beached along coasts posing a serious threat to marine life [2] and potentially dangerous also for humans, through microplastics. In the last decade alternative and more eco-solutions have found application, among which, those that seem to give the greatest benefits in terms of environmental sustainability, are polypropylene boxes, completely reusable and recyclable. For massive production fishing fleets (e.g. small-pelagic) the substitution of disposable boxes with reusable ones promises large benefits also in economic terms. In order to assess the economic impact in terms of costs and benefits related to the adoption of more ecologically sustainable boxes than those currently used, different scenarios have been simulated (Figure 1). This analysis was carried out by structuring a specific simulation model able, under certain assumptions, to predict the probable trend, over time, of the main socio-economic variables of the sector and the related performance indicators [3]. The model used for this study has been structured considering the equations most widely used in the modelling applied to Mediterranean fisheries. In particular, the model is the result of an adaptation of the latest methodology used by STECF for the forecasts contained in the Annual Economic Report [4]; adaptation based on equations derived from the two main bio-economic models developed for Mediterranean fisheries, namely BEMTOOL [5; 6] and MEPHISTO [7]. Simulations have been carried out by fleet segments, referring to the EU data collection codification for fishing technique and vessel length. To provide a summary of the effects on socio-economic performance, the CR/BER (Current Revenue/Break-Even Revenue) indicator was used to assess changes in profitability (fig. 1).
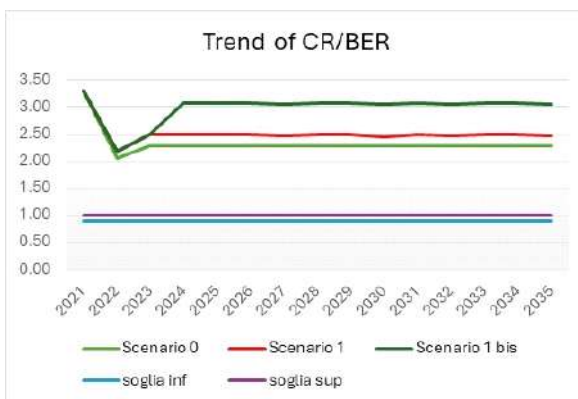

Fig. 1. _Trend of CR/BER for Adriatic TM_18-40_

CBA (Cost-Benefit Analysis) was conducted, on the other hand, on other two socio-economic indicators: Value Added and Gross Profit (fig. 2).
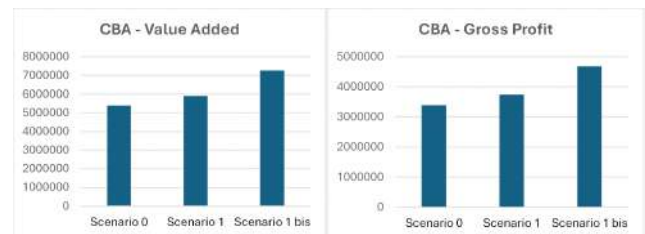

Fig. 2. _CBA for Value Added and Gross Profit for Adriatic TM_18-40_

Results highlight that profitability, measured by CR/BER, is increasing, compared to the status quo level, in all simulated scenarios. Positive results also emerge from the CBA with increases in both terms of VA and GP (discounted value of projections to 2035). Additionally, businesses may benefit from market access associated with sustainability initiatives. Using eco (reusable and recyclable) boxes for the transport of fish can significantly contribute to the environmental and economic sustainability of the fishing industry.

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ICATMAR SCIENTIFIC MONITORING ON COMMERCIAL FISHERIES OFF CATALAN COAST (NORTHERN GSA6)

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Abstract
Since 2019, the Catalan Institute of Research for the Governance of the Sea (ICATMAR) has designed and implemented a continuous fishery monitoring program for the commercial fishing fleet on the Catalan coast (Northern GSA6) in order to address spatial management at a fine scale, complementing the management strategies in place in the GSA6. This study presents the locally-based monitoring implemented by ICATMAR in response to tue EU call for fisheries data collection, with some examples of the results obtained. Despite the short span of our dataset, it is already being used, along with data obtained through fisheries-independent surveys, daily landings, and fleet geolocation data, to inform fisheries management decisions processes at local national, and European levels.

Keywords: North-Western Medite, Fisheries, Monitoring

The Catalan coast constitutes the northern half of the GSA 6 (Fig. 1). There are three different modalities of commercial fishing: bottom trawlers, purse seiners, and small-scale. To better manage marine resources, the Directorate-General for Maritime Policy and Sustainable Fisheries of the Catalonia Government and the Institut de Ciències del Mar (ICM-CSIC) promoted the Institut Català de Recerca per a la Governança del Mar (ICATMAR), an autonomous organization to generate scientific advice for management purposes. Since 2019, It has implemented a fishery monitoring program of the main target species of the Catalan commercial fleet. The objective of this paper is to describe this fisheries monitoring [1].
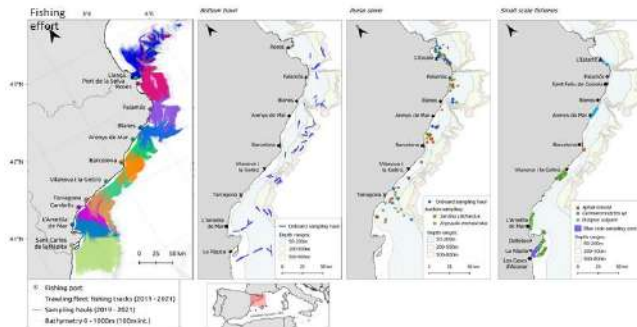

Fig. 1. Maps from the study area. Trawling fishing effort for each port base (2019.2021); Bottom trawling sampling tracks, Purse seine and Small-scale fisheries sampling in 2022

Tab. 1. Trawl catches composition in percentage of biomass from 2019 to 2022.

Catch	2019	2020	2021	2022
Commercial fraction	71	66	66	67
Discarded organisms	23	25	27	28
Natural debris	4	7	4	3
Marine litter	2	2	2	2

Bottom trawling. Present regulations implies that the fleet of each port do not seem to overlap significantly (Fig. 1). The monitoring program define 3 zones with 3 selected ports each one and 4 sampling depths: coastal shelf, continental shelf, upper slope, and middle slope. Each sampling day includes experimental hauls on-board at a different depth range and was standardized species biomass and abundance (Fig. 1). On board all species of the commercial fraction were identified and measured. A total of 7 identified target species (European hake; red mullet; blue and red shrimp; Norway lobster; deep-water rose shrimp; spottail mantis shrimp; and horned octopus) were selected and subsampled to the laboratory where length, weight, and sex stage was determined. From the discarded fraction (non-commercial species, natural debris and marine litter) of each haul, a subsample is analyzed (Table 1).

Purse Seine. Sampling was done through the acquisition of batches of European pilchard and European anchovy at the fish market and, complemented with sampling of both species on-board. On-board sampling allowed to complete the estimation of the biological parameters of these species. In addition, it allowed to describe the whole catch composition, including by-catch and the discarded fraction. A standard batch of fish (approximately 10 kg) of each of the target species was bought directly at the sampled port market three times per month. Each of the three monthly batches was purchased in different ports, to cover the Catalan coast. Sampling on-board purse seiners was carried out twice a month from five main commercial ports (Fig. 1). At laboratory, all the individuals from a subsample were measured, weighed and sexed to obtain demographic and biological data. Also, in the on-board sampling, by-catch species were measured and weighted. **Small-scale fisheries.** Small-scale fisheries sampling was carried out from the zones that host a co-management plan. That includes sand eels, transparent goby, common octopus and blue crab fisheries (Fig. 1). Demographic and biological parameters of target species were obtained. **Sand eel and transparent goby fishery**, sampling was carried out on-board boat seine ("sonsera") fishing vessels where biological batches were obtained. Two monthly samplings of 1 Kg of Mediterranean and smooth sand eel and transparent goby were obtained and analyzed to the laboratory. A random subsample of 100-200 individuals was classified, measured to obtain size frequencies, weighed, and determined the reproductive stage. Discard species are identified. **Common octopus fishery**, sampling was carried out on-board fishing vessels, using pots and traps as fishing gears, where biological batches were obtained. Sampling was carried in 2 zones. Eight monthly samplings were conducted on board, alternating different gears (pots and traps). All individuals were measured, weighed and sexed. All individuals below MCRW were released back to the sea. A sample of 30 individuals of common octopus above 1000 g were transported to the laboratory where their reproductive state was assessed. **Blue crab fishery**, samples were collected once a month at the fishing auction. The depth and the location was provided by the fishers. Between 30 and 50 individuals were measured, sexed, and in females the presence of eggs and their developmental stage were determined.The monitoring program provides data for target species, fishing discards, marine litter, biodiversity changes, invasive species, and distribution and abundance of the marine living resources in the area. The web site from ICATMAR (icatmar.cat) offers further information on all the studies done and a viewer with public access to fisheries data. (ICATMAR Team: L. Recasens, J.B. Company, A. Lombarte, P. Abelló, A. Sabatés, P. Sánchez, R. Villanueva, M. Blanco, M. Balcells, F. Bustos, M. Carretón, A.I. Colmenero, M. Demestre, E. Galimany, M. Garriga-Panisello, M. González-Mingote, C. López-Pérez, V. Lopez, J. Ribera, A.J. Rico, A. Rojas, X. Puigcerver, M. Pujol, J. Sala-Coromina, R. Santos-Bethencourt, M. Silvestre).

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IDENTIFICATION OF THE RELEVANT COMMERCIAL FISHERIES TO ADDRESS THE ECOSYSTEM-BASED APPROACH TO FISHERIES MANAGEMENT (EAFM) IN THE MEDITERRANEAN AND BLACK SEA

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Abstract

Identifying relevant fisheries is a critical first step towards implementing the ecosystem-based approach to fisheries management in the Mediterranean and Black Sea. Focusing on key fisheries ensures that fisheries management policies are aligned with broader conservation and sustainability objectives. Nevertheless, due to the considerable diversity among Mediterranean fisheries, pinpointing pertinent fisheries entails various essential steps and factors. These include systematically analyzing data on target species, fishing techniques and prioritizing species based on their ecological significance and economic value. The statistical process allowing to reduce the initial métiers (441) to a final 107 of commercial fisheries is presented thus allowing a reduced effort in establishing the knowledge base required to give EAFM-relevant advice

Keywords: Mediterranean Sea, Fisheries

Identifying relevant fisheries is crucial for the successful implementation of the ecosystem-based approach to fisheries management (EAFM) in the Mediterranean and Black Sea because different fisheries have varying impacts on marine ecosystems. By identifying relevant fisheries, managers can focus their efforts on understanding the specific ecological interactions and dependencies within those fisheries and can develop targeted management measures that promote both ecological sustainability and the socio-economic well-being of coastal communities. The paper presents the results and the method applied in the EU Study on ecosystem-based approaches applied to fisheries management under the Common Fisheries Policy for the Mediterranean and Black Seas (EASME/2020/OP/0012) in relation with the identification of relevant commercial fisheries in the Mediterranean [1]. Commercial fisheries are defined as the basic unit to which management measures and policy instruments apply. They are identified so that they correspond to a unit of gear type, target species (group) and area, and therefore be expected to have the same (or sufficiently similar) impacts on the ecosystem and its different components. The relevant commercial fisheries under the CFP are identified for each of the ecoregions considered in the study. Identification of ecoregions (Figure 1) is based on grouping the GSAs consistently with the management units as reported in the EU WestMedPlan (EU Reg. EU 2019/1022) and the GFCM management plans in the Adriatic Sea (GFCM/43 /2019/5, GFCM/42/2018/8), Ionian Sea, (GFCM/42/2018/4), Levant Sea (GFCM/42/2018/3), Strait of Sicily (GFCM/43/2019/6), Alboran Sea (GFCM/43/2019/2) and Black Sea (GFCM/43/2019/3).
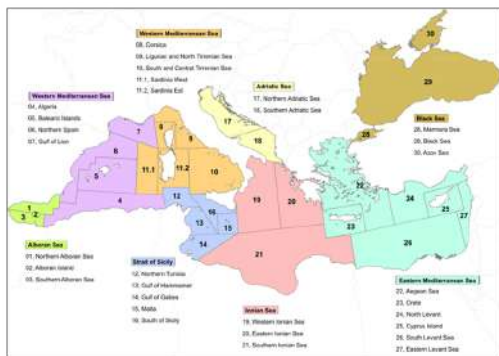

Fig. 1. Figure 1: Geographical subareas (ecoregions) for the selection of fisheries [1]

The analysis was implemented using the Scientific, Technical and Economic Committee for Fisheries (STECF) Fisheries Dependent Information (FDI) database [2] which contains total effort and landings per species by geographical subareas (GSA). These data were aggregated using the Data Collection Framework (DCF) métier level 6, country and vessel size by applying a cluster analysis aimed at identifying catch profiles at ecoregion level. This process led to the grouping of métiers according to the similarities in gear type and species composition (see figure 2 for an illustration).
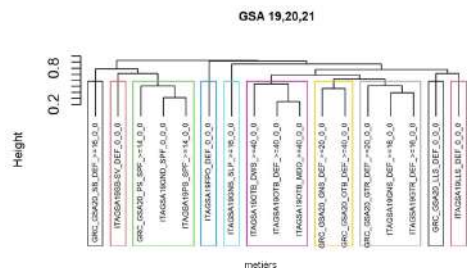

Fig. 2. Illustration of fisheries identification in GSA 19 [1]

The statistical process led to a reduction from the initial 441 métiers to 106 relevant fisheries with an additional one fishery identified for the bluefin tuna (*Thunnus thynnus*) across the whole Mediterranean Sea. Fisheries were identified through an aggregation process, considering their target species and operational area. However, this approach assumes that it sufficiently captures the potential impacts of each fishery on the ecosystem. Given that EAFM necessitates addressing the entire social-ecological system, it's imperative to comprehend the connections between the fishery and the broader social framework, encompassing economic and governance structures.

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HOW SEA SURFACE WAVES CAN HELP IDENTIFY POTENTIAL FISHING DAYS. PRELIMINARY APPROACH FOR TWO GREEK FLEETS.

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Abstract

It is widely acknowledged that the state of the sea and the associated waves are among the main factors determining when fishers will go to fish. This study tries to investigate the relationship between fishing effort and sea waves height, revealing a strong correlation. The maximum available fishing days estimated for bottom trawlers were 300 in the central Ionian Sea and for purse seiners 287 in the outer part of the Thermaikos Gulf.

Keywords: Waves, Fisheries, Aegean Sea, Ionian Sea

Introduction

Waves can affect the accessibility and safety of fishing grounds and pose significant risks to fishing vessels by limiting their ability to operate and deploy fishing gear. However, very few studies have investigated the direct relationship between fishing effort per fishing gear and sea wave height. This paper analyses the relationship between fishing effort, significant wave height (SWH) during fishing operations and the corresponding spatiotemporal fishing restrictions. The aim is to determine the potential availability of fishing days and areas for two fishing fleets, the otter bottom trawlers (OTB) and purse seiners (PS), in forecasted and retrospective periods.

Materials and Methods

Hourly data on the SWH (in meters) for the period 2012-2020 were downloaded from Copernicus Marine Environment Monitoring Service (CMEMS). Fishing effort data for the Greek fishing fleet spanning 2012-2020 were obtained from Global Fishing Watch (globalfishingwatch.org) and derived from AIS data processed by convolutional neural network models [1]. The daily mean SWH (DmSWH) was calculated separately for each day, fishing gear and grid cell, based on the SWH during the fishing hours per gear. The daily restrictions maps were derived from literature [2], adding any new legislation that came into effect after 2017. The total available fishing effort was estimated for the three GSAs (20,22, 23) retrospectively for 2023 and a forecasting period from 01/03/2024 to 09/03/2024 using SWH values and the 95% DmSWH thresholds for each gear.

Results and Discussion

The DmSWH threshold for PS is 0.55 m and 0.90 m, representing 95% and 99% of cumulative fishing activity, respectively. The OTB has a higher DmSWH threshold than PS, with values of 1.08 m and 1.56 m for the 95% and 99% of cumulative fishing activity, respectively. For OTB in the year 2023, the available number of fishing days ranged from 0 in areas where fishing is completely banned (such as below 1000 meters) to 300 days in the central Ionian Sea. Similarly, for PS, the available number of fishing days varied from 0 up to 287 days in the outer part of the Thermaikos Gulf (Figure 1).

Fig. 1. Retrospective estimation of total available fishing days from January 1st to December 31st 2023 for (a) OTB and (b) PS fishing gears based on 95% DmSWH and gear corresponding spatiotemporal restrictions, within GSA 20,22 and 23.

This method of estimating fishing days could be useful for marine spatial planning by directly being integrated into corresponding models and providing a forecasting and retrospective assessment of fishing effort availability.

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EFFECT OF ARTIFICIAL LIGHT ON THE CATCHES OF THE BLACKSPOT SEABREAM *PAGELLUS BOGARAVEO* (BRÜNNICH, 1768) IN LONGLINE FISHERIES

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Abstract

A first trial was conducted to investigate the effects of artificial light sources on longline fisheries targeting *Pagellus bogaraveo* in the Aeolian Islands under two moon phases. The effect of artificial light was negligible on *P. bogaraveo* catch under full moon conditions. Conversely, some effects were recorded during partial moon conditions. Artificial light seems to have a positive effect on the catch of the by-catch species during both lunar phases.

Keywords: Tyrrhenian Sea, Fish behaviour, Management, Artisanal fishery, Teleostei

Introduction - *Blackspot seabream* (*Pagellus bogaraveo;* Brünnich, 1768) (SBR) is ubiquitous throughout the Mediterranean Sea, particularly abundant in the western region, less common in the eastern Mediterranean Sea, and absent from the Black Sea. It is a benthopelagic species with a protandrous hermaphroditism. Adults reproduce all year round with maximum reproduction occurring in colder seasons according to region. Juveniles are often found in coastal areas, while adults inhabit the upper slope at depths of up to 400 meters [1,2]. Blackspot seabream, valued for its high commercial value, is targeted by both artisanal and recreational fisheries. Considering the signs of overexploitation (e.g. GFCM 41/2017/2) and the increasing use of artificial lights in both commercial and recreational fisheries, a first trial was conducted off the Aeolian Islands (South Tyrrhenian Sea) to test the effect of artificial light on the catches of this species.

Material and Methods - In spring 2022, in the fishing ground of Lipari Island (Aeolian Islands) known as "Secca del capo" (DD, 15.4306 E, 38.0910 N), four fishing trips were conducted under two different lunar phases: full moon (brightness equal to 100% and 96%) and partial moon (brightness equal to 50% and 31%). During each trip, four 200-meter longlines were alternately deployed in a circular manner around the top of the bank at depth of about 200m. Four longlines were equipped according to the local fishers specialized on SBR fishery; two of these were designated as control, while the remaining two were equipped with eight LED bulbs emitting green and white with peak wavelengths of 520 and 460 nm, respectively, with an intensity of 3.5 cd (data from manufacturer) placed in the armrest floats (test; Fig. 1).
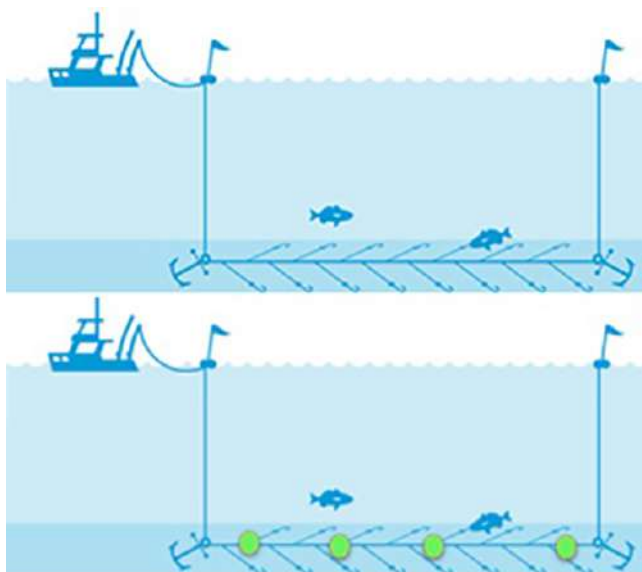

Fig. 1. Representation of the experimental plan. (A), longline without lights (control), (B) longline with lights (test).

Results and discussion - Catches in number of target SBR and by-catch (other fish and cephalopods) has been recorded through the test and control. Although Kruskal-Wallis test comparison showed non-significant differences ($p > 0.05$) for SBR catches between full and partial moon (Fig. 2) seems that the catches were lower in the test with full moon, while they were slightly higher with a partial moon. Conversely, the by-catch was higher during both moon phases in the test. This study has revealed highly variable effects of artificial light on the catch of SBR, with a potential increase during periods of reduced moon brightness. Considering the recent extensive use of artificial light in both commercial and recreational fisheries, further evaluation of its impact on SBR catch is needed. This is essential to avoid a scenario where an increase in CPUE can lead to a further depletion of these already overexploited stocks.

Fig. 2. Number of specimens of target SBR (blue) and by-catch (red) caught by the test and control during the different phases of the moon (FULL and PARTIAL).

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CIESM Congress Session : Research towards sustainable aquaculture
Moderator : Fabiano Capparucci – Univ. of Messina, Italy

Session's Synthesis

The session on "Research for Sustainable Aquaculture" began with a presentation highlighting the importance of sustainable aquaculture, focusing on the negative aspects of conventional aquaculture practices and the critical role of research in this area to improve the safety and quality of aquaculture products. Improving research, can create an aquaculture industry that is resilient, responsible and sustainable for the future generations.

The meeting was well attended by researchers interested in the topic. In this context, several speakers presented the results of their research, focusing mainly on the use of benthos (macrobenthos and megabenthos) as a key organism for the environmental assessment of waters surrounding offshore aquaculture facilities, which in certain situations can cause eutrophication and anoxia phenomena due to high fish waste production. However, the studies carried out suggest that the aquaculture activities have not significantly degraded the local environment. In contrast, other research has assessed the impact of organic waste from rearing cages by examining meiofaunal communities and found a change in species composition. Meiofauna abundances at exposed sites tended to decrease, suggested a localized environmental impact that is restricted to the farming area. In addition, findings indicate that proximity to aquaculture activities may positively influence the somatic health of bogue populations.

The final discussion among the participants highlighted the continued necessity for the implementation of environmental management measures to mitigate the adverse effects of traditional aquaculture activities and to safeguard the ecological integrity of vulnerable marine ecosystems.

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SCAVENGING MEGABENTHOS BELOW TUNA CAGES IN MALTA

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Abstract

The population density of megabenthos below tuna pens in Malta is significantly higher (ANOVA; $p < 0.05$) when compared to reference sites, particularly for the echinoids *Stylocidaris affinis* and *Centrostephanus longispinus*. Population density is highest during the peak period, and in some cases remains high during the fallow period, compared to equivalent reference sites without pens. Overall, there appears to be no gross degradation of the benthic environment.

Introduction - Impacts of fish farming on the benthic environment are mostly due to uneaten feed and waste products [1]. Whole fish, including mackarel and sardines, are used as feed in tuna ranching instead of the dry food pellets used for other cultured species [2]. Large amounts of feed-fish are required to obtain a conversion ratio of around 15 - 20 : 1 for tuna [3], with a proportion of such feed often ending up on the seabed below the cages, hence impacts on the benthic environment may be appreciable. Most studies of such impacts have focussed on benthic infaunal communities, mostly macrofauna. Here we consider the megabenthos at a tuna ranching site in Malta.

Methodology - ROV videos of the seabed were recorded twice a year in April - June (during the fallow period) and in September – October (during the peak production period) from 2019 to 2023, at a tuna ranching site off the SE coast of Malta, and at four reference sites located approximately 1 km away from the tuna cages to the N, S, E and W. Due to operational delays, the 2022 fallow period survey took place in July, when some cages were already full with tuna. During each session, the seabed was filmed directly below 12 tuna pens, and at the 4 reference sites. Water depth at the tuna ranching site and reference sites ranged from 65 m - 100 m. Within a depth of 65 m – 90 m, the bottom consisted mostly of a mixture of coarse and fine sediment with accumulations of rhodoliths; deeper than 90 m, the bottom was mostly bare, fine sediment.

Results & Discussion - The video records clearly show an increase in particular megabenthic species at the farm site when compared to the reference sites, especially the echinoids Stylocidaris affinis, and, to a slightly lesser extent, also Centrostephanus longispinus. Population density of S. affinis was reduced during the fallow period, although it was not significantly different to that during the peak period (ANOVA, $p = 0.28$), but was still significantly higher than at the reference sites during the fallow period (ANOVA, $p < 0.05$), indicating that the area remained an attractive feeding ground for these echinoids. Densities of C. longispinus were significantly higher at the farm site than the reference sites during the peak period (ANOVA, $p < 0.05$), but during the fallow period densities were reduced to a level comparable to the reference sites (ANOVA, $p = 0.17$). The estimated maximum densities for each year are presented in Figure 2.
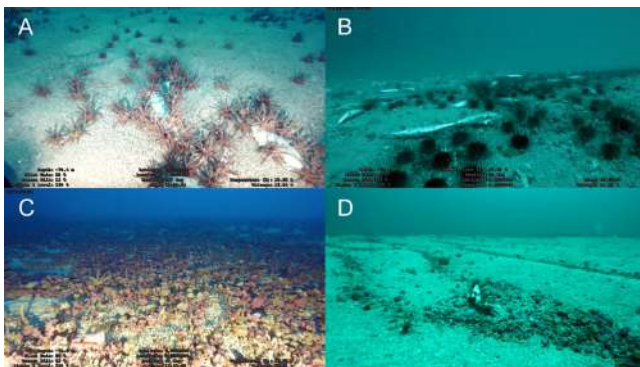

Fig. 1. Populations of *S. affinis* (A) and *C. longispinus* (B), during peak tuna production season, scavenging dead feed-fish. Rhodolith bed at the farm site during the fallow season, showing few echinoids (C), and a coarse bottom with sparse rhodoliths and very few echinoids at one of the reference sites (D).

The results indicate a partial recovery of the seabed during the fallow period as also noted from studies on benthic infauna [4]. Both S. affinis and C. longispinus were observed feeding on dead fish during the production period, whereas no dead fish were recorded during the fallow periods (except in July 2022), indicating that these species contributed to effective scavenging activity and removal of uneaten feed-fish present on the seabed below the cages. To our knowledge, this is the first recorded instance of mass scavenging activity by these echinoids. Despite the obvious input of organic matter to the seabed, the overall state of the benthic environment appeared to be good, with a significant cover of rhodoliths that were in a good state, and no sign of anoxic conditions or bacterial mats.

Fig. 2. Estimated population densities of *S. affinis* and *C. longispinus* during peak and fallow periods for each year. Both species were present at densities of < 1 individual / m² at the reference sites throughout each year.

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MACROBENTHIC COMMUNITIES OF AQUACOLE FARMS IN CENTRAL ALGERIA

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Abstract

This study investigates macrobenthic fauna at aquaculture farms in central Algeria. Samples were collected during the cold season from farms in Ain Taya and Tipaza. Six grab samplings were conducted at each farm to characterize the macrobenthic community's composition, structure, and functioning. Preliminary results reveal 10,735 individuals and 210 species at Tipaza, and 2,912 individuals and 96 species at Ain Taya. Five benthic indices (H', J', AMBI, M-AMBI, BENTIX) suggest "Moderate" to "High" ecological status across all sampling stations. Monitoring and control efforts are crucial to prevent disturbances that may impact production, economy, and sustainable development of aquaculture activities.

Keywords: Zoobenthos, Aquaculture, Algerian Sea

Introduction

Aquaculture is an essential food sector worldwide, supplying a significant amount of seafood to the global market, currently the fastest growing food production sector, with an annual growth rate of 5.8% between 2001 and 2016 [1]. The environmental sustainability of aquaculture has attracted a large amount of attention in recent decades, in particular due to the global expansion of the industry, with production reaching around 160 million tons in 2014 [2]. A faunistic and ecological study on the benthic macrofauna was carried out in the shellfish farm of « CULTMARE » in Kouali (Tipaza), in the central region of Algeria. This study aims to characterize the composition, structure, and functioning of the benthic community in order to have a reference state and bioecological quality of the shellfish farm, as well as to monitor their evolution through a sampling and observation methodology adapted and used by the scientific community at the international level. This informations are necessary in order to provide an essential knowledge and enrich databases for the development of a sustainable aquaculture industry.

Material & Methods

Macrobenthic fauna samples were taken during the cold season (February) at two aquaculture farms in the east (Ain Taya) and west (Tipaza) of the central Algerian region of Algeria (Fig. 1). For each farm and each station, 6 grab samplings were carried out: one station in the center of the aquaculture farm and two stations at the extremities, in order to cover the total area of the farm. Different indices were evaluated and measured based on benthic community characteristics (Richness species, abundance, zoological groups, biotic index) and indicator species.

Results & Discussion

Preliminary results of macrobenthos community, at the two aquaculture farms, allowed the collection of 10735 individuals, 210 species at the Tipaza farm; 2912 individuals and 96 species at the Ain Taya farm.

The results of the five benthic indices (H', J, AMBI, M-AMBI, BENTIX) clearly indicate that «**Good**» and «**High**» ecological status assessments are relevant in all sampling stations of the surveyed zone.

Tab. 1. Spatial evolution of the biotic indices in the shellfish farm.

	BENTIX	EQR	AMBI	M-AMBI	H'
F1	4,53	0,75	1,045	0,99	5,47
F2	3,26	0,54	1,725	0,75	3,9
F3	3,55	0,59	1,149	0,68	4,37
T1	4,96	0,83	0,286	0,89	4,22
T2	4,92	0,82	0,368	0,99	5,09
T3	4,94	0,82	0,579	0,91	4,80
TC	4,97	0,83	0,305	1	4,02

Conclusions & Perspectives

Collectively, findings obtained from this study gave a reference state of the soft-bottom communities of the aquaculture farm but also showed that macrobenthic assemblage is an excellent indicator of ecological status. The four indices H', AMBI, M-AMBI and BENTIX are very close in terms of diagnosis. Further developments considering abiotic and biotic interactions are needed for a more complete environmental evaluation, for a better aquaculture production and the development of an environmentally responsible aquaculture.

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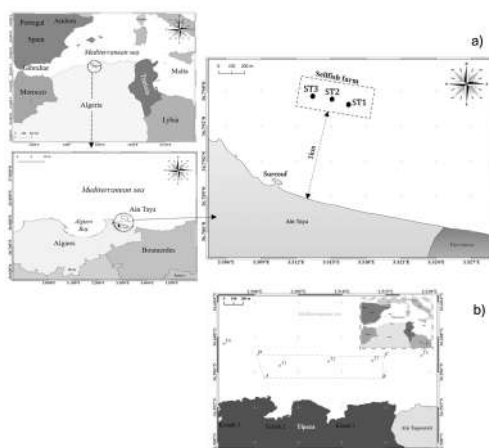
Fig. 1. Location and sampling stations of a) Orca marine shellfish farm (Ain Chorb, ex Ain Taya-Algiers) and b) CULTMARE shellfish farm (Kouali, Tipaza).

AQUACULTURE INFLUENCE ON THE SOMATIC INDEXES OF WILD BOGUE *BOOPS BOOPS* (LINNAEUS, 1758) IN THE EASTERN ADRIATIC SEA

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Abstract
Biometric parameters of the bogue *Boops boops* (Linnaeus, 1758) during spawning season from the different areas of the eastern Adriatic Sea were studied to analyse aquaculture influence on the somatic indexes of the bogue populations. A significant difference in the Fulton's condition index (IK) was observed with regard to the location of sampling; bogues from breeding cages had significantly higher condition index (mean ± SD=1.18 ± 0.18) than those from immediate vicinity of the cages (mean ± SD=1.02 ± 0.09) and specimens caught far from the breeding cages (mean ± SD=1.03 ± 0.13). Our data provide a base for further study of the changes in somatic indexes of wild bogue populations that interact with aquaculture fish.

Keywords: Aquaculture, Biometrics, Spawning, Adriatic Sea

The bogue *Boops boops* (Linnaeus, 1758), is an opportunistic fish species that feeds on diverse marine organisms. Besides being caught in fishing, it is very often aggregating at fish farm, where nutrients from cages are concentrated, but it can also be found in the cages, where it lives in coexistence with farmed fish [1, 2]. In addition to being attracted to food, bogue can also hide near breeding cages and find protection from predators [3, 4]. Therefore, the aim of this study was to investigate the aquaculture influence on the somatic indexes of wild bogues.

The research was carried out in May 2023, during the intensive spawning of bogue. Samples (N=133) were collected from three locations in the middle part of the Eastern Adriatic: the immediate vicinity of the cages (A), cage breeding (B), and a location far (>3000 m) from the breeding cages (C). After total length (TL), total weight (TW) and gonad weight were measured, sex was determined, and gonadosomatic index (GSI) and Fulton's condition index (IK) were calculated according to formula: $IK = 100 \times (TW/TL^3)$; $GSI = 100 \times (GW/TW)$.

The research results showed that there were more females (N=77) than males (N=56) in the samples (N=133). A significant difference in the Fulton's condition index (IK) was observed with regard to the location of sampling; bogues from breeding cages had significantly higher condition index (location B: average IK=1.18) than those from immediate vicinity of the cages (location A: average IK=1.02) and specimens caught far from the breeding cages (location C: average IK=1.03) (Table 1).

Tab. 1. Biometry of bogue (*Boops boops*) (total length LT, total weight TW, Fulton's condition index (IK) and gonadosomatic index (GSI), (mean ± SD), from the immediate vicinity of the cages (location A), cage breeding (location B), and far from the breeding cages (location C), middle eastern Adriatic Sea

Location	Total length (cm)	Total weight (g)	Fulton's condition index (IK)	Gonadosomatic index (GSI)
A	31.97±2.05	336.26±65.83	1.02±0.09	3.35±0.96
B	29.01±4.17	316.65±140.25	1.18±0.18	5.17±3.18
C	29.14±1.83	254.98±48.17	1.03±0.13	5.01±1.58

In addition, gonadosomatic index (GSI) of bogues from breeding cages had higher values (location B: average GSI=5.17) than samples caught in immediate vicinity of the cages (location A: GSI=3.35) and from bogues sampled far from the breeding cages (location C: GSI=5.01) (Table 1). The coefficient of determination (R^2=0.099) indicated a negligible correlation between Fulton's condition index (IK) and gonadosomatic index (GSI) in bogue from all three sampled locations (Fig.1).

As in our study in the Adriatic Sea, fish farms along the Mediterranean coast had effect on the condition index and also lipid content and chemical pollutant levels of bogue, caught both inside or in the immediate vicinity of the cages [4, 5]. This effect seams to disappeared completely at 3 km from the sea cages [4]. In general, fish farms aggregate wild fish around the floating structures, which leads to altering wild fish physiology, occurrence, schooling and feeding behavior [2, 3, 4].
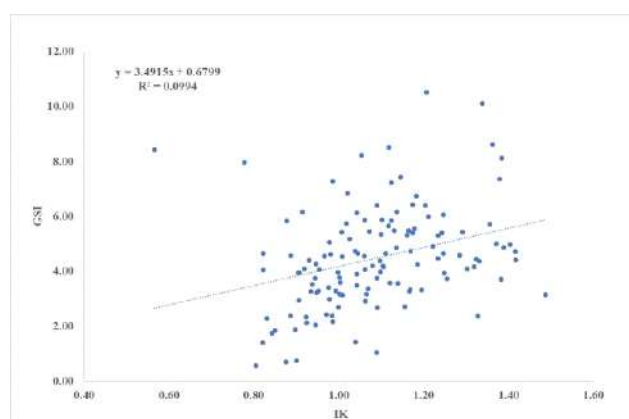

Fig. 1. Relationship between Fulton's condition index (IK) and gonadosomatic index (GSI) in bogue (*Boops boops*), middle eastern Adriatic Sea

Further research on aggregating fish species and biomass around fish farm would be of great interest to better understand ecological changes of wild fish population which should also be taken in consideration for future aquaculture management plans.

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THE BIOFOULING OF CAGE NETS IN FISH FARMING: A PILOT STUDY

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Abstract

The aim of this paper is to present the data on biofouling of cage nets in a fish farm in the Adriatic Sea (Croatia). This study was conducted in the field using the underwater visual census method - quadrat sampling. The three-factorial ANOVA test revealed statistically significant (p<0.001) effects of Side, Depth and Time on mesh size.

Keywords: Aquaculture, Fouling, Adriatic Sea

Introduction

Biofouling on aquaculture cages reduces the size of the mesh openings and slows down the exchange of water masses through the net [1,2]. As a result, the oxygen concentration in the cages decreases [3], as does the weight of the net [1]. The reduced water quality in the cages and the need to clean the nets can affect the quality of the cultured organisms and the economic viability of the farm [4].

Material and methods

The study was conducted in a sea bass cage farm *Dicentrarchus labrax* (Linnaeus, 1758) in the Adriatic Sea (Croatia). In the aquaculture concession, the succession of biofouling was studied on a random cage (four-sided cage) and a control net. The nets were immersed into the water on 04/04/21. Samples were collected *in situ* using an autonomous diving apparatus (ARO) and an underwater camera. The underwater visual census method, quadrat sampling [5], was used for continuous sampling. This method does not require the removal of fouling organisms and is therefore ideal for successive monitoring of fouling organism growth. The average area of mesh size (in mm^2) was measured at three different depths (1m, 4m, 8m). The measurements were repeated six times from April to July and analysed using a three-factorial ANOVA (Side, Depth and Time).

Results and discussion

Figure 1. shows the average surface area of the mesh size (mm^2) for six different sampling Times (21/04/21, 12/05/21, 25/05/21, 12/06/21, 06/07/21, 21/07/21) and three different depths (1m, 4m, 8m). It is evident that the largest differences were observed at the last sampling (1m: 60.54 mm², 4m; 119.89 mm^2 and 8m: 169.07 mm^2). The three-factorial ANOVA test revealed statistically significant (p<0.001) effects of Side, Depth and Time on mesh size (Table 1).
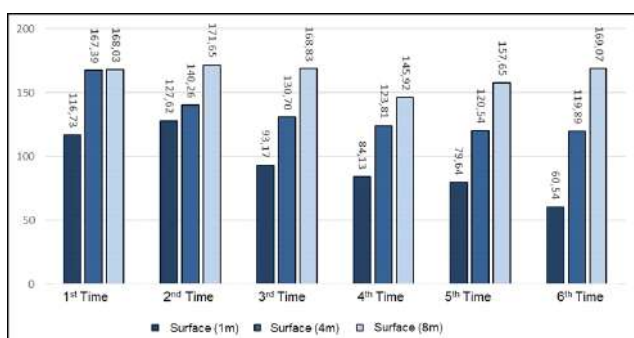

Fig. 1. The average surface of the mesh size (mm^2) free from biofouling for six Times from three different depths (1m, 4m, 8m).

Tab. 1. Results of the three-factorial ANOVA (Side of the net: North, West, South, East and Control; Depth: 1m, 4m and 8m and Time: 21/04/21, 12/05/21, 25/05/21, 12/06/21, 06/07/21 and 21/07/21) for the variable of the area of mesh size free of fouling (p<0.001; η2 – Partial Eta Squared).

FACTOR	F-value	p-value	η2
Side	769.187	<0.001	0.756
Depth	3050.910	<0.001	0.860
Time	282.481	<0.001	0.221

It was observed that the cage nets were more heavily overgrown in the period from April to May than in the period from June to July at 1m and 4m. In the initial phase of growth, growth is more intense because there is free space for growth and abiotic factors, including heavy rainfall, favour growth. According to [6], low salinity favours the growth of vegetation on substrates in the marine environment. In addition, this site is characterised by the inflow of freshwater from the mainland [7], which could increase the intensity of biofouling in the studied area [8].

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MONITORING THE IMPACT OF A NEWLY ESTABLISHED FISH FARM FACILITY ON MEIOFAUNA COMMUNITY STRUCTURE IN THE LIMSKI KANAL BAY (ADRIATIC SEA, CROATIA)

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Abstract
Meiofauna is taxonomically heterogeneous size category of benthic metazoans (64-500 μm) larger than microfauna and smaller than macrofauna. Alteration in the composition and abundance of meiofauna proved to be a suitable indicator of different natural and anthropogenic impacts in marine ecosystems. In this paper, spatial and temporal alteration of meiofauna assemblages were studied to assess the effect of the newly established fish farm in the Limski kanal bay, for eight years (2010-2017) after its commissioning. Samples of meiofauna were collected at two sites directly exposed to organic waste from breeding cages, and the control site C, set up at 1,5 km distance from the farming area. Sampling was carried out once a year, when feeding rate and biodeposition impact on meiobenthic assemblages are expected to be at the maximum level.

Keywords: Zoobenthos, Adriatic Sea

Introduction - Impact of fish farming on marine sediments is much greater than its effects on the water quality. The main impact is related to the intensive biodeposition of the faeces and unconsumed food that modify the environmental characteristics of the benthic habitats and affect benthic communities. During the last decades intensive farming of seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*) in the Mediterranean Sea has grown exponentially, inducing an increasing concern for potential negative impact on coastal marine environments. Due to its geomorphologic value, as well as its beneficial for fish over-wintering and spawning, Limski kanal is declared a Protected Landscape since 1964, Special Marine Reserve since 1980 and Natura 2000 site since 2019. Limski kanal is shelter and semi-enclosed bay, with low water exchange and silty bottom. Such locations were recognized as places of high environmental risk [1-2] and require increased monitoring of the ecological conditions. Except the mariculture, all human activities are suppressed. In this area, intensive cultivation of european sea bass and the gilt-head sea bream have started in 1981 and lasted 40 years, until the cessation in 2021. New concession area was established 1,5 km westward, and operated by computer-driven nutrition and maintenance technology. It consisted from six fish farming fleet, each contained 10 circular floating cages (unit dimension φ=16m, volume 2300 m2) with the overall production up to 500 t year-1. In this paper, the impact of newly established fish farm on the meiofauna communities structure was studied.

Materials and Methods - Limski kanal is a fjord-like bay about 11 km long that indents deeply into the Istrian peninsula (E 13°37'- 13°45', N 45°10'- 45°11') in W-E direction.Samples of meiofauna were collected at two sites directly exposed to organic waste from breeding cages, and the control site C, set up at 1,5 km distance from the farming area.Sampling was carried out once a year, in early autumn, from 2010 to 2017. Samples were collected by SCUBA divers manually with PVC core samplers (surface area 10 cm2, length 15 cm). At each site and occasion 4 replicate sediment samples were taken, 3 for meiofauna analysis and 1 for redox potential measurement. Samples for analysis meiofauna were fixed with a neutralized 4% formaldehyde solution in seawater with the addition of Rose Bengal and were subsequently processed, using standard laboratory methods.The meiofauna was analyzed at the level of constitutive units and its density is expressed by the mean value of the number of taxa present within three replicate samples (No.ind. 10 cm-2). Statistical processing of the results was made, which includes basic descriptive statistics and multivariate analysis (n-MDS, ANOSIM).

Results and Discussion - Negative values of redox potential (Eh) were measured along the sediment column at farm sites (measurement intervals 1 cm), including the surface layer 0-1 cm: P1 -164 mV, P2 -176 mV. At the control site, two upper centimeters of sediment RPD values were positive.Total organic matter content was higher at farm sites (14-28%), compared to control site (4-8%). A total of 16 meiofauna taxa were found. Taxonomic richness ranged between 4 and 15 taxa, and was significantly lower under the cage (4-8) compared to the control site (13-15). Nematoda, Copepoda, Polychaeta, Kinorhyncha and Turbellaria were found at all sites. Isopoda, Cumacea, Acari and Hydroza were present only at control site, and Gnathostomulida only at farm sites. Meiofauna abundance was significantly lower at farm sites F1= 322.04±44.96, F2= 332.33±66.77, C=531.96±49.51 At all sites meiofauna assemblages dominated by Nematoda (F sites =92% , C=77%), followed by Copepoda (F sites =3% , C=10%) and Polychaeta (F sites=3% , C=4%). All other taxa together comprise 2% of total meiofauna abundance at F sites and 9% at the control site. Both, hierarchical agglomerative clustering and Non-parametric multidimensional scaling (MDS) clearly separated samples belonged to control sites from those associated with fish farm sediments. The stress value obtained for the MDS plot were far lower than 0.1, indicating excellent representation of the meiofaunal data in two dimensions. In order to test differences in meiofauna assemblages structure between selected data sets, pairwise test (ANOSIM) was calculated between all pair of sites. The results of ANOSIM (global R=0,737; p=0,1) revealed differences in meiofauna assemblages structure among farm sites related to control site: F1 vs C=1, F2 vs C=0,996, but no differences between farm sites F1 vs F2=0,004). The results of the SIMPER analysis indicated high average similarity within selected data sets: F1 83%, F2 81%, C 90%, low dissimilarity between F1 and F2 sites (18%), and rather high dissimilarity among farm sites and control site: F1 vs C 43%, F2 vs C 42%). Our results are in accordance with results obtained in other Mediterranean fish farms [2-3]. Conclusions The meiofauna assemblages structure in the fish farming area is modified compared to the control site. Changes were detected on a qualitative and quantitative level and related to: reduced taxonomic diversity and abundance, poverty and/or absence of more sensitive taxa (Copepoda, Kinorhyncha, Amphipoda, Ostracoda, Isopoda, Cumacea), presence of oportunistic Gnathostomulida and elevated Ne:Co ratio. The influence of cage farming of fish on the meiofauna of sediments in the Lim Channel is localized, i.e. limited to a small area of the seabed below the cage.

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CIESM Congress Session : Higher vertebrates
Moderator : Alen Soldo – Univ. of Split, Croatia

Session's Synthesis

Although amphibians are considered the most threatened class of vertebrates on Earth—with 41% of species threatened with extinction according to the IUCN Red List of Threatened Species—large fish species (greater than 1.5 m in total length) face even greater risk. Among these, half are threatened with extinction, particularly sharks, rays, and sturgeons. Globally, sharks and rays are the second most threatened vertebrate group, but in many regions, they are the species most at risk. For example, the Mediterranean Sea is considered the most problematic region for chondrichthyans, with approximately 60% of species threatened with extinction. In some Mediterranean areas, the situation is even more critical; recent assessments show that 70% of species in the Adriatic Sea are threatened, including three species now regionally extinct.

This urgent situation highlights the importance of gathering more data on the biology and ecology of sharks and rays in the Mediterranean to support management measures that will aid in their recovery and preservation. Fortunately, there are increasing numbers of studies focused on various Mediterranean shark and ray species. A recent CIESM expedition in Türkiye revealed that many shark and ray species, particularly those endangered or data-deficient, are often caught as bycatch in coastal fisheries. Additionally, the Strait of Sicily has been identified as a crucial area for pregnant and spawning females of the deep-water shark *Etmopterus spinax*. Further north, the Aegadian Islands have been recognized as a seasonal aggregation site for the large common eagle ray (*Myliobatis aquila*), one of only a few aggregation sites for sharks and rays documented in the Mediterranean.

Despite being the second-largest fish species, very little is known about the basking shark (*Cetorhinus maximus*). Recent data suggest that the waters off the Syrian coast may serve as a breeding and nursery area for this species, supporting the theory of a distinct basking shark population in the Mediterranean. Aggregation sites for sharks and rays aren't limited to natural habitats; for example, research near Maltese bluefin tuna farms found that several batoid species scavenge on fish used in tuna fattening. Understanding different habitats and how they impact feeding strategies is crucial to studying the complex marine ecosystem. A recent study on the diet of the small-spotted catshark (*Scyliorhinus canicula*) in the southern Tyrrhenian Sea exemplifies the type of research essential for gaining insights into the biology and ecology of sharks.

Although citizen science has contributed valuable data, this information can only serve as a preliminary basis for understanding the distribution of sharks and rays. Further rigorous field research is needed to achieve a comprehensive understanding of their ecological importance and conservation status.

*-The title "Second record from Edremit Bay, *Isurus oxyrinchus* Rafinesque, 1810" by authors Havva Cimen and Dilek Turker was not presented.

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IDENTIFYING ESSENTIAL FISH HABITAT OF A DEEP-WATER SHARK SPECIES IN THE STRAIT OF SICILY

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Abstract

Etmopterus spinax (Linnaeus, 1758) is a deep-water shark species of the Squaliformes order. Widely distributed in the Mediterranean Sea, it often comes as a bycatch by trawl fisheries, especially for deep-water shrimp the main fishery sector in the area of the Strait of Sicily. While abundant, it's late maturity and its low fecundity makes it vulnerable to fishing mortality. This works aims at, using scientific trawl survey data, identifying the population structure in GSA 16 to observe spatial distribution of the different life stage. Using spatial interpolation, we found persistent areas for pregnant and spawning females and individuals less than 1 year old, in order to highlight the most important areas for its life cycle.

Keywords: Sicily Channel, Elasmobranchii, Habitat, Fisheries

Introduction

The lantern shark *Etmopterus spinax* (Linnaeus, 1758) is an abundant shark species inhabiting the upper slope of the Nord-East Atlantic and Mediterranean Sea.It is characterized by a late maturity and a low fecundity. It's life cycle is viviparous, and is a benthopelagic forager. Its depth range is estimated to be between 100 and 2000 meters and is naturally co-occuring with deep sea fisheries for Deep water shrimps, in the Strait of Sicily, making it a common bycatch which may endanger the population. Using MEDITS scientific trawl survey conducted in spring-summer, We focused on two critical stage to investigate preferred areas to support bottom trawling management ; Young of the year (YOY) which represent the first cohort, and females in middle/late pregnancy. The spatio-temporal distribution of these categories may represent potential Essential Fish Habitat for the species.

Material and Methods

Young of the year (YOY): Bhattacharya's decomposition and NORMSEP algorithm were applied on the Length Frequency Distribution (LFD) within the FISAT II software. This technique, based on the assumptions that : (1) the LFD of a population is an aggregation of the different cohorts size distributions, (2) that the growth coefficient and mortality are relatively higher at early stages of life of the species. We analyzed the LFD of *E. spinax* which showed a clear bimodal distribution. The first gaussian was identified, and its parameters were obtained. The sum of the computed mean and standard deviation was used to calculate a size threshold of 109+14 = 123 mm. For spawning females, we chose individuals in middle to late pregnancy.In order to find persistent areas, i.e areas of high fidelity for spawning, the data was partitioned in 4 tri-annual periods, from 2010 to 2021. For each timeframe and life stage, Abundance (n/km2) by haul was interpolated using kriging.The continuous maps were made using a 4km regular grid. Each layer was then converted to discrete presence/absence using a threshold of 1 n/km2.
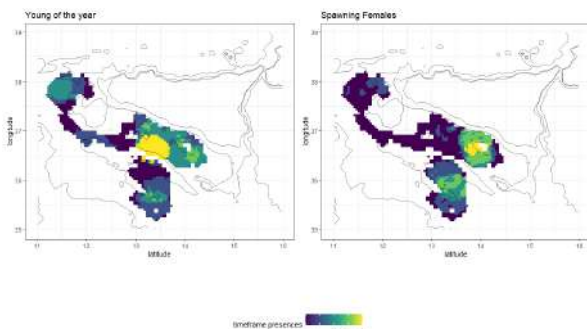
Results

Fig. 1. Temporal persistence of presence of life stages of E. spinax. in GSA 16 for the 2010-2021 timeframe.

Figure 1 highlights distinct areas for spawner, especially west of the Malta bank, with a defined hotspot of pregnant and spawning females present in all timeframe considered. West of this area is found an hotspot of YOYs with 4 out of 4 presence. Spawners are also found south of GSA 16, but with a maximum of ¾ timeframe presence, overlapping with some YOY presence, Several YOY areas are found in GSA 16 but with lower persistence and no nearby spawner areas.

Discussion

These areas highlighted suggest a presence of a hotspot for spawning in deeper areas centered into 14°N;36.5°E, where pregnant and ready to spawn individuals were collected during the whole timeframe. It is possible that young individuals born in the area then migrate to shallower areas in the YoY hotspot at 13.5N°;36.5E°, where they may find suitable habitat to feed and grow during their first stage of life. Other hotspots for young individuals are found in the study areas, for which is it conceivable that they are sustained by spawners outside of GSA 16. It is important to note that the depth range of *E. spinax* exceed the maximum survey depth of MEDITS data, and the depth distribution of spawners may hint that they actively migrate in deeper waters to spawn. This separation may indicate that young individuals are more at risk to overlap with fishing areas, as 800 meters is the main technical limit of bottom trawling in the area, and 1000 meters is the legal limit in the Mediterranean. This study however highlight is the groundwork for an assessment to identify Essential Fish Habitats for elasmobranchs in the Mediterranean.

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COMMON EAGLE RAYS MYLIOBATIS AQUILA (LINNAEUS, 1758) AGGREGATION IN THE "EGADI ISLANDS" MARINE PROTECTED AREA – SOUTHERN MEDITERRANEAN SEA

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Abstract

Elasmobranchs are globally threatened by over-fishing and by-catch pressures, with the Mediterranean Sea experiencing an alarming increase in extinction risk compared to other marine regions. Sharks and rays seasonally aggregate in sensitive habitats to conduct critical life stages, increasing their vulnerability to fishing mortality. Underwater video surveys conducted in the "Egadi Island" Marine Protected Area over a four-years period since 2020, aimed to characterize schooling behaviors of the common eagle rays. The abundance of common eagle rays and intra-specific interactions may be reduced by unmanaged scuba diving during summers. Incidental by-catches from small-scale fisheries using trammel nets threats the common eagle rays in months preceding the aggregation and in various areas of the archipelago.

Keywords: Elasmobranchii, Sicily Channel, Marine reserves, Conservation

Introduction

Sharks and Rays play crucial roles in coastal and deep ecosystems by controlling food chains as apex predators or as intermediate links [1]. The International Union for Conservation of Nature (IUCN) has identified the Mediterranean Sea as a critical area for the decline of elasmobranchs, with over 50% of classified species threatened, showing no signs of improvement in recent decades [2, 3]. Some elasmobranchs exhibit 'seasonal residency', returning to specific sites to conduct important phases of their life cycles, such as reproduction, and remaining in the area for several months at a time (at least 90 d) before moving elsewhere [4].The common eagle rays can be found in groups with significantly higher abundances in the summer at a depth ranging from 10 to 50 meters [5,6,7]. The species is classified as Vulnerable according to the Mediterranean IUCN assessment, due to a decline by at least 30% over three generations [8]. A summer aggregation of common eagle rays occurs on the southern side of Marettimo, the most remote island of the Egadi Archipelago MPA [9] (Fig.1 a).

Materials and methods

Since 2020, the relative abundance and behaviors of the common eagle rays during the aggregation were assessed through no-inasive and low impact methods, such as Remotely Underwater Video (RUVs) and Diver Operated Video systems(DOVs), as well as the evaluation of the effects of scuba-diving activities.

Results and Discussion

The aggregation is composed of hundreds of common eagle rays, with a female-biased sex ratio (Fig.1 b). Evidence of pregnant females (Fig.1 c) and mature adult males performing courtship and reproductive behaviors (Fig.1 d) indicate the area as the first described reproductive and mating ground in the Mediterranean Sea. Unmanaged recreational and commercial activities may threat the aggregation, particularly more than four divers at the same time may lead to a reduction in abundance, fragmentation of the group and behavioral changes, such as interruption of reproductive interactions (Fig.1 e). Single specimens are incidentally by-caught and landed by local small-scale fishery vessels before and after the formation of the aggregation. Since the aggregation area seems to be unsuitable for fishing activities, probably due to the continuous presence of strong bottom currents and the rugged morphology of the seabed, common eagle rays are usually by-caught outside the area during their individual and daily movements (Fig.1 f).

Conclusions

We suggest a participative management of human activities through the adoption of a code of conduct, including self-regulation for scuba-divers within the aggregation area during summer months, and the promotion of good-practices among small-scale fishers to reduce fishing mortality and unintentional by-catch of the common eagle rays during their individual movements across the entire archipelago.
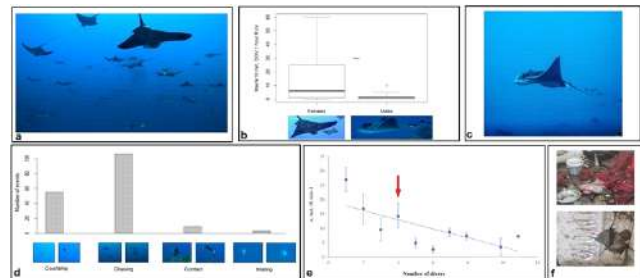

Fig. 1. a) Common eagle rays aggregation in Marettimo island; b) Female-dominated sex ratio; c) Pregnant females; d) Courtship and reproductive behaviors; e) Effect of scuba-diving on aggregated individuals; e) Small-scale fishery landings in Marettimo and unintentional by-catches of the common eagle rays.

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FIRST OCCURRENCE OF A NEWBORN BASKING SHARK (ELASMOBRANCHII, LAMNIFORMES, *CETORHINIDAE* OFF THE SYRIAN COAST (EASTERN MEDITERRANEAN)

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Abstract
The authors report in this work the first occurrence of a newborn basking shark *Cetorhinus maximus* (Gunnerus,1766), off the Syrian coast (Eastern Mediterranean). This specimen is an babe shark newborn,138 cm total length and weighing 62 kg. This is the second record for *C. maximus* and the first record of newborn in the Syrian marine water. By linking this event with the occurrence of a pregnant female about to give birth in this region in April 2012, and another in a neighboring area within Turkish waters in 2015, most likely indicates that Syrian marine waters form part of the basking shark's breeding and nursery area, but confirming this hypothesis requires more monitoring.

Keywords: Elasmobranchii, Conservation, Levantine Basin

Introduction - The basking shark is the second largest in size after the whale shark among sharks in the Mediterranean Sea. This species is widely distributed in temperate waters, but a large number of specimens tend to be concentrated in a few favored coastal areas where feeding and perhaps activity take place. Breeds at or near the surface [1]. Annual changes in observations and catch records may be strongly influenced by climatic and environmental conditions, subsequent changes in the distribution and abundance of zooplankton .C. maximus is one of the species that needs protection measures the most due to its reproductive strategy [2] .The current work aims to add new data on the presence of basking shark new born on the far eastern shore of the Mediterranean Sea.

Material and Methods - On 27 February 2024, a basking shark babe *Cetorhinus Maximus* (Gunnerus, 1765) was accidentally caught by a gill net at a depth about 30 meters from the Syrian coast, off Banias city, 35°06'14.4"N 35°53''08.0"E (Fig. 1). The specimen was a new born, with a length 138 cm (TL) and weight 62 kg . This specimen was measured to the nearest cm and weighed to the nearest kg (Fig. 2). The taxonomic position has been determined based on the distinctive characteristics of the basking shark [3].
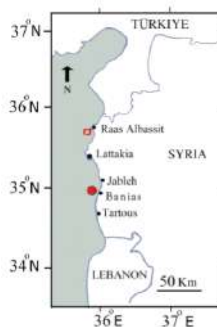

Fig. 1. Map of the Syrian coast indicating the capture site of New born basking shark off the coast of Banias (red circle) on February 17, 2024 (this study), and the capture of a pregnant female, 7m long and weighing 2.5 t.

Fig. 2. The newborn basking shark *Cetorhinus maximus* (Gunnerus, 1765), 138cm TL, from the Syrian coast (eastern Mediterranean) Scalebar = 50cm.

Result and Discussion - Identification of the species is based on the following descriptive characters [3]: five very long gill slits almost surrounding the head, gill arches with hair-like crests and the presence of a gill crest on the internal gill slits , the snout is rather long and pointed, it has a large subterminal mouth with many fine, hooked teeth, they have a caudal stem with pointed lateral keels, an almost asymmetrical crescent-shaped caudal fin, and a black to grayish-brown body color (Fig. 2). This species has been declared Vulnerable (VU) by the International Union for Conservation of Nature [1]. Concerning the Mediterranean Sea, *C. maximus* is included in the UNEP Action Plan for the conservation of cartilaginous fishes. The main threat to basking sharks comes from fishing operations targeting basking sharks and bycatch, or bycatch. Other fisheries. Basking sharks were historically hunted for their liver oil and meat. It usually occurs singly or in small groups, although it also makes large-scale vertical migrations between the surface and deep waters of the continental shelf and its edge. Capturing young and newborns, as well as pregnant females, more than once in the same geographical area (Syria, southern Turkey, Cyprus, Lebanon, Palestine) [4; 5] indicates that the Eastern Mediterranean region, the Levant Basin, may be a breeding and nursery area for the basking shark, and that suitable environmental conditions are available for feeding, growth and reproduction. To support the proposal to create Areas of Special Importance to protect this and similar species at risk of extinction, the issue requires further monitoring and survey.

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BATOID FISHES ASSOCIATING WITH TUNA FARMS IN MALTA

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Abstract
Batoid fishes (*Bathytoshia lata*, *Dasyatis pastinaca*, *Myliobatis aquila*, and to a lesser extent, *Torpedo marmorata*) are present in large numbers below some pens at Maltese tuna farm sites during the peak production season, and appear to scavenge dead feed-fish from the seabed, contributing significantly to seabed cleanup. The opportunity for food around the farms could be a factor in establishing an assemblage of such fishes, some of which are not common and threatened, in the vicinity of the farms but also has management implications.

Keywords: Eastern Mediterranean, Elasmobranchii, Tuna, Fish behaviour, Conservation

Introduction Fish farms may aggregate fishes [1], including batoids [2]. Batoids are known to scavenge discarded fish from fishing operations [3] while such species as sardines and mackerels, used as feed-fish on tuna farms, are a frequent component of their diet [4]. Maltese tuna farms appear to attract large numbers of batoid fishes due to the deposition of, at times, large quantities of uneaten feed-fish on the seabed below some tuna pens, providing ample resources for opportunistic feeding.

Methodology Videos of the seabed were recorded twice a year using an ROV, in April - June (during the fallow period) and in September – October (during the peak production period) from 2019 to 2023, at a tuna ranching site off the SE coast of Malta. The area surveyed each year was approximately 10,600 m² during each period, and the water depth ranged 65 m – 100 m. Between ca 60 m to a depth of ca 90 m, the bottom consisted mostly of a mixture of coarse and fine sediment with accumulations of rhodoliths; deeper than 90 m, the bottom was mostly bare, fine sediment. The video records were analysed and batoids were identified and counted.

Results & Discussion Four species of batoid fishes were recorded: *Bathytoshia lata*, *Dasyatis pastinaca*, *Myliobatis aquila*, and *Torpedo marmorata*. *D. pastinaca* was the most common with a total of 83 individuals, followed by *B. lata* with 32 individuals, in the surveyed area over the five years. Numbers were clearly higher during the peak season (Figure 1), when the quantity of dead feed-fish present on the seabed below the pens was at a maximum. The number of batoids varied from year to year, presumably depending on the amount of feed-fish deposited on the bottom below the cages. The video record clearly shows direct scavenging of feed-fish by *D. pastinaca* and *M. aquila* and, although less clearly visible, by the other two species. Although members of the Batoidea are known to scavenge, we believe that this is the first recorded instance, supported by video footage, of such mass mixed scavenging assemblages by these species. In some cases, up to 20 individuals in a multi-species assemblage were observed below a single pen. Batoids therefore contribute significantly to clearing the seabed of dead feed-fish at tuna farms. Although the number of batoids was mostly low during the fallow period compared to the peak production period (except in 2022, but in this case, due to operational delays, the fallow period survey took place in July, when there was already tuna in some pens), yet the farms still attracted these species (Figure 1).

Except for *Torpedo marmorata*, the other three species observed in the video surveys are listed by the IUCN as 'Vulnerable' in the Mediterranean [5]. *M. aquila* is considered an occasional species in the central Mediterranean and rare elsewhere in the sea, and *B. lata* is a rare species overall [5]. Therefore, the occurrence of large populations of these species in areas reserved for tuna ranching is not only beneficial in terms of cleaning up the seabed, but also in terms of conservation, even if there is some concern that provisioning batoids with food (in the present case, in the form of deposited feed-fish from the tuna pens) may alter their natural behaviour [6]; however, in general, there is no strong evidence to date that fish-farms act as 'ecological traps' [7].
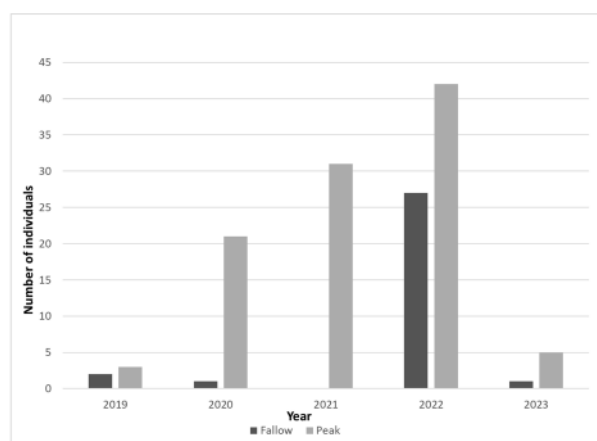

Fig. 1. Total number of batoid individuals recorded each year during the fallow and peak periods.

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DIET AND FEEDING HABITS OF THE SMALL-SPOTTED CATSHARK *SCYLIORHINUS CANICULA* (LINNAEUS, 1758) IN THE SOUTHERN TYRRHENIAN SEA (MEDITERRANEAN SEA)

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Abstract

The study of the feeding ecology of marine top predators, such as sharks, is crucial to define their trophic roles within the ecosystem and to advance our knowledge of how marine ecosystems work. In this study diet and feeding habits of *Scyliorhinus canicula* (Linnaeus, 1758) were studied through the stomach contents analysis, on specimens caught during two experimental trawling campaigns, Marine Strategy and MEDITS, carried out in october and december 2023 in the southern Tyrrhenian sea. From a total of 91 specimens, 68 stomachs were taken, 62 of which were found to contain preys. Teleosts and crustaceans were the most important prey groups (%IRI = 35.76 and %IRI = 35.07 respectively). This study provides new insight into the trophic ecology of these sharks and contributes to understand their ecological role within the community.

Keywords: Elasmobranchii, Trophic relations, Diet, Tyrrhenian Sea, Food webs

Introduction

Sharks play an important role as predators in the marine environment, exerting top-down influences on communities. Unfortunately sharks populations are undergoing a decrease in marine ecosystems around the world, mostly due to fishing activity, pollution and habitat degradation[1], that's the reason why they have become the focus of the marine ecology research[2]. An important step in the conservation and management of shark population is to obtain informations about their ecological role, by studying their feeding habits and trophic interactions. The small-spotted catshark, *Scyliorhinus canicula*, is the most widespread demersal elasmobranch in the Mediterranean sea, living on sandy, muddy or gravelly bottoms[3] between 40 m and 500 m of depth[4]. Several studies have been carried out in the Mediterranean sea on the feeding habits of this species, however none of them were done in the southern Tyrrhenian sea (GSA10, according to the General Fisheries Council for the Mediterranean, GFCM). This study bridges the gap expanding knowledge on *S. canicula*'s diet, expecially in the GSA 10, for the first time.

Material and Methods

Samples were collected in october and december 2023 as part of the Marine Strategy and MEDITS (International bottom Trawl Survey in the Mediterranean) projects, the first carried out in the Gulf of Patti (southern Tyrrhenian sea) between 0 m and 200 m of depth, the second involving the entire GSA 10 (southern Tyrrhenian sea) between 0 m and 800 m of depth. Out of the 21 stations for Marine Strategy, and 56 for MEDITS, the species has been caught just in 5 and 11 stations respectively, for a total of 91 specimens. For each of them, total length, weight, sex and maturity stage were recorded. Among all specimens, 6 and 62 stomachs have been taken for Marine Strategy and MEDITS respectively, for a total of 68 stomachs analyzed. These were weighed, their fullness degree assessed, and preserved in 70% ethanol before the stomach contents analysis was carried out. Each prey item was then identified to the lowest taxonomic level possible, counted and weighed to nearest 0.01 grams. Sex ratio (SR), vacuity index (%VI), frequency of occurrence (%F), percentage of abundance composition (%N), percentage of biomass composition (%W) and index of relative importance (%IRI) were calculated and used to describe the trophic spectrum.

Results

Out of 68 stomach contents examined, 62 were found to contain preys. Just 6 of them were found to be empy (%VI = 8.82%). The taxonomic groups of preys were found to be four: teleosts (%IRI = 35.76), crustaceans (%IRI = 35.07), cephalopods (%IRI = 12.56) and polychaetes (%IRI = 0.05). Several prey items have been recognized through the otoliths and beaks identification, showing a degree of diversity within each taxonomic level (16 different species of cephalopods have been identified, 12 for teleosts and 8 for crustaceans). Most of the prey items, however, were unidentifiable (% IRI = 16.54). The sex ratio (calculated on the number of specimens whose stomachs have been taken) was found to be SR = 0.54, with females slightly more abundant than males. Two different analysis have been done on the diet of male and female specimens. The results showed, for females, a slight preference of crustaceans over teleosts (%IRI = 37.72 vs %IRI = 35.16), in contrast to males, whose preference is directed more towards teleosts (%IRI 36.94 vs %IRI 33.23). One specimen had evident plastic pieces in its stomach.

Discussion

The stomach contents analysis shows that *Scyliorhinus canicula* has a broad diet spectrum. In the Tyrrhenian sea, the most consumed prey groups are teleosts, crustaceans, and cephalopods, as noted in other Mediterranean areas[5]. No significant differences were found between males and females diets, however it would be appropriate to deepen the analysis by investigating the evolution of the diet as the animal grows, and also taking into account seasonality, which could have an impact on it. The results obtained may help shed light on the ecological role of this species in the Mediterranean trophic network and may be a basis for future studies related to its protection.

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CIESM Congress Session : Assessment of fishery resources
Moderator : Karim Mezali – Univ. of Mostaganem, Algeria

Session's Synthesis

In this session we had 9 out of 10 talks (the speaker T. Filali was absent). During the session we debate the economic importance, the culinary values, the sustainable harvesting practices of some benthic invertebrate's and vertebrate species (sea cucumbers, sea urchins, gastropods, fishes…) which have been presented during the session; this to avoid overfishing and ensure the sustainability of aquatic ecosystems. Also, a conservation measures contributing to the protection of immature individuals and endangered species were debated.

In this session there were interesting quantitative data on: 1) the catch surveys (on fish *Sardina pilchardus* and other target species); 2) the biological observations (size and weight measurements and 3) the acoustic surveys (MEDIAS) using technologies to estimate the spatial population structure of fish (i.e.: *Sardina pilchardus*).

We require during the session a specific systematics information's on the species, its biology and ecology before carrying studies on the analysis and estimation of their stocks structure (i.e., last talk: confusion between sea cucumbers species *Holothuria tubulosa* and *Holothuria mammata*). We debated also, the effect of the gear's types on the species composition of the total catch and on the size composition of marine organisms (octopus and the purple dye murex).

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DEMOGRAPHIC STRUCTURE AND RELATIVE GROWTH OF THE EUROPEAN EEL IN FOUR DIFFERENT HABITATS IN EASTERN ALGERIA

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Abstract

The demographic structure study revealed the dominance of yellow eels. Relative growth models reveal positive allometry in all sites, with a significant difference in mass and length between them. The Fulton condition factor shows overall low values with a significant difference between sites. Age is estimated by the indirect method of Battacharya, which gives an age-length key characterizing each location.

Keywords: Fishes, Growth, Algerian Sea, Mediterranean Sea

Introduction

The European eel *Anguilla anguilla* (Linnaeus, 1758) is a thalassotocous migratory species, classified as critically endangered. The objective of this study is to study demographic structure of eel fractions, the length-mass relationship, the monthly evolution of the condition factor and the distribution of subpopulations into cohorts by indirect age estimation. A comparison of all these parameters is considered to reveal, possibly, an influence of the habitat on the growth of each fraction.

Material and methods

The data come from 4 ecosystems in northeastern Algeria, located in North Africa: El Kebir wadi (lotic ecosystem), El Mellah Lagoon (lagoon ecosystem), Tonga Lake and Oubeira Lake (lentic ecosystems). The sampling campaigns took place between November 2008 and January 2010, monthly, by professional fishing using fixed traps. A total of 2213 individuals were collected. Size (in cm) and weight (in g) were measured. The length-mass relationships were calculated using the equation $M = a*Lt^b$ [1], and the condition coefficients using the equation $K=(M/L^3)*100$. Age is studied by the indirect method of Battacharya which uses size frequency distribution statistics. It consists in decomposing a population into normal components, each representing a cohort theoretically having the same age. It is applied using the FISAT II software (version 1.2.0).

Results

The demographic structure clearly shows that there is a predominance of yellow eels in the 4 sites. The values of relative growth models and the mean condition factor obtained are represented in table 1. The non-parametric statistical test of Levene confirms that there is a significant difference (at the 95% confidence level) between the four populations. The non-parametric statistical test of Kruskal-Wallis applied to the values of the condition factor confirms that there is a significant difference (at the 95% confidence level) between the four eel populations.

Tab. 1. Relative growth model and mean condition factor values of different eel fractions

Site	Total count	a	b	T_{obs}	Type d'allométrie	R^2	Condition factor
El kebir wadi	444	$2,99475.10^{-4}$ $\pm 3,40929.10^{-5}$	3,45132 $\pm 0,0266$	5,61	Majorante	0,96330	0.18174 ± 0.01668
Tonga lake	443	$5,20198.10^{-4}$ $\pm 8,10689.10^{-5}$	3,30747 $\pm 0,03674$	5,62	Majorante	0,95906	0.18744 ± 0.04044
El mellah lagoon	627	$5,40704.10^{-4}$ $\pm 7,79099.10^{-5}$	3,25858 $\pm 0,03525$	10.03	Majorante	0,90296	0.14790 ± 0.01269
Oubeira lake	699	0,00226 $\pm 4,38978.10^{-4}$	2,95392 $\pm 0,04431$	8.84	Majorante	0,90781	0.22858 ± 0.10929

The analysis of the size frequencies of the different fractions gave the histograms presented below (figure 1). The Battacharya method gives an age-length key characterized by 8 age groups, at Lake Oubeira, 6 groups at Lake Tonga and 5 groups at El Kebir wadi and El Mellah lagoon.
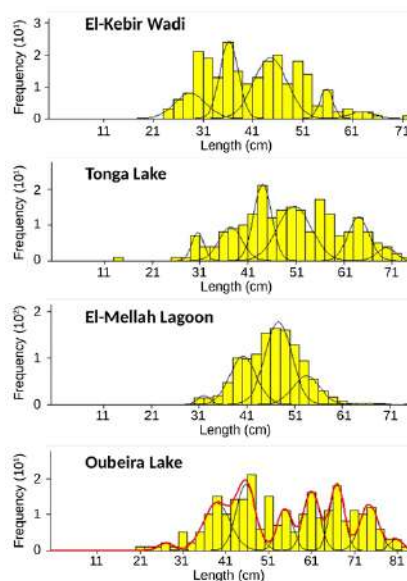

Fig. 1. Cohorts obtained by the Battacharya method

Discussion

This present study shows that the yellow stage is the most common in all the sites studied, because it represents the sedentary form of the eel in continental waters, and corresponds to the largest ecophase of its life. All the length-mass relationships of the 4 fractions studied present a major allometry, which means that the eels evolve in good ecological niches. Oubeira lake has the highest condition factor, and this could be due to the presence of individuals of more advanced stages compared to the other sites, as we can clearly conclude that this lake is the most suitable environment for this species [1], because the fraction colonizing this place presents a better fattening compared to the other sites. However, El Mellah Lagoon has the lowest factor, this could be explained essentially by its geographical location, which forms an interface between continental and marine environments, it is therefore characterized by strong seasonal fluctuations of their ecological factors, which disrupts the development of the fish on the one hand. On the other hand, it could be linked to the decline in the biological productivity of the environment which influences the state and the degree of nutrition. The significant differences revealed by all the statistical tests could be explained by the difference in the type of ecosystems characterizing each of the locations (lagoon, lacustrine, etc ...), which confirms the hypothesis of the influence of the habitat on the evolution and growth of the eel.

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MORPHOLOGICAL VARIATION OF HORSE MACKEREL (*TRACHURUS TRACHURUS*) ALONG THE ALGERIAN COAST: IMPLICATIONS FOR STOCK IDENTIFICATION

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Abstract

The Horse mackerel is a reef-associated pelagic fish widely distributed and consumed all along the Algerian waters. The purpose of this study was to examine the stock structure of *Trachurus trachurus* using morphometric data. Canonical discriminant analysis (CDA) showed that stocks were successfully discriminated with shape data and gives more than 90% of classification rate. The percentage of well classified individuals of Horse mackerel in predefined groups varied between 65.2 to 81.8% depending on sites. These spatial patterns were most likely linked to differences in environmental conditions between areas and sites. The result of this study confirmed the presence of different stocks of *Trachurus trachurus* across the Algerian coast.

Keywords: Fisheries, Habitat, Algerian Sea, Western Mediterranea

Introduction

Several different methods are currently employed for the identification of fish stock units. The morphometric analysis of the body being one of the most used [1]. The study of morphometric traits, being one of the first techniques to be used for this purpose, has been subject to several improvements in recent years, due to the development of new methods and tools to register, describe and analyse shapes [2]. The shape of a fish body is defined by an interaction between genetical and environmental factors [3], especially during its early development stages. Morphometric variations with growth, that may change between different locations, may be useful for the discrimination of stock units. However, consistent morphometric differences between locations may indicate a populational separation, hence the existence of different stock units.The aim of this study is to verify the relationship between fluctuation in abundance, and distribution of commercially important fish stocks and environmental factors using morphometric analysis.

Materials and methods

During the period of January-June 2023, a total of 76 *Trachurus trachurus* adult individuals were collected in two heterogeneous locations: Oran in the extern western Algerian coasts (n=45), and Annaba (n=31) in the Eastern Algerian coasts. Individuals were obtained from commercial trawls as well as through local fisherman. Measurements were taken to the nearest millimetre and sexes were determined by gonad observation. Fish were photographed for geometric morphometric analyses by a digital camera mounted on a camera stand. A total of 18 characteristics were used: 14 morphometric and four meristic. Morphometric characters were standardized to the overall mean total length. This regression model was chosen because none of these variables could be considered either independent or explanatory. A canonical analysis of variance, as well as a discriminant analysis of each group of individuals was carried out using the SPSS 21 software package.

Results and discussion

The numerical characters studied in hake frome the Gulf of Annaba, have a fairly similar amplitude of variation (Tab. 1).

Tab. 1. Distribution and comparison of numerical characters studied in the two populations of *Trachurus trachurus* of Algerian coast

numerical characters	Area	n	mean	Mode	Extreme values	t_{obs}	CD
1st dorsal fin rays	Oran	45	6,97	7	5 - 8	-	-
	Annaba	31	7,02	7	6 - 8	-	-
2nd dorsal fin rays	Oran	45	10,53	10	7 - 15	-	-
	Annaba	31	10,80	10	7 - 13	-	-
Branchiospinae	Oran	45	49,97	56	32 - 59	9,21*	0,47
	Annaba	31	55,25	58	48 - 66		
Vertebrae	Oran	45	22,33	22	19 - 25	12,8*	0,5
	Annaba	31	22,03	22	21 - 23		

The mean and the mode have similar values. The number of rays of the second dorsal fin (10) is identical to that reported by Fisher et al. (1987). The number of vertebrae corresponds to that reported by Fisher et al. (1987), or 22 vertebrae. The metric characters examined are significantly correlated with total length or cephalic length ($0.5 \leq r \leq 0.99$; P = 0.001). 80% of these characters show isometric growth. The numerical characters studied in the group of *T. trachurus*

from the Bay of Oran have a slightly different amplitude of variation. The mean and the mode have very close values. The number of rays of the first dorsal fin (7) is identical to that reported by Fisher et al. (1987).

On all samples, the first axis of the applied discriminant analysis represents 90% of the variability (l=0,004, P < 0.001). It makes it possible to discriminate very satisfactorily between the two populations of *Trachurus trachurus* (Gulf of Annaba and Bay of Oran) based on their morphometric characters (Fig. 1).
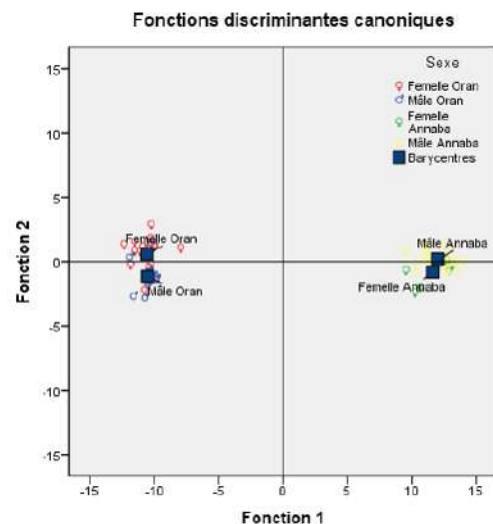

Fig. 1. Canonical discriminant analysis (CDA) applied to the biometric characters of the two populations of *Trachrus trachurus* of Algerian coast

The Cohen-Kappa test reveals a high rate of reclassification within the original groups (81.8%). The same result is obtained to separate the males and females of the Oran Bay population (l = 0.53, P < 0.001). On the other hand, discrimination between the sexes of the population of the Gulf of Annaba is poor (l = 0.79, P < 0.001). The result of this study confirmed the presence of different stocks of *Trachurus trachurus* across the Algerian coast.

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STATUS OF PARACENTROTUS LIVIDUS IN THE MALTESE ISLANDS

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Abstract

The Purple Urchin *Paracentrotus lividus* is well studied in the Mediterranean Sea due to its ecological and culinary value, the latter making it prone to overexploitation. Data from 2019 for this species around Malta indicated very low abundances, which prompted implementation of a two-year moratorium on its harvest. A survey of *P. lividus* abundance was carried out in 2023 at five localities in the Maltese Islands, with a main aim of acquiring recent data on the local abundance of this species.

Keywords: Infralittoral, Echinodermata, Fisheries, Malta Channel, Mediterranean Sea

Introduction

Paracentrotus lividus is associated with infralittoral algal forests and seagrass meadows in the Mediterranean Sea and Eastern Atlantic Ocean, down to a depth of around 20 m. This urchin usually feeds on *Posidonia oceanica* leaves and on brown and green algae. Heavy grazing on fleshy algae can lead to coralline barrens [1]; hence the urchin may greatly affect infralittoral algal habitats. In recent decades, *P. lividus* in the Mediterranean has been extensively harvested for culinary use [2]; which together with rising sea temperatures, disease, and pollution, have led to population decline [1]. To counteract the latter, several conservation measures have been implemented, which include: licensed harvesting; enforcing quotas; implementing seasonal bans and a moratorium on harvesting; and allocating no-harvest zones.

Method

Between July and September 2023, using snorkelling, the abundance of *P. lividus,* adults and juveniles (> 2 cm) was surveyed on hard bottoms at a depth of 1 m – 2 m in five inlets located on the northeastern coast of the Maltese Islands: Marsalforn Bay, Ramla tal-Qortin, Salina Bay, Qalet Marku and Kalanka t-Tawwalija (Figure 1). The abundance surveys were made along the northwestern headland of each inlet, which was divided into sections, each 50 m long and some 5 m wide.
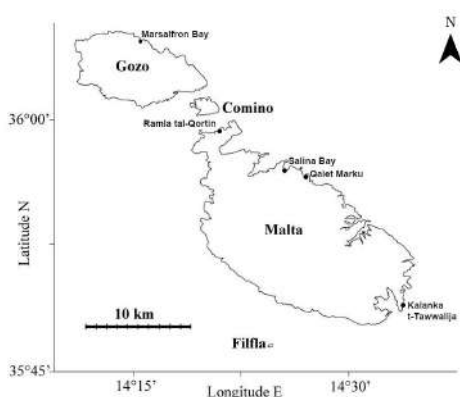

Fig. 1. Map of the Maltese Islands showing the study localities

Results & discussion

The abundance of adult and juvenile *P. lividus* varied amongst the study inlets (Figure 2). ANOVA indicated that the abundance of adult urchins at Marsalforn was significantly higher (< 0.01) compared to that at the other inlets, but this was not the case for juvenile urchins whose abundance amongst the different study inlets was not significantly different. This seems to indicate that, in some coastal areas, abiotic and biotic factors other than harvesting may be responsible for the population decline noted around Malta in recent decades.
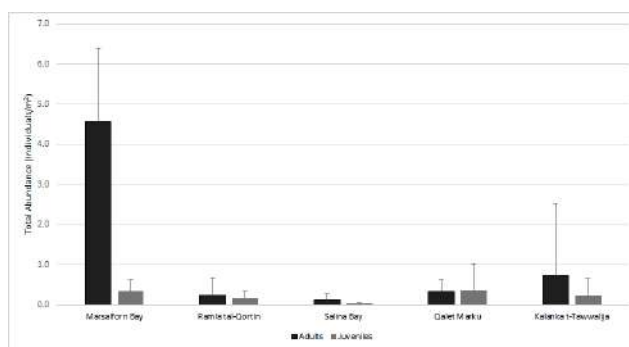

Fig. 2. Total abundance of adult and juvenile *P. lividus* recorded from the five study localities.

A local study carried out in 2019 and commissioned by Malta's Environment and Resources Authority (ERA) indicated low abundances of 0 – 0.00525 and 0 - 0.00425 individuals/m^2 in the pre- and post- bathing season, respectively [3]. These results formed the basis of a two-year moratorium on harvesting implemented by the Maltese Government as of July 2023 (Legal Notice 149, under Subsidiary Legislation 549.156). The present results indicate higher abundances than those reported in the study commissioned by the ERA; i.e. between a minimum of 0.17 individuals/m^2 recorded from Salina Bay to a maximum of 4.92 individuals/m^2 recorded from Marsalforn Bay. However, the former are still much lower than values recorded historically around Malta; for example, up to 100 juvenile *P. lividus* individuals/m^2 were recorded by Gamble in 1966 [4].

The present results highlight the importance of further surveys and monitoring of the local *P. lividus* population for proper evaluation of spatial and temporal abundance trends in abundance of this species around Malta.

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TOWARDS MSC CERTIFICATION OF THE SMALL-SCALE COMMON OCTOPUS TRAPS' FISHERY IN THE NORTHERN AEGEAN SEA

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Abstract
A total of 58 scientific observations on board fishing vessels that use traps and target common octopus were conducted in the northern Aegean Sea, one of the most important fishing grounds for the species at national and Mediterranean scale. Our findings highlight the effect of the gear type on the species composition of the total catch and on the size composition of common octopus, as well as the seasonal fluctuations in the size composition of the target-species regardless of the gear type.

Keywords: Cephalopods, Fisheries, Mediterranean Sea, Artisanal fishery

Introduction
In Greece, the common octopus (*Octopus vulgaris* Cuvier, 1797) traps' fishery is being monitored in the frame of the national DCF. Nevertheless, according to the recent pre-assessment report about this fishery in the Aegean Sea, it has been identified that it does not yet fulfil the MSC Fisheries Standard criteria for sustainability [1]. One of the improvement actions towards sustainability includes the enhancement of fisheries-dependent data by scientific observations on board fishing vessels, especially by gear type, namely pots and traps (FPO) and fyke nets (FYK), and not by gear group, namely traps, which is the EU requirement. Herein we present the preliminary results of a field survey conducted in the northern Aegean Sea.

Materials and methods
A total of 58 scientific observations (43 in Thracian Sea and 15 in Thermaikos Gulf) were carried out in collaboration with the common octopus fishing fleet that uses traps from May to November 2023. The gear types monitored included fyke nets (FYK) and pots (FPO-p) in Thracian Sea, and FYK and rectangular traps (FPO-t) in Thermaikos Gulf. Species identification was conducted to the lowest possible taxonomic level. For each *O. vulgaris* specimen, dorsal mantle length (ML) and total weight (TW) were recorded.

Results and discussion
In Thracian Sea, 320-1000 pairs of fyke nets and 305-1480 pots were recorded per fishing trip (N=11 and 32, respectively). The FYK fishery took place between 10.4-39.0 m of depth mainly on *Posidonia oceanica* seabeds, while the FPO-p fishery took place between 10.0-80.5 m of depth on sandy/muddy substrata. In Thermaikos Gulf, 200-420 pairs of fyke nets and 100-250 rectangular traps were recorded per fishing trip (N=8 and 7, respectively). The FYK fishery took place between 5.0-30.0 m of depth, while the FPO-t fishery took place between 3.0-14.6 m of depth, both on sandy/muddy substrata.

Total weight frequency distributions per gear type and location are shown in Fig. 1A; B. In Thracian Sea, the median value of TW was statistically significantly higher in FYK compared to FPO-p (W=417425, P_W<0.05), with the majority of non-commercial *O. vulgaris* specimens (<500 g) recorded in autumn regardless of the gear type, probably because it follows the period with the peak of reproduction [2]. In Thermaikos Gulf, the median value of TW was statistically significantly higher in FYK compared to FPO-t (W=93243, P_W<0.05). In Thracian Sea, among the 68 different bycatch taxa the most abundant species in FYK fishery included: *Scorpaena porcus*, *Scyllarus arctus*, *Diplodus annularis*, *Arbacia lixula* and *Sepia officinalis* and in FPO-p fishery: *Marthasterias glacialis*, *Coscinasterias tenuispina*, *Gobius niger* and *Serranus hepatus*. In Thermaikos Gulf, 52 bycatch taxa were identified with the most abundant including: *D. annularis*, *S. porcus*, *Mullus barbatus*, *M. surmuletus*, *Diplodus vulgaris* and *Squilla mantis* in both fisheries. The impact of the common octopus traps' fishery on Endangered, Threatened and Protected species (ETPs) was considered minor with two records of *Caretta caretta*. Non-indigenous species were also recorded including *Diadema setosum*,
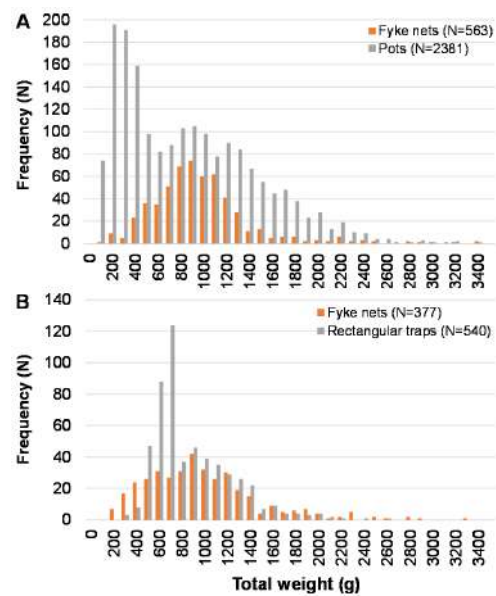
Callinectes sapidus and *Stephanolepis diaspros*.

Fig. 1. Total weight frequency distribution of *Octopus vulgaris* in Thracian Sea (A) and in Thermaikos Gulf (B) by gear type.

FRI Team: Chryssanthi Antoniadou[2], Fotis Arapoglou[1], Georgios Gitarakos[1], Christos Papadopoulos[2], Konstantinos Touloumis[1], Pavlos Vidoris[1]

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SPATIAL MODELLING OF DEMERSAL SPECIES IN THE WESTERN MEDITERRANEAN: PRELIMINARY RESULTS FOR IBIZA AND FORMENTERA (BALEARIC ISLANDS)

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Abstract
The spatial modelling of demersal species is basic for applying management measures in fisheries. This work analyses for the first time the spatial distribution of demersal species in the westernmost Balearic Islands. Our results showed marked differences among species, with clear spatial patterns for some and with a bathymetric-based distribution for others. These results, together with additional analysis may be useful for providing advice for management.

Keywords: Models, Demersal, Balearic Islands, Western Mediterranea

Introduction. The spatial distribution of marine species is key to understand their population dynamics and to serve as a basis for defining essential fish habitats and applying adequate management measures to ensure a sustainable fishing exploitation. For demersal species, information collected from bottom trawl surveys is valid for modelling this distribution. This work analyses for the first time data collected in the westernmost Balearic Islands. The analysis of three years of data allows us to have some preliminary insights of the spatial distribution of demersal species and could be useful for the provision of advice for management.

Material and methods. Data were collected during the MEDITS bottom trawls survey, carried out since 1994 in the Mediterranean [1], but from 2021 in Ibiza-Formentera (Figure 1). Sampling was carried out between 50 and 800 m. The target species of the multiannual plan for the fisheries exploiting demersal stocks in the western Mediterranean (European hake *Merluccius merluccius*, deep-water rose shrimp *Parapenaeus longirostris*, blue and red shrimp *Aristeus anntenatus*, Norway lobster *Nephrops norvegicus* and striped red mullet *Mullus surmuletus*) were modelled. For each species, different fractions of the population were used: individuals under the minimum conservation reference size (<MCRS), individuals smaller (<L_{50mat}) and larger (>L_{50mat}) than the length at first maturity. Standardized abundance data (individuals/km^2) were used in Generalized Additive Models [2], using a two-stage approach [3]. The spatial predictions were mapped using QGIS.

Results and discussion. First results showed marked differences among species, some of them with a clear spatial pattern, as for individuals <MCRS of European hake, mainly distributed in the eastern part of the islands (Figure 2a). This trend was also found for individuals <L_{50mat} and >L_{50mat} of this species as well as for Norway lobster (>L_{50mat}) and blue and red shrimp (<L_{50mat} and >L_{50mat}). Other species showed a more homogeneous distribution, mainly guided by the bathymetry, as for individuals <L_{50mat} of the deep-water rose shrimp (Figure 2b). This trend was also found for individuals >L_{50mat} of this species, as well as for striped red mullet (>L_{50mat}). This results, applied to demersal target species, could serve as a basis to the application of management measures, such as spatio-temporal closure areas, already considered in the management plan to protect juveniles and spawners of the target species. Expanding these analyses to other demersal and benthic species would help to identify areas of high density of vulnerable species, such as elasmobranches, and areas of high diversity, which would allow to implement an ecosystem-based approach to fisheries management.
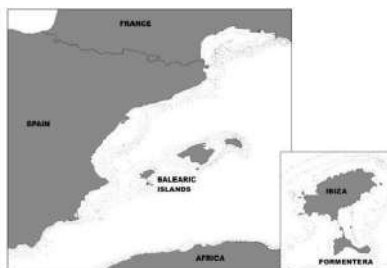
situation of Ibiza and Formentera in the Balearic Islands. The 50, 100, 200, 500 and 1000 meters isobaths are shown.
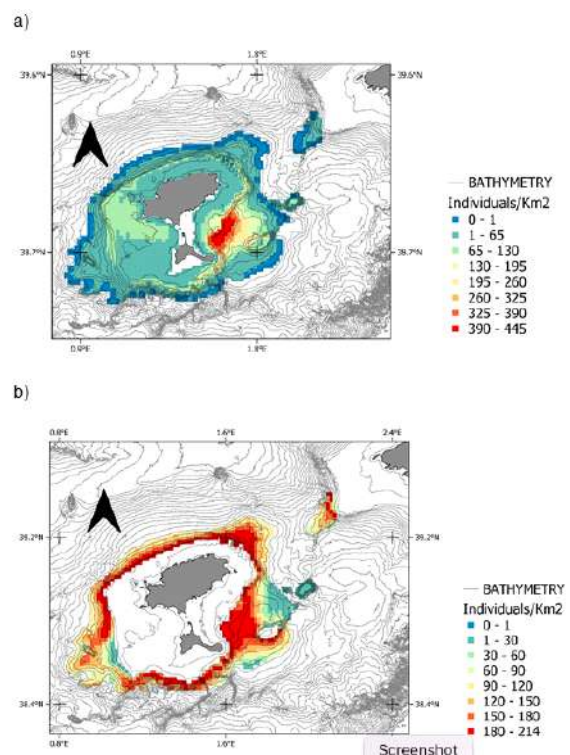

Fig. 2. Map of the modelled abundance (individuals/km^2, average 2021-2023) from the bottom trawl surveys around Ibiza and Formentera for individuals <MCRS of European hake (a) and <L_{50mat} for deep-water rose shrimp (b).

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Fig. 1. Map of the study area, showing the western Mediterranean and the

IMPLEMENTATION OF AN INTEGRATED STOCK ASSESSMENT IN THE WEDGE CLAM (*DONAX TRUNCULUS*) FISHERY IN THE GULF OF CÁDIZ, SPAIN. MANAGEMENT IMPLICATIONS.

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Abstract

The aim of this document is to methodologically carry out the stock assessment of the wedge clam (*Donax trunculus*) through a model with size and age dynamics implemented in Stock Synthesis (SS3, v.3.30.21) for the Gulf of Cádiz, Spain. This work is part of framework of the scientific advisory conducted by IEO and associated with the FEMP_AND_04 project. Furthermore, the utility of the population and fishery monitoring programs, which have been conducted since 2013, is emphasized in this approach. These monitoring programs have provided biological, fishery, and environmental information crucial for this stock assessment implementation, marking a novel stock assessment exercise for the wedge clam.

Keywords: Stock assessment, Artisanal fishery, Monitoring, Gulf of Cadiz, Management

The wedge clam (*Donax trunculus*) artisanal fishery is one of the important both socially and economically in the Gulf of Cadiz over the last three decades and nowadays is concentrated in the Doñana National Park, with, both ecological and ecosystem considerations, where the exploitation must be precautory and science based. This invertebrate fishery is classified as "S" type, indicating it is small-scale, spatially structured, and involves sedentary stocks [1]. Most of these stocks are considered data-poor. However, in this instance, the wedge clam fishery has been the focus of a long-term monitoring program since 2013, conducting monthly surveys. Additionally, several scientific studies on reproductive, morphological, and life history parameters have been undertaken [2] contributing to increase the quality of information, placing it fishery in a category with more and better available information. The data from monitoring program has facilitated scientific advice through population and fishery indicators. However, the lack of knowledge regarding the exploitation status under scientific standards, remains a challenge in the assessment and management of this resource. Our aim is to establish the first stock assessment using an integrated model that allows diagnosing the exploitation status based on reference levels and give advice to stakeholders and government to a sustainable exploitation. This is a recent and novel methodological process with a set of steps and considerations (Fig 1).
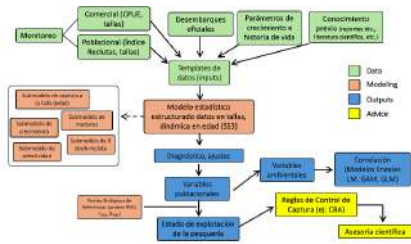

Fig. 1. Conceptual diagram to methodological implementation in stock assessment to wedge clam dynamic population.

The stock assessment model was configured using Stock Synthesis (SS3 hereafter SS3) with the most updated version (V.3.30.21) [3] called "*Integrated stock assessment analysis model*". SS3 has a stock population sub-model that simulates growth, maturity, fecundity, recruitment, movement, and mortality processes, and observation sub-models and expected values for different types of data. The model is coded in `C++` with estimation parameters enabled by automatic differentiation (ADMB) (Fournier, 2012). All data sources from the wedge clam fishery, such as the long-term monitoring program, official landings, and life history parameters, are standardized and stored to build templates for the stock assessment process. In sensibility sense, we test a set of scenarios Concerning the uncertainty linked to official landing (underreporting) with the aim of know the impact on population status (Fig 2).
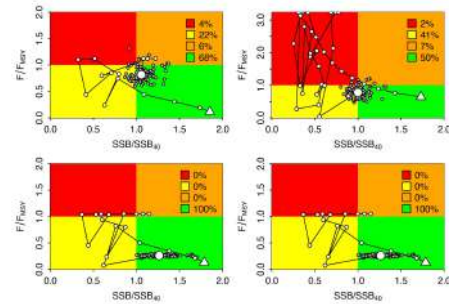

Fig. 2. Kobe diagrams indicating the status of wedge clam based on 4 landing scenarios.

The primary findings suggest that it is possible to identify the exploitation status within a range of scenarios for the *Donax trunculus* population. This work integrates available sources of information from long-term monitoring programs as well as scientific studies related to crucial biological aspects of the wedge clam. This kind of approaches are applicable to small scale invertebrate fisheries and can be highly useful for providing science-based management recommendations. We consider that long-term monitoring programs and knowledge of the status in invertebrate fisheries like *Donax trunculus* in Cádiz Gulf, is a vital and key component that allows us to better understand the evolution of the fishery and, in turn, to give advice in management and conservations measures in the face of possible changes in the environment in any of its dimensions.

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GASTROPOD FISHERIES: THE CASE STUDY OF *BOLINUS BRANDARIS* (MURICIDAE) IN THE NW MEDITERRANEAN

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Abstract

The purple dye murex (*Bolinus brandaris*) is fished with bottom trawl, beam trawl and trammel net in the Catalonian coast. At present the fishery concentrates in the area of the Ebro River delta. Over the last two decades (2002-2023) a decreasing trend has been observed in landings, daily catch per vessel and fishing days with purple dye murex landings. In addition, the presence of immature individuals in the landings is high. These observations suggest that the species would be being exploited unsustainably.

Keywords: Fisheries, Gastropods, Ebro Delta, Western Mediterranea, Time series

Introduction

The purple dye murex (*Bolinus brandaris*) has been exploited in the Mediterranean since ancient times. Numerous Phoenician and Roman archaeological remains have been found, aimed at the extraction of the purple dye, that was one of the costliest dyes [e.g. 1]. At present it is commercially exploited for human consumption locally in Spain, France, Italy, Greece, Turkey and Tunisia, as well as in the Gulf of Cadiz and Portugal (Atlantic Ocean). In the Catalonian coast the purple dye murex is exploited by bottom trawl and two small scale fishing gears, beam trawl (locally called "rastell") and trammel net. A plan for the management of the fishing with "rastell" was implemented in 2016, limiting its use to the fishing port of La Ràpita. A two-months ban in July and August is implemented for bottom trawl and "rastell", in coincidence with the main reproduction period of the species. A minimum landing size (MLS) has been set at 25 mm shell width (55mm total length, TL). The species size at first maturity (L50) is 51 mm TL (own data not published).

Methods

Data on landings, income from first sale at the auction and daily catch by vessel with purple dye murex landings have been obtained from ICATMAR [2]. The study area is the Catalonian coast (around 550 km). Commercial samples of each gear have been purchased monthly at the fishing port of La Ràpita during 2023. *B. brandaris* were measured at the laboratory using a digital calliper (precision of 0.01 mm).

Results

The species is fished all along the Catalonian coast, although at present fishing concentrates in the area of the Ebro River delta (fishing port of La Ràpita). It the last two decades, from 2002 to 2023, a steady decreasing trend has been observed in the landings (92%), daily catch per vessel (78%) and fishing effort (days with sale of purple dye murex at the auction; 63%) (Fig. 1). *Bolinus brandaris* is a species appreciated by consumers (mean price in 2023, 11 euros/kg).
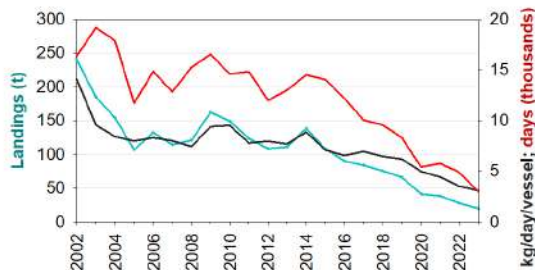

Fig. 1. *Bolinus brandaris* landings (left axis), daily catch by vessel (right axis) and fishing days (right axis) in the Catalonian coast, over the period 2002-2023.

In 2023 the landings of purple dye murex in La Ràpita amounted to 12.3 tonnes. Of these, 44% and 41% corresponded to bottom trawl and "rastell" respectively, and 15% to trammel net. Nevertheless, when expressed in number, "rastell" landings represented more than 50% of the total. Small sized individuals are returned to the sea alive, so mortality is presumably negligible. A great amount of the landings consists of individuals below MLS (50%) and, also, the presence of immature individuals is high (27%). This is particularly evident in the case of "rastell" and trammel net (Fig. 2).

Fig. 2. La Ràpita 2023. *Bolinus brandaris* annual length frequencies distributions for bottom trawl, "rastell" and trammel net. Vertical lines indicate the size at first maturity (51 mm TL) and the minimum landing size (55 mm TL).

Conclusion

The steady decrease in landings and in the daily catch per vessel, along with the high presence of immature individuals in the landings, suggest that the purple dye murex would be being exploited unsustainably.

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SARDINA PILCHARDUS AGE-SEGREGATED SPATIAL DISTRIBUTION ALONG THE NW MEDITERRANEAN SEA INFERRED FROM ACOUSTIC SURVEYS 2010-20

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Abstract

Taking advantage of the data collected in the MEDiterranean International Acoustic Survey (MEDIAS), the spatial population structure of *Sardina pilchardus* has been determined along the NW Mediterranean Sea. Results revealed a marked *S. pilchardus* spatial segregation by length and age in the study area, highlighting the importance of considering the spatial component in the assessment and management of commercial fish populations.

Keywords: Acoustics, Continental shelf, Population Dynamics, Pelagic, North-Western Medite

Introduction

S. pilchardus is a key species in the NW Mediterranean Sea continental shelf pelagic ecosystem. In addition to supporting a specific fishery in the area, it constitutes a connecting link between primary production and top predators. It is strongly dependent on recruitment processes [1] and highly vulnerable to food availability and climatic changes [2]. Fortunately, it presents an extreme resilience capacity. The study of population structure considering the spatial perspective is crucial to understand fish population fluctuations and contribute to its sustainable management. The purpose of the present study was to analyze the spatio-temporal pattern of *S. pilchardus* length and age classes aggregations in the NW Mediterranean.

Material and methods

Annual abundance estimates of *S. pilchardus* were obtained from MEDIAS surveys conducted in the NW Mediterranean in July, combined acoustic (total NASC, m^2nm^{-2}) and biological data (species composition), according to the EU Data Collection Framework. For each identification haul, a random sample of *S. pilchardus* individuals was measured to the nearest 0.5 cm and 5 otoliths per length class were removed. Age assignment was made according to the conventional birthday (1st of January) and the date of capture following international standard procedures. Arc GIS 10.4 (ESRI) software was used to combine mean length and age data with abundance data per nm. For each year, the spatial distribution of the *S. pilchardus* mean length was determined using a grid of 8*8 nm. Moreover, the existence of bathymetric segregation by length was tested using a simple linear regression (SLR) model. Likewise, the aggregation areas per age class were inferred as the mean of the time series 2010-20 over an 8*8 nm grid.

Results and discussion

The total abundance of *S. pilchardus* estimated in July during the 2010-20 time series showed an erratic temporal trend in the study area. The spatial analysis revealed a marked segregation by length (Fig. 1) and age (Fig. 2). *S. pilchardus* length increased significantly with increasing depth (Ad. R^2=0.65 p-values<0.05). Its demographic structure was based on 5 age classes, from 0 to 4 years old individuals, each of them presenting a preferential distribution area (Fig. 2). Recruitment was mainly located in Ebro Delta surrounding areas, age class 1 and 2 was mainly found in the Gulf of Valencia, while age class 3 and 4 were located in the northernmost and in the southernmost part of the studied area. Cohorts recruited in Ebro Delta area (recruitment hotspot) flow out during pre-adult and adult life and supply adjacent areas such as Alicante Gulf waters where recruitment would be insufficient to sustain local populations and fisheries. Results highlight the usefulness and necessity of considering the spatial component [3] in the analysis of the fish population structure and the importance of MEDIAS surveys to get it.

Fig. 1. *S. pilchardus* mean length spatial distribution per year estimated using MEDIAS survey 2010-20 data.

Fig. 2. *S. pilchardus* mean abundance per age class inferred from MEDIAS 2010-20 survey data

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ABUNDANCE AND SIZE DISTRIBUTION OF SEA CUCUMBERS (*HOLOTHURIA TUBULOSA/MAMMATA* COMPLEX) IN THE CENTRAL ADRIATIC SEA, CROATIA

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Abstract
Holothurians influence benthic marine ecosystems by cleaning sediment, recycling nutrients, and perturbing the substrate. In the Mediterranean, sea cucumbers are being exploited due to overfishing in the Indo-Pacific region. This study investigates the abundance and size distribution of *Holothuria tubulosa/mammata* complex in three Croatian Central Adriatic Sea locations: Petrcane, Pakoštane, and Vodice. We recored variations in abundance (46-255 individuals per transect, averaging 136+-47.4) and size distributions (9-44 cm, on average 21.3+-4.51 cm) over three years. The observed variations can be partly attributed to variations in documented habitat. This study helps improve our understanding of sea cucumbers' abundance and size distribution, which will contribute to the long-term preservation of their populations in the Adriatic Sea.

Keywords: Adriatic Sea, Echinodermata

Introduction:
Through sediment cleaning, nutrient recycling, and substrate perturbation, holothurians are essential to benthic marine communities and significantly impact the ecosystem's health [1]. Light, food supply, substrate properties, and hydrodynamic conditions affect their distribution and abundance [2,3]. Holothurians' nutritional and medicinal properties have caused a significant market demand [4], resulting in overexploitation and threatening their populations worldwide, including in the Mediterranean and Adriatic Sea [5,6]. As numerous Holothuroidea species are cryptic, it can be difficult to distinguish between them based only on their morphology [7], and genetic barcoding is needed in the case of *Holothuria tubulosa* and *H. mammata* [8]. In this work, we therefore consider it an *H. tubulosa/mammata* complex and aim to evaluate their size and abundance distribution in the Central Adriatic Sea.

Materials and methods:
The research was carried out over three years (2019-2021) to monitor and understand the abundance and size distribution of *H. tubulosa/mamata* complex in three locations in the Central Adriatic Sea, Croatia (Petrcane, Pakostane, and Vodice). Habitat type (sediment, sediment on rock, and shelly sediment) and year (2019-2021) were considered. Standard visual census methods were used with autonomous diving equipment at 5-15 m depth. Two-way ANOVA (location * year) was used to test for differences in abundance and size of the holothurians.

Results and discussion:
A total of 11,092 individuals of the *Holothuria tubulosa/mammata* complex were recorded and measured. Significant differences in abundance among locations and years were found ($p<0.01$), with no interaction between these factors (Figure 1).
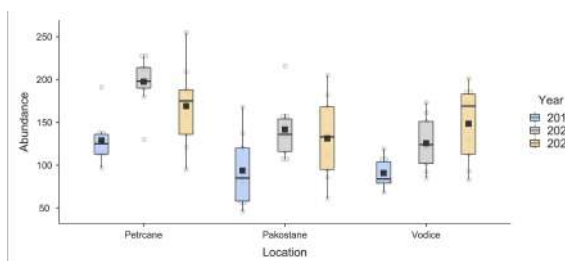

Fig. 1. Bar plot illustrating the abundance of *Holothuria* sp. across multiple locations over three years.
Abundance ranged from 46 to 255 individuals per transect, with relative abundance varying from 90.7 individuals per 100 m² in Vodice (2019) to 197.4 individuals per 100 m² in Petrcane (2020). The average relative abundance was 136.28±33.68 individuals per 100 m². An increase in abundance was noted in 2020 compared to 2019 across all locations, with Vodice showing continuous growth through 2021. Individual sizes ranged from 9 to 44 cm, averaging 21.3±4.51 cm, with most individuals falling within the 15-25 cm range.

The study highlights the need for further research to understand the intricate ecological interactions and various factors influencing the *Holothuria tubulosa/mammata* complex. These findings carry socio-economic implications, as the abundance and size distribution data can provide critical insights for developing sustainable harvesting practices. This, in turn, can help prevent overexploitation of the species' and support the livelihoods of local fishermen. Given the high market demand for sea cucumbers, the results underscore the potential for increased market attention in the Central Adriatic Sea. This attention can promote not only ecological preservation but also substantial economic benefits for coastal communities. Consequently, there is a pressing need to balance conservation efforts with economic interests to ensure the long-term sustainability of both the species and the human communities that rely on them.

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CIESM Congress Session : Recreational Fisheries
Moderator : Marco Albano – Univ. of Messina, Italy

Session's Synthesis

The session "Recreational Fisheries" hosted four contributions from three research groups, one from Greece (two contributions), one from Spain and one from Croatia, for a total of 11 authors. The interesting presentations were mainly focused on recreational fishing statistics from the interested countries but analysed several aspects with interesting insights. The two studies from Greece covered two different aspects collecting and analyzing data from boat fishing in the North Aegean Sea in the first case and comparing two national phone surveys as methods for recreational fishing data collection in the second. The study from Spain analyzed some social aspects which drive the preferences for recreational fisheries in that country, resulting in an interesting speech about the undervalued role of women in this field. The study from Croatia investigates the national field statistics and evaluates data from a digital survey. The most shared aspect was the analysis of statistics from surveys based on different kinds of interviews with fishermen, which sometimes highlighted difficulties comparing different areas or socially developed countries. From the general question time after the speech, comes the difficulty of collecting valid data just from interviews and the detachment among fishermen and governance which still affects several European countries. From this point of view, was interesting to know how Croatia could represent a good example for other countries, with a more regulated sector with an obligatory fishing license system and a logbook to be kept up to date for each recreational fisherman, which could help researchers in data collection. An interesting discussion comes from Dr Morales-Nin's presentation about the difference in approach to this topic based on gender, being that Spain is one of the most represented countries in women's recreation fishing, representing from this point of view, an innovative inspiring vision for other countries. The discussion emerged also, how, in Greece, recreational fishing is influenced in methods and prey by the environment, composed of several small islands and different fish habits along the Greek coasts. Despite the importance of the topic, source of essential marine coastal and inland water data, it still affected the difficulties in data collection and standardization among different countries and methods; but, from the actively participated discussion, emerged the willingness by the researchers of this field in finding shared solutions in this sense, for better European perspectives.

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RECREATIONAL FISHING BY BOAT IN NORTH AEGEAN SEA: GEARS AND THE MAIN SPECIES IN CATCHES AND CATCH PER UNIT EFFORT

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Abstract
Boat fishing is one of the three main modes of fishing in the North Aegean, Greece and is associated with several different species in marine recreational fishing catches. The present work discusses the analysis of data collected from on-site sampling during 2023 and provides information on the various fishing gears, the catches that were recorded and the catch per unit effort. The most recorded gear was the handlines (35%) and a significant presence of species from the Sparidae family was noted in the catches.

Keywords: Fisheries, Aegean Sea

Introduction
Marine recreational fishing is an established outdoor activity in Greece, and according to a phone survey at 2019, it is estimated that approximately 8% of the country's population are marine recreational fishermen [1]. Data are collected within the framework of the National Data Collection Program of Fisheries Data. The present work focuses on the various gears used while boat fishing in the North Aegean area and the main species caught and recorded during the on-site survey of 2023, as conducted by the Fisheries Research Institute.

Materials and Methods
The sampling scheme and the questionnaire used on-site are both designed according to the guidelines of the Handbook for data collection on recreational fisheries in the Mediterranean and the Black Sea [2]. The on-site sampling was conducted with face-to-face interviews with marine recreational fishers (MRFs) at ports or areas with access to the sea. During 2023, 4 seasonal sampling trips were conducted in the North Aegean area. In total 2563 gears were recorded in recreational fisheries, while 890 of those are gears used while fishing by boat.

Results and Discussion
Boat fishing can be conducted with a variety of fishing gears, and the recorded ones are presented in fig.1. In regards with the productivity of each gear type, based on the number of individuals in the catches, 50% of the catches were caught with handlines. 17% were caught with boat troll line, 15% with squid troll line, 7% with longline set and 4% with drifting troll line. In sum, 93% of the total catches are associated with the above types of fishing gears.
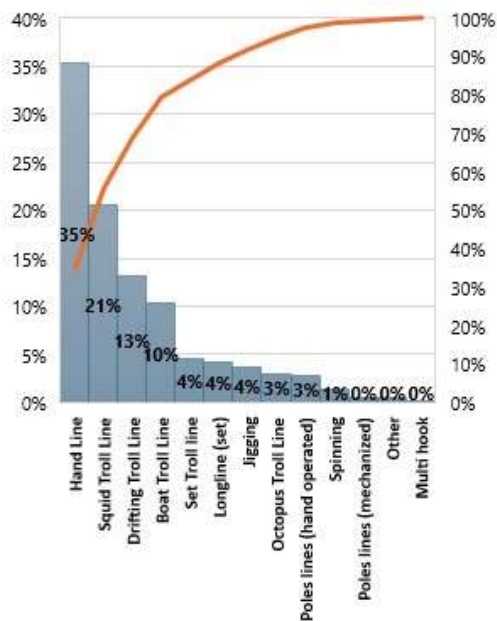
The catch per unit effort (CPUE) was calculated as number of individuals per gear per hour in the four quarters, Q1,Q2,Q3,Q4 (mean values) and it is estimated for Q1: mean=2.8, median=1,07, Q2: mean= 2.9, median=1,67, Q3: mean=3.7, median=2,59 and Q4: mean=3.9, median=2,75. The statistical analysis Kruskal-Wallis ANOVA by Ranks showed statistically significant differences in the median for CPUE among the quarters – Kruskal-Wallis test: H (3, N= 548) =15,56754, p=0,0014<0,01. Significant differences were observed between Q1 and Q3, Q1 and Q4, and Q2 and Q4– p<0,05. The most common species in catches throughout 2023 with the highest number of individuals recorded is the common pandora (_Pagellus erythrinus_), reflecting 12% of the catches and 89% were caught with handlines. The main species recorded in the catches are presented in fig.2 and represent cumulatively 72% of the total catches. In total, 5701 individuals from 75 different species and 8 different genera were recorded.

Fig. 2. The main species represented in the catches and their respective percentage of the total catches.

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Fig. 1. Fishing gears used by boat. The left axis represents the total percentage per gear, while the right axis shows the cumulative percentage.

RELEVANCE AND SOCIAL ASPECTS OF RECREATIONAL FISHERIES IN SPAIN

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Abstract

The participation rate in recreational fisheries in Spain is on average 10% [CI 7-12 %] of the population. Recreational fishing is embedded in all demographic segments of society, with the exception of gender where males were found to be overrepresented. By contrast, the probability of participating in recreational angling was found to be independent of age, residency, education, and income, indicating that recreational fishing is widespread in the male Spanish population. The general public was found to have a generally positive opinion about recreational fishing and to view catch-and-release fisheries positively. We evaluated the human dimensions of the natural resource use assessing the motivations and wildlife-related value orientations of Spanish recreational fishers, moreover gender differences were considered.

Keywords: Fisheries, Mediterranean Sea

In Spain, several studies have examined different aspects of marine recreational fisheries (RF) at regional scales [1-2] (*inter al*).

Recently, we carried out a survey using probability-based sampling strategies, addressing the magnitude, social and cultural relevance, and motivations of RF at national level. A random telephone survey was carried out in 2017 at national level targeting the Spanish adult population (+18 years) to evaluate different aspects of recreation. The sampling design was random at the national level applying a quota per Spanish regions. A total of 3,306 random telephone calls were carried out obtaining N=1,279 completed surveys (response rate = 38.7%). The estimated sampling error was lower than 3% for a confidential interval (CI) 95.5% and maximum dispersal of data ($p=q=0.5$). The telephone survey consisted in a series of questions related to (i) participation in RF; (ii) social-economic segmentation variables, (iii) motivations to practice RF, and (iv) statements that represent a variety of the ways people feel about fish and wildlife. Gender was considered as a key factor in the analysis [3].

Participation rates at the national level were 6.6% (over 2.5 million) from all economic and education levels, albeit with woman being substantially less involved. Motivations to engage in RF were "to be close to nature", "to experience tranquility", "to get away from the usual demands of life", "to relax psychically", "to stay with family" and "to get exercise". Although recreational fishing is foremost a leisure activity, the harvest of fish for personal consumption was also relevant to contribute to satisfaction.

To determine the wildlife value orientations, we used the four categories: mutualist, utilitarian, pluralist, and distanced [4]. The RF were mostly mutualist (50.5%), followed by distanced (28%), pluralist (12.9%) and a minority utilitarian (8.6%). We found that female RF were significantly younger (average 37 years) than their male counterparts (45 years), but other socioeconomic variables did not differ. Females attributed significantly greater importance to the motivation to practice recreational fishing to be with family than males, and they also more strongly rated the motive "to learn new things and to discover something new" than men. There were not significant differences in the WVO between females and males.

We conclude that recreational fishing is a widespread recreational activity in Spain, embedded in all the segments of the society. The reasons for the low female participation might be related to gender differences to leisure time. Although recreational fishing is increasingly popular in the Mediterranean, there is a scarcity of related data and aneed to develop studies and collaborations to contribute to the knowledge of this activity conducting to a future good management.

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COMPARISON BETWEEN THE TWO NATIONAL TELEPHONE SURVEYS FOR THE ESTIMATION OF MARINE RECREATIONAL FISHERS IN GREECE.

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Abstract

During 2023, Greece completed the second nationwide telephone survey in order to estimate the number of marine recreational fishers (MRF), to identify the main fishing methods, to estimate their effort, economic aspects of their activity. MRF's are estimated to be 8.45% of the country's resident population. Three main fishing methods were identified, fishing from the shore, fishing by boat and spearfishing. It is estimated that Greek MRF's carry out on average 17.300.000 fishing trips/year, their total catch is 12.845 t/year and the total yearly expenditure is 230 million Euros.

Keywords: Marine reserves, Recreational fisheries, Fishing techniques, Eastern Mediterranean

Introduction Marine recreational fishing is an overtime established outdoor activity in Greece. It has always been a source of life, inspiration, recreation, discovery and sustenance. It offers numerous opportunities with multiple ports, marinas and easily accessible coasts due to its extended coastline with more than 15,500 kilometers. Scientific data regarding marine recreational fisheries are collected within the framework of DCF. During 2019 a telephone survey was conducted for the first time in the country [1-2], estimating the number of active recreational fishers in Greece. Three main modes of fishing were identified (Shore, boat, underwater/spearfishing) with boat fishing, though not as popular as fishing from coast, associated with larger amounts of catches with Sparidae being the majority of species caught or released. Annual expenses constitute a considerable contribution of recreational fishing to this part of the economy. In the present study, a result comparison is attempted between the two national telephone surveys.

Materials and Methods The second national telephone survey conducted within the framework of DCF, between December 2022 and March 2023 using a sample of 16,500 telephone interviews. A structured questionnaire consisted of 24 numbered questions was used. As MRF was considered men and women residents of the country, older than 15 years of age engaged at least once in recreational fishing during the past 12 months. The selection of the sample was based on a population consisted of 9,247,018 people with quotas in terms of distribution in the basic administrative regional units (RU) in Greece. The sample was spatially stratified and weighted in order to be distributed appropriately in all RUs.

Results and Discussion The overall response rate was 18% in 2023 (vs 17% in 2019) which corresponds to the ratio of interviews to total interviews and denials. The total number of MRF in Greece estimated to be 8,45% of the population (vs 7.93% in 2019) and that currently amounts for ~780.000 MRF. Three main modes of fishing were again identified: fishing from the coast 69.97% (vs 63% in 2019), by boat 39,69% (vs 48% in 2019) and by spearfishing 18,75% (vs 21% in 2019). All modes are practiced more during July to September and mainly during weekends and summer holidays with an average of 22,05 days/year (vs 15,69). The average total annual catch is 16,44 kg/year (vs 12.80 kg/year in 2019) most of them (48,54%) by boat fishing. Sparidae are the main catches with Sea bream the most frequently caught species (about 1 in 3). The average expenditure is 294 € per year, (vs 180.95 € per year in 2019) most of them spent on gears. Although the number of recreational fishers remains relatively stable, qualitative and quantitative aspects of the activity seem to differentiate as a result of economic and social developments.

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CHARACTERIZATION AND PRELIMINARY DATA OF MARINE RECREATIONAL AND SPORT FISHERY IN CROATIA

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Abstract

Recreational and sport fishery in Croatia represents a significant aspect of its cultural heritage and contributes to local economy. With Croatia's diverse aquatic ecosystems, including its indented coastline along the Adriatic Sea, the country offers abundant opportunities for recreational and sport fishing. In 2022, around 100 000 licenses were issued for this type of fishery. In order to obtain data on fishing effort and catch composition in recreational and sport fishery, as well as to investigate the social diversity of recreational fishers, structured questionnaires were digitally distributed to users of annual fishing licenses. The survey yielded 889 responses. Boat fishing was the most common modality and majority of respondents were over 65 years old while catch composition varied depending on fishing modality.

Keywords: Fisheries, Adriatic Sea, Fishes

In the Mediterranean Sea, impacts of recreational and sport fishing on fish stocks remain still unknown [1]. Marine recreational and sport fishery are regulated by the national legislation in Croatia [2]). Recreational fishing is defined as fishing for recreational purposes, while sports fishing is defined as fishing for sports purposes. Both types of fishing are conducted on the basis of licenses which can be obtained for both types of fishing and are issued by the Ministry of Agriculture, Directorate of Fisheries, Croatian Federation of Sports Fishing on the Sea and its member associations. According to data from the Ministry of Agriculture, Directorate of Fisheries, 103 104 licenses were issued in 2022, of which approximately 79 000 were annual recreational/sports licenses, while 24 000 were for other types of licenses such as daily, multi-day and special licenses for fishing in areas under special fishing regulations as well as licenses for the use of additional fishing gears and other equipment. Data for the year 2022 were collected using an online questionnaire distributed by e-mail to users of annual sports and recreational fishing licenses. The survey methodology followed the FAO recommendations [3] and was based on recollection of fishing activities from the previous year. The questionnaire contained questions about fishing activities, fishing effort and qualitative and quantitative composition of the catch and were designed on Google Forms platform, divided into sections based on the fishing modality: boat fishing, shore fishing, and spearfishing. The survey yielded 889 responses, with 96.1% of respondents being male. The majority of respondents were over 65 years old, and most had completed a college education. The primary motivation for sea fishing was relaxation and recreation, with the highest activity occurring during the summer season. Boat fishing was the most common modality, followed by shore fishing and spearfishing (Figure 1.).

Among fishermen operating from the boat, the most commonly used fishing methods were handlines (casting), trolling lines and vertical hand lines. In 2022, they spent an average of 25 days fishing, with an average yearly catch of 26,2 kg. Species which mostly contributed by weight were European squid (*Loligo vulgaris*), common pandora (*Pagellus erythrinus*), and a group of fishes *Trachurus* sp., *Scomber* sp., Mugilidae, and *Boops boops*. Shore fishermen primarily used handlines and spent an average of 22,4 days fishing, with an average yearly catch of 11,8 kg. Species which mostly contributed by weight in this modality were a group of fishes *Trachurus* sp., *Scomber* sp., Mugilidae, and *Boops boops*, followed by gilthead seabream (*Sparus aurata*) and European squid (*Loligo vulgaris*). Spearfishermen spent an average of 27,6 days fishing, with an average yearly catch of 19,9 kg. The most frequently caught species by weight were gilthead seabream (*Sparus aurata*), common octopus (*Octopus vulgaris*) and European seabass (*Dicentrarchus labrax*). These results provide preliminary insights into the demographics, behaviors and catch composition of marine recreational and sports fishermen in Croatia and emphasizes the need for constant monitoring of recreational and sport fishery.

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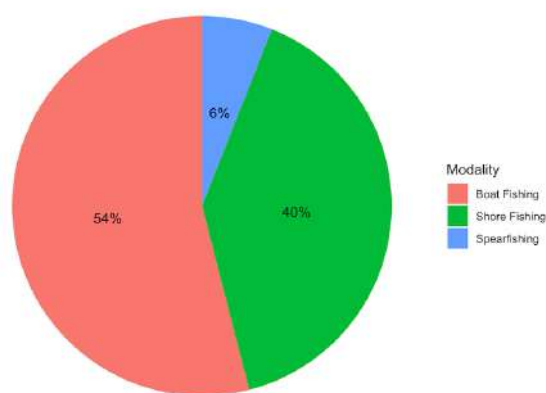
Fig. 1. Fishing modality

COMITÉ 6

Systèmes côtiers

Président : Ernesto Azzurro

CIESM Congress Session : Science Engaging Civil Society
Moderator : Francesco Tiralongo – Univ. of Catania, Italy

Session's Synthesis

The session on "Science Engaging Civil Society" featured six insightful contributions exploring the vital role of citizen science and local ecological knowledge in advancing marine research and conservation. Presenters highlighted diverse projects that successfully integrate non-expert communities into the scientific process, with a strong focus on coastal and marine environments. Topics ranged from community-driven biodiversity monitoring to the documentation of environmental changes observed by fishers, demonstrating the profound value of local observations in detecting early signals of ecological shifts. Key discussions revolved around methodologies for collecting and validating data from citizen participants, emphasizing both rigorous scientific standards and the accessibility needed to sustain long-term engagement. Several speakers underscored the role of training programs and technological tools, such as mobile applications and user-friendly identification guides, that empower communities to contribute reliable data. The potential for this data to supplement traditional scientific methods was illustrated by successful case studies from multiple Mediterranean sites. A notable theme was the use of local ecological knowledge to monitor species of relevance for fishery. This cross-section of science and community action emphasized that local knowledge not only enhances data richness but also fosters a sense of stewardship within coastal communities. In addition to data collection, discussions focused on the broader impacts of citizen science for environmental policy and sustainable practices. Speakers proposed certification schemes and collaborative platforms that could bridge scientific findings with policy frameworks, enhancing the societal impact of research. The session concluded with an energetic exchange on the future of citizen science and LEK in marine conservation, underscoring the value of cross-disciplinary partnerships and the growing contributions of civil society to marine knowledge. These discussions set a positive trajectory for future collaborations, highlighting the indispensable role of citizen science and local ecological knowledge in shaping a sustainable future for Mediterranean marine ecosystems.

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SUSTAINABLE MANAGEMENT OF *SARDINA PILCHARDUS* AND *SARDINELLA AURITA* IN THE MEDITERRANEAN SEA

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Abstract

This work presents a case study of a project carried out by the Department of Mediterranean Fisheries of the Sicilian Region in collaboration with Sicilian fishing communities. The project aimed to develop monitoring, research, and study plans on the populations of *Sardina pilchardus* and *Sardinella aurita* in Sicilian waters to understand the sustainability of fishing for juveniles of these species. Using a LEK methodology, we focused on collecting data through questionnaires administered to fishermen regarding the environmental, social, and economic aspects of this type of fishing over time, aiming to assess the impact of fishing on larval stages on the sustainability of these resources.

Keywords: Mediterranean Sea, LEK, Larvae

Introduction

The problem of fishing for the first stages of development of sardines in Sicily has historical origins: we find it on the agenda of the Italian Parliament since the 19th century. In fact, in the parliamentary documents of 21 April 1883 we find that the Sicilian deputy Palizzolo, on behalf of the fishermen, asked for the ban on fishing for newborn sardines, introduced a few years earlier by the Italian government, to be revoked [1]. Evidently, these first stages of development had a much higher economic value than the adult stages. The research carried out was therefore aimed at understanding whether it is once again possible to create a management plan for larval and juvenile stages to satisfy the needs of fishermen. The first part of the research was aimed at collecting information on how to improve knowledge of the environmental aspects that influence the development of Sardina (*Sardina pilchardus*) and Sardinella (*Sardinella aurita*) populations in the coastal waters of Sicily. To obtain a historical-economic reconstruction of the traditional "newborn" or "whitebait" fishing, the second part of the research focused on the shared experience of fishermen who have dedicated themselves, or still dedicate themselves, to this type of fishing.

Materials and Methods

Data collection within the SEVENS project was carried out together with the collection of biological samples and oceanographic and genetic analyzes to directly identify the state of the environment and resources. The socioeconomic analysis was carried out using the "Local Ecological Knowledge" (LEK) method. There is another study that used this method and which was aimed at fishermen who practiced youth sardine fishing until 2010 and aimed to collect data on the specific skills of fishermen in relation to the type of fishing, reconstruction of fishing activity over time, average catches and economic data (sales prices and profitability). The experience gained by fishermen throughout their lives is a valuable resource that can provide much information about the marine environment and local species, as they spend their lives in close contact with them [2]. From the first questionnaire, administered in seven provincial capitals along the coast of Sicily, 28 interviews were collected, with the age classes of the respondents ranging from 36 to 65 years. The interviews revealed that the type of fishing practiced is the "circuizione" that is carried out in the evening/night hours, between the months of March and October. The collection of information related to the special fishing of the "neonata" took place by interviewing the owners of the time, who said that the "neonata" fishing was concentrated in the winter season, mainly between February and March, from dawn to dusk. The main gear used for the catches was the seine, consisting of nets whose length varied from 150 to 300 meters, the narrowest part of which normally had a size of 1-2 millimeters. According to the fishermen, the indiscriminate fishing of "neonata" should be avoided, instead proposing the use of catch quotas and territorial limits to the exercise of special fishing.

Results and Discussion:

The LEK approach evidenced how, over the years, there has been a shortage of sardines and anchovies, and this is not solely attributed to overfishing but also to climate change, which has instead favored the reproduction of *Sardinella aurita*. Given this, a sustainable management plan for these resources would seem to be aimed at fishing for *Sardinella aurit*a, while discouraging the fishing of sardine. In drawing up a proposal for a sustainable management plan, account must be taken not only of the biological and ecological characteristics of fish species but also of the fleet, the social and economic dimension of fishing and its role in the economic development of the Sicilian coastal territories. During the last special fishing season, the income average, per boat, was between 25,000 and 30,000 euros for the entire fishing season, the equivalent of 30 - 40% of the average annual income of the same boats. From the closure of the special fishing, some shipowners have totally suspended the winter fishing activity, considered little or not at all profitable, others have diversified their activity.

Sicily should take inspiration from the virtuous Catalan model, in which fishermen, researchers, administrators and environmentalists have worked together to formulate specific objectives and management measures based on robust scientific knowledge on the biology and fisheries of the species [3].

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LOCAL ECOLOGICAL KNOWLEDGE ON BYCATCH MITIGATION IN THE MEDITERRANEAN SMALL-SCALE FISHERIES

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Abstract
Local ecological knowledge (LEK) of small-scale fishers on bycatch mitigation in Italy, Turkey and Croatia was collected using the survey method. Respondents report incidental catches during fishing, species were mostly caught alive and released. Damage to fishing gears and catch are mostly caused by dolphins. Fishers don't use mitigation measures in practice considering that applying such measures would complicate work and reduce catch. They doubt on mitigation effectiveness. Fisher's reluctance to agree to an interview revealing they were overwhelmed by the many similar questionnaires in recent years. For sure, building trust with fishers in face-to-face meetings is essential to receive reliable data to support the identification of existing, acceptable and applicable solutions.

Keywords: LEK, Mediterranean Sea, Artisanal fishery, Elasmobranchii, Cetacea

Bycatch is the incidental, unintentional capture of non-target species during a fishing operation for target species consisting of commercial or non-commercial fish species and incidental catches of vulnerable species (marine mammals, sea turtles, seabirds, elasmobranchs), and is of particular concern for long-lived species with low reproductive rates and delayed sexual maturity. The nature and frequency of incidental catch depend on several factors (fishing methods and fishing gear characteristics, species life history and ecology, spatio-temporal overlaps between fishing activities and critical habitats). Gear modifications, temporal or spatial closures, adaptation of fishing strategy and more selective fishing methods represent possible mitigation measures that can help reduce the impact of fisheries on megafauna species. Overall, bycatch is a major threat to the survival of many endangered marine populations and species around the world [1], including the Mediterranean Sea, where it seriously affects the profitability and sustainability of fisheries. The value of LEK has been increasingly recognized by conservation biologists worldwide [2, 3], that further enable access to the unique life-experience information of fishers. LEK surveys are fast, inexpensive tools in comparison with on-board observers that are considered as the most reliable and accurate method for quantifying actual bycatch rates [4].

In total, 78 responses were received. Fishers reported that it is possible to accidentally catch all targeted vulnerable group of organisms (mostly dolphins) while fishing and that they personally had such experiences. Fishers expressed their respect and try to avoid killing vulnerable species (ETP). Additionally, for most shark species, the market value is often too low to be interesting to land it, and thus these individuals are released immediately after catch. Generally, Italian and Croatian fishers had a more negative attitude towards the mitigation although the answers are not based on their personal practical experience. Further on, they perceive reporting incidental bycatch as additional work and that they fear the future consequences of reporting the incidental catch, having the most negative attitude towards the entry of these species in the logbook. All fishers consider incidental bycatch as rare events, and they consider their behaviour protectionary, since they release all accidentally caught live animals. In practice, they use only simple mitigation measures such as fishing gear selectivity, scaring birds with sound and avoiding feeding or spawning areas for turtles, mammals, sharks and rays. Fear of additional costs is a major factor in negative attitude towards applying mitigation measures (Figure 1). Fishers mainly reported that abundance of dolphins and birds has increased while for elasmobranchs it has decreased in the last five years due to overfishing, climate change and pollution. Thus, small-scale fishers require support to access to funds to improve practices and also for potential losses (fishing closure or damage compensation). Fishers were reluctant to agree to an interview especially in Italy, because they were overwhelmed by the many questionnaires filled out for various projects in recent years, revealing that bycatch issue is currently being addressed by several different organizations using a similar methodological approach for data collection. It is necessary to build trust between fishers, experts and the legislator in the sense that all future actions and measures will not be taken to penalize and complicate the fisher's work but to achieve the common welfare in terms of both endangered, threatened and protected species (ETP) conservation and sustainable fisheries achievement.
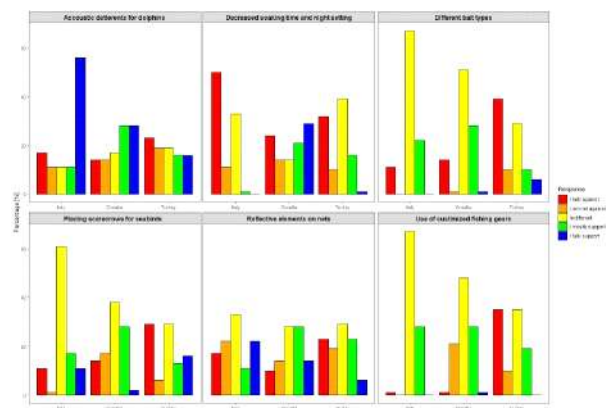

Fig. 1. Supporting technical mitigation measures in the study area

Conclusions:
- Simple and cheap mitigation measures should be proposed that will not reduce the catch of the target species!
- Proposed mitigation measures must not increase the time and complexity of fishing activity!
- Mitigation measures must be such as not to endanger the fishing vessel and crew, especially in bad weather situations.

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FACTORS AFFECTING COMMUNITY PARTICIPATION IN ACTIONS AIMING AT ENVIRONMENTAL PROTECTION

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Abstract

This study explores the factors affecting people's decision-making process to adopt a pro-environmental behavior. The survey was carried out on a convenience sample of 215 people. The main goal of the study was to explore the factors affecting community decisions for taking part in environmental protection actions. Measurement of environmental behavior, environmental motivation, and nature connection was done using the MEPS scale. According to the results the factors that push individuals to adopt a pro-environmental behavior are multifactorial and often interdependent. Also, environmental motivations are influenced by various socio-economic factors, such as age, education level and marital status.

Keywords: Coastal management, Hellenic Arc, Ecosystem services, Behaviour

Introduction - As the effects of climate change and environmental degradation become more and more intense, society demands that ways be found to prevent climate change and limit environmental degradation. But what prompts us to adopt a pro-environmental behavior? Human survival is inextricably linked to the natural environment. A balance should therefore be maintained between the consumption of natural resources by humans and the ability of the natural environment to renew itself. However, people often forget their dependence on nature and act as independent from it [1]. Addressing environmental problems requires significant and urgent actions to reduce negative impacts and immediate action [2]. Therefore, the factors that influence, either positively or negatively, the pro-environmental behavior of people should be sought. Understanding these multidimensional factors, which can be either psychological, social, cognitive, or structural, could provide very important information to policymakers, either on a global scale or on a more local scale, so that proper planning can be done to develop effective strategies aimed at changing people's pro-environmental behavior and to achieve a more sustainable future for all. The specific objectives of this research were: 1) the investigation and measurement of environmental motivations influencing the participation of citizens in actions for the protection of the environment; 2) the investigation of the relationships between environmental motivations and environmental knowledge, ecological behavior, and demographics.

Materials and methods - A survey was carried out on 215 randomly selected residents. The research sample was chosen in such a way so as to examine whether the proximity to the sea affects the opinions of citizens about the environment. A self-administered questionnaire was created. Also, the MEPS scale was used for measuring environmental behavior, motivation, and connection with nature. More specifically, MEPS [3] is a scale that evaluates the various motivations that push people in participating in environmental actions. Finally, questions aimed at collecting data on the ecological profile and environmental knowledge of the respondents were also used, such as what recycling means, how much money they pay for water and electricity consumption, what they use for heating, and their engagement with the land.

Results and Discussion - The results revealed that most respondents (61%) were females. The mean age was 40.53 (+10.73) years, while the mean monthly income was 886.72€. €. Based on the answers given by the respondents to the ecological questions, the group showed an ecological profile (Fig.1). The largest percentage of the respondents demonstrated to have also environmental knowledge (Fig. 1). To measure environmental behavior, the scale of environmental behavior in public and private spheres [4] was used. This includes six different categories/ domains of behavior: citizen actions and policy support in the public sphere and recycling, transport choices, household environmental behavior, and consumption habits in the private sphere (Fig. 2). Our sample has pro-environmental behavior mainly in the private sphere and primarily at the household level with consumption habits and recycling. The transportation options are marginally positively pro-environmental (average score 2.5783) and this may be because most of the respondents do not live in an urban area. Thus access to public transportation is not easy. The lowest participation rates are noted in pro-environmental actions in political activism and in supporting politicians. The MEPS scale [4] was then used as a five-point Likert scale, which evaluates the multiple motivations related to environmental protection (Fig. 2). Relationships between the seven new variables with gender, age, education level, marital status, occupation, proximity to the sea, and ecological behavior were then sought using correlations.
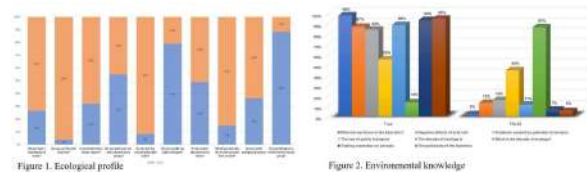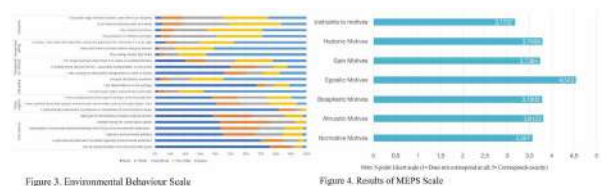

Fig. 1. Sample profile

Fig. 2. Sample behavior

Note: K. P. Pasintelis, PhD student of the Department of Ichthyology and Aquatic Environment School of Agricultural Sciences University of Thessaly was also a member of the research team.

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DIVERSITY AND TRENDS OF JELLYFISH SPECIES IN TÜRKIYE'S SEAS: A CITIZEN SCIENCE MONITORING PROGRAM "YAYAKARSA?"

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Abstract
The spatial distribution of 14 jellyfish species in Turkish waters is presented based on the citizen science sighting program "YaYakarsa?" between 2014 and 2024. This monitoring program allows regular reporting of specific jellyfish blooms occurring in cetain region and seasons, thereby enabling us to understand regional and seasonal patterns.

Keywords: Monitoring, Mediterranean Sea, Black Sea, Invasive species

Introduction

Jellyfish blooms have been observed frequently in many parts of the world in recent years with increases in the number of non-indigenous species (NIS). These blooms can be triggered by many factors, such as increasing pollution and climate change, as well as a variety of other complex dynamics. In particular, changes in the physical conditions of the water have led to the adaptation and increased abundance of many species that were previously rarely encountered in the region [1]. The increase in *Mnemiopsis leidyi* blooms in the Black Sea in the 1990s, followed by numerous destructive changes, and the subsequent blooms of species such as *Rhopilema nomadica* in the southeastern Mediterranean, highlight both the impact of NIS and the damage caused by their blooms. These developments underscore the importance of monitoring jellyfish populations over time. Furthermore, new alien jellyfishes, like "Lessepsian species" that enter the Mediterranean via the Suez Canal, cause ecological and socioeconomical problems in the Eastern Mediterranean Basin. Citizen based records are becoming more critical to science, especially where species occur temporarily or geographically patchy because the species is in the early stage of colonization and still rare [2].

Methods

Turkish Marine Research Foundation (TUDAV) started in 2014 a web-based programme named "YaYakarsa?" (meaning: "what if it stings?" in Turkish, www.yayakarsa.org) to learn and understand abnormal jellyfish occurrence, outbreaks and their negative impacts on our coasts. Its uitimate goal is to move the subject to a scientific monitoring platform and to guide the decision makers. Each report is submitted by a person with a photo or footage with the information of time, location, density and possible identiication of species. The ID is verfied by experts and finally uploaded to website (Figure 1).

Fig. 1. Submitted observations on the coast of Turkey.

Results and Discussion

Since 2014, a total of 559 jellyfish reports were submitted. In this study, the processed data extends up to March 2024. Of all incoming data, 89% provided species identification. Upon examining the data diversity, the highest number of reports belongs to *Rhizostoma pulmo*, followed by *Aurelia aurita*, *Chrysaora hysoscella*, and *Cotylorhiza tuberculata*. In total 17 species have been identified. Scyphozoa constitutes 94% of the data, while Hydrozoa accounts for 3%. The majority of the data has been submitted from the shores of Aegean Sea and followed by Sea of Marmara. Among the species, *Drymonema dalmatinum* was reported in the Marmara Sea for the first time [3]. In December 2020, a mass mortality event of *R. pulmo* was observed on the coast of Istanbul. This mass mortality event, reported in both academic studies and the press, was corroborated by the data submitted to "YaYakarsa?" by the public [4]. Another significant outcome was the data indicating a substantial increase in *C. tuberculata* observed in the Aegean Sea in 2021, which was also submitted by the public from the northern Aegean Sea. More recently, species with an increasing number of reportings are *Pelagia noctiluca* and *R. nomadica*. In addition, a bloom of *R. pulmo* observed along the Aegean coast in 2023 was accurately reported through the online submissions to YaYakarsa. The current research demonstrated the benefit of citizen science initiatives monitoring jellyfish where scientific fieldwork is limited. Nevertheless, maintaining public involvement to ensure uninterrupted data collection requires consistent promotion of the program and involvement of experts in this field. Monitoring programs like "YaYakarsa?" for jellyfish not only provide valuable information about species abundance and distribution but also serve as early indicators of potential increases, offering data to the scientific community.

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THE SUCCESS OF FISHERIES CO-MANAGEMENT IN CATALONIA (NW MEDITERRANEAN SEA)

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Abstract

The sandeel fishery (*Gymnammodytes cicerelus* and *G. semisquamatus*) regulated by a specific management plan and monitored by a Co-management Committee, presents annual fluctuations of abundance. The application of quotas, by the co-management committee, in the sandeel fishery has allowed, on the one hand, the conservation of the stock and, on the other, to increase the benefits of the fishermen of a traditional fishery on the coast of Catalonia.

Fisheries co-management has emerged as a successful approach to sustainable resource management in various small-scale fishing communities worldwide. This collaborative model brings together local fishers, government agencies, NGOs and scientists to jointly oversee fisheries resources and make decisions that ensure long-term viability. Catalonia (NW Mediterranean Sea) boasts a success story in fisheries co-management.

The Management Plan of the traditional small-scale fishery targeting sandeel (*Gymnammodytes cicerelus* and *G. semisquamatus*) with boat seines "sonsera" was implemented because this fishery was deemed not legal when the European legislation (EU Reg. 1967/2006) prohibited the use of boat seines, due to their perceived negative impact on coastal ecosystems since it was considered as trawler fishing less than 50 m deep. The fishery was forced to close on March 2012 but on April 2012 a Co-management Committee was organized and a Management Plan, in 2014, was submitted and approved by the European Commission.

The Sonsera Management Plan, the first in Catalonia, aims to maintain a sustainable fishery by limiting the catches of the target species, avoiding *Posidonia oceanica* vulnerable habitats and regulating discarded rates (1). "Sonsera" has a catch quota that varies monthly depending on the availability of the resource, this regulates the market and with less fishing effort (3-months biological ban is carried out), larger benefits are obtained than before the implementation of the Management Plan.

Sandeel fishery displayed large variations over 2000-2023. In the annual series of catch and total income of sandeel (*Gymnammodytes* spp.) between 2000 and 2023 (Figure 1) a clear inflection point is observed when it came into force the Sonsera Management Plan in 2014. From this year we see how, as the fishery is regulated, the catches decrease from a maximum 818 t in 2012 to an average of 218 t in the following years (2014-2019) and the average first sale price, on the contrary, increases by from 1.80 €Kg in the first stage to 20,5 €Kg in 2023. Nevertheless, landings trend changes in 2012, to such an extent that the fishery was closed in July 2015 due to very low catches. In 2016, landings slightly increased but in 2017 it is again a year of low catches. In the years 2018-2019 the sandeel (*Gymnammodytes* spp.) landings increased again (Figure 1). Catches are not very high as low quotas were maintained as a precautionary measure. From 2021 to 2023 the quota established by the Co-management Committee was an average of 50-60 kg/vessel/day. Concerning to discarded rates, 97% of the catch of the sandeel fishery are both target species (*Gymnammodytes cicerelus* and *G. semisquamatus*) (Figure 2A). The most abundant species in sandeel discard are *Scomber colias* and *Pagellus erythrinus* (Figure 2B).

The Co-management Committee is a dynamic body that adapts to the different circumstances that appear over time. As an example, in 2019, a modification was introduced in fishing quotas. Two different quotas were established, one for small specimens and another for medium and large specimens. This modification was introduced to limit the selective capture of small specimens, which have a higher price in the market. In this way, an important part of the population was allowed to grow and reach sizes suitable for reproduction (2). Beyond ecological and economic benefits, the co-management model reinvigorated cultural heritage and social cohesion among fishing communities. The success of fisheries co-management in Catalonia serves as an example of how collaborative governance can foster sustainable fisheries, ecological resilience, and prosperous communities.
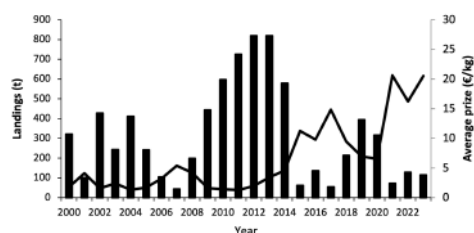

Fig. 1. Sandeel (*Gymnammodytes* spp.) annual landings and average price (€kg).
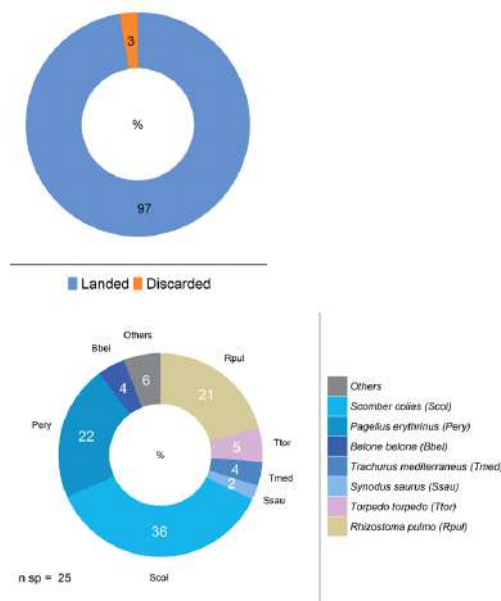

Fig. 2. Sandeel (*Gymnammodytes* spp.) fishery catch composition. Percentage by weight of landed and discarded catch (A). Sandeel discarded species composition. Percentage by weight of each discarded species (B).

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PUBLIC ATTITUDES ABOUT PLUVIAL FLOODS IN THE CITY OF METKOVIC (CROATIA)

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Abstract
The aim of this research was to investigate the level of awareness, understanding of the causes, consequences and preparedness for pluvial flooding among the local population in the city of Metkovic. The variables were categorized into five factors and the data were analyzed using inferential statistical methods. The results showed statistically significant differences between genders. Respondents showed a strong awareness of the risks of flooding, suggesting that additional education is not necessary, although they consider the city to be more vulnerable to flooding compared to other Croatian cities. The majority of respondents have indirect experience with flooding, so most of them have not taken preventive measures (66%) or insured their property. The results obtained can guide decision-makers in future spatial planning decisions.

Keywords: Geohazards, Adriatic Sea

Introduction

Urban areas with high population density and a high level of built infrastructure face numerous challenges today. One of them is pluvial flooding, which is caused by sudden and heavy rainfall that the soil cannot absorb quickly enough [2]. For this reason, various national, regional and local management strategies and plans have been adopted in recent years, including proposals from the population. Consequently, opinion polls on this topic are becoming increasingly important [1]. Public perception is influenced mainly by qualitative factors such as the severity of consequences, the sense of control, and the recency and perceived frequency of the hazard [2]. Understanding flood risk perception is crucial for effective risk communication, providing insights into residents' preparedness, and helping identify potential community vulnerabilities and disparities [2]. The aim of this research was to investigate the awareness of the local population about the risks, causes, consequences and preparedness for pluvial flooding in the city of Metkovic.

Materials and Methods

The survey research process comprised the following: (1) questionnaire construction, (2) survey administration to the selected sample population through face-to-face interviews, (3) data entry, database creation, and geocoding, (4) statistical analysis, and (5) interpretation. A questionnaire was completed among 5% of the urban population (N = 77) and five factors were formed based on the variables studied (F1 - Awareness of risk; F2 - Anthropogenic causes of flooding; F3 - Natural causes of flooding; F4 - Future consequences of flooding; F5 - Preparation for flooding). It was found that the reliability of the questionnaire was high for all factors (0.60 - 0.89). The data were analyzed using descriptive and inferential statistical methods (Cronbach's alpha, Kolmogorov-Smirnov test, Shapiro-Wilk test, Mann-Whitney U test, Kruskal-Wallis H test, Chi-square test) in the SPSS 26.0 program.

Results and Discussion

Mann-Whitney U and Kruskal-Wallis H test showed statistically significant differences ($p<0,05$) in relation to the gender of the respondents for the F1 "risk awareness" and F3 "natural causes of pluvial flooding" [Fig 1]. However, respondents have a strong awareness of the risks of pluvial flooding and there is no need for additional educational work, even if they believe that the city is exposed to a greater flood risk than other Croatian cities. Respondents have mostly had only indirect experience with flooding (51%), so the majority of them have not taken preventive measures (66%) or insured their property.

Results by factor:
F1 – General awareness of the risk of pluvial flooding was good (3.22), with as many as 92% of respondents being familiar with the concept of pluvial flooding. Most respondents considered the risk to be moderate (63%), which can be explained by the fact that the population is located along the river and is familiar with occasional flooding in the area.
F2 – This factor has the highest mean score (3.70) and a relatively low standard deviation (0.75), indicating that responses were closely clustered around the mean. The majority of respondents (51%) stated that they had indirect experience of flooding, meaning that 66% of them had not taken any preventative measures. They consider urbanization to be the main cause of flooding, while research shows that population density has no influence on flooding.
F3 - The overall perception was rated with a mean value of 3.61 and a standard deviation of 0.69. According to the respondents' answers, the soil type (2.69) and topographic conditions (2.75) were perceived as moderately prone to pluvial flooding. Respondents linked the occurrence of rainfall-induced flooding to climate change. The highest mean of 3.88 and a standard deviation of 1.233 show that this is consistent.
F4 – The overall perception was rated with a mean value of 3.11 and a standard deviation of 0.82. Respondents generally had moderate expectations regarding an increase in the frequency of heavy rainfall (3.66), material damage in urban areas (3.55), public awareness (3.12) and financial investment (2.72) to prevent pluvial flooding over the next ten years. The rating in relation to the increase in damage to respondents' homes was 2.15, with a standard deviation of 1.257. However, while some respondents expected lower changes in the future, others had higher expectations, which is reflected in different standard deviations.
F5 - The mean value of this factor is 3.23 and a standard deviation is 0.43. Notably, 59% of the respondents had not insured their property against floods. Regarding the statement that decision-makers have taken adequate measures for pluvial flood protection, respondents generally disagreed (2.19) and believed that certain institutions should do more in the contex of prevention. Furthermore, most respondents (67%) believed they were ill-equipped to defend against flooding independently and ewpressed a lack of confidence in the adequacy of risk mitigation measures taken by decision-makers. This underscores the need for improved flood risk communication and infrastructure measures.

	Awareness of risk (F1)	Anthropogenic causes of flooding (F2)	Natural causes of flooding (F3)	Future consequences of flooding (F4)	Preparation for flooding (F5)
Mann-Whitney U	375,000	499,000	449,500	524,000	378,000
Wilcoxon W	1701,000	1877,000	1827,500	1902,000	1506,000
Z	-2,907	-1,141	-1,960	-1,383	-1,263
Asymp. Sig. (2-tailed)	,004	,254	,050	,167	,206

Grouping variable: Gender

Fig. 1. Display of differences in relation to the factors observed in the analysis

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CIESM Congress Session : Sustainable Blue Bioeconomy
Moderator : Roberta Salomone – Univ. of Messina, Italy

Session's Synthesis

The session "Sustainable Blue Bioeconomy" hosted seven contributions addressing different topics related to solutions, practices and innovations to drive sustainability in coastal and marine areas.

These contributions discussed the role of Blue Carbon Ecosystems in climate change mitigation presenting two different nature-based solutions, respectively on the potentialities of protected areas and on the potentialities of the specific case of vegetation in the Red Sea Region (Egypt).

The role and contribution of specific sectors towards a sustainable Blue Bioeconomy has been explored, reporting on specific practices referred to three cases in maritime transport, marinas management, and nautical tourism, namely: i) to provide know-how and support to small operators in the Mediterranean for the transition to carbon-neutral maritime transport; ii) to provide scientifically-based information, through Pressure-State-Response (PSR) model, to help managing marinas and neighbouring waterfronts and plan proper interventions aimed at enhancing water quality; iii) to collect evidences from 5 years of applications of the Marine Strategy Framework Directive (MSFD) in Alicante (Spain).

Finally, two specific impacts on coastal and marine areas were examined, highlighting the related pressure and need for proper management practices to mitigate the effects: i) the transfer of non-indigenous and invasive species throughout the marine environment through the ships ballast water and ii) the artificial light at night (ALAN) that causes anthropogenic disturbances in marine coastal areas and in marine protected areas.

An interesting conclusive discussion allowed the participants to further stress the main challenges emerged during the session. The sustainable blue bioeconomy is a cross- sectoral investigation research area that could benefits from synergies emerging from different policies. But this also implies an inherent complexity that need to be well identified and interpreted, for the implementation of proper solutions. This ask for improved data collection, management efforts, and international collaboration, as well as interdisciplinary research and clear policy interventions.

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CARBON STOCKS IN EUROPEAN BLUE CARBON ECOSYSTEMS: DOES PROTECTION MATTER?

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Abstract

Protected areas can contribute to effectiveness of nature-based solutions by preventing the degradation of blue carbon (BC) ecosystems. Seagrass, saltmarsh and mangroves ecosystems are known as sinks of CO_2 and have the potential to be included in the emerging blue carbon markets. However, there is a lack of in-depth knowledge of the stocks of Mediterranean and European BC coastal. A systematic review allowed us to examine the state of art on carbon stocks of European BC systems under different protection levels, with the aim to emphasize their role as key ecosystem service providers to consider in conservation priorities. Results provided baseline information on the status of European BC systems, useful to identify relevant management actions to reduce potential threats and enhance their stability thus contributing to climate mitigation.

Keywords: Carbon, Organic matter, Coastal processes, Mediterranean Sea

Introduction

Other than providing multiple ecosystem services, including biodiversity enhancement, coastal vegetated ecosystems such as seagrasses, saltmarshes and mangroves act as natural carbon sinks [1]. Conservation and restoration of blue carbon (BC) ecosystems is receiving increasing attention for their role in climate change mitigation, by sequestering CO_2 and increasing long-term carbon stocks. In this context, protected areas can serve as valuable laboratories to test the effectiveness of protection on the potential of the BC systems [2]. Here we conducted a systematic review to examine the state of art on carbon stocks of European BC systems under different protection levels, with the aim to emphasize their role as key ecosystem service providers to be included in conservation priorities.

Materials and Methods

The literature search was focused on seagrass and saltmarsh ecosystems using Web of Science and Scopus databases, and data from 18 countries were extracted from 42 papers out of 832 retrieved, which were published between 1994 and 2023. PRISMA method [3] was followed for reporting and meta-analyses.

Results and Discussion

The majority of protected sites were covered under the Natura 2000 Habitats Directive (EU Countries) or were Special Area of Conservation (extra-EU Counties). Overall, significant differences emerged by comparing the top meter soil C_{org} stocks (kg C_{org} m^{-2}) of seagrass habitats in protected *vs* unprotected areas, but not for saltmarsh habitats. These results provide baseline information on BC systems at the European level and highlight the need to increase the spatial coverage of carbon stock studies, especially in Mediterranean Marine Protected Areas, to provide a more comprehensive picture of their potential role in climate change mitigation.
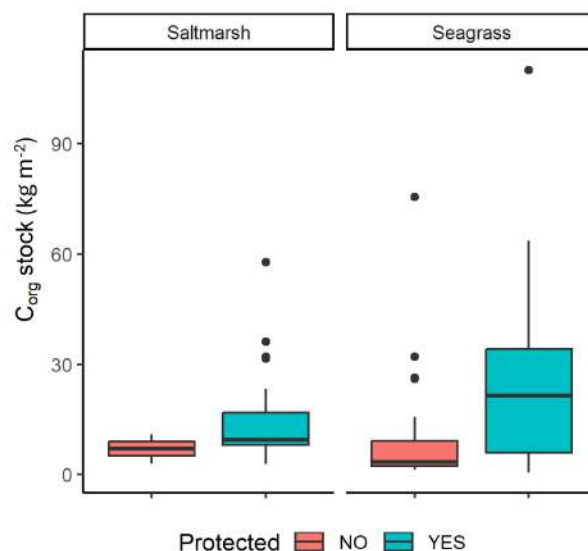

Fig. 1. C_{org} stocks (kg C_{org} m^{-2}) of the top 100 cm soil in European protected and not protected saltmarsh and seagrass ecosystems.

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THE ROLE OF BLUE CARBON ECOSYSTEMS ALONG THE RED SEA COAST OF EGYPT IN CLIMATE CHANGE MITIGATION: STATUS ASSESSMENT AND POTENTIAL

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Abstract
This article examines and evaluates the potential blue carbon ecosystems in the Red Sea. It tackles the questions of how much carbon are currently sequestered, how vegetation can improve the sequestration rates, and what are the current and expected economic benefits and challenges. The answers to these questions are key to climate mitigation efforts in Egypt and the Red Sea Region.

Keywords: Carbon, Red Sea, Ecosystem services, Coastal systems

Background

Blue carbon ecosystems have emerged as crucial players in mitigating climate change impacts, supporting adaptation, and facilitating the achievement of national and global net-zero goals. The Red Sea coast of Egypt stands out for its unique biodiversity as well as the presence of key blue carbon ecosystems, seagrass meadows and mangroves. In this article, we link the outcomes of several case studies focused on seagrasses and mangroves along the Red Sea coast, aiming to quantify their carbon storage potential and evaluate their ecological and economic viability as climate change mitigation tools.

Methodology

A total of 4 sediment cores were collected from Wadi Elgamal protected area (Fig. 1), 2 from mangroves and 2 from seagrass ecosystems, plus 2 cores from unvegetated areas to act as background references. The sediments organic content and physical characteristics are analyzed and blue carbon parameters are calculated [1].

Results and conclusions

Both mangroves and seagrasses from Wadi El Gemal area showed promising carbon storage potentials. In both ecosystems, the average carbon sequestration rate (CSR) was significantly higher compared to unvegetated areas (Fig 2). CSR was found to be rather linked to the type of and the species with in the ecosystem than the sediment characteristics. The total mangrove area in the study region increased from 56,810 m2 in 2001 to 64,710 m2 in 2021, with a net gain of 7,900 m2 due to plantation projects. The data on the distribution and the biomass of seagrasses available are not sufficient to construct an estimate of their total carbon stock. Mangroves have higher localized biomass and have shown successful implantation projects, while seagrasses are more sparsely distributed with limited successful implantation trials. The results emphasize the economic and ecological benefits of protecting and implanting mangroves and seagrasses.

Fig. 2. CSR (g C m^{-2} yr^{-1}) in blue carbon ecosystems and unvegetated areas.

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Fig. 1. Sampling sites (green= seagrasses, red= mangroves).

TRANSITION TOWARDS CARBON NEUTRALITY OF SMALL OPERATORS IN THE MEDITERRANEAN BASIN

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Abstract
The transition towards carbon neutrality in maritime transport requires short-term and medium-term solutions. Short-term solutions include using available technologies and transition fuels (such as LNG and electricity). In contrast, the medium-term solution is based on alternative fuels (such as methanol, electricity, and wind) that still need to be fully available. Dealing with such complexity is not easy for the operators of smaller ships, such as fishing vessels and local ferries, of small ports and marinas due to lower investment capacity and lack of technical and managerial skills. To help address this issue, the POWER4MED EU project (2023-2025) aims to provide know-how and support to small operators in the Mediterranean basin towards their short-term and medium-term transition to carbon-neutral maritime transport.

Keywords: Carbon, Mediterranean Sea, Marine policy, Global change

The Challenges

The Mediterranean is facing a double challenge: restoring its health and ensure wealth to its increasing population. Both have equal importancce and they must be achieved jointly and synergically. This is well understood in common international instruments such as the Mediterranean Action Plan (agreed by all the Mediterranean Countries within the Barcelona Convention) and the FAO fishing policy. Besides common policies, the transition to carbon neutrality requires short & medium-term solutions (Fig. 1) for which several options are proposed. However, most of them are neither affordable nor yet fully available (e.g., LNG fuels, green hydrogen, methanol, electricity and wind). To achieve decarbonization goals, thereis a need for a more widespread transition to new fuels.
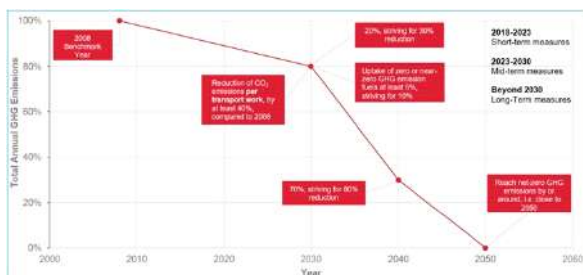

Fig. 1. Targets of short-mid and long term of GHG reduction measures [1].

The Maritime Forecast to 2050 (Fig. 2) has presented a comprehensive global fuel production database, showing that shipping will require 30-40% of the estimated global supply of carbon-neutral fuels to meet the expected demand by 2030, taking into account the IMO current GHG strategy.

POWER4MED aim and objectives

Assessing all available options, in line with the increasingly ambitious IMO targets, is essential. To this end, the POWER4MED project focuses on the transition towards carbon neutrality of small operators in the Mediterranean basin by developing, testing, and launching the POWER4MED Supporting Structure with a Team of multidisciplinary experts, as well as setting up toolkits to support the path to carbon neutrality in the three sectors of maritime transport: fishing boats, commercial vessels (ferries), and marinas. POWER4MED objectives are: 1) Analysis of maritime operators' needs and of available alternatives of fuels; 2) Assessment of options for energy investments; 3) Assessment of technological alternatives towards decarbonisation; 4) Assessment *via* pilot studies of adaptation costs for greening local infrastructures and ships transition to fully sustainable fuels; 5) Study on regulatory aspects building on ongoing consultations to support fleet transition; 6) Assessment *via* pilot studies on financial tools for decarbonisation; 7) Capitalise on experiences/ models being developed in EU ports/ shipping companies by developing sectoral/ national POWER4MED tools (strategies, transition plans, capacity building tools);

8) Development of the POWER4MED supporting structure to ensure a follow up after the end of the project; 9) Development of a network with relevant related initiatives and maximise dissemination in the Mediterranean.
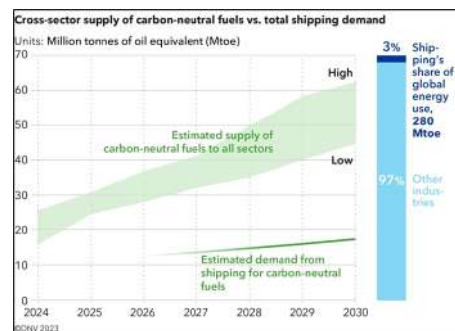

Fig. 2. Outline of ambitions and minimum indicative checkpoints in the revised IMO GHG strategy [2].

The countries surrounding the Mediterranean Sea are increasingly interested in reducing greenhouse gas emissions and fighting global warming. This is especially relevant for maritime sectors such as ferries, fishing operators, and yachts, which face common environmental challenges. As a result, tailored regulations are needed to address these issues. The first part of this project aims to provide an overview of the rules set forth by the two leading players in decarbonization in the Mediterranean Sea: the EU and the IMO. The purpose of these rules is to mitigate the environmental impacts caused by maritime activities without negatively impacting the growth of the maritime trade. The project will provide a brief overview of the European Green Deal and focus on measures that will impact the maritime sector, such as the EU ETS, FuelEU, and CII. These measures apply to vessels over 5,000 gross tons that transport passengers or cargo. Since these vessels have their own unique operating profile and continuously varying power demands, it is difficult to define standards that can be applied to every type of vessel. Moreover, retrofitting smaller vessels with new technologies may prove to be challenging due to limited space availability and overall cost compared to larger vessels, such as container ships and tankers.

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THINK GLOBALLY, ACT LOCALLY – THE NECESSITY OF PORT MONITORING FOR SUCCESSFUL BALLAST WATER MANAGEMENT FOR BIODIVERSITY LOSS PREVENTION

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Abstract

The ships ballast water facilitates the transfer of non-indigenous and invasive species throughout the marine environment. Port monitoring as envisaged by the Ballast Water Management Convention is crucial for the protection of local biodiversity from the negative impacts of ships ballast water and is the only real preventive approach. The analysis of the ports of origin of ballast waters discharged in the port of Rijeka (Adriatic Sea, Mediterranean) for the period 2014-2020 is done with the intention of illustrating the true extent of potential exposure of this port to non-indigenous and invasive species.

Keywords: Adriatic Sea, Marine policy, Invasive species, Coastal management, Biodiversity

Ballast water (BW) is a proven vector for the spread of NIS (non-indigenous species) over long and short distances in the sea [1]. For example, one of the IAS (invasive alien species) most likely introduced into the Mediterranean Sea by BW is the sea walnut, the ctenophore _Mnemiopsis leidyi_, which is reported to have drastically affected fisheries in the Black and Azov Seas [2] and to begin affecting anchovy (_Engraulis encrasicolus_) in the Adriatic [3].

Tab. 1. Origin ports of discharged BW in port of Rijeka during at least two years in the investigated period from 2014 to 2020.

COUNTRY	ORIGIN PORT	2014	2015	2016	2017	2018	2019	2020
Albania	Durres				■			
Algeria	Skikda (ex Philippeville)		■	■				
Belgium	Antwerpen	■						
Croatia	Ploče						■	■
Croatia	Pula							■
Croatia	Rijeka - other	■	■					
Croatia	Šibenik					■		
Egypt	El Iskandariya (= Alexandria)				■			
Egypt	Port Said						■	
Greece	Astakos					■		
Greece	Other ports - Greece						■	■
Italy	Ancona	■	■		■	■		
Italy	Bari			■	■			
Italy	Barletta			■		■		
Italy	Brindisi				■			
Italy	Chioggia		■	■				
Italy	Corigliano Calabro				■	■		
Italy	Manfredonia			■				
Italy	Marghera		■	■				
Italy	Marina Di Carrara				■			
Italy	Molfetta	■			■			
Italy	Monfalcone		■		■			
Italy	Monopoli					■		
Italy	Ortona			■				
Italy	Porto Nogaro				■			
Italy	Pozzallo			■				
Italy	Ravenna	■	■	■	■			
Italy	Salerno				■			
Italy	Taranto		■		■			
Italy	Trieste	■	■	■	■			
Italy	Vasto			■				
Italy	Venezia	■	■	■	■			
Libya	Tripoli	■						
Malta	Malta (Valetta)	■	■					
Montenegro	Bar					■		
Montenegro	Bijela	■						
Slovenia	Koper		■	■	■			
Spain	Barcelona				■			
Spain	Motril			■	■			
Tunisia	Sfax				■			
Turkey	Gemlik				■			
Turkey	Iskenderun, Hatay	■	■		■			
Unknown	Unknown	■	■					

An important step towards NIS management was taken in 2004 when the International Maritime Organization adopted the International Convention for the Control and Management of Ships Ballast Water and Sediments [4]. The Convention requires all ships to have a BWM treatment system installed on board after 8 September 2024 and sets the BW discharge standard: <10 viable organisms (≥ 50 µm in size) per m^3, <10 viable organisms (10-50 µm in size) per ml, and the indicator microbes below certain thresholds. However, weaknesses of this standard have already been reported as it does not require identification of species after BW treatment [5], does not consider organisms <10 µm in size [5] and, despite the required abundance reduction, the set thresholds still allow the release of a species inoculum [6].

However, the Convention calls for a continuous port monitoring for the early detection of harmful aquatic organisms and pathogens (HAOP) that may affect the environment, human health, property or resources. To illustrate the true extent of potential exposure to HAOP transfer through BW, a seven-year BW discharge database was analysed for the port of Rijeka in the northern Adriatic Sea (Mediterranean). The quantities of BW discharged from 2014 to 2020 ranged from 44078 in 2019 to 203238 m^3 in 2014. The origin ports of BW discharged included a total of 116 ports from 32 countries (Table 1).

In cases where HAOP are present in the port, the Convention suggests that the BW intake should take place in an alternative area that does not contain HAOP or from alternative sources such as drinking or treated water. These alternatives are the only real prevention of HAOP transfer by BW available today [7]. BWM treatment systems will reduce HAOP transfer to some extent, but prevention of HAOP transfer would be even more effective if BW intake were prevented when HAOP is observed in port. Early detection of HAOP could be facilitated by conducting regular port monitoring - globally.

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ARTIFICIAL LIGHT AT NIGHT (ALAN) IMPACT ON COASTAL AND MARINE PROTECTED AREAS IN EUROPEAN SEAS

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Abstract
Artificial light at night (ALAN) is a significant anthropogenic pressure affecting coastal marine environments. ALAN, visible from satellites over large distances, disrupts natural behaviors in photosensitive marine organisms and influences ecosystem dynamics. This study examines and compare the intensity and distribution of ALAN in marine coastal areas and in marine protected areas (MPAs) within European seas. Results indicate that ALAN levels in MPAs are not significantly different from those in adjacent coastal areas, highlighting the widespread reach of light pollution. This underscores the vulnerability of MPAs to anthropogenic disturbances and calls for improved management practices to mitigate these impacts.

Keywords: Marine reserves, Light pollution, Coastal management, European Seas

Introduction
Artificial light at night (ALAN) is an increasingly recognized environmental pollutant, particularly in coastal areas [1]. ALAN disturbs natural behaviors in photosensitive organisms, such as reproductive cycles, feeding, and migration patterns. In European coastal zones, ALAN is closely associated with urbanization and economic development, often linked to gross domestic product (GDP) [2]. As part of the European Union's Blue Growth strategy, efforts to support sustainable growth in marine sectors must address the negative externalities of light pollution [3,4]. This study aims to assess the impact of ALAN on marine protected area (MPAs), which are intended to conserve marine biodiversity[5].

Material and Methods
This study focused on the 23 European Union Coastal Member States (CMS), examining coastal zones from the shoreline up to 500 meters inland, as well as marine areas extending to the Exclusive Economic Zones (EEZ). ALAN data was obtained from satellite imagery, with light intensity measured in digital numbers (DN). Using GIS tools, the spatial distribution of ALAN in MPAs was analyzed and compared to surrounding coastal areas. Geographic datasets were used, including the World Database on Protected Areas (WDPA) and Corine Land Cover (CLC) 2018 dataset (Figure 1).

Fig. 1. Example of Geographical Information System (GIS) analysis results of ALAN effects on marine protected areas near coastal zones. The example represents a small area in the Gulf of Naples and the full analysis was conducted across all European coastlines and is summarized in a heatmap accessible by the figure's QR code.

Results and Discussion
The analysis of ALAN intensity in MPAs revealed no significant difference between light pollution levels in MPAs and those in adjacent coastal zones. Approximately 39% of coastal zones near MPAs showed moderate to high levels of ALAN. The high levels of light pollution observed indicate that even areas designated for conservation are affected by human-induced light pollution. These results suggest that MPAs, though intended to protect biodiversity, are highly vulnerable to the encroaching impacts of urban development. Artificial light at night is a pervasive pollutant affecting marine protected areas across European seas. This study highlights the need for enhanced regulatory frameworks to reduce light pollution, particularly in regions designated for biodiversity conservation[6]. By integrating these findings into coastal management practices, policymakers can better address the challenges posed by ALAN and improve the resilience of MPAs.

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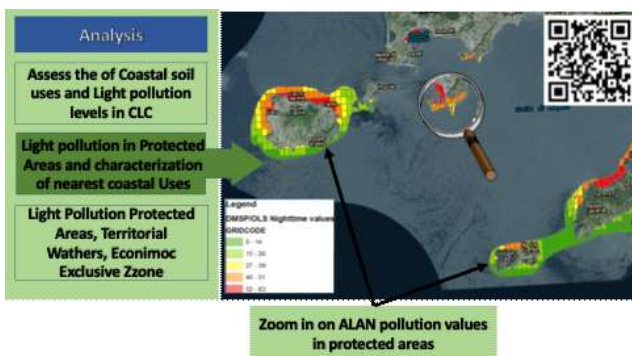
ATLAS OF ENVIRONMENTAL RISK OF WATER QUALITY FOR PORTUGUESE MARINAS

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Abstract

This study applies the Pressure-State-Response (PSR) model to assess the environmental risk of marinas along the coast of mainland Portugal. The goal is to provide decision-makers, such as government agencies and harbour managers, with scientifically-based information that helps to manage marinas and neighbouring waterfronts. The classification and hierarchization of the risk is applied to 27 marinas along the west and south Portuguese coast. The environmental risk shows an asymmetric distribution with marinas having low risk in the west Atlantic coast and high to very high risk in the Algarve.The resulting maps can help establish priorities for intervention plans aimed at enhancing water quality.

Keywords: Pollution, Mapping, Coastal management, North Atlantic

Marinas play a key role in supporting recreational sailing activities and are integral infrastructures within coastal and maritime tourist sectors. They often encompass a wide variety of ecosystems that are under intense environmental change due to pollution, eutrophication and urbanization, among other pressures. Despite their significance, marinas in many parts of the world, including Portugal, lack the application of simple methodologies designed to provide a quick and cost-effective assessment of environmental risk based in existing data, that can be applicable uniformly to a large number of marinas. Here we follow the methodology proposed by [1] to map the spatial variability of risk factors for water quality in the principal marinas along the coast of mainland Portugal. The first step of the method consists of estimating the environmental pressures (Pri) related to the human activities with negative impacts in water quality at each marina. The indicators for pressures include the density of boats (berth/m^2), the presence of gas stations and dry docks, the frequency of dredging operations and the types of land use developed in a 1 km buffer surrounding the marina. The second step includes the assessment of environmental conditions at each marina described by a functional relationship between the environmental susceptibility to disturbance, the ecological value, and the naturalness of the environment. The indicators for the environmental state (Sti) are a combination of the flushing capacity of the water volume where port activity takes place, the number of ecological singular elements such as the protected areas in the vicinity of the marina and a parameter for the type of marina (simple anchorage or harbour) used as a proxy for naturalness. The third step considers the management actions, or responses (Rpi), applied at the marina level to mitigate and prevent the effects of human pressures. The indicators for responses are the number of adopted measures and instruments to reduce the pressures and improve the environmental performance, such as for example waste management practices and Blue Flag instruments.

The risk-index on water quality is the multi-parametric index defined for each marina as Ri = Pri x Sti + Rpi [1]. A database with the characteristics of each marina was compiled based on information from Marinas de Portugal. For all marinas the digitalization needed to compute the indicators, parameters and metrics was performed using GIS, Google Earth Satellite Images and CORINE Land Cover Data. Figure 1a shows an example of the data classification and buffers considered to estimate the indicators and metrics of environmental risk. All the indicators are normalized by the maximum value obtained. The thresholds for defining classes for Pressures, States and Responses have been defined specifically for Portugal (Table 1).

Tab. 1. Criteria to evaluate Pressures, State and Response categories for the Portuguese marinas.

Factor	Category	Criteria	Portuguese thresholds
Pressures (Pr)	VL (2/16)	Pri ≤ P25	Pri < 2
	L (14)	P25 < Pri ≤ P50	Pri = 2
	M (9)	P50 < Pri ≤ P75	2 < Pri ≤ 3
	H (1)	Pri > P75	Pri > 3
State (St)	VL (7)	Sti ≤ P25	Sti ≤ 0,6
	L (6)	P25 < Sti ≤ P50	0,6 < Sti ≤ 0,73
	M (7)	P50 < Sti ≤ P75	0,73 < Sti ≤ 1,5
	H (6)	Sti > P75	Sti > 1,5
Response (Rs)	Optimal (13)	Rsi ≥ P50	Rsi ≥ 0
	Insufficient (13)	Rsi < P50	Rsi < 0

VL: Very low; L: low; M: moderate; H: high; P25: 25th Percentile; P50: 50th

The multi-parametric index of the environmental risk for water quality was computed for the main 27 marinas along the Portuguese coast (Figure 1b). The distribution of the risk is not homogeneous, with most marinas in the north displaying very low risk. The marinas with high and very high risk are mostly concentrated in South Portugal. The ones with the highest risk are Lagos and Portimão in the western sector of the Algarve. The factors that most contribute to the risk in Portimão are the pressures, namely the dredging and navigation activity. In Lagos, the factor that dominates the risk is the susceptibility which is related to the flushing capacity of the water volume combining hydrodynamic and morphological characteristics of the marina through the Complexity Tidal Range Index. These marinas have implemented effective measures and instruments, as they demonstrate the highest levels of response through their current practices. Nevertheless, they should maintain their focus on environmental planning actions to further mitigate the environmental risk.

Fig. 1. a) Example of delimitation of areas and land use classification for the computation of the pressures and state indicators. b) Atlas of environmental risk of water quality for Portuguese marinas. Risk is classified into five classes: very Low, Low, Moderate, High, and very High.

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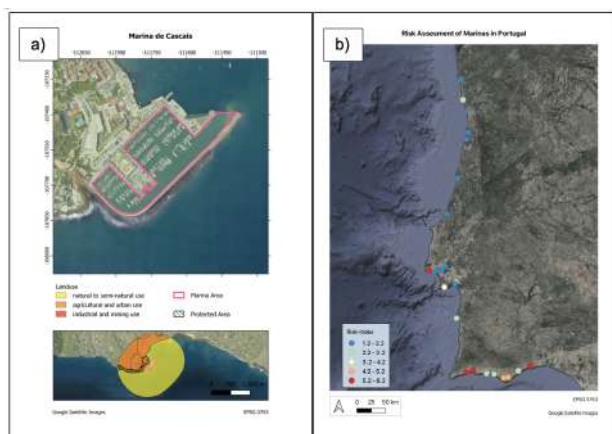
THE MARINE STRATEGY FRAMEWORK DIRECTIVE AND THE NAUTICAL TOURISM IN ALICANTE (SPAIN)

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Abstract
The application of the Marine Strategy Framework Directive (MSFD) in Spain led to the development of an administrative authorization process to protect and preserve the marine environment from human activities. We currently have the experience of 5 years of applications/ resolutions on the compatibility of nautical activities with the MSFD in Alicante (Spain). The results confirm that bureaucracy has increased. Other consequences include difficulties in the assessment of pressure descriptors as "seabed integrity" (D6) and, above all, "underwater noise" (D11).

Keywords: Mediterranean Sea, Marine policy, Management

The nautical tourism usually takes place in inshore waters where marinas or boat launch facilities are available. Nautical recreational activities create up to 234.000 jobs and generates €28 billion annual revenue. Moreover, about 48 million EU citizens play regularly water sports, with 36 million participating in boating activities [1].

The Marine Strategy Framework Directive (MSFD) has provided an ecosystem-based approach to protect and preserve the marine environment in the Member States. It is the cornerstone of the sustainable blue economy, developing measures designed to protect the marine ecosystems and ensure economic activities. The Member States have developed during the last years their own marine strategies for the waters under their jurisdiction. The national strategies contain 1) an assessment of state of the marine environment and the impact of human activities; 2) a definition of "good environmental status" based on a list of 11 descriptors; and 3) clear environmental targets.

The transposition of the MSFD in Spain has included an administrative process to authorise any activity involving the use of the sea bottom. The aim of this procedure is to ensure the compatibility with the national strategy. The authorisation is based on the descriptors developed for assessing the pressures and impacts of human activities on marine and coastal resources. The resolution may be either unfavourable or favourable (with or without limitations).

In the Spanish mediterranean waters, the activities that required authorisation are very likely related to nautical tourism. The assessment of coastal tourism in this subregion considers biodiversity (D1) as state descriptor as well as the following pressure descriptors: non-indigenous species (D2), contaminants (D8), marine litter (D10), energy, including underwater noise (D11), and possibly seabed integrity (D6). The applicants for authorisation must consider this pressure descriptors and fulfil the environmental targets. The competent administration should respond in the light of possible mismatches between the human activities and the "good environmental status" of the marine biodiversity.

The coastal province of Alicante is one of the most important Spanish tourism destinations. Nautical tourism is a dynamic type of tourism that takes place all year round, although the intensity is higher in the summer. "It encompasses aspects of marine tourism such as sailing, yachting, cruising and diving, as well as harbour-side developments, coastal water sports such as jet skiing, boat shows, port tours, and marine heritage destinations" [2].

We currently have the experience of 5 years of applications/ resolutions on the compatibility of nautical activities with the MSFD in Alicante. The first consequence of the administrative authorization process is the increase in bureaucracy. The applicant is usually the local administration, and the resolution is responsibility of the first administrative level. Furthermore, another serious consequence are the challenges in implemeting the compatibility assessment. The majority of the applications for authorising nautical activities are related with buoying and motorised vessels [3]. The competent administration usually find it difficult to assess projects with buoys because of the lack of large-scale maps. This information is important to ensure moorings are suitably located on the ecosystems they protect. The burden is on the descriptor "seabed integrity" (D6) but the applicants have a wide range of methodologies to allocate coordinates of buoys. These methodologies require skilled professionals and usually the operation of marine technologies.

When the activities are related to motorised watercraft the challenge is much bigger. There is evidence that powerboating exert pressures linked to underwater and above water noise disturbance to marine mammals, fish, and birds. However, the pressure descriptor "underwater noise" (D11) is currently under development (second implementation cycle). The marine strategy assumes the lack of definition of the "good environmental status" for this descriptor and has not established threshold values. This situation impedes the systematic assessment of engine operations during the recreational activities. Unauthorised nautical activities may affect the competitiveness of the tourism model in Alicante and have a serious impact on GVA and employment.

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CIESM Congress Session : Research in MPAs
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Session's Synthesis

The field of Marine Protected Area (MPA) research is constantly evolving, but several key issues and knowledge gaps remain at the forefront dealing mainly with four main thematics, such as:

- the impact of climate change and the questions of mitigation or adaptation,
- the efficiency and equitability of governance and management,
- the emerging threats (e.g., deep-sea mining, marine renewable energy) and pathogens (notably the risks they posed to biodiversity and habitats and ecosystem services within MPAs) and opportunities, and
- the effectiveness and benefits of MPAs.

Questions related to this latter topic may include:
- (1) What are the optimal size, shape and connectivity of MPAs to achieve the best conservation benefits?
- (2) How do MPAs contribute to economic development and sustainable fisheries?
- (3) How effective are MPAs in conserving ecosystem health, biodiversity and biomass?

The questions addressed in the presentations of this session were mainly related to this latter issue and the main topics, biologicals models and tools addressed during the session are presented hereafter. One of the main themes was that of the effect of protection through MPA on biomass and biodiversity with the study of before and after variations and the study of impact of fisheries, such as trawling, in these areas. Several biological models were used including the habitats and commercial crustaceans and fishes. Among the topics was also those of regime shift with the study case of sea urchin barrens versus macroalgae beds. The main study areas were located in North Western Mediterranean Sea, Adriatic and Aegean Sea. Among the tools employed in these studies were: the underwater visual census, fisheries logbooks and the use of optical properties of the sea.

The discussion notably highlighted the complex and interconnected challenges facing stakeholders (e.g. MPA's researchers, fisheries stakeholders, managers, ...). It also focused on the importance of inter-AMP connectivity. The debates could also have focused on synergies between various stressors such as marine pollution, invasive species, habitat degradation, overfishing, sea level rise and ocean acidification on MPA resilience, and their cumulative effects or adaptive capacity. Looking ahead, addressing these issues would require closer interdisciplinary collaboration (e.g. stakeholder engagement), innovative approaches (e.g. drones, artificial intelligence) and a strong commitment to conservation and sustainable development.

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COMMERCIAL CRUSTACEAN VARIATIONS BEFORE & AFTER MPA IN KITROS, THERMAIKOS GULF, NORTHERN AEGEAN

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Abstract

This research tracks commercial crustacean abundance and biomass changes in the Marine Protected Area in Kitros, Pieria, Greece, focusing on *Penaeus kerathurus*, *Farfantepenaeus aztecus*, and *Parapenaeus longirostris*. MPAs aim to benefit local fisheries by enhancing catch per unit effort (CPUE). Artificial reefs provide habitat, trawling protection, fisheries support, habitat enhancement, erosion prevention, and recreation, fostering marine health. Post-MPA, species showed slight abundance increase but significant biomass rise.

Keywords: Crustacea, Aegean Sea, Artificial reefs, Biomass, Coastal waters

Introduction - The Kitros MPA in Pieria, Greece, influenced by freshwater from nearby rivers and seasonal solar changes, has a diverse ecosystem shaped by the mixing of Black Sea and Levantine waters. Since installing an artificial reef in 2014, surveys from 2015 to 2017 recorded over 70 fish species, a significant increase from before the reef's installation [1]. Research continues to track species like *Penaeus kerathurus*, *Farfantepenaeus aztecus*, and *Parapenaeus longirostris*, assessing the reef's impact. MPAs like Kitros benefit local fisheries by improving catch rates and providing habitat, protection from trawling, and opportunities for recreation and research [2].

Materials and Methods - Before the artificial reef (AR) installation, four ichthyological surveys were conducted between 2007 and 2008 in the Thermaikos Gulf near Kitros. These samplings utilized a modified bottom trawl method with specific fishing routes. Each sampling date included three bottom trawl hauls, with results averaged and presented in (Table 1). Trawling operations, both pre- and post-MPA establishment, were consistent in vessel, location, and alignment. Each session included three trawl hauls at depths of approximately 27 to 36 meters along the future AR complex perimeters. Results from these three hauls per session were aggregated to produce a composite average figure representing species abundance and biomass at each specified sampling time. Following the AR construction in 2014, seasonal surveys were conducted from June 2015 to September 2017, forming part of a three-year monitoring initiative post-reef establishment, using consistent sampling stations employed in earlier surveys from 2007-2008 and 2015-2017.

Results - Following each trawl haul, the catch was identified down to the species level. On the vessel, the lengths and frequencies of each species were documented, along with their respective numbers and weights. The primary metrics used for analysis were abundance and biomass, with abundance defined as the number of individuals per square kilometer (individuals/km²) and biomass quantified as kilograms per square kilometer (kg/km²).

Tab. 1. List of commercial crustacean species abundance /km^2 and biomass (kg/km^2) during the surveys before (2007–2008) and after (2016–2017) the creation of the artificial reef and the subsequent declaration of the Marine Protected Area at field sites in the outer region of the Thermaikos Gulf in the Aegean Sea, offshore of the coastal zone of Kitros, in the Pieria region of Greece.

Abundance N/km²	30-May-07	10-Sep-07	14-Apr-08	13-Jun-08	7-Apr-16	8-Jun-16	7-Apr-17	8-May-17	7–8 Avg.	16–17 Avg
Penaeus kerathurus	0	55	18	0	12	24	79	55	18	42
Parapenaeus longirostris	28	18	28	0	1	3	206	173	18	95
Penaeus aztecus	0	0	0	0	0	85	39	0	0	33

Biomass kg/km²	30-May-07	10-Sep-07	14-Apr-08	13-Jun-08	7-Apr-16	8-Jun-16	7-Apr-17	8-May-17	7–8 Avg.	16–17 Avg
Penaeus kerathurus	0	0.8	0.2	0	320.6	1093.4	3.4	2.2	0.3	354.9
Parapenaeus longirostris	0.2	0.2	0.2	0	276	589.5	0.6	0.6	0.2	216.7
Penaeus aztecus	0	0	0	0	8.9	209.2	2.5	0.2	0	55.2

Discussion - Crustacean fisheries are expanding globally. Notable among these is the Mediterranean caramote prawn, *Penaeus kerathurus* which experiences rapid growth in its first year, leading to significant biomass increases in Marine Protected Areas due to enhanced food availability and reduced mortality from fishing restrictions. The deep-water pink shrimp (*Parapenaeus longirostris*), has shown minor abundance increases but significant biomass growth post-MPA, similar to the caramote prawn [3,4]. The invasive brown shrimp (*Farfantepenaeus aztecus*) spread to the Aegean Sea by 2014, likely introduced via ballast water [5]. Its colonization in the Mediterranean, particularly in the Kitros MPA with its rocky and sandy substrate, underscores its adaptability and the reef's role in creating favorable new habitats [3]. It is worth noting however that these species are greatly affected by seasonal weather variations. Efforts to restore marine ecosystems, such as through Artificial Reefs and their surrounding MPAs, are recognized for enhancing species recruitment and addressing reef degradation due to climate change [6]. These initiatives, crucial for ecosystem recovery, must be well-planned and assessed to ensure their effectiveness [7].

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TEMPORAL EVOLUTION OF PHASE SHIFT: SEA URCHIN BARRENS VS. MACROALGAL BEDS IN A NORTH-WESTERN MEDITERRANEAN MARINE PROTECTED AREA

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Abstract

The evolution of sea urchin barrens was monitored over time until 2018 in a Marine Protected Area of Menorca, after their detection in 2011. The sea urchin population declined and the macroalgal beds were restored in less than ten years. Recovery was independent of changes in fish biomass.

Keywords: Algae, Echinodermata, Fishes, Biodiversity, Balearic Islands

Introduction. Sea urchin barrens and macroalgal beds are the two alternating ecological states in the infralittoral rocky reefs of temperate zones [1]. The shift between these states depends on variations in the intensity of sea urchin grazing and has major impacts on habitat complexity and biodiversity. Large areas of sea urchin barrens were detected for the first time in the North Menorca Marine Reserve (RMNM) in 2011 and monitored since then to better understand the relationship between macroalgae coverage, herbivore abundance and biomass (sea urchins) and the biomass of sea urchin predator fishes. The main hypothesis of this study was that sea urchin density could be affected by higher fish abundance resulting from reduced fishing intensity in marine protected areas.

Methods. Surveys were conducted in late May or early June from 2012 to 2018 in three areas along the northern coast of Menorca, two within the RMNM (no-take zone and regulated professional fishing zone) and one outside the RMNM. Within each zone, sea urchin predators (carnivorous wrasses and sea breams) were censed along eight transects (50 x 5 m). Algal cover and sea urchin density (_Paracentrotus lividus_ and _Arbacia lixula_) were also measured within the same transects using 50 x 50 cm quadrants (five quadrants placed randomly every 10 m along the transect; 50 quadrants per transect). The macroalgae were classified into: crustose Carallinaceae (representing sea urchin barrens); turf algae; _Ericaria_ (= _Cystoseira s.l._) spp. and other erect macroalgae (Dictyotales, Sphacelariales, Ceramiales). Sea urchin barrens were defined here as patches with a coverage of crustose Corallinaceae > 60% and for the latter analysis, the temporal dynamics of sites with sea urchin barrens in 2012 was compared with that of sites with macoalgal beds in 2012, across the whole study area.

Results and Discussion. Sea urchin barrens were only detected in the no-take zone within the RMNM. The ANCOVA results showed that Corallinaceae cover and sea urchin density were the only two variables analysed that exhibited significant differences in temporal evolution between sea urchin barrens sites and macroalgal bed sites (Interaction: Corallinaceae cover ($F_{3,3}=9.12$, $p<0.001$), sea urchin density ($F_{3,3}= 11.33$, $p<0.001$). Sea urchin density and Corallinaceae cover were significantly higher within sea urchin barrens sites compared to macroalgal bed sites in 2012 and 2014, but these differences vanished in 2016 and 2018 (Fig. 1). Conversely, no statistically significant differences were found between years or sites for the cover of turf, _Ericaria_ spp. and erect macroalgae. Moreover, no significant differences in fish biomass were observed between years and sites, leading to reject the original hypothesis that changes in fish biomass trigger changes in sea urchin density. The overall evidence suggests that in oligotrophic systems, singulars events of high primary production can increase the abundance of sea urchins thanks to a greater food availability for the larval urchin, an event observed in the North of Menorca between 2009 and 2010, favouring the emergence of the sea urchin barrens observed [2]. Six years after that settlement peak, sea urchin abundance has not been maintained by the recruitment of new cohorts and the sea urchin barrens have vanished (Fig. 1). It has been suggested that in more productive regions, sea urchin barrens may persist in time after their formation [3], but our results indicate that this mechanism is not operating in the oligotrophic system of Menorca. This is because urchin recruitment is seriously limited by highly reduced planktonic primary productivity. This explains the great resilience and the long-term persistence of macroalgal beds dominated by long-lived species such _Ericaria_ spp. This study confirms that episodes of increased larval survival that increase the settlement of juvenile sea urchins in oligotrophic environments can cause the emergence of sea urchin barrens, but the system returns to its initial state in less

than a decade and without significant changes in perennial algal cover.

Fig. 1. Annual mean of sea urchins density, fishes biomass and cover (%) of turf algae, erect algae and _Ericaria_ spp. in sites with or without sea urchin barrens.

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MENORCA CHANNEL HABITAT CHARACTERIZATION COMPARING PROTECTED AND TRAWLED AREAS

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Abstract

Designated as a Site of Community Importance (SCI) within the Natura 2000 network, the Menorca Channel has some Fishing Protection Zones (FPZ) inside the SCI polygon, where bottom trawling is banned. The main objective of this study is to characterize the different types of habitats in both protected and non-protected areas since the implementations of these regulations. To achieve the purpose, we took video samples from 35 stations and a total of 109 tracks, with a photogrammetric sledge HORUS, to characterize habitats and structuring species. In addition, we sampled each station with an epi-benthic beam trawl to identify and quantify the epi-fauna. Our results have allowed a rigorous overview of the habitats in the Menorca Channel, and highlight the positive effects of protecting sensitive habitats when compared to unprotected areas.

Keywords: Fisheries, MPAs, Western Mediterranea

Introduction

The continental shelf of the SCI Menorca Channel, between 50 and 90 meters deep, is an area heavily affected by strong north winds and marine currents [1,2]. Located in the western Mediterranean, it presents a wide distribution of species and habitats of conservation interest, such as coralligenous platforms, rhodoliths beds, and biogenic detritic bottoms [3]. Due to this, in 2014 it was declared SCI within the Natura 2000 network, covering an area around 1674 km^2. In 2016, two FPZ were also designated within the Menorca Channel, where trawling was banned. The current Ecosystem Approach to Fisheries Assessment and Management pays special attention to the conservation of sensitive habitats (SH) and Essential Fish Habitats (EFH) and Menorca Channel is particularly interesting because of their special habitats, vulnerable to the impact of bottom trawling [4]. The current study was developed within the framework of the SosMed project and aims to characterize the benthic communities of circalitoral sedimentary bottoms, in order to assess the effect of reducing and banning trawling on their benthic communities.

Materials and methods

A scientific survey was conducted from the 17th to the 29th of October 2023 onboard the R/V *Ramón Margalef*. During this survey, we collected data with an epi-benthic beam trawl and photogrammetric sledge HORUS to obtain samples of macro-benthic flora and fauna and images of the seabed and its benthic biota, respectively. The samples where from 3 areas: FPZ, LIC and ADJ (an adjacent zone nearby Menorca channel opened to trawling).

Results and discussion

We collected a total of 109 videos with the HORUS and 35 tows with the beam trawl. Six main types of habitats were identified (Figure 1). Moreover, FPZ and LIC have higher coverage of algae, rhodoliths and slow-growing species as *Paramunicea sp*. than the non-protected areas with a higher density of small crustaceans and molluscs. Results evidence differences between the trawled and non-trawled zones, with no-presence of *L. rodriguezii* in ADJ zone. It is important to note that protected areas can beneficiate trawled areas located nearby, when the area has special habitats and species like Menorca Channel, and good monitoring is necessary to better understand and regulate these areas.

Acknowledgments

Fig. 1. Main habitats identified with the photogrammetric sledge HORUS. (i) Sand and muds, (ii) Detritic sands with *Laminaria rodriguezii*, (iii) Rhodoliths/maërl beds presence, (iv) Detritic sand with brown algae presence such as *Halopteris filicina* and *Dyctiotae*, (v) Detritic sand with red algae presence such as *Peyssonelia spp*., *Phyllophora crispa* and *Osmudaria volubilis*, (vi) Detritic sand with *Neopycnodonthe cochlear*

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FISHING LOGS IN THE PORT-CROS NATIONAL PARK: 20 YEARS OF DATA PROVIDED BY FISHERMEN IN SUPPORT OF THE FISHING CHARTER

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Abstract

The Port-Cros National Park now has a long series of catch and effort data compiled from the fishing logs of professional fishermen operating around the island of Port-Cros. This tool, established with the fishing charter, attests to the positive results of the participatory management experienced over the past 20 years.

Keywords: Fisheries, Management, Marine reserves, Monitoring, North-Western Medite

Within the Port-Cros National Park (PCNP), fishing is only prohibited in diving sites and mooring zones (80 ha, or 6.2% of the archipelago's area). Around Port-Cros island, recreational fishing is nearly prohibited, while professional fishing is practiced by around ten vessels smaller than 12 meters, which operate daily. These vessels employ various fishing gears, primarily nets and longlines, targeting different species seasonally.

The PNPC has been a pioneer marine protected area in implementing monitoring and management tools dedicated to professional fishing. In 1999, a Partnership Fishing Charter was established with professional fishers around the island of Port-Cros (a band of 600 meters around the islands and islets corresponding to 1,300 ha; [1]. This charter includes regulations on authorized gears, mesh size and net length, set times and durations, and the number of vessels allowed to fish. Fishers wishing to operate in this area must submit a request and commit to providing the Park with information on their fishing practices and catches. This information must be recorded in a fishing log provided to them at the beginning of the year. The charter is reviewed and discussed annually and may be modified based on requests from fishers or from the PNPC, following validation by both parties during an annual meeting. Fishing authorization is only granted after signing the Charter and obtaining approval from the PCNP Director, and since 2013, an additional authorization must be issued by the State services. Data is analyzed and presented to fishers at the subsequent charter meeting.

Tab. 1. Number of fishing nets, fishing days, and declared fishermen in the logs by fishermen who had activity in the waters of Port-Cros island between 2000 and 2020 (from 2000 to 2002, only trammel net information could be collected due to limitations in the log format).

Years	Trammel nets			Gill nets			Depth combined nets		
	Number	Nb days	Nb fishers	Number	Nb days	Nb fishers	Number	Nb days	Nb fishers
2000	262	102	7						
2001	363	119	7						
2002	407	113	7						
2003	304	108	6	26	20	2			
2004	414	145	7	74	66	2			
2005	504	159	8	124	91	4	10	7	1
2006	441	140	8	88	77	4	149	82	2
2007	493	160	9	117	85	4	48	37	3
2008	531	161	9	116	81	5	23	18	3
2009	820	159	8	122	87	3	36	32	4
2010	598	142	7	122	95	4	29	19	2
2011	583	155	5	92	65	4	95	75	4
2012	678	154	5	145	104	5	34	33	2
2013	527	152	5	49	34	3	19	18	1
2014	439	149	6	92	65	3	46	46	1
2015	488	141	7	191	104	5	77	65	1
2016	472	142	5	131	89	3	66	66	1
2017	350	109	7	53	47	3	54	54	1
2018	323	100	6	81	55	3	50	50	1
2019	226	119	3	88	71	2	60	60	1
2020	285	123	6	115	68	4	29	29	1

Fishing practices have been compared in terms of effort, gear characteristics, and catch composition for the main declared target species. In the absence of stock assessments in this type of multispecies coastal fishery [2; 3], the annual and seasonal variability of catches for nets and longlines has been assessed, along with total annual and target species average yields.

This monitoring, initiated in 2000, indicates trends and helps understand the evolution of practices and catches made by fishers within the framework of this shared fisheries management approach. It is complemented by regular series of onboard samplings (24 outings totaling approximately 80 sampled nets), conducted since 2015, to obtain precise measurements of catch sizes, list of target species, and bycatch.

Fig. 1. Total biomass harvested (kg) by nets and declared by professional fishermen who had activity in the waters of Port-Cros island between 2000 and 2020.

After more than 20 years of experience and overcoming challenges by fishermen and managers, it can be said today that sharing knowledge of fishing activity, the species involved, their life traits, and establishing genuine consultation on management measures seems to be a constructive and effective approach to ensure compliance with regulations and practice adaptive and sustainable fisheries management [3; 4]. In 2019, the model was thus adapted to the island of Porquerolles, also located within the heart of the Park.

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OPTICAL PROPERTIES OF THE ADRIATIC SEA: LIGHT THE WAY TO THE PRESERVATION OF COASTAL ISLAND ECOSYSTEM

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Abstract
Light intensity $[W/m^2]$ was modeled over time and depth using measured attenuation coefficients and modeled surface irradiance at the Lastovo Archipelago Natural Park, Adriatic Sea. The model was applied to the average isotherm depth in order to assess optical properties during observed island trapped waves (ITWs) event. Our findings reveal the matching phase of light and ITWs and indicating that the ITWs effect on primary production could be driven by light.

Keywords: Adriatic Sea, Islands, Upwelling, Models, Time series

Introduction
The Adriatic Sea is the most northern part of the Mediterranean characterized by strong stratification during summer months, which decreases net primary production. However, internal oscillations can disrupt stratification and influence the marine food web by enabling the transport of nutrients to the euphotic zone and bringing phytoplankton closer to the light [1]. Lastovo Archipelago is a Nature Park, an area in the South Adriatic Sea protected for its biodiversity. Island trapped waves (ITWs) phenomena have been observed at Lastovo Island, causing vertical thermocline oscillations up to 30 m [2],[3]. ITWs have a consistent diurnal cycle so thermocline at the island's southern cliff Struga is at the shallowest and the deepest around 5 PM and 5 AM (UTC+1), respectively. Only recently it has been shown that these oscillations affect the picophytoplankton and bacteria the most [4]. However, it is not clear if the NPP is increased by nutrient flux or light availability.

Methods
Temperature loggers (°C) were mounted at the southern cliff Struga (Fig.1a) at nine depths between 5 and 45 m during the stratification period of 2022. Additionally, PAR sensors were mounted at 10 m and 40 m from 23 July to 5 October 2022. Temperature time-series data were analyzed to determine the depths of 20°C isotherm representing thermocline (z_i [m]). PAR time series data were filtered for weeks when ITW episodes were recorded: 31 July - 2 August, and 24 - 26 August 2022. The attenuation coefficients of PAR (K_{PAR}) were estimated using model $K_{PAR} = \ln(PAR_{40} / PAR_{10})$ x $-(1/\Delta z)$. K_{PAR} time-series data were edited for outliers, and daily average values were calculated and then interpolated to 5-minute intervals (~K_{PAR}). Surface irradiance was modeled as $I_0 = I_0^m$ x $\sin(\pi$ x $t/D)$ where I_0^m $[W/m^2]$ and D [h] are monthly averages of surface irradiance and daylength, respectively, obtained from the Croatian Meteorological and Hydrological Service, and t [h] is one day. The light was modeled by applying $I(z, t) = I_0$ x e ^$(-(\sim K_{PAR})$ x $\sim z)$, where $\sim z$ [m] is a model depth vector. Model $I(z,t)$ was implemented to z_i and to average isotherm depth (z_{avg}), resulting in $I(z_i, t)$ and $I(z_{avg}, t)$, and the difference between the two yielded an anomaly in light intensity caused by internal oscillations.

Results and discussion
During the first and second ITW episodes, the K_{PAR} values ranged between 0.037 - 0.150 and 0.033 - 0.162, with modeled ~ K_{PAR} values being 0.094 – 0.098 and 0.085 – 0.095, respectively. The light model $I(z,t)$ with overlayed thermocline oscillations shows a possibility of phytoplankton receiving more light during the ITWs (Fig. 1b,d). Modeling light behavior at observed isotherm depths indicated a shift in optical properties during ITWs ($I(z_i, t)$), in comparison to the period without ITWs ($I(z_{avg}, t)$)(Fig. 1c,e). The difference between the curves (Fig. 1c,e) elucidated increased light intensity for up to 60 W/m^2 in the afternoon at Struga cliff.

Fig. 1. Optical properties at the southern cliff Struga at Lastovo Island (a). Light model $I(z, t)$ $[W/m^2]$ with isotherm depths shown as red line (b,c). Light model applied to isotherm depths $I(z_i, t)$ and average isotherm depth $I(z_{avg}, t)$ (d,e). Orange lines represent ITW periods.

In conclusion, we observed that during an ITW episode there is increase of light conditions in the thermocline at the island's southern side in the afternoon. Since picophytoplankton and bacteria response to ITWs was observed in the same area, we suggest that ITWs' effect on biology could be driven by changes in the optical properties that enhance phytoplankton light exposure. The results of this research could create a basis for the proposition of „no take" zones at Lastovo Archipelago to further conserve biodiversity.

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PANELS

Open Science Panel – Toward an Ethical Scientific Policy

Moderator:
Braeg Saenen (Science Europe)

Participants:
Marco Malgarini (ANVUR, Italy)
Laurence El Khouri (CNRS-DDOR, France)
Johan Rooryck (cOAlition S, The Netherlands)
Mohamed Hichem Kara (AAST, Algeria)
Ana Persic (UNESCO)
Justine Fabre (Académie des Sciences, France)

The open science panel at the CIESM Congress explored pathways for a more equitable transition to open science. This discussion held particular significance for the CIESM community, which encompasses diverse perspectives from the European Union and its Mediterranean neighbours. This session underscored the importance of fostering inclusive and sustainable practices within the evolving landscape of open science.

Guided by the UNESCO Recommendation on Open Science, the panelists presented the broad and ambitious scope of open science. They highlighted established practices, like open access to research outputs (such as publications, data, and software), alongside emerging aspects like open research methods, open evaluation, societal engagement, citizen science, and more.

A focal point of the discussion was the diamond open access (Diamond OA) model, which has received increasing attention from public sector organisations and policymakers. This model provides open access to research outputs without charging fees to authors or readers. It prioritises equity by rejecting the extractive nature of commercial publishing and ensures that scholarly communities retain ownership and control over content-related elements.

Joint CIESM / SDG4MED Panel – Social Psychology Applied to the Marine Environment: And how the sea sets the *scene* for different perceptions and actions

Moderator:
Raquel Bohn Bertoldo (Aix-Marseille Univ. / AMU-ISS, France)

The panel joined several researchers and practitioners around the mediterranean whose activities imply a direct or indirect engagement of governments and populations.

The panel was framed by key points identified through the years by risk analysts involving human perception and social practices. The first is the idea that risks only exist for inhabitants when they are perceived. And perception can be shaped by several cultural, personal and institutional factors. The example of optimism bias was used as an illustration of how individuals are often motivated to downplay key risk information to preserve well-being.

Key processes studied in risk analysis have also been mentioned: institutional trust, place attachment or risk experience.

Marine Hazards and Coastal Vulnerability

Participants:
Beladjine Boumediene (Univ. Science & Technol. Oran, Algeria)
Francesco Chiocci (Univ. La Sapienza, Rome, Italy)
Christian Gorini (Univ. La Sorbonne, Paris, France)

The presentations have emphasized how coastal and geological risks are underestimated in relation to the climate crisis. Interventions have raised points related with the need to involve communities in risk management planning. The Roya experience is a case study of how collaborative research can bring communities and scientists together to reinforce risk management and preparedness.

Marine Bioinvasions: ecological and economic implications

Participants:
Manuela D'Amen (ISPRA, Roma / CNR-IRBIM, Ancona, Italy)
Nicola Tavoletta (ACLI Terra, Italy)
Enico Toja (Elafonisos ECO, Greece).

The presentations have mainly underlined the environmental changes brought about by constant anthropic environmental changes. Presentations indicated adaptation strategies pertinent to novel situations, for instance promoting the consumption of 'invasive' species.

Marine and Human Health

Participants:
Dorota Czerucka & Hervé Raps (Centre Scientifique de Monaco)
Marie-Yasmine Dechraoui Bottein (Univ. Cote d'Azur, Nice, France)
Fabio Marino (Univ. Messina, Italy)

The presentations have described several new biological risks that are already associated with a warming water. While some presentations call for more attention to the risks that a decaying

environment presents to the proliferation of new diseases; others have emphasized that some of these diseases are restricted to the marine environment and pose little risk to human populations.

Anthropic impact on ocean changes, the collective awareness

<u>Participants:</u>
Fanny Karatchoudjoukova (CNRS / Univ. Aix-Marseille, France)
Christian Tamburini (Med. Inst. of Oceanogr., Marseille, France)
Andrea Zito (Swan Hellenic Ltd., Monaco)

The presentations have illustrated the difficulties of communicating and engaging the public with the deep ocean and the far lands. Colleagues underlined the importance of raising awareness of the public about the major importance of preserving these environments – deep sea mining being one major and imminent threat. Finally, the direct contact of the public with savage, pristine environments like the artic have also been discussed as a means of raising awareness.

This rich panel have underlined that risk management policies around the Mediterranean must be designed with the public as a guiding principle. Local inhabitants are a source of inspiration for how they live and the risks they perceive, and we must design risk preparedness policies departing from *their socially shared worlds* more than from a scientifically justified perspective.

Open Session - Creative Digital Tools to Depict Ocean Data

Moderator:
Kaveh Rassoulzadegan, CIESM

Participants:
Giuseppe D'Auria, Fisabio, Valencia, Spain
Renata Denaro, IRSA, CNR, Italy
Kaveh Rassoulzadegan, CIESM
Martin Staege, Martin Luther University, Germany
Mikhail Yakimov, ISP-CNR, Messina, Italy

Summary

The session showcased various software samples and IT prototypes for the analysis of scientific datasets and addressed issues related to their 3D visualization.

3D ocean data visualization

This part of the session focused on the 3D visual tools, tackling scale-related issues, the fast rendering, and scientifically reliable filling of data gaps for the purpose of their visualization. The session was also an opportunity to present the CIESM IT tool to visualize 3D oceanographic data.

More into details, the following issues were addressed:

• Managing data of largely different spatial distribution, i.e. from microbial –related to physical, and geochemical parameters of relevance for oceanographic research studies;

• Biochemical models (i.e., quantifying biotic versus abiotic processes);

• Processing geo-localized data for 3D visualization (including high-performance volume rendering technologies).

The 3D oceanographic data visual CIESM tool, still under development, is open source and will be freely available online for scientific users to map their own data. After presenting the CIESM data 3D visualization prototype, Kaveh Rassoulzadegan (CIESM HQ) profited on participants' input, to discuss advances in its implementation. The specific expertise in global metagenomic data, in particular, contributed with highly valuable and especially original inputs to the brainstorming discussions.

Gene expression melodies

Among the innovative methods for analyzing and presenting gene expression, a unique approach has been developed to transform gene data into sound, characterized by frequency (pitch) and duration. The novel Gene Expression Music Algorithm (GEMusicA) can be used to distinguish between samples with different biological profiles and to characterize differentially expressed genes.

Open Session – Red Corals

Moderator:
Sylvie Tambutté (Centre Scientifique de Monaco)

Participants:
Lorenzo Bramanti (Observatoire Océanologique de Banyuls-sur-Mer, CNRS-Sorbonne Université)
Sylvie Tambutté (Centre Scientifique de Monaco)
Bruna Giordano (Observatoire Océanologique de Banyuls-sur-Mer, CNRS-Sorbonne Université &
University of Cagliari)
Stéphanie Reynaud (Centre Scientifique de Monaco)
Romie Tignat-Perrier (Unité de Biologie des Coraux Précieux CSM – Chanel)
Philippe Ganot (Unité de Biologie des Coraux Précieux CSM – Chanel)
Maria Concetta di Natale (Univ. Palermo, Italy)

Participants were invited to presentations on the groundbreaking research conducted on the Mediterranean red coral, *Corallium rubrum*. Despite recent advances, much remained to be understood to ensure the effective management and conservation of this vital marine resource.

The Centre Scientifique de Monaco has engaged in an ambitious research project, partly supported by the French CNRS and the Prince Albert II of Monaco Foundation, to carry out:

- **Fundamental Research**: Unveiling the mechanisms behind coral growth and the intricate relationships with its microbiota, crucial for coral health and resilience against environmental stressors.

- **Applied Research**: Developing optimized cultivation techniques and exploring key factors affecting coral survival and reproduction, both in natural habitats and controlled laboratory conditions.

- **Public Engagement**: Raising awareness through educational conferences, publications, and programs designed to foster a deeper understanding of the importance of red coral conservation.

The different topics presented were:

- An underwater laboratory to develop a protocol for *Corallium rubrum* restoration
- Advancing Understanding and Conservation of the Mediterranean Red Coral: A Comprehensive Research Initiative
- Unraveling reproductive strategies in Mediterranean red coral (*Corallium rubrum*). Implications for Restoration and Conservation
- Newly born Corallium rubrum colonies in Monaco caves
- Changes in microbial communities associated with the precious red coral *Corallium rubrum* during thermal anomalies
- Long term laboratory cultures of *Corallium rubrum*

Video projection
"Red Coral: Birth in Controlled Conditions in Monaco"
https://youtu.be/ELZwJH7VPUw?feature=shared&t=2838
Directed by: Roberto Rinaldi
Editing and production: Manuela Petrocchi - GG Productions, Rome

AN UNDERWATER LABORATORY TO DEVELOP A PROTOCOL FOR *CORALLIUM RUBRUM* RESTORATION

Lorenzo Bramanti [1]*, Bruna Giordano [2] and CSM-CHANEL Consortium [3]

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Abstract

Current conservation strategies often fail to enable the natural recovery of declining coastal ecosystems, requiring active restoration efforts. The Mediterranean red coral (*Corallium rubrum*) is threatened by climate change, especially in shallow waters where harvesting is banned. Effective restoration necessitates understanding the species' life history traits. Unlike fast-growing tropical corals, in fact, *C. rubrum*'s slow growth makes typical transplantation techniques ineffective. This study aims to improve sexual reproduction methods to ensure the long-term maintenance of *C. rubrum* populations.

Keywords: Corals, Restoration, Western Mediterranean

Restoration ecology is an emerging branch of environmental science, and it is anticipated to become one of the most important fields within conservation science [1]. During the last 20 years, restoration actions have been focused mostly on terrestrial ecosystems [2]. Current marine environment conservation actions mainly aim to reduce environmental stressors by creating MPAs, but this passive protection is often insufficient to allow the natural recovery. Coastal marine ecosystems, in fact, are being lost at alarming rates and active restoration actions could counteract these alarming declines.

Corallium rubrum is listed in the IUCN red list, but its harvesting is banned only in the first 50 meters depth, where climate change poses a threat to the populations and recovery is very slow. Thus, there is an urgent need to develop restoration techniques for this precious species to ensure its long-term maintenance in shallow areas. To this aim, a thorough understanding of the population biology is required. Indeed, basic transplantation techniques, which are widely used in tropical coral reefs restoration, could result inappropriate for extremely slow growing species, such as *C. rubrum*. An alternative restoration approach could be based on sexual reproduction. We thus aim at focusing on the sexual reproduction as main vector of restoration, testing the efficacy of in situ and ex situ techniques. A single female *C. rubrum* colony can release thousands of offspring each year. This potential far exceeds that ability of humans to transplant individuals for restoration. However, reaching this potential requires high rates of fertilization, settlement and post settlement survival. Moreover, corals reproduce by releasing sperms, which must drift to locate female colonies where fertilization takes place. This process of reproduction requires a critical density of males to allow for successful fertilization. Indeed, one of the major consequences of overexploitation of marine species is reproductive failure caused by male and subsequent sperm limitation (Allee Effects). All these processes are characterized by a huge loss of larvae and settlers with a very small percentage of released larvae arriving to reproductive age.

In the last decade, several studies focused on *C. rubrum* reproduction, larval behavior, settlement and post settlement dynamics, growth and recovery dynamics, but all these studies are sparse and focused on the ecology and dynamics of this species in its natural environment (e.g.[3,4,5] and there's a lack of an integrative study focused on the whole process of restoration, also considering mixed strategies involving both in situ and ex situ techniques. Some attempts of using artificial substrates have been made [6] but not embedded in a thorough protocol aimed at the restoration of this precious species. Private companies and environmental associations have proposed restoration plans based on transplants mainly inspired by tropical corals transplantation but lacking a scientific approach.

We applied a scientific approach to *C. rubrum* restoration based on a series of experiments addressing specific questions linked to the optimization of restoration techniques. We ground on the extended knowledge on this species and on the use of semi natural environments (underwater artificial caves) to develop an efficient method for restoration which would be part of a sound ecological engineering strategy.

To this aim, underwater artificial caves have been placed at known distance one from the other and far from natural *C. rubrum* populations, to test fertilization success and distance. *C. rubrum* colonies have been placed inside the caves at known sex ratios and densities to obtain larvae and to study: 1) settlement and post settlement processes, 2) fertilization rates and distance; 3) larval production. Implanted colonies, as well as larvae and recruits have been genotyped. Parallel aquaria experiments test the optimal conditions for larval settlement. The restoration of this engineering species will allow the development of coral forests and their associated ecological functions. Moreover, the return of this emblematic species at shallow depths will foster the development of sustainable tourism.

CSM-CHANEL Consortium *by alphabetical order*
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LONG TERM LABORATORY CULTURES OF *CORALLIUM RUBRUM*

Philippe Ganot [1]*, Guillaume Loentgen [1], Éric Tambutté [2], Denis Allemand [2] and Sylvie Tambutté [2]

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Abstract

The Centre Scientifique de Monaco has successfully cultured the precious red coral, *Corallium rubrum*, since 2013. Seawater is carefully collected, filtered and controlled for temperature to provide an ideal environment for the coral. Sustainable practices are followed by collecting small fragments from larger, unharmed colonies. Two primary culturing methods are employed: suspending colonies from rigid supports and growing them horizontally on glass slides. These methods allow for increased density of coral per aquarium, easier handling, and detailed monitoring of growth. While challenges exist, particularly with the slower-growing horizontal cultures, laboratory culturing provides year-round access to coral for research and holds promise for developing sustainable conservation strategies.

Keywords: Corals, Laboratory cultures, Western Mediterranean

For several decades, the Centre Scientifique de Monaco (CSM) has cultivated stony corals. Leveraging this expertise, we successfully initiated long-term culture of the precious red coral, *Corallium rubrum*, within our facilities in 2013. Seawater is collected 300 meters offshore Monaco and delivered to our labs via pipelines. Here, it undergoes a multi-stage filtration process that may include charcoal, sand filtration, and UV sterilization. Finally, the temperature is tempered to 15°C before continuous delivery to our open-circuit aquaria. Colonies are maintained in darkness and fed daily of frozen plankton mixture. Our first cultures were established using fragments (less than 3 mm thick and 5-10 cm long) sampled in the Parc des Calanques de Marseille in 2013. We have supplemented these cultures with additional fragments over the years to meet research needs while adhering to sustainable practices. Crucially, these fragments are specifically chosen to be of minimal commercial value, ensuring minimal impact on the wild population. Furthermore, all sampled fragments are collected from larger colonies that are left unharmed to regenerate. We have maintained colonies from both the original and ongoing samplings, with regular growth monitoring since 2020. Initially, the fragments were suspended on strings. We have since refined our culturing methods, offering two options: suspension using rigid sticks or lateral growth on glass slides.

Suspended cultures

Our initial approach involved suspending the coral fragments on strings. However, as the number of colonies increased, they began to crowd each other, hindering polyp expansion, which is an indicator of healthy growth. To address this, we transitioned to a method using rigid supports. This new approach allows for a higher density of colonies per aquarium and simplifies handling. We monitored the growth of ten representative colonies using two key parameters: buoyant weight and volume. To measure volume precisely, we acquired a 3D scanner (Einscan HX). This technology enables us to capture the intricate three-dimensional structure of the coral colonies. Beyond precise volume measurements, the scanner allows us to track the branching patterns. By combining this data with buoyant weight measurements, we can estimate the volumetric mass, providing valuable insights into the ratio of tissue growth to calcification (calcified structures are denser than tissues). Our observations revealed growth rates significantly exceeding those found in natural environments, with variation between individuals. A common trend is a significant increase in tissue volume accompanied by extensive branching, rather than a thickening of the coral skeleton.

Lateral growth culture technique

Since 2015, we have adapted a technique originally developed for stony corals at the CSM. In this method, coral tissues spread laterally across a microscope slide, calcifying between themselves and the glass, rather than growing a vertical axial skeleton [1]. However, due to the slower growth rate of red coral tissues, this technique requires significant time before the material is usable for research. Additionally, maintaining these cultures is demanding, requiring constant care. Despite these challenges, we've observed that larger colonies exhibit faster tissue extension. The primary advantage of this culture technique is the ability to observe growth details under a microscope. To this end, we have developed a time-lapse monitoring system with a macroscope. This system captures high-magnification images of developing colonies every 10 minutes, enabling long-term observation of growth processes that would be very difficult to study otherwise (Fig. 1).

Fig. 1. Left: Laboratory coral culture on slides. Right: detail of a colony on a slide.

Benefits and Challenges of Laboratory Culture

Culturing *C. rubrum* in a laboratory environment requires significant investment in materials and personnel. However, this approach offers year-round access to this valuable biological material. Beyond supporting scientific research, controlled laboratory cultures offer a potential avenue for developing sustainable out-of-sea nurseries. This approach could prove crucial for the conservation of this species, which faces growing threats from global warming, adding to the established threat of overfishing over the past centuries.

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UNRAVELING REPRODUCTIVE STRATEGIES IN MEDITERRANEAN RED CORAL (*CORALLIUM RUBRUM*). IMPLICATIONS FOR RESTORATION AND CONSERVATION

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Abstract

Corallium rubrum is an octocoral endemic of the Mediterranean Sea, which suffers from population decline due to overfishing and warming-driven mass mortality events [1,2]. For several years, scientists and managers have been interested in fostering the persistence of this resource, promoting various conservation and restoration actions. Understanding how the mating system influences the spatial distribution of a species, along with the parameters affecting its reproductive success, is crucial to planning efficient and successful conservation and restoration initiatives [3].

Keywords: Corals, Reproduction, Conservation, Restoration, Western Mediterranean

Introduction

In recent years, relatedness and kinship analysis suggested that breeding units in the red coral are highly restricted in space, even at a scale of half a meter [4]. This strong spatial genetic structure could be ascribed to short larval dispersal or restricted fertilization distance. Hence, in this study, we aim to disentangle the processes underlying the genetic structure of *Corallium rubrum*.

Methods

Uncovering such information by studying natural populations is challenging and requires a significant sampling effort. To overcome this problem, we set up an artificial population, defined as "a population artificially established in terms of the number of individuals, density, and sex ratio, where all the corals are known under diverse biological features such as gender, genetic fingerprint, and morphology". To do this, we took advantage of a system of six submerged caves placed at a known distance, where the corals can be arranged and displaced according to the experimental design. Through two breeding seasons (summer 2022 and 2023), we studied this artificial population to explore 1) the potential fecundation distance and 2) the effect of sperm dilution of *C. rubrum*. After collecting all the larvae released during both seasons, we performed genotyping on both offspring and parents on an array of 70 SNPs de novo developed. To investigate the potential fecundation distance of the species, we performed parentage analysis to assign each larva to its respective parents.

Fig. 1. A) Female coral polyp about to emit a larva B) *C. rubrum* larva.

Results and Discussion

The results of paternity assignment allocate 82% of genotyped larvae with a confidence level of 95%. The reasons for non-assignation could be ascribed to the power of used markers or sperm coming from outside the cave system. Results show that polyandry is likely the norm in *C. rubrum* and that the species potential fertilization distance can reach tens of meters. In addition, we observed a significant effect of sperm dilution on the fecundity of female colonies, recording significantly higher larval production of females placed close to male individuals than those isolated (< 0.5m or > 4m away from males, respectively). These results show for the first time that the relatedness observed between corals at a small scale could be more related to limited larval dispersal than short sperm fecundation distance. Male gamete dispersal capacity could buffer the increase of genetic drift expected in a declining population affected, for instance, by overexploitation or climate change, offering an excellent recovery potential for the species. These results give crucial insights into conservation practices, underlying the relevance of local management and fishing regulation, and restoration initiatives, providing information such as optimal transplantation distance.

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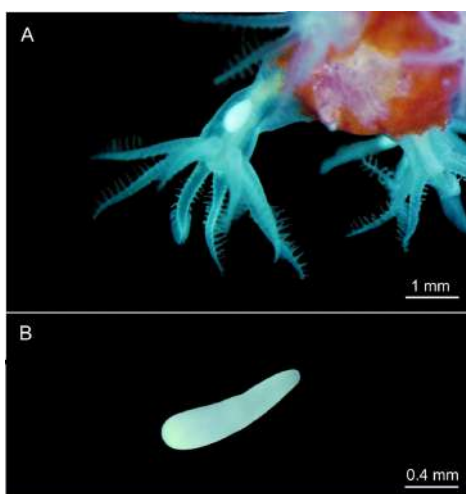
CHANGES IN MICROBIAL COMMUNITIES ASSOCIATED WITH THE PRECIOUS RED CORAL *CORALLIUM RUBRUM* DURING THERMAL ANOMALIES

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Abstract

Marine heat waves have increased in frequency and intensity worldwide, causing mass mortality of Mediterranean benthic organisms including the precious red coral *Corallium rubrum*. Temperature anomalies can affect the balance of the symbiotic association between the host and its microbiota (*i.e.*, bacteria and microeukaryotes), thereby compromising the overall health and disease resistance of the host. To understand the response of the red coral holobiont to changes in seawater temperature, we conducted a comprehensive study including laboratory experiments and *in situ* measurements during the unprecedented marine heat waves of 2022. In light of ongoing global warming, our study helps predict the consequences of MHWs on *C. rubrum* populations.

Keywords: Corals, Microbiota, Physiology, Marine Heat Waves, Western Mediterranean

The precious red coral *Corallium rubrum* is an emblematic species in the benthic coralligenous ecosystem of the Mediterranean Sea. It is a long-living, slow-growing colonial animal whose branching colonies contribute to the structural complexity of its ecosystem, thus providing a place to live and shelter for many species [1]. However, its population has declined significantly these last decades because the coral has been harvested for jewelry since ancient times and is threatened by microbial diseases and mass mortality events caused by summer heat waves [2-4]. In such cases, temperature anomalies can affect the balance of the symbiotic association between the host and its microbiota, thereby compromising the overall health and disease resistance of the host.

We conducted a comprehensive study to improve our knowledge of the biological response of the red coral and its microbiota to thermal anomalies. We did a controlled experiment where red coral colonies were maintained at 15 °C or were gradually exposed to 24 °C which is a common temperature for shallow populations of *C. rubrum* in summer. We also did *in situ* measurements during the intense marine heatwaves (MHWs) recently experienced by the Mediterranean Sea. Indeed, in 2022, between three and seven record-breaking MHWs hit the Mediterranean basins between May and September, with sea surface temperatures reaching unprecedented records of 27 °C. Red coral samples with either 0% or 90% tissue loss were collected at different locations in two marine national parks of the Northern Mediterranean Sea, *i.e.*, the Calanques National Park (Marseille, France) and the Portofino Marine Protected Area (Italy).

We followed the dynamics and functioning of the microbiota (bacteria and microeukaryotes) using amplicon sequencing, taxon-specific qPCR analyses and metatranscriptomics. In addition, we measured the tissue composition (*i.e.*, lipids, proteins, carbohydrates) and gene expression (*i.e.*, HSP70, TNFR1 genes) to assess the effects of thermal stress on the host.

Our results showed considerable changes in the bacterial and eukaryotic microbiota of heat-stressed colonies that underwent tissue loss. Especially, the absolute abundance of Spirochaetaceae, which are the predominant bacterial symbionts under healthy conditions, remained unchanged in heat-affected colonies, although their relative abundance based on amplicon sequencing decreases. We observed a significant increase in the total abundance of microbial opportunists, including putative pathogens such as *Vibrio*, which was not evident when only their relative abundance was considered. Metatranscriptomics showed a down regulation of microbial genes involved in several metabolisms such as amino acid and vitamin metabolisms. This might have contributed to impair nutrition supply and increase coral stress.

In the light of ongoing global warming, our study helps predict the consequences of MHWs on coralligenous reefs and the biodiversity that depends on them.

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NEWLY BORN *CORALLIUM RUBRUM* COLONIES IN MONACO CAVES

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Abstract

Restoration ecology is a growing field of research still underdeveloped in the marine environment. While marine protection efforts, like MPAs, help reduce stressors, active restoration is necessary for severely damaged habitats. The Mediterranean red coral, *Corallium rubrum,* faces threats from overharvesting and climate change. A scientific protocol using artificial caves is used to promote sexual reproduction. In Monaco and Banyuls-sur-Mer, colonies of *C. rubrum* are placed on plates in caves. Genetic analyses and monitoring are conducted to assess larval settlement preferences and colony growth. Results from 2023 show successful larval settlement in caves with optimal sex ratios. Adjustments in colony numbers and sex ratios in caves have led to positive outcomes in larval settlement and recruitment.

Keywords: Corals, Restoration, Caves, Western Mediterranean

Restoration ecology is an emerging branch of environmental science [1]. In the last 20 years, restoration actions have been increasingly carried out all over the world. Current measures to protect the marine environment primarily aimed at reducing environmental stressors, for example through the establishment of MPAs, but this passive protection is not sufficient to allow the natural recovery of very degraded habitats. In this later case, active restoration actions are needed. The precious Mediterranean coral *Corallium rubrum* is listed in the IUCN red list. ln several countries, the deep stocks are heavily harvested [2]. Climate change poses an additional threat to the shallow populations and their recovery is very slow. While tropical corals can quickly grow from a tiny coral piece into a new colony, this is not the case for *C. rubrum*. Therefore, basic transplantation techniques are inappropriate for this extremely slow growing species. The only successful way to obtain more colonies is through reproduction and the generation of newly born colonies. Our goal is therefore to establish a protocol based on science that focuses on sexual reproduction as the main vector of restoration. To this aim, we set up colonies of *C. rubrum* in artificial caves and focused on finding the ideal sex ratio and colony density to obtain an optimal reproduction. The caves constitute an underwater laboratory in semi-controlled conditions and allow the development of standardized rearing protocols that are optimized for the restoration *C. rubrum* populations.

The experimental set-up in Monaco follows that of Banyuls-sur-Mer (France): 6 artificial caves (1m x 1m x 1m) were installed at 40 m depth in a hexagonal shape (size 10 m) in 2021. In each cave, the roof was fitted with rails into which 9 plates (20cm x 20 cm) could be inserted. Several colonies of *Corallium rubrum* (5-10 cm heigh), already identified as male or female, were placed on each of these plates. The sliding tiles can be removed and brought back to the laboratory, to monitor the recruitment success or the growth of the colonies. They are also movable, so that the location of each male or female colony can be changed to assess which is the best sex ratio for an optimal reproduction. Each tile was divided into 4 parts onto which 4 substrates were glued (smooth and rough terracotta, and red and white marble) to find out whether the larvae have a settlement preference. In addition, each colony has been genotyped and genetic analyses of larvae and recruits will be carried out.

Detailed monitoring of the caves concluded that little or no reproduction took place in the summer of 2022, although the water temperature at a depth of 40 m did not exceed 23 °C. Two hypotheses were considered: 1) the colonies were not yet "adapted" to their new growth conditions; 2) the coral biomass in the caves was too low to maximize the encounter of male and female gametes. Therefore, before the summer of 2023, the number of male and female colonies in 4 of the 6 caves was increased, while maintaining the originally established sex ratio. The results of the summer of 2023 show that two of the 6 caves were particularly favorable to larval settlement as we counted 139 and 102 larvae attached to the substrates. Concerning the sex ratio, the presence of one or at most 3 males for 6 to 8 females was the most favorable combination. In these caves, we counted 250 recruits in total, with 84 recruits on the terracotta without distinction between smooth and rough, and 166 recruits on marble (64 on red and 79 on white marble). The other recruits were attached randomly on the plastic tile between the substrates.

While white marble was colonized by green encrusting algae, red marble showed a completely different type of colonization, and the two terracotta were only very sparsely colonized.

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ADVANCING UNDERSTANDING AND CONSERVATION OF THE MEDITERRANEAN RED CORAL: A COMPREHENSIVE RESEARCH INITIATIVE

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Abstract

Recent advances in the understanding of the biology of the Mediterranean red coral, *Corallium rubrum*, have revealed gaps in fundamental knowledge preventing effective conservation. A joint project between the Centre Scientifique de Monaco and Maison Chanel aims to close these gaps. As part of the basic research, the growth dynamics and symbiotic relationships with the associated microbiota are being investigated using data mining and controlled experiments. Applied research optimizes cultivation techniques and evaluates the factors that influence survival and reproduction. At the same time, proactive communication strategies are used to raise public awareness through educational initiatives. By promoting understanding and support, the project seeks to ensure sustainable management and conservation of this vital marine resource.

Keywords: Corals, Conservation, Western Mediterranean

In recent years, significant progress has been made in the study of the complex biology of the Mediterranean red coral, *Corallium rubrum* [1]. Despite this progress, there are still many gaps in our knowledge that prevent the effective management and conservation of this invaluable marine resource. In response to this urgent need, an ambitious research project has been designed, between the Centre Scientifique de Monaco and la Maison CHANEL. This comprehensive initiative includes fundamental scientific research, applied research methods and proactive communication strategies aimed at raising public awareness and engagement.

The fundamental research component of this program aims to unravel the underlying mechanisms of *Corallium rubrum's* growth dynamics and explore the intricate symbiotic relationships it shares with its associated microbiota. A multi-faceted approach to coral growth dynamics has been pursued, starting with comprehensive data mining efforts to identify key growth factors. Subsequently, these identified factors are rigorously tested through experiments with microcolonies cultured under tightly controlled laboratory conditions. At the same time, the study of the coral-associated microbiota involving sophisticated metagenomic analyses have allowed deciphering its taxonomic composition and functional diversity. In addition, the role of the microbiota in holobiont health and resilience will be investigated through the isolation, cultivation and subsequent inoculation of microorganisms in unhealthy coral organisms. In addition, this research project explores the response of coral microbiota to anthropogenic stressors, such as rising seawater temperatures, and thereby shed light on potential mitigation strategies.

In the area of applied research, efforts are focused on optimizing cultivation techniques for *Corallium rubrum* and comprehensively evaluating the myriad factors that influence the survival and reproduction of their larvae and juveniles. This multifaceted approach includes experimental studies conducted both in natural habitats, such as caves, and under controlled laboratory conditions. Key areas of investigation include assessing substrate quality, clarifying the biogenic composition of substrates and exploring the effects of sex ratios on coral reproduction, which are investigated through careful experimentation both in the laboratory and in natural cave environments. In addition, work is underway to refine protocols for coral culture in the laboratory, with a focus on determining optimal fragment sizes and substrate compositions that favor the establishment and growth of microcolonies.

In parallel to these scientific efforts, the initiative focuses on proactive communication and public awareness to spread knowledge about *Corallium rubrum* to various target groups. This includes the organization of educational conferences, the publication of a book aimed at a young audience and the development of educational programs that can be integrated into school curricula. By promoting a deeper understanding of the ecological importance and need to protect Mediterranean red coral, these efforts are intended to gain public support and facilitate informed decision-making for the sustainable management and conservation of coral for future generations.

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TABLES RONDES

Round Table on CIESM Program "Hydrochanges"

Participants:

Abeer El Saharty (National Institute of Oceanography and Fisheries (NIOF), Egypt)

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Safo Piñeiro (Insituto Español de Oceanografia (IEO), Spain)

Mustafá Yucel (Middle East Technical University (METU), Institute of Marine Science, Turkey)

César González-Pola (Instituto Español de Oceanografia (IEO), Spain)

Jesús García-Lafuente (Universidad de Málag, Spain)

Dimitris Velaoras (Hellenic Centre for Marine Research (HCMR), Greece)

Sana Ben Ismail (Institut National des Sciences et Technologies de la Mer (INSTM), Tunisia) Vanessa Cardin (National Institute of Oceanography and Applied Geophysics (OGS), Italy)

Stefano Miserocchi (Institute of Polar Sciences (CNR-ISP), Italy)

Nadia Lo Bue (Istituto Nazionale di Geofisica e Vulcanologia (INGV), Italy)

Leonardo Langone (Institute of Polar Sciences (CNR-ISP), Italy)

Patrizia Giordan (Institute of Polar Sciences (CNR-ISP), Italy)

Mª Carmen García (Instituto Español de Oceanografia (IEO), Spain)

Francesco Paladini (Institute of Polar Sciences (CNR-ISP), Italy)

Katrin Schroeder (CNR-ISMAR Istituto di Scienze Marine, Italy)

Anthony Bosse (Institut Méditerranéen d'Océanologie (MIO), France)

Ingrid Puillat (European Multidisciplinary Seafloor and water column Observatory (EMSO -ERIC), EU)

Laura Beranzoli (EMSO-ITALY, Italy)

Rosa Balbín (Hydrochanges Coordinator,Instituto Español de Oceanografia (IEO), Spain)

Main Highlights

• Long term monitoring is a priority in the context of global change. HYDROCHANGES is a network of simple (easy to maintain) CTD moorings, deployed at key points of the Mediterranean basin. CIESM supports the HYDROCHANGES monitoring program since 2002. The HYDROCHANGES strategy is to study long-term changes in hydrological characteristics linked to shorter time scales to get information on processes that affect the Mediterranean Sea.

• A review on HYDROCHANGES network status was prepared and presented by the participants. See the annex

• Some conclusions of the review were: In 2024 there is the same number of active moorings as in 2013, operated by France, Italy, Greece and Spain. But geographical coverage has been drastically reduced, so there are very important geographical gaps. We lack an overview and perspective of all the data we have. The information we can provide as a network is not enough to properly characterize the Mediterranean basin behavior.

• Open Questions that were addressed during the meeting were how to extend effectively the network to southern and eastern countries, to fill the gaps, how to apply for funding as a network, how to collaborate with other networks as MonGOOS or EMSO and how to organize a collaborative scientific work.

• There is agreement on the fact that there is a lack of funding to maintain the sites at the southern and eastern part of the Mediterranean basin. At the beginning of HYDROCHANGES, CIESM was financing some of the sites, but this is not happening nowadays. HYDROCHANGES should look for funding as a consortium.

• Anyway, MonGOOS, also a network for oceanographic observations, is also not funded. Both networks are a way of stablishing collaborations and it would be useful to stablish collaboration between them.

• EMSO ERIC, the European Multidisciplinary Seafloor and water column Observatory, is a European research infrastructure established as a legal entity under the European Research Infrastructure Consortium (ERIC) legal framework since September 2016 for the observation of the deep-sea bo`om and water column. It is open to new countries and offers HYDROCHANGES the possibility of studying a strategy for future development.

• To find the gaps in the observing network it is necessary to clarify which processes we need to study to improve the knowledge of the long-term changes, because most of the processes that condition the Mediterranean dynamics are happening in the northern part of the basin.

• It would be useful to plan a collaborative work on the progress of hydrological characteristics on the last ten years.

Roundtable on Sharks (CIESM Program "Highly Migratory Species")

Participants:

(in person)
Alen Soldo (Univ. Split, Croatia)
Simone Panigada (Tethys Research Institute, Italy)
Nuri Başusta (Univ. Firat, Türkiye)
Abeer El-Saharty (NIOF, Egypt)
Mohamed Said (NIOF, Egypt)
Ernesto Azzurro (ISPRA, Italy)
Eleonora de Sabata (MedSharks, Italy)
Simona Clo (MedSharks, Italy)
Lyle Glowka (Biodiversity Strategies International, Abu Dhabi)
Bayram Öztürk (Univ. Istanbul, Türkiye)
Loriane Mendez (CIESM)
Eva Jacquesson (CSM / CIESM)

(virtually)
Rima Jabado (IUCN SSC Shark Specialist Group, Dubai)
Fabrizio Serena (IRBIM-CNR, Italy)
Mahmoud Farrag (Univ. Al-Azhar, Egypt)
Sara Al Mabruk (Marine Biol. in Libya Society, Lybia)
Elizabeth Grace Tunka Bengil (independent, Türkiye)
Tahar Filali (CNRDPA, Algeria)
Emanuela Fanelli (Univ. Politecnica delle Marche, Italy)

Introduction

Simone Panigada (President of Tethys Research Institute / Chair of CIESM Committee 5 "*Living Resources & Marine Ecosystems*")

The CIESM Scientific Program "Highly Migratory Species," co-funded by The Prince Albert II of Monaco Foundation, has been ongoing since 2021 and is set to continue beyond the funding period, which ends in 2024. The program focuses on two main areas: seabirds and elasmobranchs.

An online guide for Mediterranean skates and rays was launched in 2022. To understand shark migration, the program is leveraging fishermen's knowledge to identify shark presence and habitat hotspots. A protocol developed through discussions with the CIESM Shark Task Force in 2023-2024 aims to gather this crucial data. Following the identification of hotspots, satellite transmitters will be deployed to track shark movements. Initial tagging efforts took place in Yumurtalik Bay, Türkiye, in 2024.

This roundtable aims to present the latest updates on CIESM shark activities while focusing on fostering collaborations, discussing synergies between these initiatives, and establishing future priorities for research and conservation efforts. The goal is to develop a cohesive strategy that integrates studies of seabirds and elasmobranchs, rather than treating them as separate initiatives.

SHARKnowledge: Using Local Ecological Knowledge

The new Guide to Shark Identification, featuring the updated species list discussed during a previous Workshop in NIOF, Alexandria (May 2024) was provided to all participants. This resource aims to facilitate communication between researchers (National Experts) and the interviewed fishers.

- ● **Presentation of the latest protocol**
  Ernesto Azzurro (IRBIM - CNR, Ancona / Chair of CIESM Committee 6 "*Coastal Systems & Marine Policies*")

The protocol was briefly described to all participants, most of whom were already familiar with it. A particular emphasis during this roundtable was placed on Questionnaire 1, which addresses Target A (common) species. This protocol was efficiently revised after the presentation of the preliminary results (see the following paragraph).

- ● **Practical application / Preliminary results from Egypt and Turkey**
  Loriane Mendez (Head of Program 'Higher Marine Vertebrates', CIESM)

Two national experts, Mahmoud Farrag (Egypt) and Nuri Başusta (Turkey), conducted in-situ testing of the questionnaire a few days prior to this roundtable and brought forward the following comments for discussion:

- - The length of the questionnaire is too long, leading some fishers to leave before being interviewed.
- - The timing of the interviews should be reconsidered to avoid when fishers are working (fishing or actively cleaning).
- - Fishers tend to be hesitant to provide truthful responses.
- - Many fishers struggle to recall sightings from several years ago.
- - Some fishers operate in more than one harbors and in different seas
- - The questionnaire is not adapted for retired fishers who are no longer active

The main focus of the discussion was how to shorten the questionnaire. It was decided to concentrate the Questionnaire 1 (Target Species) on just two or three species.

The idea of conducting parallel interviews—where several responses are recorded simultaneously for the same question—was proposed but quickly dismissed. Rima Jabado noted that better results are achieved when interviews are conducted one-on-one between a scientist and a fisher, as this approach fosters individual expression and avoids the tendency for group consensus.

Some questions in the questionnaire were updated directly in the working Google Document. In Questionnaire 1 (General Info), we added the question, 'Are you still active?' along with a follow-up asking for the year they stopped fishing if the answer is no. In Questionnaire 2 (Target A / Common Species), we revised the questions about historical trends to read: 'How was the abundance of the species when you first started fishing?' and 'What is the current abundance of the species or its

abundance in the year you stopped fishing?' This formulation ensures that the questionnaire is applicable to retired fishers who are no longer active.

It was decided that the mapping exercise would be optional, only to be conducted if a fisher is willing to continue the interview and has one or more specific hotspots to highlight.

- **Questions / Discussion**

European collaborations are being formed, including initiatives such as LIFE EU Sharks and LIFE Prometheus. Once the questionnaire is finalized, Eleonora de Sabata, Simona Clo, and Emanuella Fannelli intend to adapt it for use with divers and recreational fishers within the context of their European projects.

The representation of IUCN, through the participation of Fabrizio Serena, Alen Soldo and Rima Jabado, has confirmed a mutual commitment to future collaborations and synergies aimed at addressing the data gap, particularly in the Eastern Mediterranean. This partnership will assist in establishing a data policy that promotes data sharing across the Mediterranean basin.

Satellite Tracking of Sharks

- **Yumurtalik, Turkey: Opportunistic data collection on skates and rays**
  Alen Soldo (University of Split / Head of CIESM Shark Task Force)
- **Yumurtalik, Turkey: Preliminary results on sharks**
  Eva Jacquesson (Scientific Centre of Monaco / Co-coordinator of CIESM shark-related activities)

The field mission in Türkiye last June was presented, highlighting the observation of over a hundred elasmobranch specimens caught as bycatch in coastal fisheries, including four species of rays classified as Critically Endangered or Data Deficient according to IUCN. Additionally, one sandbar shark (*Carcharhinus plumbeus*) was successfully tagged with a MiniPAT, providing precious location data over a period of 51 days. The track was presented for the first time during this roundtable.

- **Discussion / Perspectives**

Measurements and samples were collected, and the data is set to be analyzed shortly.

Prof. Abeer El-Saharty, President of the National Institute of Oceanography and Fisheries (Egypt), stated in her intervention that NIOF, in collaboration with the Ministry of Environment, held a workshop in Hurghada on July 22, 2023, to prepare a study on shark behavior in the Red Sea. The study is divided into three phases: (i) a preliminary phase to gather data on previous observations; (ii) the installation of sensors, which will take several months to monitor the behavior of the various targeted shark species; and (iii) analysis of the data collected by the sensors at different time intervals. From May 21 to 24, 2024, CIESM, in collaboration with NIOF, organized a workshop on sharks. The workshop was coordinated by Dr. Loriane Mendez and Eva Jacquesson and was hosted at the National Institute

of Oceanography and Fisheries in Alexandria, Egypt. Prof. Abeer El-Saharty confirmed that NIOF is eager to continue its collaboration with CIESM on studying shark behavior in the Mediterranean.

Video projection

"How to unhook and release sharks and rays" (Life EU Shark / CIESM) Eleonora de Sabata (MedSharks) *LIFEEUSharks Channel* https://www.youtube.com/watch?v=AsD01aOZ1rc

"TUDAV - Bycatch of Cartilaginous Fishes in Turkish Waters" Bayram Öztürk (Univ. Istanbul) *TUDAV Channel* https://www.youtube.com/watch?v=MwQ5X-DpaKo

"CIESM field mission on Elasmobranch (Türkiye June 2024)" (not projected due to time constraints on-site) *CIESM Channel* https://www.youtube.com/watch?v=GqtxzVjLEvM

This collaborative document has been prepared and approved by all participants following the meeting.

DISCOURS DES AUTORITÉS

<u>Speech of Francesco Principe</u>
Regional Commander of the Italian Army

 I would like to extend my most sincere and warmest greetings in this Cavallerizza.
The Cavallerizza, also known as the Royal Stables, dates back to 1567 and is located next to the historic Sclafari Palace from 1330.
This place will, in the coming days, become a meeting point for the scientific community tasked with addressing crucial challenges for our Mediterranean.

The Mediterranean, a crossroads of cultures, a heritage of biodiversity, and a vital resource for millions of people.
The millennial history of the Mediterranean bears witness to commercial exchanges, cultural encounters, and scientific discoveries that have shaped all the civilizations that still thrive on its shores today.
Now more than ever, it is crucial to continue studying and protecting this precious marine environment to ensure a sustainable future for the next generations.

First and foremost, I would like to thank His Serene Highness Prince Albert II of Monaco for being here today to preside over this ceremony. Thank you.
But if today we can all share this splendid and magnificent historical and cultural heritage, it is thanks to the decisive and synergistic work of the Government of the Sicilian Region and the Sicilian Regional Assembly, the Superintendency for Cultural Heritage, and the Municipality of Palermo, as well as, last but not least, the Italian Army.

The men and women of the army are not only tasked with safeguarding free institutions and defending the borders of the homeland and its alliances but also with being careful custodians of the historical and architectural assets entrusted to us, both in Italy and abroad when we are called to act.

Allow me, therefore, to thank the President of the Region, Senator Renato Schifani, Assessor Scarbinato, the President of the ARS and the Federico II Foundation, the Mayor of Palermo, and Dr. Selima Giuliano.

Last but not least, I would particularly like to thank the International Commission for the Scientific Exploration of the Mediterranean for choosing us as hosts of this 43rd Congress. A special thanks to the General Director, Dr. Laura Giuliano.

I conclude by quoting the phrase that the Roman Senate used to pronounce when crowning a new emperor, Felicio Rabusto Berio Traiano, as a wish for this 43rd Congress to be luckier than Augustus and more capable than Trajan.

Thank you, and I wish everyone a successful event.

Speech of Francesco Paolo Scarpinato
Regional Minister

Distinguished guests, Ladies and Gentlemen,
It is a great honor for me to extend my warmest greetings on behalf of the President of the Region, Renato Schifani, on the occasion of the 43rd International Congress of the Commission for the Scientific Exploration of the Mediterranean (CIESM). Hosted in this unique setting of the Real Scuderia at the Norman Palace, a place that encapsulates centuries of history, art, and culture, it is a symbol of the wealth that Sicily has offered and continues to offer to the world.

First, I would like to thank His Serene Highness Prince Albert II of Monaco for his valuable presence and his constant commitment to the protection of our marine environment.
His leadership is an inspiration to all of us, and his support for scientific research in safeguarding the Mediterranean is particularly significant at this historical moment. Our Mediterranean, a cradle of civilizations and a crossroads of cultural, economic, and scientific exchanges, represents a fragile ecosystem that requires continuous attention. The work you, members of CIESM, carry out with dedication is essential to ensure the preservation and enhancement of our marine heritage, an indispensable resource for the future of generations to come.

In this context, the theme of coral, at the heart of this congress's discussions, symbolizes a connection between nature and culture. Trapani, as many of you may know, has been one of the most important centers for coral craftsmanship in the Mediterranean. From the 15th century onwards, the master artisans of Trapani created works of extraordinary beauty and value, often intended for religious worship.

The works on display, from the regional gallery at Palazzo Abatellis and the superintendence of Palermo, demonstrate the incredible craftsmanship of local artisans and their ability to combine precious materials such as coral, copper, silver, and ivory. Thus, art intertwines with science in this event, as both tell stories of discovery, connection, and shared reality. On this note, I would like to draw your attention to the extraordinary exhibition of archaeological artifacts from the superintendence of the sea, including a wreck from the Egadi Islands. These underwater treasures remind us of how deeply our history is tied to the sea and how it is our duty to preserve it.

Finally, allow me to make a special mention of the exhibition following this congress, dedicated to the equestrian equipment of Viceroy Marcantonio II Colonna, another example of the artistic and historical grandeur of our land. This equipment, usually carefully stored in the deposits of the Regional Gallery of Sicily, represents another testimony to the rich cultural heritage that Sicily safeguards in each of the nine provinces of its islands. It is our duty to protect and promote it so that all people can enjoy it.

I wish you a productive congress and a pleasant stay in Palermo. Thank you.

Speech of Roberto Lagalla
Mayor of Palermo

Mr. President of the Assembly, Mr. Regional Commander of the Army, Mr. Prefect, Mr. Assessor, civil and military authorities, it is my great pleasure to address all of you today with my greetings, my warm welcome, and my wishes for productive work on behalf of the city of Palermo, to which I add my personal thanks. I extend particular gratitude to CIESM for choosing this city, the capital of Sicily, as the venue for its 43rd scientific gathering. An ancient and historic city that we are still proud to recall and designate as such. This choice comes at a moment when, thanks to the joint work of institutions, as highlighted by General Principe, we are also celebrating the opening of this extraordinary Cavallerizza Hall, which in some way reflects and anticipates the beauty of the Royal Palace that overlooks us.

Palermo is a city naturally oriented toward the sea, but not always in a virtuous relationship with it. Together with the Sicilian Regional Government, the Port System Authority, and the renewed programming capacities of the City of Palermo, we are working to restore to the people of Palermo a new and different connection with their sea. This effort includes completed projects like the "volo trapezoidale," integrating the city with the sea, as well as resources from the PNRR that enable us to launch an organic process for the rehabilitation of Palermo's southern coast—once ravaged by the speculative development that followed the Second World War.

This is why, Your Highness, I thank you for choosing this city as the venue for this Congress. As I mentioned earlier, Palermo is gradually restoring its historic and fundamental connection to the sea. Palermo, founded by the Phoenicians, was a navigation point from Africa and across the Mediterranean, which for 43 years has been central to CIESM's research and work. The Mediterranean is not just a sea or a geographic location; it is an open stage of history, a space of extraordinary opportunities, and a theater of diverse peoples and ethnicities. It represents both peace, inclusion, and integration, and yet too often, pain and conflict.

We have a duty, as coastal nations, to build a new identity I like to call the Euro-Mediterranean identity. This identity unites the experiences, histories, narratives, opportunities, and perspectives of the nations along the northern and southern shores of this sea. The Mediterranean remains essential for biodiversity, transportation, the economy, energy, and climate challenges—everything that will shape the happiness or suffering of future generations. That is why we must act with clear vision, meticulous planning, proper resource management, and international collaboration, as exemplified here with 23 countries participating in this congress.

I also wish to emphasize the indispensable relationship between science and politics. Scientific data, its objectivity and rigor, provide a necessary foundation for guiding political decisions, especially in a space like the Mediterranean. Finally, I warmly welcome all participants, from Europe and beyond, wishing you a wonderful experience in Palermo, a city with a longstanding tradition of hospitality and peaceful coexistence of the three monotheistic religions for centuries. Thank you, and I wish you all a productive event.

Speech of Gaetano Galvagno
President of the Sicilian Regional Assembly

Your Serene Highness,
Civil and military authorities, distinguished guests,
It is with immense pleasure and profound honor that I welcome you here today in Palermo, in this historic setting, on the occasion of the Congress of the International Commission for the Scientific Exploration of the Mediterranean. This event represents a moment of great significance for all of us, an opportunity to join forces and share vital knowledge for the preservation of our Mediterranean Sea, a cradle of civilizations, a symbol of unity and dialogue among cultures. Its precious and vital biodiversity is today more threatened than ever by pollution and climate change.

Palermo, with its rich history and timeless beauty, is the ideal place to tackle these challenges, which urgently require a collaborative and multidisciplinary approach.
I am confident that the work of these days will lead to significant results, contributing to charting a path toward a future of desirable sustainability. I would first like to express my sincere thanks to General Francesco Principe, who is hosting this event, to Professor Laura Giuliano, Director General of CIESM, and to the entire organizing committee, including the Anton Dohrn Zoological Station in Naples, the University of Palermo, and the University of Catania. I am convinced that your work will inspire new ideas and projects for the protection of our marine heritage.

A special greeting goes, of course, to His Serene Highness Prince Albert II of Monaco, whose presence today greatly enriches this event. Between Sicily and the Principality of Monaco, there is historically a strong bond, built on friendship and collaboration. A few years ago, the University of Palermo awarded an honorary degree to Prince Albert II of Monaco in recognition of his great sensitivity to environmental issues, especially those related to the Mediterranean basin and coastal regions.

It is also worth noting that scientific research has long been a tradition in Monaco. The Monaco Scientific Center, founded in 1960, has been focusing since 1990 on coastal ecosystems, particularly tropical and temperate corals, in relation to global climate change. In this context, the exceptional exhibition of red coral specimens, treasures of Sicilian ventures from the 17th and 18th centuries, enriches today's inauguration. It highlights the research conducted by the Monaco Scientific Center, which recently managed to artificially reproduce these corals in captivity, paving the way for the possible repopulation of these diverse marine species.

The support provided to the scientific community by the Principality of Monaco has always been tangible. Through the Prince Albert II of Monaco Foundation, His Serene Highness is strongly committed to combating climate change, desertification, and promoting hubs for the preservation of marine biodiversity and the use of renewable energies.

Finally, I would like to recall that the Sicilian Regional Assembly, within the scope of its exclusive legislative powers, approved in 2019 an innovative regulation aimed at safeguarding marine culture and identities and fostering the development of the blue economy.

To address today's challenges, we are all called to build bridges of understanding and cooperation, overcoming historical divisions. Only in this way can we guarantee a better future, not only for our sea but also for all future generations.

I will not linger further. I wish you fruitful work, rich in discoveries and inspiration, and I hope that these days in Palermo will be an opportunity to strengthen the bonds of friendship and collaboration among us all.

Thank you.