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Ce volume rassemble sous la forme d'articles synthétiques toutes les communications scientifiques présentées lors du 42ème 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 Cascais en octobre 2019, offre un panorama représentatif des recherches marines menées actuellement en Méditerranée et dans les mers adjacentes avec une attention particulière portée aux échanges entre les eaux Méditerranéennes et Atlantiques.

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 Cascais par leur auteur ont été retenues pour cette publication. Les rapports des modérateurs des sessions ont pour leur part été édités par mes soins.

*Frédéric Briand
Directeur Général, CIESM*

Editeurs scientifiques

Les Présidents des comités scientifiques de la CIESM (2016-2019) :

***** EN ORDRE ALPHABÉTIQUE**

Silvia Ceramicola (Géosciences marines),
Toste Tanhua (Physique et climat de l'océan),
François Galgani (Biogéochimie marine),
Frank Oliver Glöckner (Microbiologie et biotechnologie marines),
Jamila Ben Souissi, Salud Deudero and Natalya Milchakova (Ecosystèmes marins et ressources vivantes),
Ernesto Azzurro (Systèmes côtiers)

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Table des Matières

JOINT SESSIONS	5
Deep Sea Research I	7
Deep sea research II	15
Atlantic / Mediterranean Exchanges	21
Global change	27
Climate-related events	35
 COMITÉ 1 - Géosciences marines	 41
Paleoceanography	43
Coastal, shelf and slope dynamics	53
 COMITÉ 2 - Physique et climat de l'océan	 61
Basin and sub-basin circulation	63
Mesoscale variability	69
Open Sea Processes	77
 COMITÉ 3 - Biogéochimie marine	 85
Contamination / Traces metals in the marine environment	87
Contamination / Processes	95
Biogeochemistry & cycles / State & processes	101
Biogeochemistry & cycles / Trends & changes	107
Ecotoxicology	113
Marine Litter / Methods and Assessments	129
Microplastics	137
Biogeochemistry & cycles / Coast & shelves	143

COMITÉ 4 - Microbiologie et Biotechnologie marines	151
Ocean health	153
Phytoplankton / Bacterioplankton	159
Blue biotechnology	167
 COMITÉ 5 - Ressources vivantes et écosystèmes marins	 175
Bioinvasions / Biogeography	177
Bioinvasions / Ecology	185
Fish ecology and biology	193
Ecology of lagoons and estuaries	201
Fish population dynamics	209
Seaweeds / Seagrasses	217
Gelatinous plankton	223
Higher Vertebrates	231
Other zooplankton	239
 COMITÉ 6 - Ecosystèmes côtiers	 247
Blue economy	249
Human impact on biodiversity	255
Cooperative research with society	259
MPA Research and Tools	265
Small scale fisheries	275
Bioinvasions' impact on fisheries	283

JOINT SESSIONS

CIESM Congress Session : Deep Sea Research I
Moderator : Marina Cunha, CESAM, Univ. of Aveiro, Portugal

Moderator's Synthesis

The deep ocean is currently one of the most exciting frontiers for science, technology and economic activities. Deep-ocean ecosystems are relevant to global biogeochemical cycles and an astonishing reservoir of known and unknown biodiversity, but are also likely to be biologically fragile and vulnerable to anthropogenic impacts and global change. During this session the six speakers highlighted the uniqueness of the deep Mediterranean basins by showcasing aspects of their biodiversity (palynological community of the Deep-Sea Nile Fan, soft bottom slope megafauna at the southern Levant, lab approaches to the study of larval development of deep-sea shrimps) as well as biogeochemical and oceanographic processes (temporal variability in natural and anthropogenic carbon in the Mediterranean sub-basins, ventilation patterns in the West and Levantine basins revealed by time-series of transient tracer data and stable carbon isotopes, seasonality of mass fluxes at the DeepLev observatory).

These talks set the ground for a vibrant debate not only on particular aspects of the research cases presented, but also on several cross-cutting themes and strategic perspectives for future science. Although the CIESM community has been focused on the Mediterranean region, the session participants recognized the importance of bridging with the more Atlantic-focused scientists but identified the need for a strong engagement from science-policy and funding agencies to support research on Mediterranean–Atlantic interactions. Moreover, there was a consensual recognition of persisting knowledge gaps in deep-ocean science even with the growing research investment and recent technological advances. In order to fill these gaps it is necessary to: i) encourage deep-ocean observations and undertake concerted actions aiming a better spatial cover and sustained time-series data acquisition; ii) establish best practice guidelines to harmonize procedures and ensure consistency and inter-changeability of data products and other outputs; iii) foster international collaboration and cross-disciplinary programmes.



CARBON, TRACER AND ANCILLARY DATA IN THE MEDSEA, CARIMED: AN INTERNALLY CONSISTENT DATA PRODUCT FOR THE MEDITERRANEAN SEA.

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Abstract

A consistent, complete and formatted data product containing inorganic carbon relevant data in the Mediterranean Sea is presented. Ancillary (hydrographic, inorganic nutrients and dissolved oxygen), CO₂ (pH, total alkalinity - TA, dissolved inorganic carbon - DIC) and transient tracer data of several basin-wide cruises in the Mediterranean Sea from 1976 until 2018 were assembled. The final aim is obtaining an internally consistent data collection of interior physical and biogeochemical variables, with emphasis on CO₂ data, in order to investigate their temporal variability, natural and anthropogenic. Referred procedures for the first and secondary quality control will be applied as in previous CO₂ synthesis data products as CARINA and GLODAPV2.

Keywords: Mediterranean Sea, Open sea, Carbon, Hydrography

Introduction

The overall goal of this work is to create a merged, calibrated, homogenous, consistent and public data set collecting historic and recent water column measurements in the Mediterranean Sea involving carbon (pH, TA, TIC), transient tracer and ancillary (temperature, salinity, inorganic nutrients and dissolved oxygen) data.

Despite representing only 0.8% of the total surface area of the world oceans and the paucity of quality water column CO₂ measurements [1], the MedSea has been identified as an important anthropogenic carbon storage [2,3]. The reasons for this are the intrinsic physico-chemical characteristics of the MedSea waters, warm, salty and high in pH and alkalinity [4], thus with a low Revelle factor and prone to dissolve more inorganic carbon for a given CO₂ increase in the atmosphere. In addition this anthropogenic carbon can be rapidly transported to the interior ocean with the active overturning circulation.

Regardless of these facts, the first high quality basin wide internally consistent subsurface CO₂ data were collected in April 2011 and made publicly available at CDIAC one year after approximately [5]. Referenced, public and quality controlled data bases are valuable and extremely useful products scientists and society claim.

The MedSHIP program was designed to fulfill the particular spatial (at the sub-basin scale) and temporal (high frequency regionally, and every 6-7 years the whole MedSea) observational requirements within this marginal sea, with special focus on the CO₂ and transient tracers measurements. In 2016 three sub-basin sections were accomplished within a EuroFleets II grant, and in 2018 a whole MedSea repetition sponsored by GEOMAR.

CRUISE DATA COMPILATION

The first steps to accomplish CARIMED consisted in:

- Locate and physically find (either in public repositories, direct contact with the Principal Investigator or even typing or digitalizing old cruise reports) historical and recent CO₂, tracer and ancillary subsurface data in the MedSea, preferably those with a basin scale.
- Collect all the metadata and other information regarding those cruises and measurements: cruise reports, referenced or other publications.
- Gather all the data together (station location, date, time, depth, temperature, salinity...) for each individual cruise and create a unique formatted file with all the physical and biogeochemical data converted to common units.
- Special care was taken with pH data regarding the scale and temperature it was measured and reported. All pH measurements were converted to pH at 25°C on the Total scale.
- All the individual cruise files are in "WHP-exchange" format, a comma separated file including header names and units. Each file (each cruise) is named with an expocode.
- 1st QC (Quality Control) consisting in assigning a quality flag to each measurement, thus inspecting and scrutinizing each cruise following the recommendations in [6]

More tricky will be obtaining a consistent data product, i.e., without

systematic biases in any of the measured variable by cruise or area. Correcting those will be the aim of a 2QC to detect and quantify any measurement bias, following the expertise gained with CARINA [7]. The overall goal of this step is improving the accuracy of the data set as we want to detect and quantify changes in DIC and ascribe them to natural (modelled with oxygen and inorganic nutrient data) or anthropogenic (correlated with transient tracers) drivers. The 2QC relies on identifying areas without temporal variability. This fact will be particularly difficult in the MedSea, a compromised solution will be attained. The 2nd QC procedure consists in the following steps:

- 1) Interpolation of missing values of ancillary data (salinity, oxygen and nutrients) preferably where CO₂ data is available.
- 2) Identify areas/ layers where the assumption of being in steady-state can be applied with reasonable confidence. The oceanography in the MedSea both in the eastern and western basins has suffered dramatic changes.
- 3) Quantify the relative measurement offset between cruises
- 4) Assign an adjustment factor to data deemed to have a measurement bias that exceeds some limit adjustment.

The 2QC procedure is based on a running cluster crossover routine analysis much improved in GLODAPV2. The automatic routine has been developed to easily obtain the crossover results cruise to cruise and particularly adapted to the MedSea, with different criteria in each sub-basin. A careful inspection of the obtained adjustments will be done before applying them with an inverse technique.

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THE UPPER SLOPE MEGAFAUNA OF THE SOUTHEASTERN MEDITERRANEAN SEA: UNLIKE NO OTHER

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Abstract

We investigated for the first time the bathymetric distribution of the soft-bottom megafauna on the upper continental slope in the SE Mediterranean. 112,440 individuals comprising 119 species were identified from 200 to 600 m depth. 3 species are recorded for first time in the Levant Sea, 5 species for the south Levant Sea, and 3 Erythraean fish species were collected at 200 m depth. The zone is characterized by distinct and possibly unique assemblages. Our findings refute studies which considered the soft bottoms Israeli slope uniform and 'desert-like'. Since the Levant Sea is one of the most promising areas for hydrocarbon exploitation, the results suggest that the investigation of its deep-sea biodiversity and habitats are urgently required for *sound and informed* environmental management decisions to be made.

Keywords: *Continental slope, Levantine Basin, Deep sea ecology*

The continental margin off the Mediterranean coast of Israel has been experiencing in recent decades rapid increase in anthropogenic pressures, from global change to local offshore gas production. Yet, our ability to comprehend and evaluate impacts and possible interactions among shelf and upper slope stressors is severely hampered by the lack of data. Only scant information on the biota of the transitional zone between the shelf break and the deep sea in the southeastern Mediterranean Sea is available.

We conducted surveys in winter 2017/2018 at depths between 200 and 600 m, using a commercial trawler, aiming to define bathymetric assemblages and depth-indicator species, and to determine how they relate to soft-bottom upper slope environments elsewhere in the Mediterranean Sea. A total of 112,440 individuals comprising 119 species were identified. Three species are recorded for first time in the Levant Sea (*Rhizaxinella pyrifer*, *Ancistroteuthis lichtensteinii*, *Notoscopelus bolini*), and five species are newly recorded for the southern Levant sea (*Lytocarpia myriophyllum*, *Funiculina quadrangularis*, *Epigonus denticulatus*, *Nemichthys scolopaceus*, *Pagurus alatus*). Three Erythraean fish species (*Champsodon nudivittis*, *Etrumeus golanii*, *Trypauchen vagina*) were collected at 200 m depth [1]. Analysis of the material reveals a division to four discrete assemblages along the bathymetric profile (Table 1).

On comparing species abundance within each depth assemblage, we found dominance patterns that differ from other Mediterranean regions: *Parapenaeus longirostris* and *Chlorophthalmus agassizi* are much more dominant in the upper slope of the Levant Sea than elsewhere in the Mediterranean Sea. As dominance patterns have significant implications as to the function and structure of the assemblages, we argue that the soft bottom megafauna of the Levantine upper slope comprise several distinct and unique assemblages. Since the Levant Sea is the most promising hydrocarbon province in the Mediterranean Sea, with frenetic prospecting, bidding and extraction activity, spatially and temporally extensive surveys using sound science, appropriate methodology and transparent results are urgently needed in order to establish the true extent of habitats and their biota. Because of unstudied aspects, unintended consequences, and the precautionary principle, it behooves us to emphasize environmental safety.

Tab. 1. List of most common species at each depth. Collected October-December, 2017 off the Israeli coast.

Depth	Species
200m	<i>Parapenaeus longirostris</i>
	<i>Loligo vulgaris</i>
	<i>Dentex macrophthalmus</i>
	<i>Merluccius merluccius</i>
	<i>Macroramphosus scolopax</i>
	<i>Trachurus trachurus</i>
	<i>Argentina sphyraena</i>
320m	<i>Parapenaeus longirostris</i>
	<i>Chlorophthalmus agassizi</i>
	<i>Coelorinchus caelorhincus</i>
	<i>Plesionika edwardsii</i>
	<i>Merluccius merluccius</i>
440n	<i>Chlorophthalmus agassizi</i>
	<i>Plesionika edwardsii</i>
	<i>Parapenaeus longirostris</i>
	<i>Coelorinchus caelorhincus</i>
	<i>Ceratothoa steindachneri</i>
	<i>Aristeus antennatus</i>
570m	<i>Plesionika edwardsii</i>
	<i>Parapenaeus longirostris</i>
	<i>Chlorophthalmus agassizi</i>
	<i>Funiculina quadrangularis</i>
	<i>Aristeus antennatus</i>
	<i>Aristaeomorpha foliacea</i>
	<i>Hymenocephalus italicus</i>

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AN OVERVIEW OF DINOFLAGELLATE CYSTS POPULATION IN THE NILE DEEP SEA FAN SEDIMENT

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Abstract

The Nile deep sea fan (NDSF) is largest deep sea fans in the Mediterranean that built during the Messinian salinity crisis and covers a part of the ancient passive margin of Egypt. NDSF is characterized by fluid seepage structures outcropping in water depths between 500-3000 m [1, 2]. In order to understand the fluid seepage sediment, 14 seabed sediment were collected during METEOR M70-2 cruise (2006) from Amon, Isis, Eastern Proven, Central area and Chefren Caldera for their dinoflagellate cyst studied. Sediments from Amon, Isis and Chefren Caldera are characterised by a high concentration and relative abundances of poorly preserved heterotrophic siliceous dinocysts and fresh water algae, however Eastern Proven and Central area are dominated by *Spiniferites ramosus*, *Operculodinium centrocarpum*, *Brigantedinium* spp.,

Keywords: *Dinoflagellates, Mediterranean Sea*

Materials and Methods

In order to understand the life at seeping sediment, fourteen surface sediment samples (Table 1) were collected from the Nile Deep Sea Fan (NDSF) area (Fig.1), including Amon, Isis, Eastern Proven, Central area and Chefren Caldera, during METEOR M70-2 cruise (11/2006). All samples have been analysed using standard palynological technique for their palynological assemblages.

Tab. 1. Location and depth of studied samples.

sample no.	Location	Latitude	Longitude	Depth m.
Push_core	Amon	22.060	31	1154
1	Amon	22.150	31	1119
2	Amon	22.040	31	1122
3	Amon	22.150	31	1123
4	Amon	22.130	31	1121
5	Isis	21.870	31	1002
6	Isis	21.810	31	995
7	Isis	21.660	31	992
8	Isis	21.670	31	992
9	Eastern Prov.	21.610	32	1060
10	Central Area	31.29	30	1674
11	Central Area	32.04	30	1701
12	Central Area	32.09	30	1701
Gravity core				
13	Chefren Caldera	6.52	28	2953

Results

A total of 45 siliceous dinoflagellate cyst taxa have been identified and the assemblages related to surface and sediment conditions. The most common taxa in the NDSF are *Gymnodinium catenatum*, *Protoperidinium denticulatum*, *Brigantedinium cariacense*, *Echinidinium aculeatum*, *E. delicatum*, *E. transparentum*, *Selenopemphix nephroides*, *Operculodinium centrocarpum*, *Lingulodinium machaerophorum*, *Xandarodinium xanthum*, *Lejeunecysta oliva*, *L. Quinquecuspsis concertasabrina*, *Spiniferites ramosus*, *S. mirabilis*, and *Trinovantedinium applanatum*. Sediments from Amon, Isis and Chefren Caldera are characterised by a high concentration and relative abundances of poorly preserved heterotrophic dinocysts and fresh water algae, e.g., *Gymnodinium catenatum*, and *Brigantedinium*, however Eastern Proven and Central area are dominated by *Spiniferites ramosus* associated with *Operculodinium centrocarpum*, *Brigantedinium* spp.

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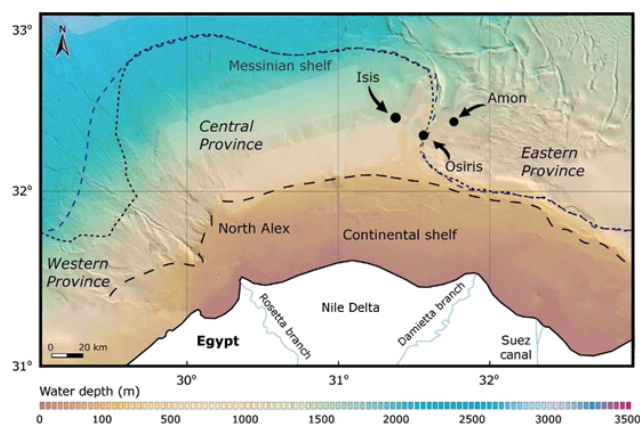


Fig. 1. Location Map (modified from [2]).

STABLE CARBON ISOTOPES AND TRANSIENT TRACERS TIME-SERIES

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Abstract

Observations of the stable carbon isotope $\delta^{13}\text{C}$ in Dissolved Inorganic Carbon (DIC) in the Mediterranean Sea have been made in 1988/90 (VICOMED), in 2011 Meteor (M84/3) and in 2018 Maria S. Merian (MSM 72). On the two last cruises observations were made of transient tracers (CFC-12 and SF6) as well as the inorganic carbon system. Transient tracers and inorganic carbon were also measured in 2016 during a Med-SHIP cruise (TalPro). Here we evaluate this time-series for implication of uptake of anthropogenic carbon, with focus on the Western Mediterranean.

Keywords: Carbon, Mediterranean Sea

The atmospheric stable carbon isotopic composition of CO_2 is changing in the atmosphere due to the light carbon in fossil fuels, the so-called Suess effect. The signal of decreasing $\delta^{13}\text{C}$ in DIC in oceanic waters can be traced and may provide an estimate of the uptake rate of anthropogenic CO_2 (C_{ant}). This way of inferring C_{ant} is particularly useful since it mimics the slow equilibration time of CO_2 across the air-sea interface and provides an independent and integrated measure of interior ocean C_{ant} storage. In the Mediterranean Sea the large interannual variability of deep ventilation and its small size makes other C_{ant} inference methods problematic, as they depend on assumptions of steady-state circulation and ventilation. Here we compare the $\delta^{13}\text{C}$ data 2011 data (Tanhua et al., 2013) with the VICOMED data from 1988 and 1990 (Pierre, 1999) and new data from a cruise in 2018 (MSM72). We put this in context of recent ventilation events and variability of ventilation in the Western Mediterranean Sea. This data set provides a unique time-series in a very active region for deep-water formation and C_{ant} sequestration. The Mediterranean Sea is one of the most prominent regions in the world for C_{ant} sequestration for two reasons: it has a high buffer capacity (due to high alkalinity and temperature of deep water), and it hosts a number of active deep-water formation sites. We focus this study on the storage (i.e. change in inventory in the interior ocean) of DIC, CFCs/SF₆, and $\delta^{13}\text{C}$. They can be treated as passive tracers that enter the ocean by air-sea gas exchange and are transported to the interior ocean by mixing, subduction or convection, mainly during late winter. All three tracers are being used to estimate the concentration of C_{ant} , or the decadal change of C_{ant} , in the ocean. However, the equilibrium time for these three tracers is very different; CFCs are equilibrated fast (order of weeks), DIC slower due to the buffering capacity of the inorganic carbon system (order of years), and $\delta^{13}\text{C}$ is even slower due to the need to exchange the whole DIC pool (order of decades). These different time-scales leads to a decoupling of the signal in the ocean. We are exploring these different time-scales and the time-series of the three tracers, together with changes in salinity and temperature, to estimate the storage of anthropogenic carbon in the deep western Mediterranean Sea, and we put that in relation to deep-water formation rates during the last two decades. The time-series of $\delta^{13}\text{C}$ is seen in Figure 1. Due to C_{ant} uptake it is expected that the $\delta^{13}\text{C}$ value will decrease with time. This is not the case in all regions considered, although a change in transient tracers and DIC can be seen.

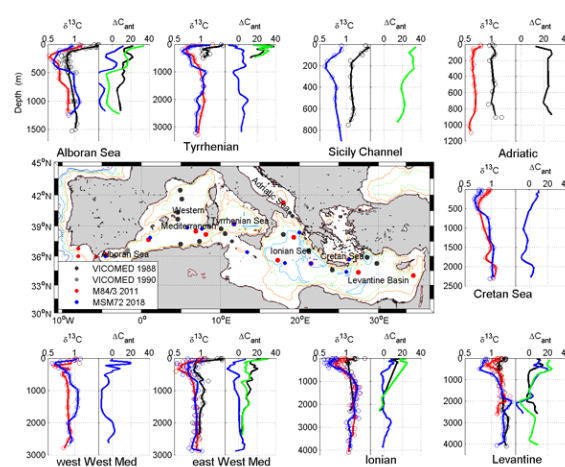


Fig. 1. Time-series of $\delta^{13}\text{C}$ in the Mediterranean Sea. This represents a unique data set to constrain the C content of the Mediterranean Sea. The black curve in the right hand panels are the difference between VICOMED and M84/3, the blue line the difference between M84/3 and MSM72, the green line is the difference between VICOMED and MSM72. The Western Med is split in the western and eastern part at 3°E.

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FIGHTING THE UNKNOWN: THE FIRST TEN ZOEAE OF THE STRIPED SOLDIER SHRIMP, *Plesionika edwardsii* (CRUSTACEA: DECAPODA: PANDALIDAE)

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Abstract

The genus *Plesionika* is one of the most speciose among the Decapoda containing more than 90 extant species. Despite the economic importance and varied ecology of this genus, many questions remain in their systematics, but most of the taxonomic studies have been based solely on the adults morphology. The larval morphology remains unknown for most of the species of *Plesionika*, and none has its complete larval development described; to date, only the early zoeae of seven species were described from laboratory reared material.

The striped soldier shrimp, *Plesionika edwardsii* (Brandt, 1851) (Crustacea: Decapoda: Pandalidae), is a deep-water cosmopolitan species, with interest to fisheries, distributed in tropical and sub-tropical areas. As a first step to understand the reproductive biology and the offspring development of deep-sea shrimps, a rearing system for the culture of these larvae under laboratory conditions, was developed and tested. After 29 days of culture, ten zoeal stages were obtained, and are here described, adding three zoeal stages to the previous descriptions. Comparing the first seven zoeal stages with previous descriptions, small differences were found besides size, although, present study describes and illustrates the second pereopod fully functional and the third pereopod as a small bud. The tenth stage already shows the first four pereopods functional but, lacks the presence of pleopods. A discussion on the morphological larval characters and on the number of zoeal stages of the genus, as well as a comparison of the previous larval descriptions is presented. This is the longest larval series for the genus obtained under laboratory conditions.

Keywords: deep-sea shrimp, larval morphology, larval rearing, laboratory conditions

CIESM Congress Session : Deep sea research II

Moderator : Luis Pinheiro, CESAM, Univ. of Aveiro, Portugal

Moderator's Synthesis

This joint session addressed several key issues in deep sea research of high relevance, not only to the Mediterranean, but also to the Atlantic and global Ocean Science in general. One of the topics addressed concerns new technological possibilities for detailed mapping of deep sea habitats with high resolution imaging techniques, using ROVs. The results obtained highlight the clear need for such high resolution studies and indicate a need to refine existing deep sea habitat classification schemes. The application of these high resolution imaging techniques appears fundamental to detail existing investigations of deep sea habitats, and one topic that came out during the discussion is that this would clearly benefit from an enhancement of the collaboration between Mediterranean and Atlantic marine scientists, namely, but not restricted to, an integrated multidisciplinary study of the extensive and diverse extreme deep-sea ecosystems associated with hydrocarbon-rich fluid seepage that occur throughout the Mediterranean and in the Gulf of Cadiz Atlantic area.

Another topic addressed in three presentations in this session was the investigation of the thermohaline circulation in the Mediterranean and the importance of repeated oceanographic surveys along selected transects, to measure both physical and biogeochemical parameters, with long term project commitment, to better understand spreading pathways and detect long-term variability. This too was highlighted in the discussion that followed as a topic of high relevance that would certainly benefit from a better coordination and an enhancement of the already existing close collaboration between Mediterranean and Atlantic marine researchers, by extending these observations through the Straits of Gibraltar into the Atlantic, in particular to the Gulf of Cadiz area, to fully understand the changing circulation patterns through time and the major interactions between the Mediterranean Outflow and the Atlantic Inflow through the Straits of Gibraltar. The link with global ocean observation networks, in particular with Argo floats equipped with biogeochemical sensors was also highlighted, including the need to strengthen this observation network.

One final topic also of high relevance for both the Mediterranean and Atlantic marine scientific communities was cold-water corals, their possible fixation mechanisms, and in particular the potential contribution of giant barnacles communities to the formation of biogenic structures. Cold-water corals are found both in the Mediterranean and the Gulf of Cadiz area and a better understanding of these would also certainly benefit from an Atlantic/Mediterranean joint research.



REFINING DEEP-SEA HABITAT CLASSIFICATION SCHEMES BASED ON RECENT SURVEYS IN MALTESE WATERS

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Abstract

ROV imagery is leading to the discovery of diverse deep-sea habitat types in the Malta Fisheries Management Zone (FMZ) at depths of 200 to 1000 meters. These include rocky bottoms with mixed assemblages dominated by cold-water corals and gorgonians, as well as sponges with both encrusting and erect growth habits. Vast expanses of different types of soft-bottom habitats are also present, mostly dominated by Anthozoa, Foraminifera and/or burrowing infauna. New habitat categories will need to be added to the existing habitat classification schemes for the deep Mediterranean Sea, including those of the European Nature Information System (EUNIS), and the Regional Activity Centre for Specially Protected Areas (RAC/SPA), to accommodate some of these discoveries.

Keywords: *Biodiversity, Deep sea ecology, Zoobenthos, Sicily Channel*

Introduction

Deep-sea habitats are less studied than their shallow-water counterparts. This has led to a paucity of deep-sea habitat types included in existing classification systems such as the EUNIS and UNEP-MAP-RAC/SPA schemes, although there are ongoing efforts to update these schemes in light of new knowledge on the deep sea [1]. Recent ROV surveys of deep-sea areas around the Maltese Islands resulted in the discovery of highly diverse habitats, including extensive rocky areas dominated by living cold-water corals and gorgonians at depths of 300–1000 m, a sub-fossil lithistid sponge reef at a depth of ca. 300 m, deep-water caves located at 270–450 m, and vast expanses of soft-bottom habitats, each of which had a rich variety of associated fauna [2]. Here we report on other habitat types which are currently not listed in existing classification schemes, based on recent discoveries made whilst analysing extensive video footage recorded in the Malta FMZ.

Material and Methods

During June–July 2015 and 2016, deep-sea areas between 200–1000 m depth in the Malta FMZ were surveyed by the R/V ‘Oceana Ranger’ using a Saab Seaeye Falcon DR ROV as part of the ‘LIFE BaHAR for N2K’ (‘Benthic Habitat Research for Marine Natura 2000 Site Designation’, <http://lifebahar.org.mt/>) project.

Results and Discussion

The habitats observed in the ROV footage were classified according to the UNEP-MAP-RAC/SPA scheme as updated in 2017 [1], which is the most comprehensive for Mediterranean deep-sea habitats available to date. Deep-sea habitats recorded from Maltese waters for which there is no close equivalent in the scheme are shown in Table 1.

In the case of hard substrata, the ‘new’ habitats recorded from Maltese waters mostly refer to mixed assemblages with two or more co-dominant species (e.g. *Callogorgia verticillata* and *Leiopathes glaberrima*) that are only included as separate habitats in the 2017 UNEP-MAP-RAC/SPA scheme. In addition, we also include living Scleractinia “reefs” with associated alcyonaceans or anthipatharians, and thanatocoenosis of corals, sponges or brachiopods. Several areas with rocky bottoms characterised by encrusting and small globular sponges were also recorded in the ROV footage. These are not included in Table 1 due to the difficulty in identifying sponges from videos, but these bottom types are also missing in existing schemes that mainly refer to large erect sponges. For soft bottoms, the ‘new’ habitats recorded from Maltese waters are ones characterised by burrowing infauna, as evidenced by abundant burrow openings seen in ROV footage, as well as habitats with co-dominant species not included in existing schemes (e.g. *Pelosina arborescens* and *Stylocordyla pellita*). A new bathyal soft-bottom habitat characterised by the hydrozoan *Lytocarpia myriophyllum* is also proposed.

The present results show that as new areas of the Mediterranean are explored, new habitats and combinations of characterising species are to be expected, necessitating regular revision to habitat classification schemes. Considering the variety of additional mixed assemblages discovered from Maltese waters,

existing schemes may however need to be revised to remove mixed assemblages, in order to avoid excessively cumbersome classification systems. Habitats with more than one dominant species could then simply be classified as areas with a mixture of two facies/assemblage types. A better understanding of the presence and distribution of such habitats is essential in order to draft monitoring and management plans for the deep sea.

Tab. 1. Deep-sea habitat types observed in Maltese waters not yet included in the 2017 UNEP-MAP-RAC/SPA scheme [1].

Hard bottom

Bathyal rock with *Bebryce mollis* and *Chironophthya mediterranea*

Bathyal rock with *Callogorgia verticillata* and *Leiopathes glaberrima*

Bathyal rock with *Madrepora oculata* and/or *Lophelia pertusa* and/or *Desmophyllum dianthus* with *Leiopathes glaberrima* and with *Pachastrella monilifera* and/or *Poecillastra compressa*

Bathyal *Madrepora oculata* and/or *Lophelia pertusa* and/or *Desmophyllum dianthus* “reefs” with *Callogorgia verticillata*

Bathyal *Madrepora oculata* and/or *Lophelia pertusa* and/or *Desmophyllum dianthus* “reefs” with *Leiopathes glaberrima*

Thanatocoenosis of corals, sponges or brachiopods

Soft bottom

Bathyal muds with *Swiftia* sp.

Bathyal sediment with *Lytocarpia myriophyllum*

Bathyal sediment with *Pelosina arborescens* and burrowing infauna

Bathyal sediment with *Pelosina arborescens* and *Stylocordyla pellita*

Bathyal sediment with *Isidella elongata* and burrowing infauna

Acknowledgements

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THERMOHALINE CIRCULATION DURING THE TRANS-MEDITERRANEAN 2018 GO-SHIP CRUISE

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Abstract

Repeated cruises are important to monitor the sea conditions and detect long term changes. Here we present the results of the last trans-Mediterranean cruise in 2018. The large-scale distribution of thermohaline properties depicts the most updated preliminary analysis of the Mediterranean Sea.

Keywords: *Mediterranean Sea, Circulation, Eastern Mediterranean, Deep sea basins, Intermediate waters*

The Mediterranean is a mid-latitude semi-enclosed sea characterised by high salinities and temperatures. Water and heat fluxes are constricted by the presence of two narrow straits (Gibraltar and Sicily). Its circulation, highly variable at temporal and spatial scales, is driven by both external and internal forcings. High variability at decadal scales. While the ocean surface is continuously monitored by satellite, changes in the deep ocean can only be detected through experimental measures. In this context, repeated cruises are essential for creating long term series for detecting long-term changes. In the framework of the GO-SHIP program a TransMediterranean cruise onboard the German R V Maria S. Merian (MSM72) was carried out during spring of 2018 (Hainbucher *et al.*, in preparation). Its main goals were to add knowledge to the different scales and magnitudes of variability and trends in the circulations, hydrography and biogeochemistry. The cruise covered an east-west transect covering the two major basins and repeating the path of historical similar campaigns i.e. M84/3 (2011).

The Eastern Mediterranean (EMed) suffered abrupt dramatic changes in the thermohaline circulation in the past, when the Eastern Mediterranean Transient (EMT) modified the deep-water formation source from the south Adriatic to the Aegean. An in-depth analysis of the variability over the last 30 years has been carried out by Cardin *et al.* (2015) using data from oceanographic campaigns from 1987 to 2011. Here we extend the analysis to provide an updated preliminary analysis of the Mediterranean circulation. Atypical deep water convection events have been also reported to occur in the Western Mediterranean (WMed), as the so called Western Mediterranean Transient (WMT, Zunino *et al.*, 2012) which produced warmer and saltier waters to fill the deeper part of the WMed.

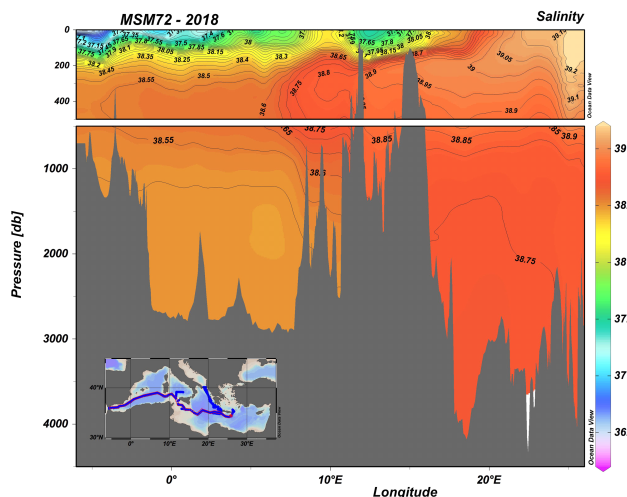


Fig. 1. Longitudinal section of salinity along the east-west track.

The longitudinal section of salinity (Fig. 1) illustrate the distribution of water masses along the east-west track during the cruise. During the last years, in the EMed the water masses have gradually changed towards a pre-EMT state, though not reaching the same steady state. Deep profiles in the central Ionian show a slight decrease in salinity (Fig. 2), but the progression is slow, and in

general the eastern basin does not show significant differences with respect to the last cruise in 2011. We need to remark that this is a partial conclusion since the easternmost part of the basin, and specially the LIW formation site, could not be covered during the cruise for political reasons. Some differences are seen in the WMed with respect to the 2011 campaign, with a increase in salinity in the intermediate and deep parts of the basin. This result is in line with recent works (Schroeder *et al.*, 2015), where a positive trend in salinity has been related to climatic changes (i.e., reduction in the evaporation) and lateral advection (i.e, propagation of the saline LIW signal).

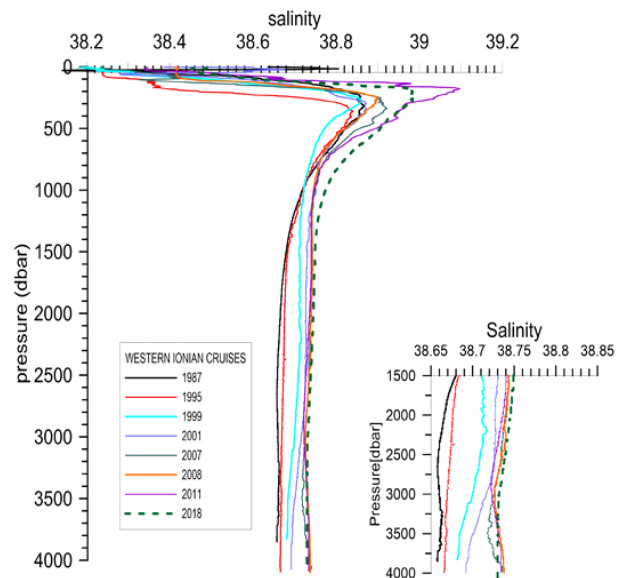


Fig. 2. Salinity profiles in the Western Ionian (between 34.5-36N and 17-19 E).

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RECENT THERMOHALINE VARIABILITY AND PROCESSES IN THE DEEP WATER OF THE SOUTHEASTERN LEVANTINE BASIN

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Abstract

The spreading pathways and variability of deep waters of the eastern Mediterranean Sea (MS) are scarcely investigated and are of importance for the understanding of the basin's water cycle. Using a data set spanning 7 years we demonstrate an apparent regime shift in the salinity minimum zone at ~1000 db, hinting to a transition from a vertical diffusion controlled system towards a more advective one. Close to the bottom of the abyssal plain, we report the first signal of the arrival of newly formed East Mediterranean Deep Water (EMDW) of Adriatic origin. Additionally, a deepening of the interface between the EMDW and Intermediate Levantine Water (LIW) is identified, attributed to the general salinification trend at shallow and intermediate levels of the Southeastern Levantine Basin (SELB).

Keywords: Deep waters, Monitoring, South-Eastern Mediterranean

Deep water formation (DWF) occurs in specific regions within the MS, characterized by an intensive positive winter mass flux, enabling strong convective penetration until the bottom [4,5]. Before the Eastern Mediterranean Transient (EMT) the established origin of the EMDW was the Adriatic Sea, which produced a rather homogeneous deep water body, with relatively stable thermohaline (T/S) properties (38.67 ± 0.02 ; $13.35 \pm 0.02^\circ\text{C}$). During the EMT period (late 80's to mid 90's) DWF shifted abruptly from the Adriatic Sea to the Aegean Sea, where vast amounts of highly dense waters characterized by relatively high S and T were released, significantly changing the T/S structure and stratification of the entire eastern basin [3]. The newly formed deep water was of Aegean origin (EMDW_AG) gradually propagated throughout the eastern MS and where first identified in the abyssal plains near the Israeli continental slope in 1996 [2]. In 2001 observations from the R/V "Meteor" gave the first evidence for the return of the Adriatic as the principal contributor of DW in the eastern MS (i.e. new EMDW_AD), frequently observed in the following years [1].

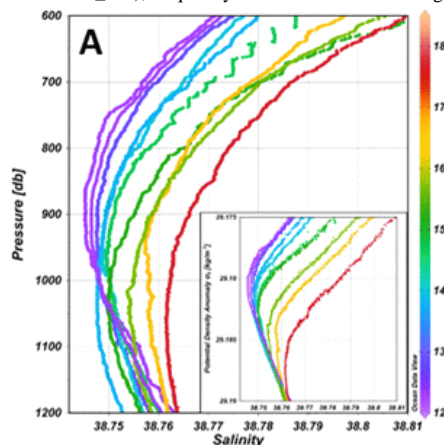


Fig. 1. Salinity profiles (600-1200 db) from H06 station of Haifa Section cruises between 2012 and 2018 (color coded by year, profiles projected against sigma-theta in insert).

Here we present the findings of 21 cruises conducted in the past 7 years (2012-2018) describing the SELB deep water evolution during this period. A data series of biannual profiles from the westernmost station of Haifa Section cruises reveals the gradual shift of the S minimum zone (centered around the 1000 db pressure level), the remnant core of the old EMDW_AD, towards higher S values (Figures 1,2). The output of a simplistic one-dimensional diffusive model using a constant diffusivity coefficient of $3 \text{ cm}^2\text{s}^{-1}$, agrees with the majority of the observations. Close to the bottom, at pressures of 1700-1750 db, where the newer EMDW_AG lies, a slow decrease of S values is noted during the period of 2012-2017 and is attributed to similar predominating diffusional processes. However, profiles taken in the period of August 2017 to October 2018 demonstrate an abrupt intrusion of less saline water in the bottom layer. A magnified T/S

projection of these three most recent profiles reveals hook inversions (Figure 2), which most probably are the first signal for the arrival of newly formed EMDW_AD to the SELB.

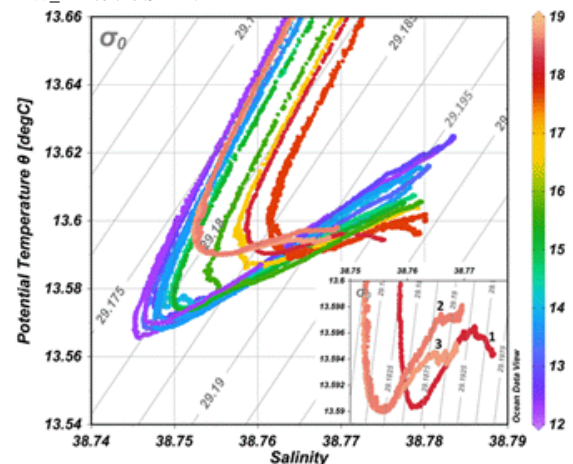


Fig. 2. TS diagram of H06 station from Haifa Section cruises covering the period of 2012-2018 (color coded by year). Inserted panel highlights the bottom values of three recent surveys performed in March (1), August (2) and October (3) 2018.

These observations highlight the variability of the East Mediterranean and call for a more systematic monitoring of this basin.

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DO GIANT BARNACLES CONTRIBUTE TO DEEP-WATER BIOGENIC REEF FORMATION IN MALTESE WATERS?

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Abstract

Deep-sea ROV surveys in the west Malta Graben allowed re-evaluation of previous work on the association of the giant barnacle, *Pachylasma giganteum*, with cold-water corals and other habitat-forming species, and this species' contribution to formation of biogenic structures. While only a minor contributor to habitat architecture when anthozoans and other large sessile species are dominant, *P. giganteum* may become a habitat-former in the absence of competing species.

Keywords: *Deep sea ecology, Zoobenthos, Sicily Channel*

Introduction: Previous research [1] suggested that the giant barnacle *Pachylasma giganteum* contributes significantly to the overall architecture of cold-water coral (CWC) habitats south of Malta. This species had been found covering up to 25% of the available space in localised patches, forming distinct aggregations with little intermingling of scleractinians and barnacles. Here we examine in more detail the contribution of these barnacles to biogenic formations along the west Malta Graben.

Methods: Video footage from the west Malta Graben was collected at depths down to 1000 m in June-July of 2015 and 2016, using a remotely operated vehicle (ROV) as part of the 'LIFE BaHAR for N2K' ("Benthic Habitat Research for Marine Natura 2000 Site Designation", <http://lifebahar.org.mt/>) project. Information on *P. giganteum* formations, including density and interaction with other habitat-forming species, was extracted from this footage.

Results & Discussion: *P. giganteum* was recorded from over 80% of the ROV dives that surveyed hard substrata in the west Malta Graben, showing it is a widespread species. A total of over 4600 individuals of this species were collectively recorded from areas with both high and low CWC densities (Fig. 1). The surveys covered a total area of 0.052 km², with hard bottom substrata covering approximately 0.04 km² of this. Other barnacles of the suborder Balanomorpha were also present, but only at exceedingly low abundances (<0.32% of all barnacles encountered).

Where CWC density was high, *P. giganteum* tended to occur as small, isolated aggregations (<30 individuals) with overall low density; barnacles in these clusters accounted for approximately 18.5% of the total recorded abundance of *P. giganteum*. Such clusters were usually observed on raised ridges or on erect dead branches of corals. This could be due to direct competition for space with the anthozoans, or because the CWC frameworks reduce water movement allowing more sedimentation and thus restricting barnacles to 'elevated' positions. However, a limited number of *P. giganteum* (~3.5% of the total number of individuals of this species) were recorded from areas characterised by low CWC density where other habitat-forming species such as sponges were present, implying some interspecific competition.

The highest *P. giganteum* densities were recorded from areas where other habitat-forming species were absent or sparse; around 78% of all the *P. giganteum* individuals were present in these areas. In such circumstances, the barnacles were attached directly to the hard substratum and generally occurred in clusters that covered large parts of the bottom; however, the barnacles did not form raised structures.

The present results suggest that the contribution of *P. giganteum* to CWC habitat architecture is relatively minor compared to that of the anthozoans. However, *P. giganteum* can be an important habitat-former on hard substrata that are not dominated by CWCs. Still, there is no evidence that the barnacles accrete to form raised formations.

Acknowledgements: The LIFE BaHAR for N2K (LIFE12 NAT/MT/000845) Project is 50% co-financed by the EU LIFE+ Funding Programme. We thank the Environment and Resources Authority and the Continental Shelf Department within the Office of the Prime Minister for granting the permits required.

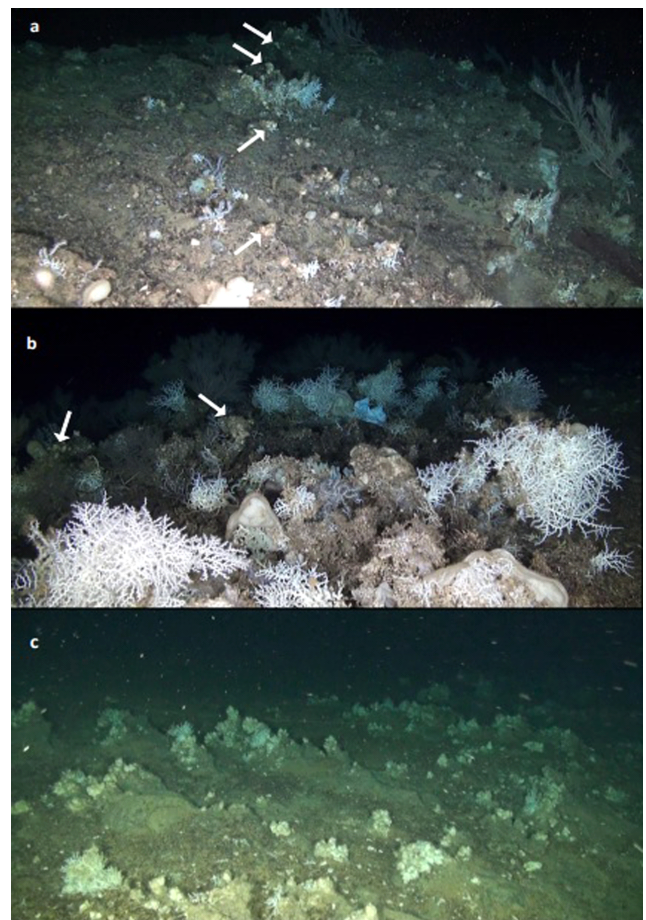


Fig. 1. (a) Low barnacle abundance in low coral density cold-water coral habitat; (b) Low barnacle abundance in high coral density cold-water coral habitat; (c) High barnacle abundance on a hard bottom substratum. Arrows in (a) and (b) indicate barnacle clusters. West Malta Graben; depth ca. 600m.

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PHYSICS AND BIOGEOCHEMISTRY ALONG THE MED-SHIP HIGH FREQUENCY TRANSECTS IN THE WESTERN MEDITERRANEAN SEA (CRUISE TALPRO-2016)

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Abstract

In the past, the Mediterranean has been sampled sporadically in time and space, mostly by national expeditions in regional waters. An outcome of a CIESM Workshop (2012) was a recommendation for repeated oceanographic surveys of the Mediterranean in a programme called Med-SHIP, to observe the changing circulation in a manner similar to the international GOSHIP programme for the global ocean. Mediterranean marine scientists have designed a network of hydrographic sections on which comprehensive physical and biogeochemical properties will be measured to highest international standards on a regular basis. In 2016 the first cycle of repeat surveys along the Med-SHIP network has been completed. Here the physics and biogeochemistry of the two meridional transects in the Western Mediterranean Sea are shown and discussed.

Keywords: Hydrography, Salinity, Temperature, Vertical profile, Western Mediterranean

TAlPro-2016 represents the Western Mediterranean basin component of the Med-SHIP (Mediterranean Ship-based Hydrographic Investigations Program) initiative. Med-SHIP includes a low-frequency (every 6-7 years, carried out in 2011 and in 2018) zonal transect from Gibraltar to the Levantine Sea, which is now included in the global network of repeat hydrography (section MED01 in GO-SHIP), and a number of high-frequency (every 3-4 years, carried out in 2016) repeated transects, two of which are located in the Western Mediterranean Sea (WMED), as described in Schroeder et al. (2015). These transect have been measured during the first round of Med-SHIP cruises, during the Eurofleets2-funded cruise in 2016, on board of the Spanish RV Angeles Alvarino, from August 18th to 29th, 2016 (PI Loic Jullien). Additional Med-SHIP cruises were founded the same year by Eurofleets2: CRELEV-2016 in the Cretan Sea and ESAW in the Adriatic Sea. The TAlPro-2016 cruise occupied two hydrographic transects across the Tyrrhenian Sea and the Algero-Provencal Basin as part of the Med-SHIP programme, plus an additional transect in the Catalan Sea. A total of 43 stations were occupied during which physical (temperature, salinity, pressure, velocity), biogeochemical (oxygen, nutrients, carbonate system, dissolved Barium, oxygen and nitrogen isotopes) and anthropic (CFCs, SF6) parameters were measured in order to monitor the physical and biogeochemical state of the Mediterranean.

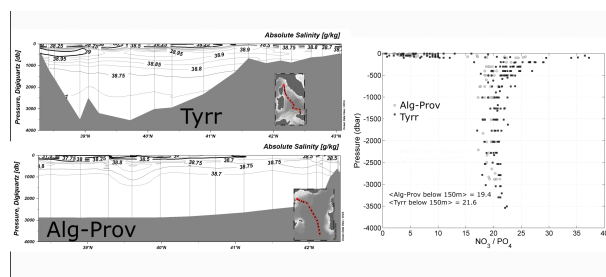


Fig. 1. (left) Vertical sections of Absolute Salinity (g/Kg) along the Tyrrhenian (above) and the Algero-Provencal (below) sections; (right) vertical profiles of NO₃:PO₄ ratios along the Tyrrhenian (black) and the Algero-Provencal (grey) sections

Along the Tyrrhenian section the southern and northern part clearly display different distributions of thermohaline properties and dissolved oxygen. In the south the inflow (coming from the Eastern Mediterranean, or EMED) of relatively young Levantine Intermediate Water (LIW) is evident, exhibiting high salinity and temperatures with a core at about 400 m. Going northward the salinity and temperature, but also oxygen, decrease with increasing age of this water mass. The recent ventilation in the deep layers of the Tyrrhenian Sea is also well evident in TS properties as well from transient tracers (SF₆/CFC-12), south of 40.5°N and below 2000 m, due to the ingress through the Sardinia channel of newly formed deep water. The Sardinia Channel (sill at 1930 m)

allows exchanges of the upper part of the deep waters to occur between the WMED interior and the Tyrrhenian Sea. At the sill a deep-sea mooring (belonging to the CIESM HYDROCHANGES Programme) monitors the overflowing dense waters in detail (Schroeder et al., 2013, 2016). The densest part of WMDW, trapped in the deep WMED interior, is overflowing the sill when uplifted by even denser WMDW. While until 2005 only the “classical” old WMDW was found at the sill, the new denser WMDW (which started to form during the Western Mediterranean Transition, or WMT, Schroeder et al., 2016) started to cross it since then. It has been reported that in 2012–2015 the thickness of the modified deep layer increased to almost 1000 m and the signature of the WMT in the Tyrrhenian Sea (typical hooks in the TS diagram) was clear in almost all stations in the interior. Hence the new WMDW crossing the sill became dense enough to cascade down to the bottom of the Tyrrhenian Sea.

Along the section through the Algero-Provencal Basin, the well-defined vein of Atlantic Water (AW) flowing eastward, and coming directly from Gibraltar, is evident in the south, along the Algerian coast. It is essentially characterized by very low salinity and its signature involves the surface layer down to 250 m south of 39.5 °N. Recent ventilation can be identified at the bottom along the whole transect, which in fact crosses the most active dense water formation site of the Mediterranean Sea. If compared to historical data, the whole water column appears to have warmed and become saltier, a tendency that is especially evident in the LIW layer, as already anticipated by Schroeder et al. (2017) who observed the acceleration of the T and S trends in the intermediate water crossing the Sicily Channel. The average NO₃:PO₄ ratios in the deep (>150 m) Tyrrhenian sea is slightly higher than along the Algero-Provencal section (21.6 vs 19.4), a feature that might be related to the higher oligotrophy (P-limited) in the Tyrrhenian if compared to the Algero-Provencal basin.

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CIESM Congress Session : Atlantic / Mediterranean Exchanges

Moderator : A. Miguel P. Santos, IPMA/CCMAR, Lisbon, Portugal

Moderator's Synthesis

The Mediterranean Outflow Water (MOW) has been showing long term trends in both temperature and salinity since the middle of the 20th century. Since the MOW is an important salt and heat source to the North Atlantic Ocean, this increase could have important consequences for the thermohaline circulation of the Atlantic Ocean, as well as the Global Ocean and the climate of the Earth System. This requires an urgent implementation of sustainable long-term ocean observing systems to monitor the variability of the MOW, in both the Mediterranean Sea and the adjacent Atlantic Ocean. The observation must progressively include the biogeochemical and biological essential variables, as soon as possible.

Those present at the session, recommend that CIESM should play a major role in the development of these long-term observing systems in the Gulf of Cadiz and the Alboran Sea. Ocean sustainable observations could not be dependent of project funding but also in long-term funding at least at a decadal scale.

It was also stressed that the setup of these monitoring programmes will only be effective when northern African countries are involved in this effort). In this sense, CIESM is in a strategic position to lead and facilitate the development of these enrolment and cooperation.



LONG-TERM MEDITERRANEAN WATER OUTFLOW VARIABILITY AND TRENDS

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Abstract

The thermohaline variability of the Mediterranean Water is investigated through an update of the study achieved by Fusco et al. (2008) using temperature and salinity data provided by the different projects and extending the available time series to the first decade of 2000's. In order to estimate temporal trends we used the non-parametric Mann–Kendall test, while trend magnitude was evaluated by the non-parametric Sen's method. Our results confirm the presence of long term trends in both temperature and salinity. Besides, we analyse some particular physical processes, characterizing the Gulf of Cadiz-Gibraltar Strait-Alboran ocean system, responsible of the interannual variability of the salt transport into the North Atlantic.

Keywords: *Hydrology, Gibraltar Strait*

Mediterranean Outflow Water (MOW) released into the Gulf of Cadiz is basically a mixture of Levantine Intermediate Water (LIW) and Western Mediterranean Deep Water (WMDW), and as shown by Millot et al. (2006), other Mediterranean waters may, some of the time, contribute to its formation. During the twentieth century also the Mediterranean basin has warmed quite significantly in the deep waters as well as in the surface layer (e.g. Rixen et al., 2005). In the Strait of Gibraltar, Millot et al. (2006), have observed an anomalous warming and increase in salinity, from the early 2000s, corresponding to $\sim 0.3^{\circ}\text{C}$ and to ~ 0.06 respectively. Fusco et al. (2008) found changes in water properties of MOW, with an average value of $0.16^{\circ}\text{C}/\text{decade}$ and 0.05 in salinity per decade in the period 1948–1999. They observed that the layer thickness ventilated by MOW increases almost regularly in time, but with an evident acceleration in the last three decades. In the present work, the dataset used in 2008 has been enriched with data collected through different projects and extending the available time series to the first decade of 2000's. In particular, data from the Sea Data cloud project (Simoncelli et al., 2018), the Medar Medatlas II project, the Coriolis CORA-3.4 Dataset (Cabanes et al., 2013) and from the World Ocean Hydrographic Profiles (WOHP - V1.0 database, in agreement with Viktor Gouretski) were aggregated and used (fig. 1).

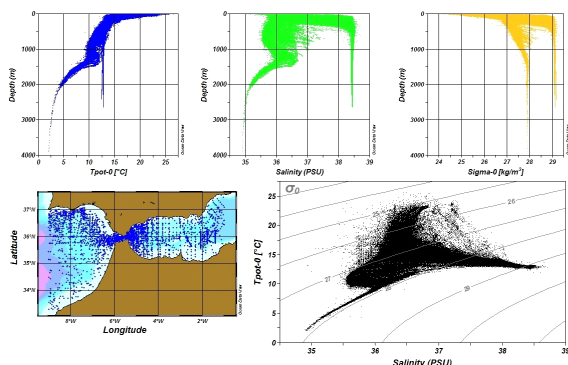


Fig. 1. Temperature, salinity, density and T-S diagram for all data selected.

Before any data analysis, some quality control procedures were adopted, in order to avoid data repetition, exclude any outlier and consider the different instruments used during the entire period covered by the composite dataset from early 1900 to the first decade of 2000. After this, data were selected on monthly basis, in order to guarantee that during every month, at least 1 profile, effectively described the physical properties of the Mediterranean Outflow in the Alboran Sea and in the Gulf of Cadiz. The procedure for the detection of temporal trends that we used is based on the non-parametric Mann–Kendall test, while trend magnitude was evaluated by the non-parametric Sen's method. The results show the presence of an increasing trend and of a significant variability at shorter time scales. In fact, a periodic oscillation with several relative maxima in the late seventies, in 1999, 2009 and 2016 is evident. These high salinity/high temperature values are coherent with a similar intermittence reported by Fusco et al. (2008) for the MOW in the Gulf of Cadiz during last

century. Correlation values for salinity and temperature, show the existence of relationship between the thermohaline characteristics of the water coming from the Alboran Sea and the properties of the MOW in the Cadiz region. These phenomena deserve to be further investigated on the basis of longer data time series, also in the framework of an analysis of the LIW contribution to the composition of the MOW. These results suggest that the transport through the Gibraltar Strait, characterized by a multidecadal variability, is more likely one of the key factor to take into account to justify the difference between the trend in the Mediterranean Sea and those observed within the intermediate layer of the North Atlantic influenced by Mediterranean outflow. At the same time the Mediterranean thermohaline circulation can show internal natural variability due either to advective-convective feedback (Pisacane et al., 2006) or to strong air-sea interaction during extreme atmospheric events, generating for example in the early 1980s the strong cooling of LIW. Moreover, in the early '90 the Eastern Mediterranean basin had experienced a climate shift in their mean thermohaline circulation, referred as the "Eastern Mediterranean Transient", producing a change of the site of the deep-water production from the South of Adriatic to the Aegean Sea involving massive changes also in the Western Mediterranean Sea (Schroeder et al., 2016). However, there is no clear evidence that the observed trends can be due only to climate change or only to climate variability; but our analysis does suggest that the natural or anthropogenic effect is accompanied by considerable decadal variability and that their relationship is more complex than previously thought and may require further investigation.

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DISTRIBUTION OF TWO MONOGENEAN OF *TRACHURUS PICTURATUS* FROM TUNISIA, MEDITERRANEAN SEA AND MADEIRA ISLAND, ATLANTIC OCEAN.

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Abstract

The blue jack mackerel, *Trachurus picturatus* (Osteichthyes, Carangidae) is considered as one of the most commercial fish in Mediterranean and Atlantic waters. On this work we aimed to study the occurrence of monogenean parasite communities on this Carangidae species in the Mediterranean Sea and the Atlantic Ocean, in order to better understand the environmental conditions for the transmission of these ectoparasites. From November 2017 to December 2018, 248 fish (126 from Tunisia and 122 from Madeira Island) were collected and examined for ectoparasites. 243 specimens of *Pseudaxine trachuri* and 50 specimens of *Gastrocotyle trachuri* were collected from the gills of *T. picturatus* from the Tunisian coast. However, only 149 specimens of *P. trachuri* occurred in the blue jack mackerel from the Madeiran coast.

Keywords: *Mediterranean Sea, North Atlantic, Parasitism, Fishes*

Throughout a one year period, 126 fish of *Trachurus picturatus* (Bowdich, 1825), were collected from local fishermen in Bizerte coast of Tunisia, and 122 specimens were obtained from a local fish market of Madeira in the north-east Atlantic. Fish samples were weighed, measured and examined for parasites under a stereomicroscope. All parasites were isolated, counted and preserved in 70% ethanol. In this study, the ecological indexes of monogenean parasites were determined according to Bush et al. (1997): prevalence (P%) is the number of hosts infected with one or more individuals of a particular parasite species divided by the number of hosts examined for that parasite species. Mean intensity (MI) is the average intensity of a particular species of parasite among the infected members of a particular host species. The abundance (A) is the average number of individuals of a particular parasite in/on a single host regardless of whether or not the host is infected. Prevalence was compared between regions using the chi-square test; for mean intensity, the Wilcoxon test was used. All the statistical tests were performed at the significance level of 5%.

In the gills of *T. picturatus* from the Mediterranean, we found two monogenean species (Monogenea: Gastrocotylidae): *Pseudaxine trachuri* (Parona & Perugia, 1890) and *Gastrocotyle trachuri* Van Beneden and Hesse, 1863. Whereas, in Atlantic specimens, fishes are infected only by *P. trachuri*.

Tab. 1. Prevalence (P%), abundance (A) ± sd and mean intensity (MI) ± sd of monogenean parasites recovered from *Trachurus picturatus* from Tunisian coast and Madeira Island.

	No. of examined fish	No. of infected fish	<i>Pseudaxine trachuri</i>			No. of infected fish	<i>Gastrocotyle trachuri</i>		
			P%	MI	A		P%	MI	A
Tunisia	126	85	67.46	2.86 ± 2.14	1.9* ± 2.2	20	15.87	2.50 ± 2.01	0.39 ± 1.2
Madeira	122	77	63.11	1.94 ± 1.14	1.22* ± 1.3	0	0	0	0

*Level of significance with P < 0.05.

The Wilcoxon test revealed a significant difference in abundance of *P. trachuri* between the two geographic regions (p = 0.0491). However, the chi-square test showed a non significant difference in prevalence of this parasite species between the Atlantic and the Mediterranean Sea (X-squared = 0.17, p = 0.68). In the Mediterranean Sea, the high prevalence of this parasite throughout a one year period, could be explained by the direct transmission, even across species from the same genus sharing the same schools (Hermida et al., 2016). But, in the Atlantic Ocean, the high prevalence could be due to the sampling period. Indeed, in summer and autumn seasons, when the water temperature increased, the biotope becomes optimal for reproduction and survival (Jansen & Bakke, 1991). However, in Tunisian waters the mean infection of *G. trachuri* is lower than the one of *P. trachuri*, possibly because of its larger body size. In fact, there is a negative correlation between the monogenean body size and the mean intensity of fish infection (Poulin, 1999).

Spearman rank correlation showed that abundances of the two parasites are positively correlated with fish size (Total length or Total weight), only for

Mediterranean specimens (Tab. 2). This could be explained by the increased colonization by monogeneans due to the larger gill surfaces providing more available habitat (Sasal et al., 1997).

Tab. 2. Correlations between parasite abundance and host features.

	Abundance	
	<i>Pseudaxine trachuri</i>	<i>Gastrocotyle trachuri</i>
Total length	P = 0.001 ; rho 0.29	P = 0.002 ; rho 0.264
Total weight	P = 0.002 ; rho 0.27	P = 0.016 ; rho 0.212

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THE M₂ TIDE DIFFRACTION AT THE STRAIT OF GIBRALTAR

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Abstract

Using the output of a general circulation model forced by the full ephemerid luni-solar tidal potential, the diffraction of the M₂ tide at the Strait of Gibraltar (SoG) is analyzed. The model grid is global with a strong zoom around the Iberian Peninsula, which permits resolving the superposition of the M₂ tidal amphidromic system in the North Atlantic (NA) with its diffraction pattern at the entrance of the SoG. Constant phase lines indicate a northward propagation of the tidal wave along the African and Iberian coasts, following anticlockwise rotation of the NA amphidromic system, while at the SoG a southward local propagation is observed. The vertically integrated energy flux vectors are orthogonal to the phase lines in the NA, but at the SoG they become parallel to the phase lines as required in a wave diffraction pattern.

Keywords: *Tides, Gibraltar Strait*

M₂ is the principal lunar semidiurnal tidal constituent with a frequency of 28.98° per hour and its observed structure in the Strait of Gibraltar has been heuristically considered to be a wave diffraction pattern [1,5]. However, up to now, 1) there has not been a description of how the North Atlantic and Gibraltar Strait's tidal configurations overlap or 2) show kinematic evidence that the M₂ sea level and currents behave according to a wave diffraction pattern in the Strait. Both of these aspects are examined here using results from a global ocean model with a high resolution around the Iberian Peninsula [3].

At every grid point a harmonic analysis of the model's sea level and current time series, provide estimates of the M₂ surface tide amplitude (h_0) and phase and of the M₂ tidal ellipse elements (M , semi-major axis; m , semi-minor axis; inc , orientation and phase) at each level of the model. An estimate of the barotropic M₂ tidal ellipse is obtained through a vertical integration of the rotary (complex) tidal components. Integrated over a tidal cycle, the energy flux vector (EFV) per unit width, oriented with respect to the local semi-major axis of the tidal current ellipse, is given by $\mathbf{P}_n = \frac{1}{2} \rho_0 g H h_0 [M \cos \phi, -m \sin \phi]$, where ρ_0 is the water density, g is the acceleration due to gravity, H local water depth and ϕ the local phase difference between high water and the maximum current [2].

The M₂ cotidal chart south of the Iberian Peninsula is shown in Figure 1. The phase lines (thick contours), which represent the crests of the tidal wave, propagate northward along the African and Iberian coasts in the North Atlantic, while in the Strait the propagation is southward with phase lines closing on the coast to the north and south of the Atlantic side of the Strait. Amplitude contours (thin contours) are orthogonal to the Strait axis and diminish in magnitude towards the Mediterranean Sea. As indicated by [5] the deep sea tide "sees" the strait as a point source at a distance greater than strait width. The tidal EFVs are perpendicular to the phase lines in all places away from the Strait, while in the vicinity and at the Strait they become parallel to the phase lines. Water wave diffraction is a phenomenon in which energy is transferred laterally along the wave crest.

The energy flux into the Mediterranean, calculated by the model, is 6.5 10⁸ W in accordance to previous estimates [1, 4]. An interesting aspect discussed by [4] is that the generated tide within the Mediterranean Sea works in opposition to this energy flux cancelling about 3/4 of its effect over the tide inside.

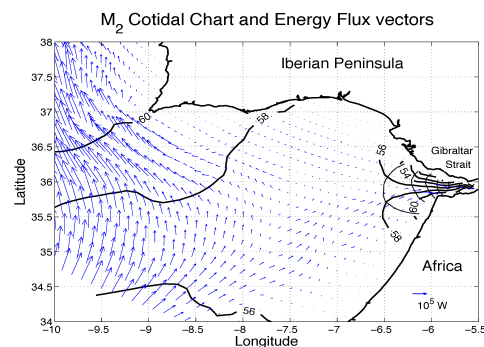


Fig. 1. Thick contours indicate constant phase lines for the M₂ surface tide (frequency=28.98°/h), with a 2-degree contour interval. Constant amplitude lines (thin contours) are drawn every 0.1 m starting with 1 m in the Atlantic side of the Strait diminishing towards the Mediterranean. The vectors are the vertically integrated M₂ tidal energy flux, per unit horizontal distance. The vector scale is on the lower right hand corner in Watts.

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COMPARATIVE STUDY OF OCEANOGRAPHIC AND PHYTO- AND PICO-PLANKTONIC PATTERNS IN THE ALBORAN SEA AND GULF OF CADIZ (SOUTH IBERIAN PENINSULA).

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Abstract

The Strait of Gibraltar is a very important point of waters exchange, due to the inflow of surface Atlantic water and the outflow of deep Mediterranean water towards the Atlantic Ocean. In this work we present a comparative study of the phytoplankton communities at both sides the Strait of Gibraltar. The data needed for this article come from two projects funded by the Instituto Español de Oceanografía: RADMED and STOCA, which monitor respectively, the Mediterranean and the Atlantic waters in the Gulf of Cadiz and in Alboran Sea. As results, we have found higher phytoplankton abundance in Spring and Fall.

Keywords: *Phytoplankton, Alboran Sea, Gulf of Cadiz*

Introduction

We present and discuss in this work the phytoplankton climatologies on both sides of the Strait of Gibraltar (Alboran Sea and Gulf of Cadiz) [1]. These areas show high variability influenced by atmospheric and oceanographic dynamics. Through the Strait of Gibraltar, a high planktonic biomass exchange is produced between Atlantic and Mediterranean waters [2]. Although greatest abundance of plankton's smallest groups are usually found in Gulf of Cadiz, in comparison with Alboran Sea [3].

Material and Methods

Water samples, meteorological and oceanographic data studied in this work proceed from several cruises carried out in 2014-2015, from STOCA (Series Temporales de datos Oceanográficos en el golfo de Cádiz) and RADMED (Series temporales de datos oceanográficos en el Mediterráneo) projects, both belonging to IEO (Fig. 1). Their goals are observation and monitoring of time variability and trends in oceanographic conditions [4] and planktonic communities in both areas. The composition and abundance of the different phytoplanktonic groups are analysed by microscopy (microphytoplankton) and flow cytometry (pico and nanoplankton).

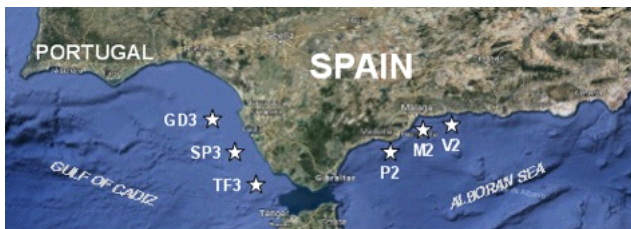


Fig. 1. Positions of the stations sampled at Gulf of Cadiz and Alboran Sea, south Iberian Peninsula. Transects from periodic cruises in STOCA and RADMED projects.

Results

We have found significant differences throughout both sides of the Strait of Gibraltar (Atlantic and Mediterranean waters) in the Fig. 2.

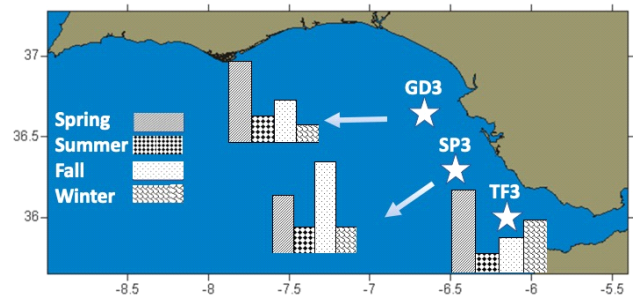


Fig. 2. Integrated seasonal phytoplankton abundance (cells/mL) in three stations (GD3, SP3, TF3) in Gulf of Cadiz.

Main phytoplanktonic groups (diatoms, dinoflagellates and flagellates) relate to meteorological and oceanographic environmental variables. A seasonal cycle of the distribution of phytoplankton will be presented. As a preliminary result, in the Gulf of Cadiz in Spring, Diatoms dominate the community (in 78%-66%) in surface layers (5 m and 25 m) in the three stations. Meanwhile, Flagellates dominate (in 94%-65%) in deeper layers (50 m and 75 m).

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CIESM Congress Session : Global change
Moderator : Carolina Madeira, MARE, Univ. of Lisbon, Portugal

Moderator's Synthesis

The presentations gathered a full perspective on how current global change trends are disrupting Mediterranean Sea biodiversity, from molecules to coastlines. The direct impacts of different global and regional stressors on marine species' physiology, performance and fitness are already evident. The decline of economically important populations of the fan mussel *Pinna nobilis* is now a generalized event occurring throughout the Mediterranean Sea and is driving this species towards extinction (confirmed cause: combined pathogen infection). However, there are other species that may be thriving under environmental change, as seems to be the case for eurythermal sea anemones of the *Aiptasia* genus in the eastern Mediterranean, likely posing a risk to the community equilibrium. Also, the significant decline of ecologically important habitat forming species, namely coral banks, due to temperature induced bleaching and dredging activities was reported in the South Adriatic and Central Mediterranean. Adding up to this, grazing regimes of habitat forming macroalgae beds are being altered due to increasing herbivory by sea urchins, leading to physiological stress of algae and decreasing their ability to cope with other stressors, putting the entire ecosystem at risk of a phase shift.

The debate identified the urgency of creating refuge/sanctuary areas for particularly vulnerable species (e.g. high salinity areas seem to protect *Pinna nobilis* from pathogen infection), as well as to study resilient individuals at the genetic and phenotypic level to then apply this knowledge in developing assisted-evolution programs for population re-stocking in the wild. We need to learn from the past through the fossil record and combine that information with novel high throughput methodologies such as genomics, to keep a continuous track of species susceptibility to different stressors. Another priority is the development of ecological observation and forecasting systems to help us determine the future course of action concerning conservation strategies and food security in the Mediterranean. The top ocean stories from the Atlantic last year – from the largest seagrass recovery ever recorded in the world at the Chesapeake bay after cutting nutrient pollution for the past three decades, to the creation of the first zero emission zones at sea in Norway fjords, to the implementation of the largest marine protected area in the Atlantic ocean around Ascension Island, are showing us by example the three elementary ingredients for successful biodiversity conservation: a solid scientific background, a pioneering spirit and political will. Adding international cooperation to this recipe will assist us in turning local and regional efforts into a common global goal: the protection of our oceans and seas.



OCCURRENCE OF CORALS BLEACHING IN TUNISIAN WATERS (CENTRAL MEDITERRANEAN)

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Abstract

Disturbance of the symbiosis between coral hosts and zooxanthellae resulting in bleaching of stony corals. This event was related to environmental stimuli especially sea water temperature increase. During surveys carried out eastern Tunisia, the corals *Cladocora caespitosa*, *Astroides calycularis* and *Oculina patagonica* showed signs of partial and total bleaching. Extent of injury was 0.25 ± 0.41 SD for the 2868 colonies of the orange coral *Astroides calycularis* with an average lesion extent of less than 10%. Coral bleaching and necrosis observed in this study could be a preliminary baseline to assess future changes of Tunisian populations and highlight an early warning system for the conservation of corals at Mediterranean scale.

Keywords: Mortality, Mediterranean Sea, Cnidaria, Global change

Introduction In the last 30 years, bleaching events caused a decline in corals. This phenomena is a stress response resulting in a loss of corals pigmentation or zooxanthellae. This event was correlated to thermal anomalies [1]. The occurrence and intensity of such events are expected to rise as sea surface temperature continues to increase under global warming [2]. A study in Australasia, Indian Ocean, Pacific Ocean and Western Atlantic, reveals that the interval between persistent severe bleaching events has reduced fivefold in the past four decades, from once every 30 years in the early 1980s to once every 5.9 years in 2016 [3]. In NW Mediterranean, similar observations were made particularly in the 1999 and 2003 events which have affected many species and led to an extensive coral bleaching [4]. There is a knowledge gap in southern Mediterranean coasts about the occurrence of corals bleaching and the main goal of this work is to provide an available data about this phenomena in Tunisian waters.

Materials and Methods During a scientific scuba diving survey conducted in 2017 at Haouaria locality (Eastern Tunisia), bleaching of three coral species was observed. Colonies were photographed and identified. Estimation of the extent of injury per colony was made for only one species by analyzing 128 (25*25 cm) photo-quadrats. Based on the presence/absence of epibionts, three types of injury were described; Type A: denuded polyps, indicating a recent necrosis; Type B: colony overgrowth by pioneer species; Type C: presence of several species and/or slow growing epibionts showing an old injury.

Results and Discussion Bleaching was detected on *Cladocora caespitosa*, *Astroides calycularis* and *Oculina patagonica* populations (fig.1).

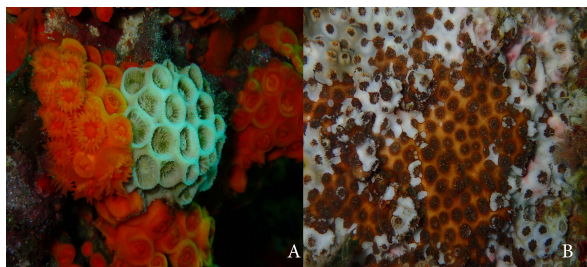


Fig. 1. Bleached colonies of A: *Astroides calycularis*; B: *Oculina patagonica* at Haouaria locality

2868 colonies of *Astroides calycularis* were analyzed within 128 photo-quadrats. Mean percentage of extent of injury was 0.25 ± 0.41 SD and all

studied populations have an average lesion extent of less than 10%. Most affected colonies showed signs of partial mortality due to recent necrosis of polyps. Bleaching event is more frequent in last decades. Among affected species, *C. caespitosa* had previously suffered severe bleaching during 1997–1999 and 2003. In fact, this species is living under its thermal limit during summer, which could be fatal for this coral [4,5]. Nevertheless, *O. patagonica* can bleach rapidly without showing tissue necrosis and due to its rapid capacity of bleaching, this scleractinian seems to be more resistant to high temperatures [6]. Experiments on *A. calycularis* have shown that under stress conditions (elevated T°), the species presented a decrease in calcification rate [8]. Bleaching is very irregular, in fact, a presence of bleached and unbleached corals was frequently encountered in the same population. This could be explained either by differences in abiotic factors or phenotypic or genetic variations between corals and their symbionts [7]. Under the present warming, bleaching could generate a harsh deterioration of coral populations. Additional studies are necessary to provide a better knowledge of the aptitude of Mediterranean coral species to recover from thermal stress and possibly acclimatize to it.

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REEF-LIKE STRUCTURE OF THE CORAL *CLADOCORA CAESPITOSA* (LINNAEUS, 1767)(ANTHOZOA, SCLERACTINIA) IN THE SOUTH ADRIATIC SEA (MONTENEGRO, CAPE JAZ)

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Abstract

Coral banks in the Mediterranean Sea are very rare and here are presented some basic characteristics of the *C. caespitosa* bank in the South Adriatic, Montenegro, cape Jaz. Unfortunately big part of the coral bank is not in good condition and most probably because of the human impacts.

Keywords: *Cnidaria, Adriatic Sea, Zoobenthos, Bio-indicators, Conservation*

The coral *Cladocora caespitosa* (Linnaeus, 1767) is the only zooxanthellate coral in the Mediterranean Sea that creates reef formations [1]. The colonies of *C. caespitosa* occurs in two ways: 1) a great number of distinct subspherical colonies (10-30cm) living more or less close to each other („coral bed“) and 2) large formation of connected colonies reaching some decimetres in height and covering several square meters in surface area („coral banks“) [1, 2]. Coral beds are known from different localities in the Mediterranean, while coral banks are rare and they were more abundant during the Pleistocene. Compared to its fossil distribution the present geographical range of *C. caespitosa* is decreased and further regression could be related to climate change and human impact [3].

One of the largest *C. caespitosa* banks in the Mediterranean Sea, is situated in the Adriatic Sea, on Mljet island, while further on the north are three smaller ones (Lim channel, Prvic, Pag) [2]. In the South Adriatic, more precisely in the Boka Kotorska Bay, big population of *C. caespitosa* was reported by Stjepcevic and Parenzan [4], but it looks that is now in recession phase. Here are presented basic characteristics of the *C. caespitosa* bank in South Adriatic that was not known so far.

The coral bank at the cape Jaz (Fig. 1) was investigated by SCUBA diving in September 2018. Coral bank was mapped using transect tapes. Mean number of corallites per colony was estimated from the photographs by counting the number of corallites in 15 replicated squares 5 x 5 cm. For the estimation of corallite growth bands of low and high density which represent 1 year were measured. For that purpose several corallites were collected, cleaned in 30% hydrogen peroxide and x-radiographed.



Fig. 1. *C. caespitosa* coral bank at cape Jaz, Montenegro, South Adriatic Sea

Coral bank at cape Jaz is situated on 23 m depth surrounded by horizontal sandy bottom, while on the western side and closer to the coast is *Posidonia oceanica* meadow. Main colony formation is 22 m long and 2 to 7 m wide, orientated almost in the north-south direction, parallel to the coast of cape Jaz. The estimation of the overall surface covered by coral bank and coral bed

reached 70 m². Number of corallites per colony in 25 cm² was 74.9 ± 9.9 which is slightly less than reported for the Adriatic Sea [2]. The mean corallite linear growth rate was 3mm/year.

Southern part of the coral bank (about 25 m²) is in better condition and here is located the biggest „satellite colony“ more than 1m wide, with the fusion in the central part. On the northern part there are much more remains of broken colonies overgrown by boring and other organisms. Some segments are almost completely dead and although there are many small colonies on few of them bleaching is evident, but in some parts necrosis of coralites is 100%. Unfortunately we don't have data from previous periods, but we can speculate that negative impact on this coral bank was caused by human impact. More precisely, 2 ditches for electrical cables were dug up on the northern side and first one is just about 25 m distant from the coral bank. Could be that the lower transparency and higher sedimentation during this work had negative impact on *C. caespitosa*. Another reason could be high seawater temperature (24.2°C) on the end of summer, but further, more detail analysis are needed.

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MASS MORTALITY OF THE FAN MUSSEL *PINNA NOBILIS* IN APULIA (IONIAN SEA) CAUSED BY *HAPLOSPORIDIUM PINNAE*

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Abstract

In August 2018 a mass mortality of *Pinna nobilis* was registered in the Taranto seas. Histological and molecular analyses lead to consider a strong aetiological relationship between the mortalities recorded in Spain and the Italian ones, with the organs of the investigated specimens infected by different developmental cell stages elements very similar to *Haplosporidium pinnae*.

Keywords: Mortality, Conservation, Bivalves, Ionian Sea, Mediterranean Sea

Introduction

Since the autumn 2016 a mass mortality of *Pinna nobilis* is going on in the Mediterranean. The cause of this event is the infection of a protozoan parasite, recently described as *Haplosporidium pinnae* [1]. In Taranto seas (Southern Italy, Ionian Sea), during the last 10 years a huge recovery of fan mussel populations was observed due to the severe regime of protection [2,3]. Starting from the early summer of 2018, more and more individuals were found dead. More than 3,000 specimens were observed in the area between July and August, very few of them still alive in some zones of the Mar Piccolo of Taranto.

Study area and Methods

The Mar Piccolo comprises two small basins, namely First and Second Inlet and has features typical of an estuarine area, with some little rivers and more than 30 submarine springs erogating brackish water, some of them with important outflows. During August 2018 three specimens in an apparent state of suffering were collected in the Second Inlet of the Mar Piccolo. They were immediately transported to the Laboratories for the investigations. The cytological examinations were carried out on digestive gland smears stained with Hemacolor (Merck), whereas samples from the foot muscle, mantle, gills and digestive glands were fixed in 10% buffered formalin for histopathology. The tissue sections were deparaffinized, stained with Harris hematoxylin and eosin and finally examined under an optical microscope. Genomic DNA was extracted from the organs (digestive gland, adductor muscle and mantle) using the GeneEx <https://www.pcr-lab-products.com/genomic-dna-purification/genex-blood-cell-tissue-kit/> Blood, Cell and Tissue (GeneAll). DNA samples were submitted to specific polymerase chain reaction (PCR) to amplify about 300 bp region of the small subunit ribosomal of *Haplosporidium* spp. using *HapF1* and *HapR2* primers [4].

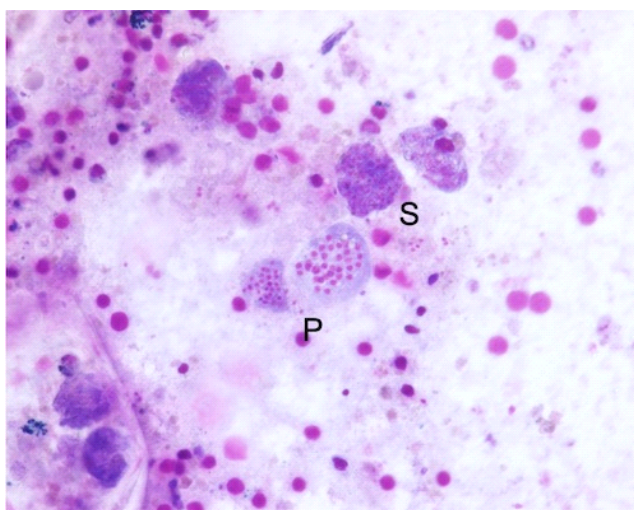


Fig. 1. Digestive gland cytology of one of the specimens collected in the Mar Piccolo of Taranto: plasmodial forms (P) and sporocysts containing sporoblasts (S)

Results and Discussion

At necropsy exam a generalized emaciation with a darkish and softer digestive gland was appreciable even if no signs specifically indicating the infection were present. The smears images evidenced the presence of mononucleate and binucleate cells together with multinucleate plasmodial forms and sporocysts. Histological examination of the sections confirmed that in all the specimens the digestive glandular tissue and the mantle had been infected by different developmental cell stages elements very similar to *Haplosporidium pinnae*, described as the causal agent of *P. nobilis* mortality [1]. All the samples subjected to the PCR produced amplicons. In addition, sequence analysis of amplicons showed the closest sequence homology (98%) with *Haplosporidium pinnae* (Accession number LC338065.1). The sequence was deposited in GenBank under accession number MK393389.1. Marine bivalve mollusks may be affected by numerous infectious diseases sustained by viruses, bacteria and protists, which are responsible for mortality outbreaks and have a substantial commercial impact on the farmed mollusks [5]. The obtained results lead to consider a strong aetiological relationship between the mortalities recorded in Spain and the Italian ones. The *P. nobilis* mass mortality, observed firstly along the Mediterranean Spanish coasts and spread up to Tyrrhenian, Ionian and Northern Aegean Sea, appears to show some difficulties to rise to the North along the Adriatic Apulian coast, probably due to the opposite North-South currents: unofficial informations, indeed, report no evidence of fan mussels mass mortalities along the Adriatic Apulian coasts. Considering the *P. nobilis* high ecological role and the related protected status, actions should be planned to defend and preserve the species; strategic topics will have to be considered as: a) definition of the exact infection spreading mechanism; b) biological and molecular characterization of the aetiological agent; c) identification of the factors, linked to the environment and to the mollusc as well, able to trigger or enhance the infection severity; d) discovering of possible natural refugia, where *P. nobilis* shows to be less susceptible to the infection, useful to setting up restoration actions; e) promotion of the engagement of citizen scientists in the data collection.

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PINNA NOBILIS IN THE NE AEGEAN SEA - THE POPULATION COLLAPSE OF AN ENDANGERED SPECIES

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Abstract

A mass mortality outbreak has eradicated *Pinna nobilis* populations over most parts of the Mediterranean Sea within only two years. We investigated the population status of *P. nobilis* in Gera Gulf (Lesvos Island, NE Aegean Sea), where one of the largest populations recorded in Greece was known to thrive until recently. Underwater visual surveys revealed a mortality rate of up to 100%, while molecular analyses rendered the parasite *Haplosporidium pinnae* as the primary suspect of the mortalities.

Keywords: *Mediterranean Sea, Mortality, Bivalves*

Pinna nobilis Linnaeus, 1758 is an emblematic Mediterranean endemic species and one of the largest bivalve molluscs in the world, reaching a maximum length of 120 cm and a life span of 45 years. Although it has been assigned a strict protection status according to several national and European regulations, its populations are still exposed to numerous stressors, especially poaching, mechanical damage and habitat destruction [1]. Since autumn 2016, a new threat has taken its toll on *P. nobilis*. A large scale mass mortality event (MME) that was originally detected off the Spanish coasts in the western Mediterranean [2], has rapidly spread throughout most parts of the basin, and has wiped out a great part of fan mussel populations. In 2016–2017 no evidence of unusual mortalities had been reported in the eastern parts of the basin, but by late spring 2018 anecdotal information from Cyprus and the Aegean Sea indicated that the wave of mortalities was already affecting *P. nobilis* in the region.



Fig. 1. Stranded dead fan mussel shells in Lesvos Island after the 2018 mass mortality event (photo by S. Katsanevakis, February 2019).

To verify unofficial reports and investigate the potential causes and effects of the MME in the Aegean Sea, we assessed the health status of *P. nobilis* populations around Lesvos Island (Fig.1), with a particular focus in Gera Gulf, an area that was recently estimated to support the largest *P. nobilis* population recorded in Greece to date (~ 215.000 individuals in 2016 [3]). Repeated underwater visual surveys were conducted during September and December 2018 in three selected sites of highest population abundance (0.093-0.108 ind/m² [3], Fig. 2), over a depth range of 2-5 m. Surveys involved the counting of all live, dead and moribund (i.e. displaying a delayed valve-closing reflex [2]) individuals, within a time frame of 60 minutes. Only individuals that were assumed to be dead for less than a year were considered, based on the level of fouling. Moreover, one healthy and two moribund individuals were collected in order to check for the presence of the parasite *H. pinnae* in the muscle, byssus gland, digestive gland, gills, mantle and gonads of sampled specimens through PCR amplification and sequencing of small subunit ribosomal DNA (SSU rDNA) gene [4].

Field surveys during early September 2018 indicated a mortality rate of 91%, 99% and 100% in the three sampling sites, while by December 2018 all sites had 100% mortality. DNA analysis of most tissue samples (apart from the gonads of the healthy individual) gave positive PCR results, and all sequences had 100% similarity with the only available record of *H. pinnae*

SSU rDNA gene [4]. This study provides direct evidence on the collapse of one of the largest *P. nobilis* populations recorded in Greece so far within less than one year, and points to *H. pinnae* as the primary suspect of this MME in Gera Gulf.

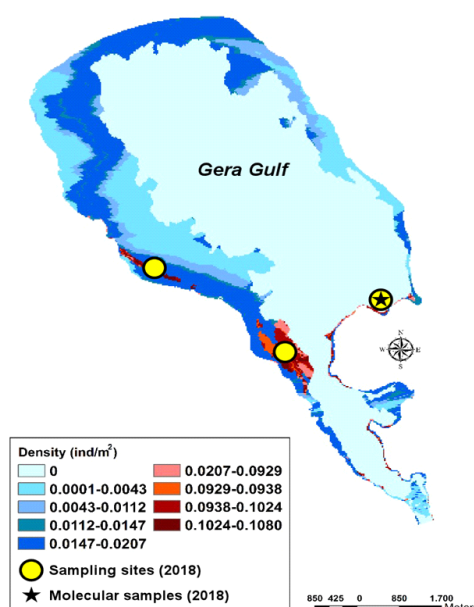


Fig. 2. Map of Gera Gulf indicating the estimated population density in 2016 [4], and the three sites sampled in 2018.

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GRAZING EFFECT OF SEA URCHINS ON HABITAT FORMING BROWN ALGAE *CYSTOSEIRA BARBATA*

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Abstract

Cystoseira spp. forms an important habitat for many marine organisms in the Mediterranean infralittoral zone. Recently, pollution, increasing seawater temperature, turbidity, coastal activities and over-grazing have all contributed to a decline in the populations of the *Cystoseira* spp. Especially in the Eastern Mediterranean, invasive alien species have become a concern. An increased number of herbivore fish and sea urchins has resulted in barren areas due to overgrazing. Although many studies aiming to understand the effects of grazing on algal forests exist, studies investigating its effect on the algal stress defense system are few. In the present study, we aim to investigate whether grazing causes a response in the algal defense mechanisms in terms of increased antioxidant enzyme (catalase, and ascorbate peroxidase) activities.

Keywords: *Algae, Mediterranean Sea, Physiology*

Seaweeds are subjected to many different types of stress, both abiotic stress factors such as temperature, light, and salinity as well as biotic factors such as pathogens and grazers. In order to survive and mitigate the negative effects of these stress factors, most of the organisms produce high levels of antioxidant enzymes and protective molecules. In order to understand the interaction between grazing stress and antioxidant defense mechanisms, we conducted an experiment where brown alga *C. barbata* was placed in an aquarium system which consisted of six tanks. Three were assigned as experimental groups (A) and the other three were control groups (C). The control group tanks only contained *C. barbata* whereas the experimental group tanks also contained sea urchins. We conducted an antioxidant enzyme activity analysis in *C. barbata* thalli on the 4th, 11th and 21st days of the experiment. CAT activity was measured according to [1]. APX activity was measured according to [2]. Both enzyme activities were expressed as a specific activity (unit mg protein⁻¹). Our results demonstrated that grazing effects of sea urchin increased the APX (Figure 1) and CAT (Figure 2) enzyme activities in *C. barbata* thalli.

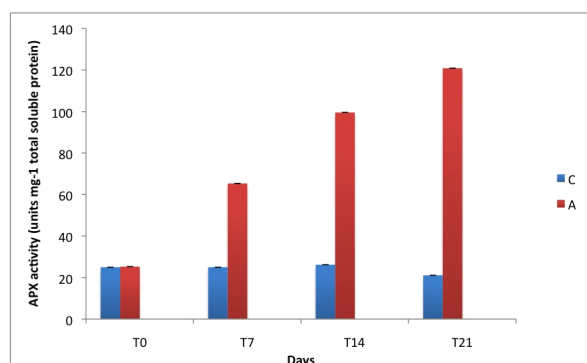


Fig. 1. The activity of APX in *C. barbata* thalli at different time periods. (T0: beginning of the experiment, T7: 7th day, T14: 14th day and T21: 21st day of the experiment; C: Control group with *C. barbata* thalli only, A: Experiment group with *C. barbata* thalli and 1 sea urchin).

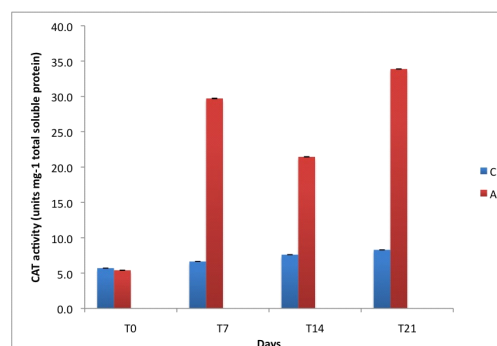


Fig. 2. The activity of CAT in *C. barbata* thalli at different time periods. (T0: beginning of the experiment, T7: 7th day, T14: 14th day and T21: 21st day of the experiment; C: Control group with *C. barbata* thalli only, A: Experiment group with *C. barbata* thalli and 1 sea urchin).

As seen in Figure 1 the APX activity increased 4.7 times at the end of the experiment compared to control group. The CAT activity represented similar results as APX with a 6.2-fold rise in the enzyme activity. Antioxidant enzymes, such as CAT and APX are involved in the removal processes of Reactive Oxygen Species (ROS) in order to diminish the oxidative stress [3] and the activity of those enzymes increase during stress conditions. It is known that big populations of sea urchins have a negative impact on algal assemblages in the Mediterranean Sea and this phenomena is also related to predator fish populations [4]. Although fish-sea urchin-algae relationships have been the subject of many studies it still merits further investigation. In order to fully explain these relationships, we tried to reveal the physiological responses of seaweeds during grazing stress. Since there is a relationship between CAT and APX enzyme activities (Fig. 1 and 2), the other antioxidant responses should be searched under grazing stress in habitat forming brown algae *C. barbata*.

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MULTIVARIATE RESPONSE OF THE THERMOPHILIC SEA ANEMONE *AIPTASIA DIAPHANA* TO PREDICTED OCEAN WARMING IN THE SOUTHEASTERN MEDITERRANEAN SEA

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Abstract

Considerable shifts in the composition and structure of ecological communities resulting from global warming are already evident and predicted to worsen in the Mediterranean Sea. Few thermophilic species are expected to benefit from those changes. In this study, we tested the impact of ocean warming on the sea anemone *Aiptasia diaphana* by exposing it to a range of temperatures between 28–36°C for 30 days. The thermal performance of *A. diaphana*, assessed by survival, habitus and asexual reproduction rates, peaked at 32°C, 4°C higher than the current summer average. While this species proliferates under current and future temperatures, many other benthic native species decline. We conclude that *A. diaphana* and similar thermophilic species may emerge as winners of the ongoing and predicted ocean warming in the southeastern Mediterranean Sea.

Keywords: Warming, South-Eastern Mediterranean, Physiology, Cnidaria

1. Introduction Recent reviews indicate the increasing footprint of climate change in the southeastern Mediterranean Sea (Levant), suggesting an average increase of about 3°C over the past three decades (Ozer et al., 2017). While an increased SST is suspected to be the cause of a significant decline of several native invertebrate species over the last decades (Rilov, 2016), some native species, due to their acclimatization potential to long term and acute thermal stress, are assumed to endure these changes and emerge as “winners” of ocean warming (Huey et al., 2012). This is because the lethal temperatures (CT_{max}) of these thermophilic species are far from the current thermal maxima in their habitats. In this study, we investigated the impact of a prolonged acute warming on an abundant benthic symbiont-bearing sea anemone of the Mediterranean Sea, *Aiptasia diaphana*, using an array of behavioral and physiological metrics to measure upper thermal tolerance performance.

2. Material and Methods During summer 2015, we assessed in a thermal outdoor mesocosm system the physiological performance of the sea anemones by measuring three response variables: survival, habitus and asexual reproduction, under four temperature levels: (i) 28°C, the average summer SST during the previous five years; (ii) 32°C, a warming scenario of +4°C according to RCP8.5; (iii) 34°C (+6°C); and (iv) 36°C (+8°C). The latter two levels were included to cover future extreme temperatures that may occur during strong heat waves. Prior to the experiment, 48 individuals of *A. diaphana* were placed in the thermal microcosm (for system description see Guy-haim et al., 2016). During the 30 days of experiment, we recorded the median lethal time (LT50) and the number of asexual pedal lacerates. Additionally, we classified changes in habitus and coloring from beneficial to highly critical (Fig. 1).

3. Results Over the course of 30 days, all the individuals that were acclimated to the average summer temperature of 28°C, as well as those acclimated to 32°C survived, whereas the median survival time for the sea anemones acclimated to 34°C and 36°C, was 30 and 10 days, correspondingly. Temperature had a significant effect on asexual reproduction, measured as the amount of produced asexual pedal lacerates (p. <0.01). The maintenance of habitus and coloring was beneficial under 28°C and 32°C, while there was a gradual deterioration in the physical appearance and severe bleaching of *A. diaphana* at 34°C and 36°C.

4. Discussion Our results show that *A. diaphana* in the southeastern Mediterranean Sea is capable of enduring acute thermal stress expected by temperatures higher than the current ambient summer average temperature in their habitat. While we observed no temperature effect on survival at 28°C and 32°C, the optimal (peak) performance of *A. diaphana* was measured at 32°C—producing more pedal lacerates and maintaining a more favorable body position and coloring, indicating symbiont presence.

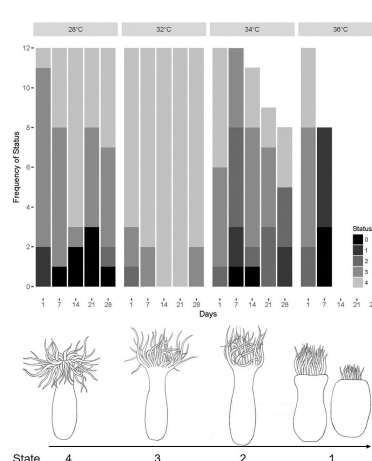


Fig. 1. Habitus states from beneficial (leftmost) to highly critical (rightmost) recorded for *Aiptasia diaphana* during 30 days.

Other thermophilic cnidarians are also known to thrive under warming conditions, and to accelerate their migration. Thus, we conclude that *A. diaphana* and similar thermophilic species may emerge as winners of the ongoing and predicted ocean warming in the southeastern Mediterranean Sea, and their abundance and distribution can be used as bioindicators for assessing these changes.

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CONFIRMATION OF A MASS MORTALITY EVENT WITHIN A *PINNA NOBILIS* POPULATION BETWEEN 2018 AND 2019 IN THE EASTERN AEGEAN SEA, GREECE

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Abstract

Pinna nobilis (Linnaeus, 1758), is the largest pteriomorphian bivalve endemic to the Mediterranean. Its endangered status has historically been linked to habitat loss, illegal fishing and anchor strikes. In the summer of 2018, underwater visual census surveys were undertaken at 11 study sites around the Greek island of Lipsi, in the eastern Aegean Sea and this estimated a mean population density of 0.34 ind/100m² in the shallow littoral zone between 0.5m – 5m depth. Of the 11 study sites, 2 sites were found to support subpopulations containing large adults, these were resampled in November 2018, with a Mass Mortality Event (MME) confirmed to have taken place at one site. Resampling in August 2019 confirmed subpopulations at both study sites had suffered 100% mortality (n=11), reflecting mortality rates recorded across the Mediterranean [1]. The cause of this MME has not been confirmed, however the rapid nature, severity and proximity to other MMEs of this species [2] suggest that pathogens may have been the causative agents. Considering the already vulnerable status of *P. nobilis*, this highly alarming rate of mortality raises concerns for the future survival of the species.

Keywords: *Pinna nobilis*, Mass Mortality Event, Eastern Aegean

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CIESM Congress Session : Climate-related events
Moderator : Ana Machado, IDL, Univ. of Lisbon, Portugal

Moderator's Synthesis



WIND EPISODES FAVOURING FLOODING OF THE ADRIATIC COASTLINE IN FUTURE CLIMATE

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Abstract

Flooding of the Adriatic coast is mainly induced by strong southerly wind episodes. This phenomenon in Venice is known as *acqua alta*. Here we studied threatening wind episodes using simulations of three Regional Climate Models (RCMs) to identify possible changes of their characteristics in future climate. It was shown that there is a small probability that frequency, intensity and annual cycle of these episodes will change in future climate. The result was robust and consistent according to all considered criteria – used RCM model, boundary conditions, climate scenario and future time interval.

Keywords: *Adriatic Sea, Wind, Sea level*

Storm surges, the dominant process in the Adriatic floods, are caused by Mediterranean cyclones crossing the area most frequently in late autumn and winter. Synoptic conditions responsible for flooding are well known [1]: air-pressure gradient over the Adriatic accompanied by wind of southeasterly to southwesterly directions. If the storm surge positively overlaps with other sea-level contributing processes (low-frequency variability, tide and pre-existing seiche) it can cause extreme sea-level rise in the Northern Adriatic. Storm-surge rise is mainly induced by wind forcing, hence only wind field was examined.

In this study we investigated impact of climate change on the Adriatic threatening wind episodes. Analysis was carried out using near-surface wind simulations of three RCMs (ALADIN52, RCA4 and RegCM4) in historical (1970–2000) and future (2041–2100) climate for two climate scenarios (RCP4.5 and RCP8.5). The ERA-Interim 10-m wind and sea-level residuals at stations Venice and Bakar (1984–2014) were used to calibrate algorithms for extraction of wind episodes. Wind episode was defined as wind field with minimum average speed of 10 m/s and direction raging from eastern to southwestern, over 70% of the Adriatic area. Statistical significance of differences between future and present wind characteristics was determined by Wilcoxon-Mann-Whitney test (WMW, [2]).

Considering ERA-Interim wind and residual sea levels in the Adriatic, it was shown that all of the extracted wind episodes are not concurrent linked with high sea levels. This is because formation of extremes is not exclusively determined by actual meteorological situation, but also by preceding conditions. It was demonstrated that existing sea-level state, induced by processes at different temporal and spatial scales (planetary waves and pre-existing seiches) can have important role in formation of final height of sea level (not shown).

Considering the wind frequency in the historical climate from the three RCMs (Fig. 1, left), evidently there are differences between the model's climatologies. ALADIN52 and RCA4 give similar yearly number of episodes (7–11), while RegCM4 exceeds it by factor 2. Comparing distributions in present and future climate, it is obvious that there are no significant differences between them – WMW test showed that only one future realisation significantly deviates from its pair in the present climate. Simulations with all three RCMs forced with different Global Climate Models (GCMs) give consistent results. The signal is robust under all criteria – it does not depend on regional or global model, possible climate scenario or future time interval (mid and late 21st century). The same conclusions were derived for wind velocity and annual cycle (not shown). The results agree with similar research based on sea-level simulations (e.g. [3]), however previous studies were built on a small number of criteria and therefore their results can be significantly influenced by outliers.

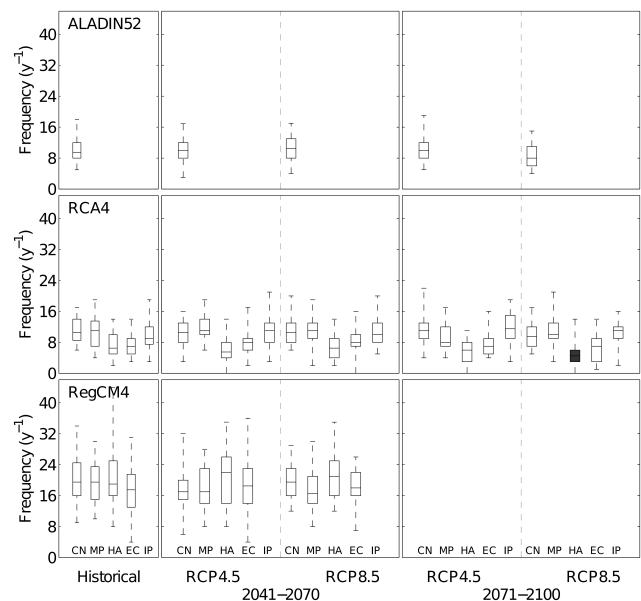


Fig. 1. Wind-episode frequency for simulations with three RCMs in present and future climate. Filled symbols stand for simulations significantly different (95% significance level) from those in historical period. At the bottom are shown GCMs used for simulations with RCMs: CNRM-CM5 (CN), MPI-ESM-LR/MR (MP), HadGEM2-ES (HA), EC-EARTH (EC), IPSL-CM5 (IP).

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SEMI-EMPIRICAL ANALYSIS AND PROJECTION OF THE MEDITERRANEAN SEA LEVEL

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Abstract

Two variants of the semi-empirical method are used to analyze and project the Mediterranean sea level. The first variant connects regional sea levels to regional temperatures whereas the second variant is based on decomposition of regional sea levels into mass-related component connected to global temperatures and steric and atmospherically-driven component connected to regional temperatures. The projections obtained under the RCP4.5 scenario are widely spread when computed with the first variant and they stay close when computed with the second variant. It is therefore concluded that some of the results of the semi-empirical method could provide a useful complement to those obtained by applying the process-based method to the region.

Keywords: Sea level, Mediterranean Sea

Sea level rise is one of the most worrisome consequences of global warming. In the analysis and projection of sea level, two dynamic methods are commonly used: the process-based one and the semi-empirical one. Both are extensively applied on a global scale [1]. When it comes to the regional scale, the process-based method appears to be more popular, but the semi-empirical method could also be useful providing that it is carefully adapted to regional conditions.

Here we apply two variants of the semi-empirical method to the Mediterranean Sea. They allow for both inertial and equilibrium response of sea level to temperature forcing. The first variant simply connects regional sea levels to regional temperatures, which is acceptable if regional temperatures are linearly related to global temperatures and if regional response times are similar to global response times. The second variant separately connects mass-related global sea levels to global temperatures and regional sea levels, from which mass-related contribution is subtracted, to regional temperatures. The variants are calibrated using global temperature data [2, with updates], global sea level data [3], regional temperature data [2, with updates] and regional sea level data [4]. It is assumed that about 50% of the global sea level change was mass-related in the past [5]. The controlling parameters are computed in two ways (C1 and C2), by fitting exponential functions and cosines to the time series [6] and by performing two-to-one orthogonal regression analysis of the data [7].

Meaningful parameters are obtained for the West Mediterranean and Adriatic Seas. Consequently, sea level projections are computed for the two basins, using global and regional temperature projections prepared under the RCP4.5 scenario [1,8]. The results are depicted in Fig. 1. They show that sea level projections spread widely if the first variant of the semi-empirical method is used and that the projections stay close if the second variant is utilized. Obviously, the global data are of better quality than the regional data and it is useful if the regional projections are at least partly guided by the global projections. The figure also shows that the mass-related contribution to the regional sea level is similar to or even slightly larger than the steric and atmospherically-driven contribution. The results obtained for the Mediterranean Sea with the second variant of the semi-empirical method are encouraging and therefore could provide a useful complement to the process-based method as applied to the region.

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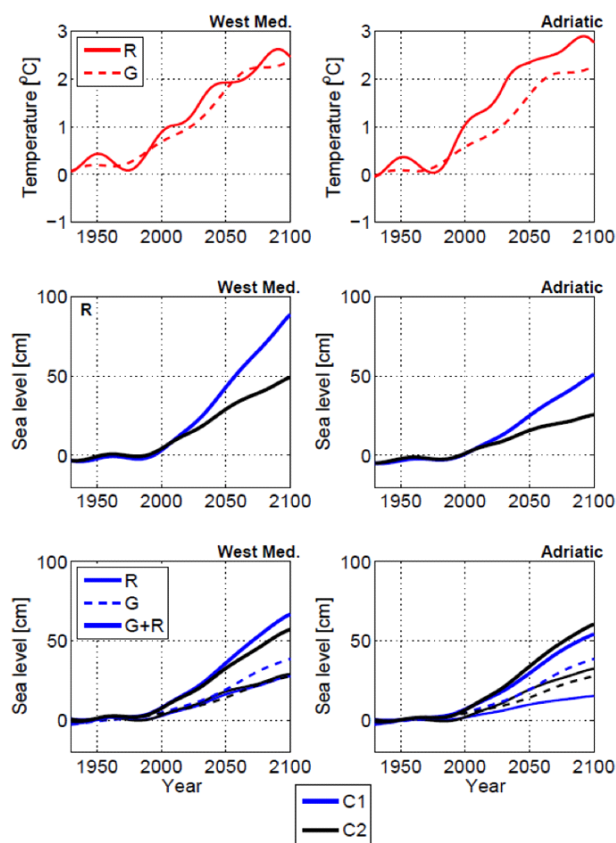


Fig. 1. Temperatures (top), sea levels obtained with the first variant of the semi-empirical method (middle) and sea levels obtained with the second variant of the semi-empirical method (bottom) for the West Mediterranean Sea (left) and the Adriatic Sea (right). Time series represent observations prior to the year 2009 and projections under the RCP4.5 scenario after that year. G indicates global time series (top) or global contribution to the time series (bottom) whereas R indicates regional time series (top, middle) or regional contribution to the time series (bottom). C1 and C2 denote two ways of computation of controlling parameters.

SPATIAL VARIABILITY OF PYCNOCLINE IN THE SPRINGTIME EAST ADRIATIC

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Abstract

High-resolution CTD data and currents from vessel-mounted ADCP obtained during two spring cruises along a vertical cross-section over the Middle Adriatic Pit are analyzed. The two cruises occurred under different meteorological and hydrological conditions, resulting in significantly different distributions of hydrographic properties as well as current profiles. Strong coastal upwelling, driven by NW winds, is documented during the first cruise, with pycnocline doming by about 20 m in the region extending to some 20 km from the coast. During the second cruise, under mild wind conditions, the pycnocline was rather flat and the current field in accordance with the typical cyclonic Adriatic circulation along the eastern coast.

Keywords: *Density, Currents, Upwelling, Adriatic Sea*

During two oceanographic cruises (C1, 24-28 May 2017 and C2, 4-8 June 2018) in the Middle Adriatic, in the area between the islands of Blitvenica and Jabuka, a CTD probe fixed to the towed undulating platform was used to obtain quasi synoptic, high-resolution (vertical ~10 cm, horizontal ~200 m) measurements of temperature, salinity and density. Simultaneously, the vessel-mounted ADCP measured currents between 10 and 70 m depth (bin size 4 m), while the ship meteorological station measured wind speed and direction. Additionally, classical measurements with CTD probe were done at several stations. Here we analyze high resolution measurements done along vertical cross-section, which starts at the eastern coast close to the town of Primosten and stretches across the Adriatic in the SW direction. During both cruises the ship followed nearly the same route, except that in C2 the cross-section extended further offshore and was deeper (Fig. 1).

During the C2 cruise, the upper layer (from surface to some 25 m depth) was found to be much warmer and fresher than during the C1 cruise, while at larger depths the conditions were similar during the two cruises. Higher heat content in 2018 could be partly attributed to the fact that C2 was performed somewhat later in the course of year. The lower salinity in June 2018 was related to wet conditions prevailing from autumn 2017 to spring 2018. Moreover, in contrast to 2017, when salinity minimum was localized close to the coast, in 2018 the low salinity layer extended far offshore.

The striking feature in the vertical density profile is a strong signal of upwelling during the 2017 cruise, seen as doming of the pycnocline by some 20 meters, and extending from the coast to about 20 km offshore. This pattern is clearly traced in the temperature field, as well. Such conditions could readily be related to strong NW wind that was blowing for several days before and during the C1 cruise. On the other hand, the C2 cruise was preceded by mild winds from northern directions resulting in a rather flat pycnocline, except in the first ~10 km close to the coast where the pycnocline was rising onshore.

The currents measured by vessel-mounted ADCP indicate different circulation regimes during the two cruises. During the C1, the inflowing currents, as part of the East Adriatic Current [1], were limited to the first ~10 km from the coast. Further offshore the wind dynamics dominated, with downwind flow in the upper layer and counter-currents below. The currents during the C2 cruise were in accordance with the general cyclonic circulation in the Adriatic.

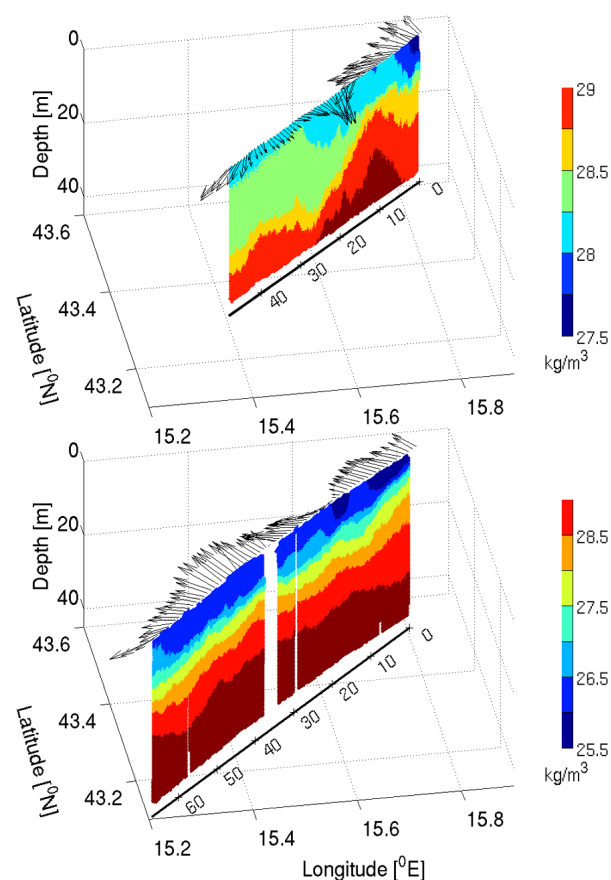


Fig. 1. The density anomaly along the Middle Adriatic cross-section measured on 28 May 2017 (cruise C1, upper panel) and on 06 Jun 2018 (cruise C2, lower panel). Note that the density scales are different. Arrows denote the currents measured by the ship-mounted ADCP. The currents are plotted at the surface, although they correspond to the 10 m depth. The maximal velocity is ~0.3 m/s. Numbers below each transect depict the distance in km.

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TEMPERATURE VARIATIONS AT TWO OUTSTANDING HABITATS IN THE OPEN MIDDLE ADRIATIC

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Abstract

Temperature time series at two sites, Jabuka and Blitvenica, which are situated at the edge of the Jabuka Pit are analyzed to identify processes that may drive vertical transport of nutrients and thus support the outstanding richness and composition of vegetation present there. These processes occur at several temporal scales. Seasonal warming at both sites, especially at Blitvenica, between June and August is overruled by cooling, indicating that, albeit interannual variability, the upwelling there is a semipermanent summer feature. Large diurnal temperature oscillations at Blitvenica reveal the impact of the tides and land-sea breeze circulation, while at Jabuka near-inertial oscillations are the dominant source of high-frequency variability.

Keywords: *Temperature, Upwelling, Adriatic Sea*

In this study we analyze temperature oscillations and variations at two islets, Jabuka and Blitvenica, both situated at the steep edge of the Jabuka Pit of the Middle Adriatic. They are known for exceptionally abundant benthic vegetation, in contrast to oligotrophic conditions that prevail along the offshore islands of the eastern Adriatic. This suggests that these are sites of intense vertical motions through which large amounts of nutrients are supplied from deeper layers to close to surface. In satellite images [1] during summer clearly visible is a tongue of colder-than-ambient water that stretches from the coast towards the open sea overlaying the Jabuka Pit. Such patches of cold water can be related to bora-induced coastal upwelling [2]. On the other hand, at Lastovo (Southern Adriatic) strong vertical mixing occurs on a daily scale due to island trapped waves that are resonantly driven by land-sea breezes and tides [3]. Our aim is to identify the processes that may drive vertical transport of nutrients at the edge of the Jabuka Pit and thus support the outstanding habitats there.

In order to study environmental conditions at Jabuka and Blitvenica temperature was measured continuously during several intervals lasting from one to three years, using small data loggers (HOBO Pendant Temperature/Light). The instruments were fixed at one or two depths between 10 and 20 meters and the data were sampled at a 15-min interval.

The time series (Figure 1) show that at Blitvenica, and to a lesser extent at Jabuka, seasonal warming is strongly suppressed. Moreover, the pronounced cooling at Blitvenica (3 to 5 °C) that takes place from June to August indicates that, although there is interannual variability, the upwelling there is a semipermanent summer feature induced by the etesian winds. Superimposed on the seasonal changes are high frequency oscillations. These are more energetic at Jabuka than at Blitvenica. Spectral analysis shows that at Jabuka the largest variability is induced by near-inertial oscillations and during intense episodes the temperature changes periodically by some 7°C. At Blitvenica, however, the largest variability occurs at diurnal frequency. It can be due either to diurnal tides or to periodic winds. Wavelet spectra of the temperature and of tidal sea level at Split suggest that the diurnal temperature changes at Blitvenica, which can reach 5°C, are not on all occasions related to the tides.

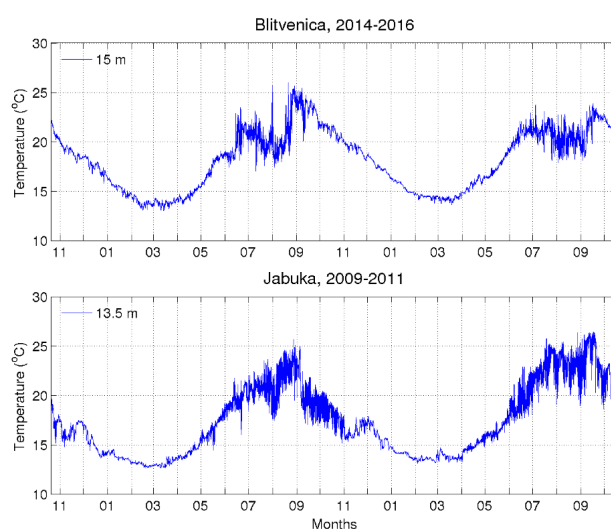


Fig. 1. Temperature time series at Blitvenica (top) and Jabuka (bottom) at 15 m and 13.5 m depth, respectively, during the selected 2-year intervals.

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COMITÉ 1
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**Géosciences marines**

*Président* : Silvia Ceramicola



**CIESM Congress Session : Paleoceanography**  
**Moderator : Fatima Abrantes, IPMA, Lisbon, Portugal?**

*Moderator's Synthesis*

Paleoceanography is an integrated way of looking into the ocean and climate of the past, of evaluating the impact of external and atmospheric greenhouse gases (e.g. CO<sub>2</sub>) forcing on the Earth system during climate states without human influence. This turns former Earth system states into the only possible models for the warming world of the coming decades.

This Congress session was very varied in terms of both temporal and spatial coverage, from the actual calibration of proxies on the Western Iberian Margin to a new model for the formation of the Messinian Salt deposits in the Mediterranean Sea. Several presentations pinpointed the importance of the S and SW Portuguese margin records to better reconstruct the variability in Mediterranean Water production and export to the Atlantic as well as its connection to global climate.

Clear collaboration between Mediterranean and Atlantic oriented researchers is already a reality which will be continued and fortified through IODP (International Ocean Discovery Program) and ICDP (International Continental Scientific Drilling Program) expeditions, either approved or submitted, to drill on either side of the Gibraltar strait and both on land and in the Ocean.



# DIAGENESIS OF CARBONATES CORRESPONDING TO EPISODIC SEA LEVEL CYCLICITY: MERSA MATRUH, MEDITERRANEAN COAST OF EGYPT.

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## Abstract

Sea level cyclicity is considered to be an important factor in the construction of the ancient Mediterranean shorelines. The existence of the successive carbonate ridges parallel to the Mediterranean shoreline of Egypt verifies their formation in the receding Mediterranean Sea during the Pleistocene. Petrographic study of Mersa Matruh Late Pleistocene coastal formation confirms its marine origin, while the presence of the alternating ooids and eolianite layers signifies the prevalence of varying environmental conditions associated with sea level cyclicity. The conceptual model developed in this study shows that Mersa Matruh formation deposition cycle was influenced by a “Transgressive phase”; generated the ooids formation, interrupted by the “Regressive Phase”, where eolianite deposits influenced the sedimentary environment.

**Keywords:** *Mediterranean Sea, Sea level, Paleoceanography, Rocky shores*

The Mediterranean northwestern coast of Egypt is characterized by the presence of a series of successive nine elevated emerged and submerged Quaternary carbonate ridges separated by eight depressions, some for about 100 km, parallel to the present shoreline (Figure 1).

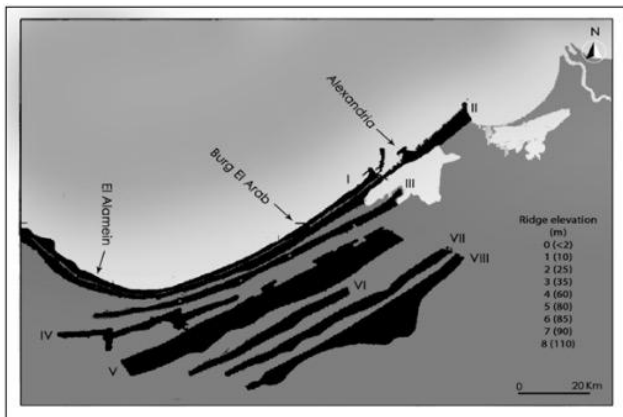


Fig. 1. The location of Quaternary carbonate ridges along the Northwestern coast of Egypt, after Butzer (1960).

Different hypotheses concerning the process/origin of these ridges have been developed both structurally and diagenetically and signify their eolianite non-marine, mixed marine-eolianite, marine and tectonic origin. The petrographic composition and diagenesis of carbonates could provide useful information on past climate and sea-level changes (Pascucci et al., 2014).

Diagenetic and petrographic study has been carried out according to Milliman (1974). Petrographic analysis of Mersa Matruh Late Pleistocene coastal formation, 300 Km west of Alexandria on the NW Mediterranean coast of Egypt, confirms its marine origin; however, mixing eolianites are marked by the occurrence of terrestrial clastic materials. Skeletal (invert thalli of calcareous plants, algae, foraminifera, echinoderms spines and mollusks “gastropods” or “bivalves”) or non-skeletal (ooids and peloids), matrix, cement and grains pore spaces are the main carbonates fabric components of Mersa Matruh formation. Ooids are confined only at certain layers of the formation. The existence of the identified alternating ooids and non ooids layers could be interrelated to distinctive climatic and environmental conditions. Well-developed ooids (true ooids) are hardly identified, while superficial and partially degenerate ooids are common.

A conceptual model of deposition and diagenesis of Mersa Matruh formation in association with sea level cyclicity is shown in Figure 2. The model revealed that the deposition cycle in Mersa Matruh nearshore area was influenced by the

transgression of the sea “Transgressive phase A” interrupted by episodic cycle of sea level presumably coupled with favorable conditions that allow the precipitation of ooids. Consequently, the first/lowermost ooids unit was formed. Recurrent cycles have been demonstrated by the formation of two other alternative ooids layers “the second/middle unit and the third/uppermost units of ooids”. During the sea regression “Regressive Phase B”, eolianite clastic terrestrial deposits influence the sedimentary environment. Diagenetic process took place during the different phases and was manifested in the dissolution, cementation, micritization and recrystallization.

The model helps in drawing the possible impacts of climate and sea-level variations during the Quaternary influencing the petrographic composition of the coastal deposits. Transgression was related to warm and dryer climatic phases, resulted in increased production and accumulation of ooids. The model further speculates on the conditions that may have led to the formation of ooids.

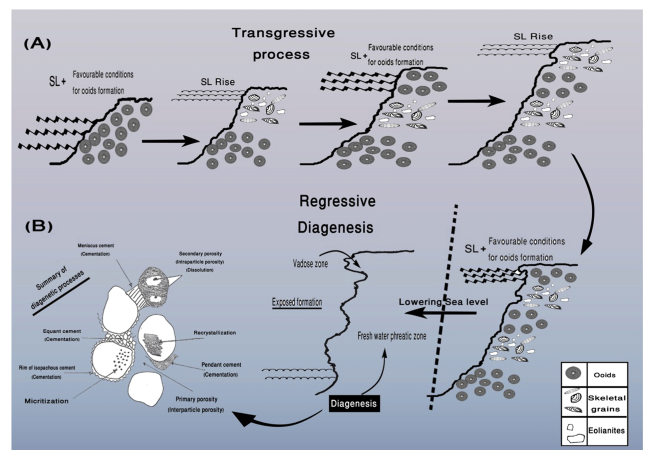


Fig. 2. Conceptual model of carbonates composition and diagenesis of Mersa Matruh formation in relation to cyclic sea level changes.

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# NEOGENE HIATUSES AND PALEOCIRCULATION OF THE IOFEE CONTOURITE DRIFT (SW ATLANTIC)

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## Abstract

The Ioffe Drift located in the Antarctic Bottom Water pathway from the Vema Channel to the Brazil Basin provides a suitable site to study past variations in bottom currents. Our multi-proxy biostratigraphic, magnetic susceptibility (MS), color reflectance and X-ray fluorescence (XRF) data from three sediments cores documented the stratigraphic sequence of the uppermost part of the sedimentary cover ranging from the recent through upper Pliocene. The reduced thickness of biostratigraphic zones and occurrence of several hiatuses indicate the intervals of enhanced bottom-water circulation, notably from 0.81 to 1.51 Ma, at ~1.9 Ma and 2.5/2.59 Ma.

**Keywords:** Western Atlantic, Deep sea sediments, Erosion, Stratigraphy, Circulation

The intensity of the Antarctic Bottom Water (AABW) production and flow to the Atlantic is known to have experienced dramatic changes through the Neogene-Quaternary time. The timing of these changes remains a key research challenge in paleoceanographic reconstructions as the AABW strongly contributes to an overall rate of the meridional oceanic overturning as well as to the shifts in lysocline and calcite compensation depths. We investigated erosional-accumulation activity of contourite currents associated with AABW and their contribution to the formation of the Ioffe calcareous contourite drift located northward of the Vema Channel. The Ioffe Drift, included into the Global contourite distribution database (Flanders Marine Institute, Ghent University, 2018), embraces a 700 m high linear SW–NE elongated ridge related to the asymmetric transverse ridge within the Florianopolis Fracture Zone in the Southern Brazil Basin, between 26° and 28°S, 900 km away from the continent. Bottom circulation on the Ioffe Drift is controlled by the upper AABW, represented by Lower Circumpolar Water (LCPW) with potential temperatures ranging from 0.2°C to 2°C. LCPW occupied the depth range from 3420 down to 4200 m. The drift is crossed by several high resolution seismic profiles acquired using the parametric echo-sounder SES 2000 deep. Three sediments cores collected along these profiles from the summit and NE slope within the water depth range 3785–3900 m are studied using the sedimentological, micropaleontological, geochemical and other proxies (Fig. 1-2).

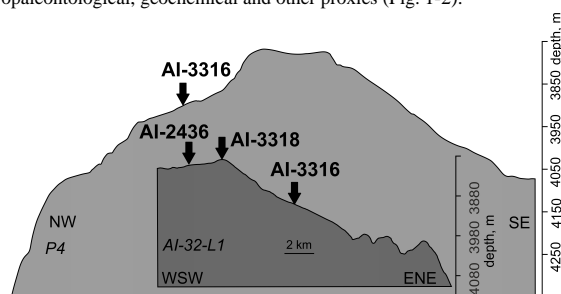


Fig. 1. Bathymetric profiles crossing the Ioffe Drift.

As a result, rather confidential identification of several biostratigraphic (planktic foraminiferal and nannofossil) zones and their correlation to MS, CaCO<sub>3</sub>, color reflectance L\* and XRF records enables us to find out several hiatuses. They are identified from the absence of biostratigraphic zones and from the specific shape of peaks, notably on MS, L\* and XRF records. The most important hiatuses well represented in all studied cores occurred from 0.81 to 1.51 Ma (roughly during the Mid-Pleistocene transition), at ~1.9 Ma and 2.5/2.59 Ma (i.e. at the onset of the modern-type deep-water circulation in the South Atlantic according to [1]). Differences in the number of hiatuses and the thickness of stratigraphic zones between the three records studied can be mainly explained by the site locations on the summit (AI-3318 and AI-2436) and NE slope (AI-3316) of the drift, influenced by the local LCPW gyre core and margin, respectively. Some (likely short-lived) younger and older hiatuses are also tentatively identified, notably in core AI-3316 from the NE slope of the drift (Fig. 2) suggesting a local erosional activity of the contourite currents.

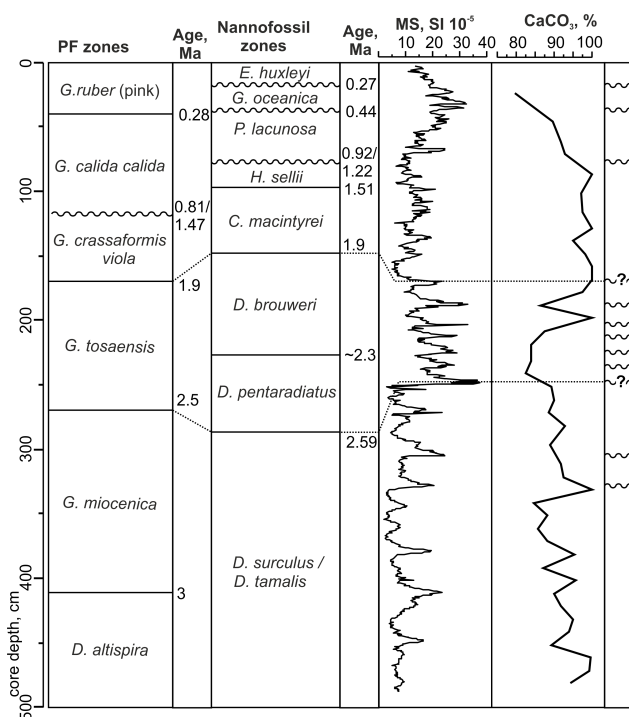


Fig. 2. Correlation of biostratigraphic (foraminiferal = PF and nannofossil) zones to changes in volume magnetic susceptibility (MS) and %CaCO<sub>3</sub> in sediment core AI-3316 from the Ioffe Drift. Suggested hiatuses are shown in the right column.

## Acknowledgments

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# THE TRIBUTE OF EARTH SCIENCES TO THE MEDITERRANEAN

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## Abstract

The first recorded descriptions of natural phenomena, chiefly made in Sicily during Antiquity, demonstrate that geological sciences were born around the Mediterranean. While in Middle age, and throughout Renaissance, it was mainly focused on mining and mineral collections, geology became to be a real science during the seventeen and eighteen centuries on the base of observations made in Italy. During the nineteen and early 20<sup>th</sup> centuries geologists compiled first regional syntheses and started to interpret the peri-Mediterranean belts as consequence of convergence between continents. These concepts were then applied worldwide. A similar evolution characterizes the offshore Mediterranean regions, which were, during the fifties, the first to be systematically studied thanks to marine geophysical tools.

**Keywords:** *Continental margin, Crust structure, Mediterranean Sea*

Through times geological sciences have always greatly benefitted from the Mediterranean environment (onshore and offshore). As a matter of fact Geology was almost born in these regions where various and spectacular natural phenomena have been described since Antiquity. For example in Sicily warm and gas emitting caves (nearby Sciacca) or mud volcanoes (near Aragona) have been visited five centuries BC by Plato. Aristotle (IV BC), Lucrecia (I BC), or Pliny the older (I century AC), already speculated on minerals formation. Pliny even proposed, in its famous "*Natural History*", a tentative classification of gems. Eratosthenes (III BC) mentioned Mediterranean Sea level fluctuations to explain the discoveries of shells far away from the coasts, while Strabo (I BC-AC) suspected that seismic and volcanic activities could have been the cause of creation of some Mediterranean straits. In his letters to Tacitus, Pliny (the young) was the first to describe, with a good scientific precision, a volcanic eruption during the Vesuvius 79 AC catastrophic event.

It is only around the years 1670, after several centuries (Middle-Age and Renaissance periods) during which mining and mineralogical collections were prevailing (Aldoravandi collection known in Bologna since 1547), that the Danish bishop Niels Stensen (or Nicola Steno) established, from observations in Tuscany, some basic concepts of Earth Sciences such as stratigraphic superposition and deformation. As a consequence of the Age of Enlightenment geology started, during the 18-century, to become a science as attested for example by the works of Buffon, published within its monumental "*Histoires Naturelles*" or by Dolomieu, published soon after several journeys in Sicily around 1780.

Throughout the 19-century studies were mainly focused around the Mediterranean on stratigraphy and paleontology and led to first regional syntheses, as well as to creation of several national Geological Surveys in charge to collect data on natural resources and to promote their exploitation. E. Suess, first, then soon after M. Lugeon, and chiefly E. Argand [1] used all available observations to interpret, in a modern way (convergence between Europe and Africa), the various Mediterranean mountain belts.

Initiated in the fifties and amplified in the sixties [2] (as a consequence of plate tectonic concepts [3-5]) numerous researches were then conducted on all peri-Mediterranean deformation belts [6-7] as well as at sea thanks to innovative geophysical tools. Today the Mediterranean domain, where almost any types of geological fields can be studied (figure 1), remains among the major target areas for many earth scientists.

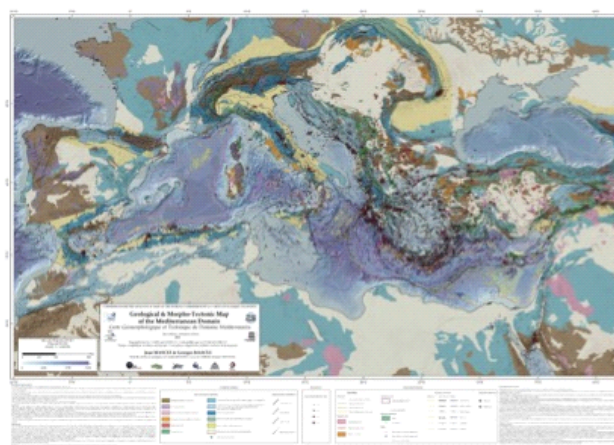


Fig. 1. A geotectonic synthesis of the Mediterranean domain as recently published by CGMW/UNESCO [4].

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# PLANKTONIC FORAMINIFERA EVIDENCE FOR SURFACE-WATER CONDITIONS OFF SOUTHERN PORTUGAL DURING MID-PLEISTOCENE MARINE ISOTOPE STAGES 20 TO 24 (790 – 940 KY)

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## Abstract

Characterized by a drastic change in the deep thermohaline circulation, the Mid Pleistocene Transition (MPT) was a global climatic event resulted in more intense and longer lasting glacial periods and cooler sea-surface temperatures. The present study's objective is characterized surface-water variations during the MPT interval at the mid-latitude southern Portuguese margin using planktonic foraminifera faunal data from Site U1387. Stratigraphy records reveals dominantly tropical and subtropical species interrupted by incursions of subpolar waters when the North Atlantic's subarctic front moved to southernmost position during the MPT.

**Keywords:** *Foraminifera, Gulf of Cadiz*

The Mid Pleistocene Transition (MPT) was a global climatic event that occurred between 1250 and 700 thousand years (ky) ago. This period was characterized by a drastic change in the deep thermohaline circulation during the glacial periods that resulted in more intense and longer lasting glacial periods (changing from 40ky to 100ky cycles) and cooler sea-surface temperatures (SST). It is believed that the MPT may have been influenced by ocean-atmosphere system changes directly linked to an increased ice volume. A consensus point is that there was a pCO<sub>2</sub> reduction which in turn reduced the atmosphere's temperature, causing the expansion of continental ice sheets [1]. In the North Atlantic, high-resolution records documenting the MPT's impact are still limited.

The present study's objective is therefore to characterize surface-water variations during the MPT interval from Marine Isotope Stage (MIS) 20 to MIS 26 at the mid-latitude southern Portuguese margin using planktonic foraminifera faunal data from Site U1387 (36.8°N; 7.7°W).

The refer site is located at the Faro Drift in the Gulf of Cadiz, explored by the Integrated Ocean Drilling Program (IODP). Nowadays, this site is dominantly influenced by subtropical surface waters. For an initial evaluation, the planktonic foraminifera fauna results were grouped into a tropical-subtropical group and a subpolar group (Fig. 1), following [2]. In the future, the faunal data will be used to calculate SST and export productivity.

Observing the results, the glacial periods (MIS 20 and MIS 22) are characterized by  $\delta^{18}\text{O}$  lower values in *G. bulloides* shells contemporary with high abundances in subpolar species. These results are more explicit during MIS 22 that experienced colder conditions than MIS 20. Based on the tropical-subtropical group, interglacial MIS 23 was a little colder than MIS 21. So, the Site U1387 stratigraphy record reveals dominantly tropical and subtropical species interrupted by incursions of subpolar waters when the North Atlantic's subarctic front moved to southernmost position during the MPT.

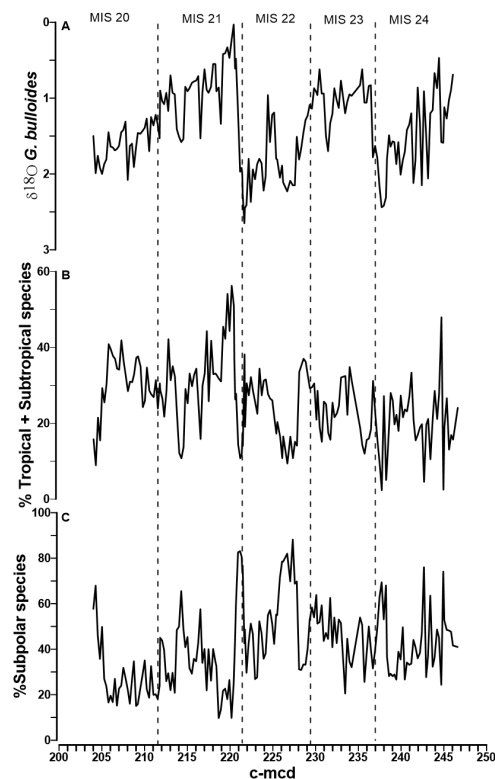


Fig. 1. A :  $\delta^{18}\text{O}$  *G. bulloides* data from Site U1387. B: Percentage of tropical and subtropical species (*G. crassaformis*, *G. siphonifera*, *G. ruber white*, *G. calida*, *G. truncatulinoides*, *G. falconensis* and *O. universa*) from Site U1387. C: Percentage of subpolar species (*N. incompta*, *T. quinqueloba* and *N. pachyderma*) from Site U1387.

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# WHAT DOES PAST CLIMATE CHANGE TELL US ABOUT GLOBAL WARMING?

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## Abstract

Climate has changed significantly along the last decades, affecting ecosystems and population. Natural events and human activities are believed to contribute to this trend. Differentiating natural from anthropogenic forcing on the climate record is one of the major challenges for climate scientists, and it is of key importance to estimate future climate predictions. Comparing the Holocene to older interglacial periods allows us to improve our understanding of natural climate variability, and therefore, to separate the contribution of natural and anthropogenic forcings to the present-day interglacial.

**Keywords:** *Paleoceanography, Geochemistry, North Atlantic*

In order to better understand the climatic and productivity conditions during past interglacials we are studying Marine Isotope Stage 19 and 11 and 5e and MIS1, in the SW Iberian margin sequence of Site U1385, the Shackleton Site, from IODP Expedition 339.

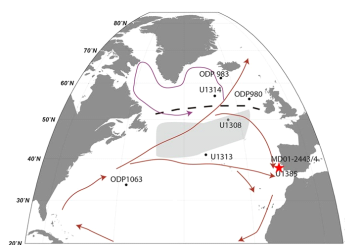


Fig. 1. Location of the study sites. North Atlantic surface circulation (red), Subpolar gyre (purple).

This work aims to shed light on interglacial climate evolution patterns to provide crucial information on the dynamics of the ongoing climate. In this study we present records of past Sea Surface temperature (SST) reconstructed using di and tri-unsaturated alkenones of 37 carbons, which are organic compounds synthesized by marine coccolithophora algae in different proportions depending on the water temperature. Episodes of advection of subpolar water masses and melt water input were recognized by the increasing percentages of tetra-unsaturated alkenone (C37:4). Interglacial occurring at around 780 ka (MIS 19) and 420 ka (MIS 11) are, in terms of orbital configuration, the closest analogues to the present interglacial. However, in terms of temperature, MIS11 shows similar temperatures to the present interglacial while MIS 19 and MIS 5e were the warmest interglacials of the last 1 Ma on the Iberian Margin. The SST record from the Iberian Margin suggests no evidence of a warming trend in the mid-latitudes during the last 1 Ma. Additionally, it shows that very warm interglacials occurred during periods of relatively low CO<sub>2</sub> concentrations such as MIS 15, MIS 17 and MIS 19, corroborating that at mid-latitudes the relationship between temperature and greenhouse gases is not straightforward, and that other forcings, such as precession/insolation, may be more important in driving interglacial strengths.

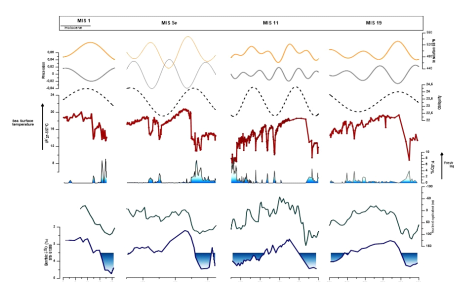


Fig. 2. Climate and ocean circulation patterns during Marine Isotopic Stage 1, 5e, 11 and 19 off Site U1385, related with variations in orbital parameters and insolation pattern (Laskar 2004). Global sea-level equivalent (meters relatively to modern) inferred from  $\delta^{18}O_w$  of Site 1123 (Elderfield et al., 2012). Benthic  $\delta^{18}O$  (black) from Site U1385 (Hodell et al., 2015) SW Iberian Margin

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# CALIBRATING STABLE CARBON ISOTOPES IN PLANKTONIC FORAMINIFERA OFF THE NW IBERIAN MARGIN: NUTRIENT APPROACH

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## Abstract

The interpretation of the carbon isotopic ( $\delta^{13}\text{C}$ ) signal of planktonic foraminifera in sediment records to reconstruct past nutrient availability is complex and poorly understood, especially in coastal upwelling areas, because the isotopic fractions of carbon incorporated into the shells may be derived from different sources and affected by different processes. To minimize the existing uncertainties, we measured  $\delta^{13}\text{C}$  from various species of planktonic foraminifera from core-top sediments and plankton net samples collected off the NW Iberian Margin and compared the results directly with water column nutrient content for the purpose of calibration.

**Keywords:** *Stable isotopes, Foraminifera, Nutrients, Sediments, North Atlantic*

The accuracy of paleo-reconstructions depends on the data set and calibration quality. Several calibration works have been defining and improving the use of proxies for productivity and nutrient cycling parameters, but are often still poorly understood in coastal upwelling areas.

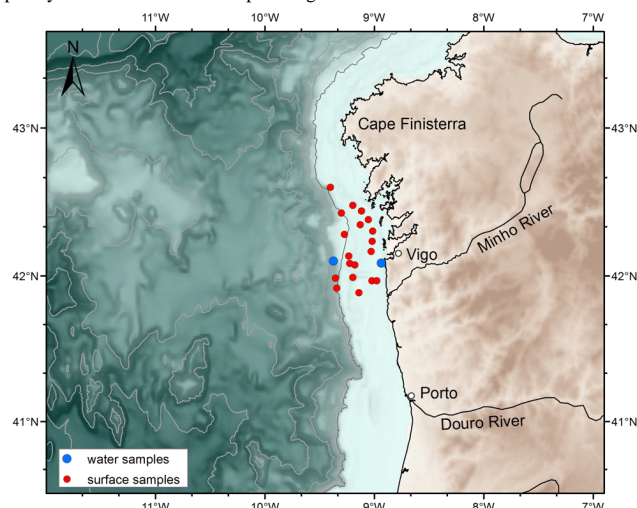


Fig. 1. Bathymetric map of the NW Iberian margin. (big dots) RAIA (75 m) and CALIBERIA (300 m) water column sampling sites. (small dots) Core-top sediment stations. Location of plankton net coincident with offshore station.

To minimize the existing uncertainties affecting the use of  $\delta^{13}\text{C}$  in planktonic foraminifera (PF) as productivity proxy in coastal upwelling areas, we investigate the content and distribution of  $\delta^{13}\text{C}$  in the water column, its incorporation into the PF shells, and how the living PF  $\delta^{13}\text{C}$  signal is related to the same PF species preserved in the sediment record. This study is based on a large data set from two stations (RAIA, CALIBERIA) located off the NW Iberian margin (Fig. 1), and includes: i) two year monthly seawater column data (temperature, salinity, nutrients, chlorophyll a, Ba/Ca, and  $\delta^{13}\text{C}$ ); ii)  $\delta^{13}\text{C}$  in multiple living PF species at both stations; and iii)  $\delta^{13}\text{C}$  in multiple PF species from a large set of core-top sediment samples in the study region. Low  $\delta^{13}\text{C}$  values of upwelling species (*G. bulloides* and *N. incompta* defined by [1]) from core-top sediments (Fig. 2) seem to reproduce the spatial variation in coastal upwelling primary production. However, it is fundamental to know if the PF species precipitated their calcite shells in equilibrium with the ambient seawater. Indeed,  $\delta^{13}\text{C}$  sea water is highly correlated with nitrate, phosphate, Ba/Ca and Apparent Oxygen Utilization (AOU) in the water column. An inverse correlation is observed between  $\delta^{13}\text{C}$  and AOU in the deeper water column and after the upwelling season, associated with the high remineralization enhanced by the shelf-ocean blocking effect generated by the presence of the Iberian

Portugal Current [2]. This finding sheds light on the understanding of how nutrient contents associated to the NW Iberian coastal upwelling regime leave their imprint in upwelling-related PF shells preserved in the sediment record. The understanding of this relationship has especially relevance since it gives fundamental information related to the past oceanic biogeochemistry and/or climate and improves the prevision of future changes against possible climate variability due to anthropogenic forcing.

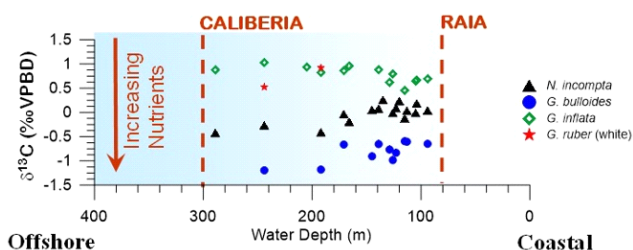


Fig. 2.  $\delta^{13}\text{C}$  for *N. incompta*, *G. bulloides*, *G. inflata*, *G. ruber* (white) from core-top sediments versus sample water depth along the NW Iberian margin

The CIESM registration was supported by FCT through CCMAR project UID/Multi/04326/2019.

CALIBERIA Team: Antje Voelker<sup>1</sup>, Fátima Abrantes<sup>1</sup>, Fernando Alonso-Pérez<sup>2</sup>, Francisco de la Granda<sup>2</sup>, Marta Rufino<sup>1</sup>, Nicolas Villaceros-Robineau<sup>2</sup>, Raquel González-Álvarez<sup>3</sup>, <sup>1</sup>IPMA & CCMAR, Portugal; <sup>2</sup>IIM – CSIC, Vigo, Spain; <sup>3</sup>Univ. of Vigo., Spain.

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# HALITE CRYSTALLIZATION ON SUBMERGED DENSITY INTERFACES WITHIN THE DEEP MEDITERRANEAN DEPRESSIONS

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## Abstract

During the Messinian Salinity Crisis, the brine in the Mediterranean became stratified and denser brines accumulated in depressions where they concentrated to NaCl saturation below a sharp density and temperature interface. Double diffusion of  $\text{Na}^{2+}$  and  $\text{Cl}^{2-}$  along with heat from the upper layer to the lower layer occurred in fingers across a sharp interface. Cooling of the fingers in the lower layer triggered the nucleation of halite crystals that rained down onto the basin floor and accumulated in the salt layer.

**Keywords:** *Evaporites, Mediterranean Sea, Messinian, Levantine Basin*

The recovery of Messinian-age sediment from directly below the massive halite in the Levant Basin of the Eastern Mediterranean [1] and below the first bed of selenite on the Balearic Promontory of the Western Mediterranean [2, 3] confirms a synchronous onset of calcium sulfate (gypsum) on the Mediterranean margins and halite in enclosed depressions (Fig. 1). The halite observed as a thick acoustically transparent layer in reflection profiles is present at elevations below today's sea surface from <1 km to > 4 km. There is strong evidence that during the Messinian Salinity Crisis the brine in the Mediterranean became stratified and denser brines accumulated in depressions where they concentrated to NaCl saturation below a sharp density and temperature interface. The presence of open marine sediment with an age of 5.97 Ma from directly below massive halite in the Levant Basin of the Eastern Mediterranean Salt is present in an acoustically homogeneous layer at elevations almost everywhere below -1.5 relative to the elevation of today's sea surface and gypsum in an acoustically bedded- layers above -1.2 km. In both the Eastern and Western Mediterranean the volume of salt is proportional to its surface area. After restriction of entering Atlantic seawater and by analogy with the modern Dead Sea [4] the Mediterranean became stratified into an upper-warmer and slightly undersaturated layer of brine above a colder, less saline, and supersaturated lower layer. As long as the upper layer retained oxygen and remained saturated for gypsum, its seabed served as a factory for bottom growth beds of swallow-tail gypsum [5], resulting in the removal of  $\text{Ca}^{2+}$  and  $\text{SO}_4^{2-}$  from the brine and thereby increasing the activity coefficients of  $\text{Na}^{2+}$  and  $\text{Cl}^{2-}$ . Double diffusion of  $\text{Na}^{2+}$  and  $\text{Cl}^{2-}$  along with heat from the upper layer to the lower layer occurred in fingers across a sharp interface [6]. Cooling of the fingers in the lower layer triggered the nucleation of halite crystals that rained down onto the basin floor and accumulated in the salt layer. The return the non-precipitated  $\text{Na}^{2+}$  and  $\text{Cl}^{2-}$  in upward fingers conserved the upper layer in a condition of under saturation for halite. The correspondence between salt volume and surface area implies that entering seawater became concentrated by evaporation everywhere and not just at progressively-greater distances from the inlet, as in traditional barrier-bar and brine-reflux models.

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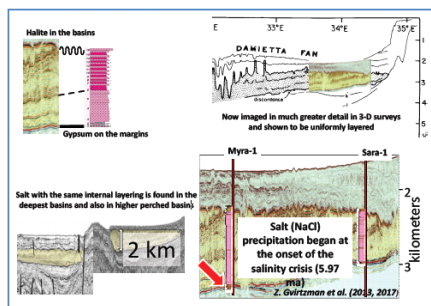


Fig. 1. Halite in the basins gypsum on the margins at the Messinian Mediterranean.



# MEDITERRANEAN OUTFLOW CONDITIONS DURING THE EARLY TO MIDDLE PLEISTOCENE LINKED TO PRECESSION FORCING

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## Abstract

The Mediterranean Outflow Water (MOW) is an important intermediate depth water mass in the North Atlantic. Here we reconstruct changes in the MOW during the early Pleistocene interval from 630 to 1760 ky, encompassing the Mid-Pleistocene Transition (MPT), which marks an important change in orbital climate forcing. Neither MOW ventilation nor MOW flow strength reveal changes related to the MPT, but incorporate variations related to precession (insolation) forcing. The MPT related change to higher glacial benthic  $\delta^{18}\text{O}$  values occurs earlier at Site U1387 than in most deep-sea records, i.e. with MIS 26 instead of the MIS 24 to MIS 22 interval.

**Keywords:** *Paleoceanography, Gulf of Cadiz, Foraminifera, Stable isotopes*

The Mediterranean Outflow Water (MOW) forms contourite drift deposits along the Iberian margin, especially in the Gulf of Cadiz, and injects heat and salt into the North Atlantic affecting the overturning circulation. We studied sediments from IODP Site U1387 (36.8°N, 7.7°W; 559 m water depth), drilled into the Faro contourite drift during Integrated Ocean Drilling Program (IODP) Exp. 339 – Mediterranean Outflow, to evaluate MOW conditions during the middle to early Pleistocene period of Marine Isotope Stage (MIS) 16 to MIS 61 (630–1760 ky). We base our observations on centennial-scale  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  records of epibenthic foraminifera (*Cibicoides pachyderma*, *Planulina ariminensis*) and the weight percent of the sand fraction >63 $\mu\text{m}$  (Fig. 1). Higher weight percentages of the sand fraction indicate contourite layers formed by a faster flowing bottom current, namely the MOW. Whereas the benthic  $\delta^{18}\text{O}$  signal combines changes in water temperature and salinity and global sea level/ice volume, the benthic  $\delta^{13}\text{C}$  data reveal the level of ventilation with lower values indicating a poorly ventilated (and thus low oxygenated) water mass.

persisted throughout the longer period as well. The poorly ventilated MOW signal in the Gulf of Cadiz has been linked to Sapropel formation and thus reduced ventilation of Mediterranean Sea waters and thus higher precipitation caused by the African monsoon [1, 2]. The Site U1387 record indicates that the MOW experienced very poor ventilation during several interglacial periods of the early Pleistocene, such as MIS 23, MIS 25, MIS 27, MIS 31, MIS 47, MIS 57 or MIS 61. For most of them the higher amplitude of the precession-filtered benthic  $\delta^{13}\text{C}$  record (Fig. 1) confirms the strong link to climate forcing by precession/insolation. Weight percent sand fraction values were low during these periods, pointing to a sluggish bottom current. On the other hand, contourite layers, related to a faster flowing MOW, are formed in response to abrupt climate events and sometimes also during/following periods of lower insolation (e.g. glacial inception) [1, 2]. The weight percent sand/contourite layer record, nevertheless, contains variations related to precession forcing as indicated by the higher amplitudes in the filtered record, in particular in the interval from MIS 32 to MIS 35 and from MIS 43 to MIS 48 (Fig. 1).

Although both MOW ventilation and flow strength reveal changes related to precession forcing, neither of them shows a clear shifts linked to the Mid-Pleistocene Transition. The change to higher glacial benthic  $\delta^{18}\text{O}$  values, on the other hand, occurs earlier at Site U1387 than in most deep-sea records, i.e. with MIS 26 instead of the MIS 24 to MIS 22 interval that usually marks the Mid-Pleistocene Transition shift [3].

This study was supported by FCT through projects CCMAR (UID/Multi/04326/2019) and MOWCADYN (PTDC/MAR-PRO/3761/2012).

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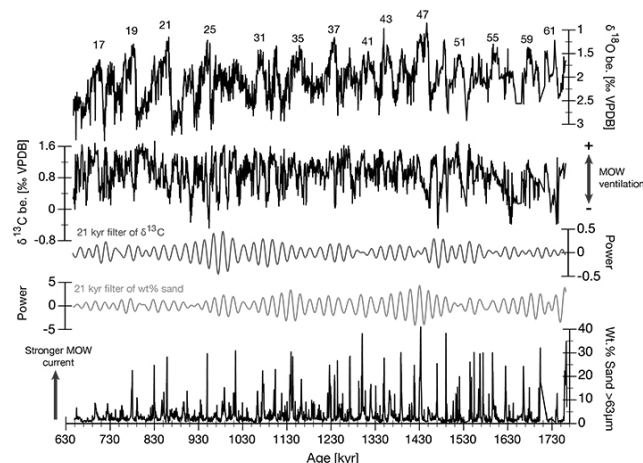


Fig. 1. Paleoclimate records of IODP Site U1387 reflecting changes in MOW conditions. From top to bottom: benthic foraminifera  $\delta^{18}\text{O}$  with numbers above marking Marine Isotope Stages; benthic foraminifera  $\delta^{13}\text{C}$  data with lower values indicating a poorly ventilated MOW; filter for precession frequency of benthic  $\delta^{13}\text{C}$ ; filter for precession frequency of the weight percent of the sand fraction >63 $\mu\text{m}$ ; weight percent of the sand fraction >63 $\mu\text{m}$  with maxima representing contourite layers.

A previous study on a shorter U1387 section [1] showed that the benthic  $\delta^{13}\text{C}$  variations are linked to insolation/precession with generally lower values/lesser ventilation related to insolation maxima (precession minima) and higher values/better ventilation to insolation minima (precession maxima). This pattern

## IBERIAN COLD-WATER CORALS OCCURRENCE PATTERN TRACES PERIODS OF LOCALLY INCREASED PRODUCTIVITY

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### Abstract

The last decades of cold-water coral (CWC) research in northeastern Atlantic margin revealed a climate-driven distribution through time. Following a glacial-interglacial see-saw pattern, CWC are present in the northern European areas (>50°N) during interglacial (warm) periods, while on the southern margins (<37°N) they are restricted to glacial (cold) periods [1]. The periods of sustained growth have been steered by enhanced food supply as a result of enhanced surface productivity and/or intermediate-depth hydrographic mechanisms (e.g. internal waves and pycnoclines), which increases food availability for the CWC ([1] and references therein). The Iberian margin is a biogeographical transitional zone, however, CWC from this area remain unstudied. To fill in the gap, we dated 5 cold-water coral samples collected from the Nazaré canyon and Fontanelas Seamount (Estremadura Spur) with Uranium-series dating, which we compare with CWC ages from the Galicia Bank. The pattern of CWC occurrence in West Iberia margin differs between the northern and southern areas, following the periods of increased surface productivity in each of these areas (e.g. [2]). The CWC from the Galicia Bank likely grow sustainably since at least 22 thousand years ago. While CWC located south, in the Fontanelas Seamount, seem restricted to the more productive interstadials of the last glacial period [2]. Future analyses of neodymium isotopic signatures could reveal if intermediate-water mass changes are also affecting CWC distribution in the West Iberia margin.

Keywords: Uranium-series dating; Glacial-Interglacial; Estremadura Spur (Portugal)

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## **CIESM Congress Session : Coastal, shelf and slope dynamics**

**Moderator : Rui Quartau, Instituto Hidrográfico, Lisbon, Portugal**

### *Moderator's Synthesis*

This session included six presentations, focused on coastal and shelf processes (namely sedimentary dynamics related to wave action), coastal erosion, coastal contour-currents, processes (namely submarine landslides, depositional, erosional and tectonic processes).

The discussion lasted the entire second half of the session and all the presentations had questions from the audience. Most of the questions were directed to the presentation about submarine landslides offshore Israel to better understand their triggers and to the presentations about the Anapa bay-bar to understand the processes behind its erosion.



# THE AGE AND SEDIMENTOLOGY OF RECENT SUB-MARINE SLIDES OFFSHORE ISRAEL

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## Abstract

Submarine slides are distributed along the continental slope of the south eastern Mediterranean. This study aims to constrain the age of these mass transport deposits offshore Israel using sedimentological and <sup>14</sup>C dating methods. The combined analyses suggest multiple sliding events that occurred along with the sea level rise following the last deglaciation, accompanied by high sedimentation rates and increased riverine influx from the Nile Delta. In addition, the proximity to the Dead Sea Transform suggests seismic events may also trigger mass transport events.

**Keywords:** *Continental slope, Sedimentation, Bathymetry, Sediment transport, South-Eastern Mediterranean*

Submarine slides play a significant role in shaping the structure of continental margins via transport of large amounts of sediments from the continental slope towards the deep basin. Yet, important parameters of submarine slides, such as frequency, timing and structure, are poorly constrained [1]. The current study main objective is to constrain the age of recent submarine slides on the continental slope of Israel, by investigating sediment cores from the slide's head scar (PHS) and the distal toe (PTL) domains.

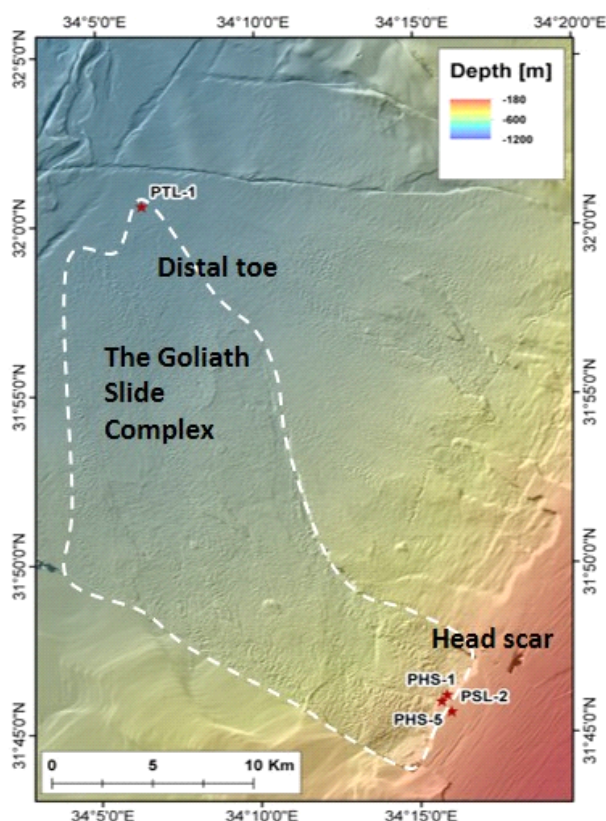


Fig. 1. Location map of the Study area. The color coded bathymetric map shows the slide (yellow dashed line) and coring locations (red stars).

To unravel the slide structure and age, we combined CT scans with sedimentological and micropaleontological analyses. Our integrated analysis divides the sedimentary sequence in the head scar domain into two different generations of deposits, separated by the slide detachment surface.

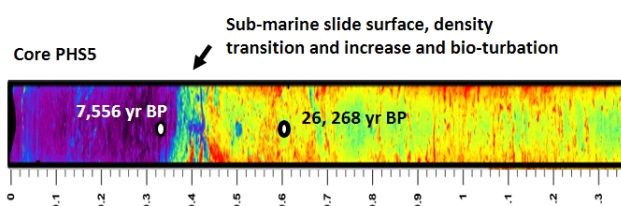


Fig. 2.  
CT analysis and Radiocarbon dating of a core from the head scar.

Two concordant C-14 ages of 7.63 cal ka BP (PHS-1) and 7.56 cal ka BP (PHS-5) were obtained for the sediments immediately overlying this surface, suggesting that the head scar was formed during one major event that occurred  $7.6 \pm 0.1$  cal ka BP. The ages of the sediments underlying the slide detachment surface are 10.29 cal ka BP (PHS-1) and 26.3 cal ka BP (PHS-5), implying a greater incision and the removal of more material from PHS-5 location. Results from the toe domain show a 1.2 m long continuous undisturbed sequence that represents the last ~14 ka BP and includes the sapropel S1 layer. This sequence overlies three disturbed units interpreted as mass transport deposits (MTD). The C-14 age at the base of the undisturbed sequence is 13.9 cal ka BP, representing the minimum age of the sliding event that transported the MTD units. The age-model of core PTL-3 shows that the ages of the MTD units are substantially older (18.6 to 28.9 cal ka BP) than above it and represent glacial aged sediments. The age model also reveals an age-inversion within the MTD sequence, which supports the interpretation of these units as MTD related. Furthermore, two nearly identical C-14 ages of ~18.6 cal ka BP were obtained across a vertical section of 57 cm within one MTD unit, suggesting significant mixing of the sediment during the sliding event. The timing of the sliding events corresponds with a period of rapid sea level rise following the last deglaciation, accompanied by high sedimentation rates and increased riverine influx from the Nile River. Together, these may have promoted slope instability and acted as preconditioning factors to the sliding events. In addition, the ~14 ka BP event corresponds with the occurrence of cave seismites in the Soreq Cave, located 40 km to the West from the tectonically-active Dead Sea Transform, suggesting that a significant earthquake might have triggered this event. The multi-proxy approach presented in this study has proven to be useful when interpreting complex sedimentary sequences such as in areas of slide scars.

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# ALONGSHORE SEDIMENT FLUXES DUE TO DIFFERENT WAVE SYSTEMS

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## Abstract

If the wave spectrum is formed as a result of interaction between several wave systems, it is reasonable to obtain separate wave characteristics for each of these systems. Two main components can be usually distinguished in the structure of surface waves: wind seas and swell. The main task of this work is evaluation of the wind sea and swell contribution to the climatic alongshore sediment fluxes on the example of the Anapa bay-bar, Black Sea.

**Keywords:** *Coastal processes, Black Sea*

Besides the fundamental scientific interest to the problem, separation of the wave field into individual components makes possible clarify the schemes of redistribution and transport of bottom sediments. For example, having separate statistical characteristics of the wave field over the climatic time interval, it is possible to estimate the contribution of individual wave components to the formation of the geomorphological appearance of the coastal zone.

The object of research is the Anapa sandy bay-bar of 40 km length and located in the northeastern part of the Black Sea (Fig. 1).



Fig. 1. Position of the Anapa bay-bar

The general trend in the dynamics of the Anapa bay-bar beaches is the almost universal reduction of their width caused by both natural and anthropogenic factors [1].

The main tasks of this work are:

- adjustment of the spectral wave model DHI MIKE 21 SW [2] parameters for correct separation of the wave field into individual components. The quality of the model is determined by the correspondence of the model and experimental two-dimensional waves energy spectra;
- calculations of the wind waves and swell parameters for the entire Black Sea for the period from 1979 to 2018. As wind forcing, the ERA-Interim reanalysis data are used;
- formation of a database of wind waves and swell climatic characteristics for the Anapa area;
- evaluation of the wind seas and swell contribution to the climatic alongshore sediment fluxes on the example of the Anapa bay-bar, Black Sea.

The main features of alongshore sediment fluxes in the coastal part of the Anapa bay-bar:

1. Mean (i.e., characterizing the order of magnitude) the volume of sediments, moving along the coast: from the NW to the SE – 30000 m<sup>3</sup>/year, from the SE to the NW – 12000 m<sup>3</sup>/year. In some years, fluxes may increase (or decrease) in 2-2.5 times.
2. Almost along the whole length of the bay-bar it is possible to observe the predominance of the sediment flux, directed from the NW to SE. The exception is the southern part of the mound adjacent to Anapa town, which is characterized by the prevalence of fluxes from SE to NW. Change of the sign of the General sediment flow is observed to the South of Vityazevo.

3. There is a strong interannual variability of flows. In the Northern part of the bay-bar, the scale of interannual variations in flows from NW to SE can reach about 30,000 m<sup>3</sup>/year. In the South direction the amplitude of interannual oscillations of these flows is significantly reduced. For flows from SE to NW, the picture is reversed: maximum interannual fluctuations occur in the southern part of the bay-bar and decrease with the advance to the North.

4. In the fluxes directed from the NW to the SE, the influence of wind seas dominates. The contribution of swell is ~25% in the NW part of the considered coast (Fig. 2) and significantly decreases in SE part (up to 6-7%).

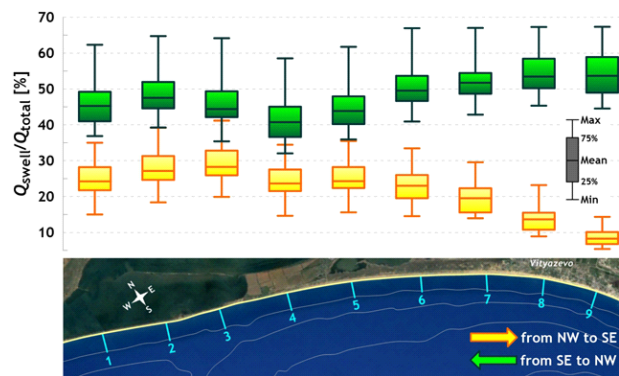


Fig. 2. Contribution of swell to the formation of alongshore flows

For flows from SE to NW, the contribution of swell is quite stable. In SE part the contribution of swell can be more than 50% and slightly reduced in the NW direction. Note that in some years, alongshore flows from SE to NW can be almost completely determined by the impact of swell waves (up to 67%).

5. Single storm events can largely determine the lithodynamic shape of the coastal zone. At the same time, the contribution of individual extreme storms to the average annual sediment flow can reach about 25%.

A similar approach can be applied to any coast, provided the correct configuration of the wave model.

## Acknowledgments

Collection of data, the office data processing and data analysis were supported by the Russian Foundation of Basic Research (grants no. 17-05-183, 19-05-00041, 18-05-80035).

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# TAMARIX RAMOSISSIMA AS INDICATOR OF THE ANAPA BAY-BAR COASTLINE RETREAT

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## Abstract

The Anapa bay-bar is big accumulative form of the Black Sea coast and important recreational resource. Analysis of remote sensing data showed that the bay-bar sea-shore retreat and its displacement towards the lagoons occurred in recent years. Values of the displacement of sea shore and lagoon shore coastlines were identified by analyzing the characteristics of the *Tamarix ramosissima* distribution.

**Keywords:** Coastal systems, Black Sea, Coastal processes, Bio-indicators, Lagoons

The Anapa bay-bar is big accumulative form of the Russian Black Sea coast and the bay-bar beaches are the natural basis for the recreational industry development in the region (Figure 1). Anapa bay-bar separates shallow lagoons from the Black Sea. The bay-bar is composed of quartz sand with an admixture of shell rock and pebbles. The width of the Anapa bay-bar varies from 80 m to 1.5 km in its northern and southern parts, respectively. It includes developed eolian forms (dunes) with the height of up to 6 m. The dunes are covered with fragmented shrub-herbaceous vegetation.

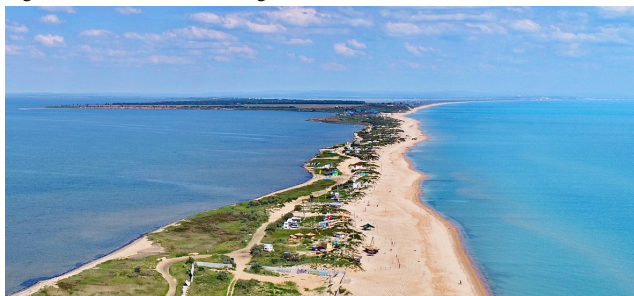


Fig. 1. Anapa bay-bar

Analysis of the different data showed that the retreat of the bay-bar sea shore and its displacement towards the lagoons occurred in recent years. The maximum erosion rate of the bay-bar sea side does not exceed 1.6 m/year [1]. The maximum sea-shore coastline retreat in 50 years is 60-80 m. Determine the previous positions of the lagoon-shore of bay-bar is difficult because of riparian vegetation, changes in lagoon level, marshiness. *Tamarix ramosissima* is a typical species for the Anapa bay-bar, but the density of its growth varies considerably on bay-bar transverse profiles. *Tamarix ramosissima* is a mezohalophyte, which allows it to successfully grow directly on the banks of salt-water reservoirs. In 2-3 months after germination it starts to consume deeper and more saline groundwater becoming a mesophyte or even a halophyte. *Tamarix ramosissima* is a pronounced heliophyte, it absolutely does not tolerate shading, especially at the time of germination [2]. That is why new plants appear only on sites that are free (or freed) from other plants. Relief is one of the important factors that determine the placement of tamarix. In this investigation (with the support of the RFBR 18-05-00333), the features of the distribution of *Tamarix ramosissima* in the coastal zone were used as indicator of the past Anapa bay-bar coastline positions. Ideal conditions for the first year of *T. ramosissima*'s survival are moisture-saturated soil during the first few weeks of life, high level of ground water and open sunlight without competition on behalf of other plants. Analysis of data showed that in natural conditions the young *Tamarix ramosissima* plants are found only along the lagoon coast [2]. However, large Tamarix plants are located on the dune crests on the Anapa bay-bar predominantly. It can be stated that all of the *T. ramosissima* specimens growing in the present time on the dunes along the sea shore of the bay-bar, used to be located on the lagoon shore some time ago. Accumulative surface increased compensated by the growth of the plants. Due to the shoreline displacement and the eolian accumulation, the plants found themselves on dune crests. The forward movement of the lagoon shore occurs by the formation of a low (up to 0.5 m) coastal bank of shell and sand by waves. Due to small slopes

of the bottom and seasonal fluctuations in the level, the bank can be formed considerably farther from the shore. A low terrace gradually overgrown by herbaceous vegetation is formed between the new bank and the old shore line. Along the bank from the lagoon side there is a gradual accumulation of residues of algae, shell rock and flotsam. It is exactly the bank contacting water and free from new vegetation that becomes a substrate for germination of tamarix. When another storm breaks, a new bank is formed and the previously appeared shrubs of tamarix move away from the shore. From the sea side of the bay-bar, the avantdunes are gradually destroyed by waves and sand is transferred by wind to the leeward side of the dune belt. Coming sand gradually covers the low terrace along with its vegetation. Herbaceous wetland vegetation dyes (being replaced by psammophile species). Tamarix bushes, on the contrary, become centres of new dunes formation. As the bush gets covered with sand, it changes its form from free-growing to coppice one. The newly-formed dune with "a frame" of tamarix gets stabilized, its further movement in the direction of the lagoon stops. The obtained data allowed clarify the reconstruction of the development stages of the accumulative body of the Anapa bay-bar. The extension of the lagoon-shore was at least 80 m. This value is same with the retreat of the sea-shore coastline. Accordingly, the accumulative body of the bay-bar shifted about 80 m towards the lagoon (Figure 2). But the width of the overwater part of the Anapa bay-bar almost unchanged.

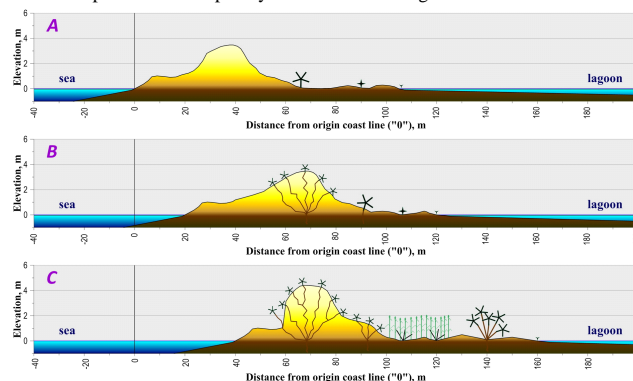


Fig. 2. Schema of the Anapa bay-bar movement

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# MORPHOGENETIC PROCESSES ON THE CONTINENTAL SLOPE OF THE GALICIA BANK (WEST IBERIA MARGIN)

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## Abstract

The physiography, morphological features and morphogenetic processes of the Galicia Banks continental slope were studied by means of multibeam bathymetric analysis, and interpretation of echo-sounder and seismic reflection profiles. The features identified were shaped by depositional, erosive, gravitational and tectonic processes, being the last one the main morphological control.

**Keywords:** *Geomorphology, Continental slope, Galicia Bank*

Continental slopes are key areas of the continental margins due to their economical and geopolitical importance and geohazards potential. The continental slopes have long been recognized as privileged pathways for sediments transport from continental shelves into the abyssal plains. They are also the place where gravity-processes dominate provoking slope instability and mass movements. These processes can in some cases produce tsunamis with potential for damaging the adjacent coastal areas. The continental slope was earlier defined by [1] as the steep (usually 3°-6°) portion of seafloor which extends from the shelf break to the base of slope grading into the continental rise. However, recently [2] demonstrated distinguish between continental slope and continental rise is a difficult task especially when both physiographic provinces are shaped by a continuum of sedimentary processes. Therefore, several authors proposed a quantitative approach to better describe continental slopes physiography using the slope curvature as a new basis for classification [e.g. 2, 3]. This approach also allowed to determine the dominant morphosedimentary processes that shaped the continental slopes. This methodology was applied to the Galicia Bank continental slope to better understand the geomorphologic processes and respective interactions that shaped this feature through time. The dataset was composed of multibeam bathymetry and GEBCO used to fill in gaps in the multibeam data; echo-sounder profiles (TOPAS); and multichannel seismic reflection profiles (Fig. 1).

The Galicia Bank is a structural high located in the NW Iberia continental margin. It presents a trapezoidal form about 220 km wide in E–W direction and 300 km length in N–S direction. The Galicia Bank had a complex structural evolution, starting in the Mesozoic rifting phases related to the North Atlantic opening; during the Alpine orogeny (Eocene-Miocene) was tectonically inverted. The Pliocene and Quaternary evolution was constrained by the reactivation of the inherited structures and was linked to the re-organization of the trajectory between African and Eurasian plates. The sedimentary cover spans from the Early Cretaceous (Valanginian) to Quaternary, and consist of turbidites, blackshales, red claystones, marls and hemipelagites/pelagites [4].

Geomorphological analysis of the SW flank of the Galicia Bank allowed the identification of tectonic, depositional, erosive, and gravitational features.

Slope curvature analysis showed that the Galicia Banks morphology departs from the three classical types of slope curves (i.e. linear, exponential and Gaussian) and can be best described by composite curves. The prevalence of out-of-grade bathymetric profiles along the Galicia Bank suggests the dominance of tectonic activity as the main shaping agent.

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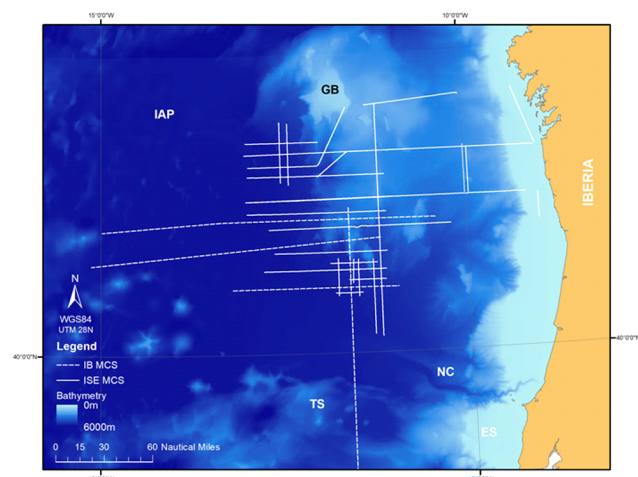


Fig. 1. Location of the multichannel seismic lines used in this work (ISE and IB lines; EMODnet Bathymetry grid; GB – Galicia Bank, IAP – Iberia Abyssal Plain, TS – Tore Seamount, NC – Nazare Canyon and, ES – Estremadura Spur).

# PHYSICAL DRIVERS OF COASTAL COUNTER-CURRENTS IN SOUTHERN IBERIA INFERRED FROM AN ANALYSIS OF VERTICAL VELOCITY PROFILES

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## Abstract

The coastal circulation along the northern margin of the Gulf of Cadiz is characterized by the temporal alternation of eastward upwelling jets produced by geostrophic adjustment and westward coastal counter-currents (CCCs) whose physical drivers are poorly known [1]. Previous studies in the area point out that their set up may result from various mechanisms [2]. This research aims at identifying the driving forces of CCCs by analysing the vertical structure of the alongshore flow when it changes direction, assuming that distinct drivers may lead to distinct flow characteristics. The analysis is based on long-term (2008-2018) velocity records from an Acoustic Doppler Current Profiler (ADCP) deployed at 23 m water depth offshore Armona island (South Portugal). Results show that velocity profiles during flow inversions (i.e., from westward to eastward) have a strong shear, with CCCs starting to develop near the bed first (64%), especially during the upwelling season in spring-summer (> 80%). In comparison, flow reversals (i.e., from eastward to westward) resulting from geostrophic adjustment present a weaker shear and as much events starting near the surface than near the bed. With the majority of inversions starting near the bed, it is excluded that the main driver of CCCs is the local wind stress. This pattern is rather explained by the relatively larger inertia of the (stronger) flow near the surface than near the bed. Similitudes with the vertical structure of oscillatory flows induced by pressure variations (e.g. tidal wave) suggest that CCCs are driven predominantly by (changes in) the alongshore pressure gradient.

Keywords: Coastal counter-currents; Gulf of Cadiz; Coastal circulation

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## GRAVITATIONAL, EROSIONAL, AND DEPOSITIONAL PROCESSES ON THE SUBMARINE ENVIRONMENT OF MADEIRA ARCHIPELAGO, PORTUGAL

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### Abstract

The submarine flanks of volcanic ocean islands are shaped by a variety of physical processes; whilst volcanic constructional processes are relatively well understood, the gravitational, erosional and depositional processes that lead to the establishment of large submarine tributary systems are still insufficiently studied [1, 2]. In this work we report detailed observations of high-resolution bathymetry of an entire archipelago and relate them with the physical and geological setting of the islands. Our observations reveal that the submarine flanks of the archipelago are deeply dissected by large landslide scars and that most of them have involved subaerial material. Below the shelf break, landslide chutes develop downslope forming poorly defined depositional lobes. Around the islands, a large tributary system composed of gullies and channels develop where no significant rocky/ridge outcrops are present. This system is likely formed by sediment density flows that are triggered by hyperpycnal flows in Madeira or by storm-induced offshore sediment transport on Porto Santo and Desertas islands. At the lower part of the flanks (-3000 to -4300 m), where seafloor gradients decrease to 0.5°-3°, several scour and sediment wave fields are present, with the former normally occurring upslope of the latter. Sediment waves are often associated with the depositional lobes of the landslides but also occur offshore poorly-developed tributary systems. Our study suggests that scours and sediment wave fields are probably formed by sediment density flows that suffer hydraulic jumps where the seafloor gradients are significantly reduced and where the currents become unconfined. Our observations show that tributary systems are better developed in prominent and rainy islands such as Madeira. On low and dry islands such as Porto Santo and Desertas, these are poorly developed and unconfined sediment density flows favour the development of scours and sediment wave fields.

*Keywords: Volcanic Ocean Islands; Submarine Environment; Madeira Archipelago*

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COMITÉ 2  
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Physique et climat de l'océan

Président : Toste Tanhua

CIESM Congress Session : Basin and sub-basin circulation

Moderator : Álvaro Peliz, Geofísica, Univ. of Lisbon, Portugal

Moderator's Synthesis

The session on Basin and Sub-basin Circulation covered many aspects of Mediterranean Sea circulation and was very diversified in terms of topics, regions and methods. Advances in the knowledge of Mediterranean circulation are noticeable, and the research community is now reaching a moment when it has a better understanding not only of the mean circulation but also of the variability processes. This offers the perspective of monitoring and forecasting so as to be able to predict how the system is going to evolve and change in the future.

When comparing the communities of the Atlantic and Mediterranean, it is clear that CIESM can bring together researcher and teams of many different countries, not only EU countries with a larger funding availability for ocean research, but also non European countries. This emerges from the number of countries co-authoring the presentations and also from the level of internationalisation of teams and projects which promoted the research produced. Such cross-collaboration is vital to ensure an enlarged and inclusive community for an area like the Mediterranean.



REGULATING AGENTS OF THE MASS TRANSPORT BETWEEN THE LIGURIAN AND THE TYRRHENIAN SEAS ACROSS THE CORSICA CHANNEL

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Abstract

The Corsica Channel (CC) connects the Ligurian and Tyrrhenian seas. Warm Tyrrhenian water flows through the CC into the Ligurian, where it joins the Liguro-Provençal Current (LPC). The LPC flows westwards into the Gulf of Lion, i.e. one of the world's most active sites for deep water formation (DWF). Understanding the CC behaviour can delineate the contribution of the Liguro-Tyrrhenian system to the western Mediterranean DWF. Several agents have been held responsible for driving the seasonal and interannual variability of the CC flow. This study describes the variability of the Liguro-Tyrrhenian system, starting from the analysis of a 25-year long water transport timeseries, in the CC. Sea Level Anomaly (SLA), sea surface stress (tx), Sea Surface Pressure (SSP) and wind fields are investigated in relationship with the CC transport.

Keywords: Deep waters, Gulf of Lyon, North-Western Mediterranean, Corsica Trough, Water transport

In the present work, the principal time series is represented by 25 years of water transport data, through the Corsica Channel (CC), from 22nd November 1985 to 12th March 2010. In situ measurements are derived from moored Rotor Current Meters (RCM) that are positioned at 4 levels (50 m, 100m, 300m, 400m) in the deepest point of the Channel. The CC water transport timeseries has been compared with local Ekman transport (calculated from tx), SSP, SLA (from gridded data and from ALES [1] reprocessed along track data), and wind fields over the Ligurian and Tyrrhenian, Figure 1 and 2.

Results and Discussion

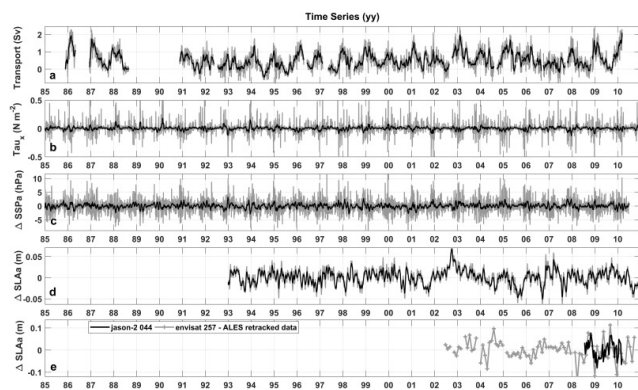


Fig. 1. a) Transport, b) x, c) SSP, d) SLA_a grid, e) SLA_a sat from tracks Jason2 044 and Envisat 257. In all plots, with the exception of e), the lighter line represents original data while the filled black line shows the filtered data with a 20 days window moving average. Subscript 'a' indicates the anomaly of a time series, i.e. series minus long term average of the same series; 'Δ' indicates the difference: Tyrrhenian basin average minus Ligurian basin average

The seasonal analysis established how all the considered agents participate in making the northward flux across the CC more intense in winter. The spectral analysis revealed interesting long-term common oscillations, ~2 and ~6 years that might be linked to large-scale dynamics such as the North Atlantic Oscillation. The time lag analysis revealed the dynamic response of the CC to the action of the northward component of the wind stress. The SSP difference between the Ligurian and the Tyrrhenian seas creates a meridional wind component. The northward wind action creates an Ekman transport perpendicular to the shore; this induces colder waters to upwell along the Corsican shelf in the CC. The upwelling of denser waters results in the tilting of the isopycnals and of the sea surface. A pressure gradient arises from this

structure, which is balanced by the Coriolis force, and gives place to a northward geostrophic current across the CC. Ekman transport is generally one order of magnitude weaker than the total transport, contributing on average for the 1.5%, but during some events, it might contribute to the flux for more than 27%. Investigating the wind and pressure patterns over the two basins let to the conclusion that strong northward Ekman transport is associated with winds coming from the east and high SSP over the Tyrrhenian, the exact opposite situation occurs during weak Ekman transport.

Conclusions

In the light of the present analyses, the atmospheric pressure patterns over the Ligurian and Tyrrhenian seas result to have a direct and permanent influence on the exchanges between the two basins with a clear and defined seasonal cycle. Sea Level Anomaly, as calculated from along track data, has a key role in the activity of the Corsica Channel. The steric gradient well resembles the CC total transport, Figure 2. The study of the winter transports revealed that, interannually, the SLA is the agent that regulates the behaviour of the Corsica Channel water flux.

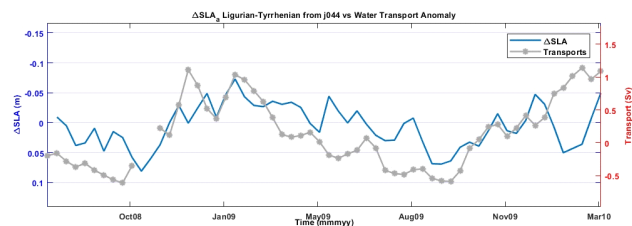


Fig. 2. SLA_{sat} difference (Tyrrhenian minus Ligurian) anomaly calculated with ALES from tracks j044 and transport anomaly across the Corsica Channel

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SPATIO-TEMPORAL VARIABILITY OF SSS AND SST IN THE WESTERN MEDITERRANEAN BASIN WITH THE TRANSMED DATA

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Abstract

Initiated by the CIESM and upgraded to the operational status within the HyMeX/MISTRALS program, the TRANSMED initiative aimed at developing an autonomous and low-cost thermosalinometer system to record SSS (Sea Surface Salinity) and SST (Sea Surface Temperature) while underway. The seven-year time series recorded from February 2012 till present between France (Marseille) and Algeria yield an unprecedented insight in the basin-wide seasonal evolution of the Western Basin, up to mesoscale features, and is used to validate the Copernicus Marine Service global operational system in the area.

Keywords: *Hydrography, Surface waters, Algerian Basin, North-Western Mediterranean, Models*

The TRANSMED system

The fully-autonomous and low-cost thermosalinometer system TRANSMED has been developed to monitor the SST and the SSS over the whole Mediterranean Sea. Indeed the Mediterranean displays intense mesoscale variability in both space and time [1], so that capturing the long-term variability and extracting a potential climatological signal is a challenge. Moreover, its central and southern parts are little known, and lack sampling facilities. The objective of TRANSMED is to use the regular routes and schedules of ships of opportunity to record SST and SSS underway, and assemble long-term time series (fig.1; details on www.ifremer.fr/transmed [2]). Such a system can be widely deployed on cross-basin routes to build a Mediterranean-wide network. TRANSMED uses Seabird SBE38 thermistor and SBE45 thermosalinometer. Data are recorded every 10s, allowing a spatial resolution <100m and reliable data at the km-scale. Data are sent to Coriolis every 24 hours.

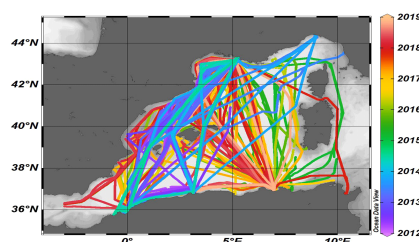


Fig. 1. Spatio-temporal distribution of the TRANSMED routes (Feb. 2012- Jan. 2019).

The CMEMS Global Ocean monitoring and forecasting system

Since 19 October 2016, and in the framework of Copernicus Marine Environment Monitoring Service (CMEMS), Mercator Ocean has delivered real-time daily services (weekly analyses and daily 10-day forecasts) with a new global 1/12° high-resolution monitoring and forecasting system [3]. The model component is the NEMO platform driven at the surface by the IFS ECMWF atmospheric analyses and forecasts. Observations are assimilated by means of a reduced-order Kalman filter with a three-dimensional multivariate modal decomposition of the background error. Along-track altimeter data, satellite sea surface temperature, sea ice concentration, and in situ temperature and salinity vertical profiles are jointly assimilated to estimate the initial conditions for numerical ocean forecasting. A 3D-VAR scheme provides a correction for the slowly evolving large-scale biases in temperature and salinity.

The horizontal resolution in the Western Mediterranean basin is around 7 km. Time series of analyses and forecasts are available since 2007 till present, with hourly outputs for the surface fields. The main features of the surface circulation of the Western Mediterranean Basin are well reproduced in average (Fig. 2).

Results

The TRANSMED time series provide an unprecedented insight in several scales and processes. TRANSMED data have also been used to assess the SMOS salinity determination quality [4].

This dataset is not being assimilated in the current Global CMEMS operational

system yet, so the TRANSMED data can be used as independent data to validate the behaviour of this system in the Western Mediterranean Basin. In a second time, these data will be assimilated in a reanalysis through the dedicated configuration of the Mediterranean Sea existing at Mercator Ocean [5,6].

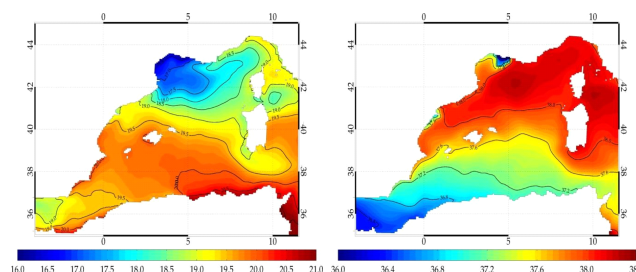


Fig. 2. SST (left, in °C, contours every 0.5°C) and SSS (right, in psu, contours every 0.4 psu) interannual average patterns (2007-2018) in the Global CMEMS operational system.

Acknowledgements

TRANSMED is part of the PartnerSHIP CIESM program, and is supported by the HyMeX/MISTRALS program (www.hymex.org) and the ANR-12-BS06-0003 ASICS-MED. TRANSMED is indebted to the maritime companies (Marfret and CMA-CGM) who allowed its installation on board, and to the crews for their dedicated assistance.

This study has been conducted using EU Copernicus Marine Environment Monitoring Service information (<http://marine.copernicus.eu/>).

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NORTHERN IONIAN CIRCULATION INVERSIONS: SIMULATIONS IN THE CORIOLIS ROTATING PLATFORM (LEGI, GRENOBLE)

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Abstract

Laboratory experiments in the Coriolis rotating platform at the University of Grenoble were carried out in order to demonstrate that inversions of the circulation in the northern Ionian basin interior are driven by discharge of water of varying density. Experimental results confirm the influence of the internal forcing on the circulation pattern in the interior of the receiving basin.

Keywords: *Circulation experiments, Ionian Sea*

A number of studies, especially since the altimetry data became available, have evidenced the sub-decadal cyclic inversions of the North Ionian circulation. Such inversions were explained in terms of the internal feedback mechanism between the Adriatic and Ionian Seas (Adriatic-Ionian Bimodal Oscillating System – BiOS). It is associated with variations of the density of the Adriatic dense water outflow, being the latter a function prevalently of its salt content [1]. In some cases however, extreme winter climatic conditions can result in a high-density water production in the Adriatic, thus making the water temperature a prevailing factor [2]. Yet, according to some numerical studies, the main mechanism generating the Ionian circulation inversions is claimed to be the wind-curl [3]. In order to demonstrate the role of the internal forcing in generating long-term basin-wide circulation inversions, a series of rotating tank experiments have been carried out in the Coriolis rotating platform at the University of Grenoble.

The rotating tank (an idealized basin of a circular shape) had a 13 m diameter. A central deep area (5 m in diameter) was surrounded by a 10% bottom slope forming a 4 m wide ring. Internal forcing was meant as a discharge of water of varying densities. The flow field was determined by the Particle Image Velocimetry (PIV) method.

Here we present results of one experiment, based on the following setup: the tank was configured as a two-layer basin; each layer was about 30 cm deep; surface layer had a fresh water density, while the bottom layer had density of 1015 kg/m³. Two sources of dense water were placed in the upper slope (180 degrees angle between each other). The rotational period (“one day”) was set up to 120 s and the total duration of experiment was about 4 hours (~130 days). The discharge of water with density 1010 kg/m³ at a rate of 0.4 l/s was carried out for 90 days from one source. At day 45th the second source was activated discharging 1.6 l/s of 1020 kg/m³ (“very dense”) water for another 45 days when it stopped. Then, one only source was kept active discharging water with density 1010 kg/m³ at a rate of 0.8 l/s until the end of experiment. The PIV measurements were done at twelve levels, so in this study we present the evolution of the current and vorticity fields at different depths during the experiment.

Fig. 1 shows the temporal evolution of the vorticity field, spatially averaged within the central deep plain. The inversion of the surface circulation from cyclonic to anticyclonic occurred rather quickly, after about ten days, upon the beginning of injection of very dense water (S2, Fig. 1b). The vorticity evolution in the intermediate layer (close to the interface) was influenced by the dense water discharge but to a lesser extent than in the surface layer. Also, at the intermediate depth, quite important vorticity oscillations were present, probably due to the occasional propagation of mesoscale cyclonic eddies from the slope area into the central region. These vortices seem to be subsurface intensified, since signals associated with them were very weak in the rest of the water column. After cessation of the very dense water discharge (S2), the anticyclonic surface circulation weakened (Fig. 1c). However, due to the relatively short duration of the experiment the restoration of the cyclonic circulation did not take place.

As a conclusion, we showed that the inversion of the circulation regime in the interior of the basin in the absence of the surface forcing was fully driven by the density of the input water. The discharged dense water gradually sunk down the slope occupying the central plain and squeezing the upper layer generating the anticyclonic vorticity. Lighter water discharge, on the other hand, produced water level increase and stretched the upper layer, resulting in a cyclonic vorticity pattern.

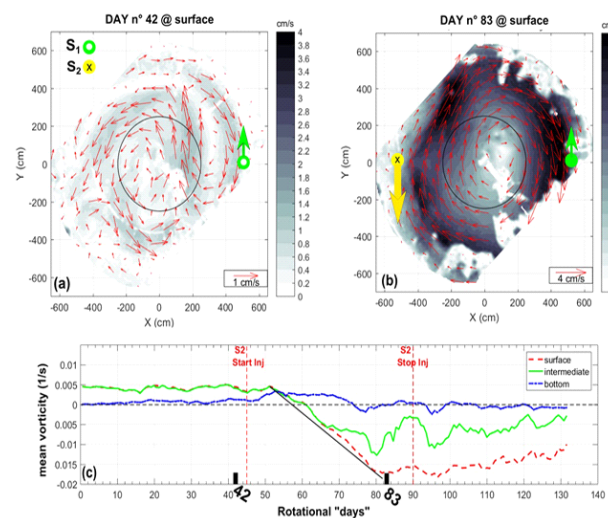


Fig. 1. Velocity distribution (a) prior and (b) after the very dense water discharge from the source S2. Time evolution of the vorticity field (c), spatially averaged within the deep portion of the tank (evidenced by a circle in a, b) at three levels: surface (mean of the three subsurface levels), intermediate and near bottom (mean of the three near bottom levels).

Other co-authors are the project coordinator Miroslav Gacic, Joël Sommeria, Samuel Vibaud, Thomas Valran, Ricardo Viana Barreto, Vanessa Cardin, Giuseppe Siena, Boris Petelin, Laura Ursella, who contributed to the experimental realisation and subsequent data analyses.

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BASIN AND SUB-BASIN SCALE VARIABILITY IN THE LEVANTINE BASIN

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Abstract

In the last six years the surface layer of the Levantine Basin was extensively studied in the framework of some international projects (ALTIFLOAT, CINEL, MELMAS, PERLE). A considerable amount of in situ data were collected in this region, giving the opportunity to produce an updated version of the surface current paths. Drifter, altimetry and Sea Surface Temperature data, collected during the period 2013-2018, were analysed and compared to the historical drifter dataset acquired between 1993 and 2010. The results show an increasing of the sea level in the southern Levantine in the period 2013-2018 with the strengthening of anti-cyclonic basin-scale structures. In the northern Levantine, the western branch of the Rhodes Gyre is strengthened and a north-westward shift of the Ierapetra Eddy core is observed.

Keywords: *Surface waters, Levantine Basin, Currents*

The surface circulation in the Levantine Basin derives from the complex interaction among multi-scale flow patterns (basin scale, sub-basin scale and mesoscale), producing a high spatio-temporal variability of the current field (Menna et al., 2012). This region is the most sensible to the climatic changes of the Mediterranean Sea, showing large increase in temperature and decrease in precipitation in recent years (Kum and Celik, 2014). These phenomena will increase in the coming years, as described by model simulations (Lelieveld et al., 2012). From an oceanographic point of view, future scenarios based on model results describe a progressive enhancement of an Eastern Mediterranean Transient – like events in the Eastern Mediterranean (Adloff et al., 2018). In this context, the present study aims to define the differences in the basin and sub-basin scale circulation of the Levantine Basin in recent years with respect to the historical data results (described in Menna et al., 2012) and eventually connect these differences with the increasing climatic variability of the region. The low-pass filtered and interpolated (6 hours) drifter tracks are used to estimate the pseudo-Eulerian mean velocity fields during the periods 1993-2010 (Figure 1) and 2013-2018 (Figure 2) in bins of $0.25^\circ \times 0.25^\circ$.

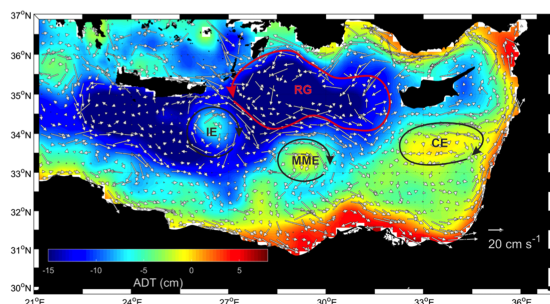


Fig. 1. Mean drifter currents in spatial bins of $0.25^\circ \times 0.25^\circ$ (arrows) superimposed on mean maps of ADT (gray shades) during the period 1993-2010.

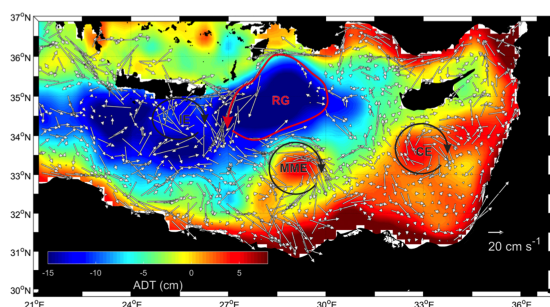


Fig. 2. Same as Figure 1 but for the period 2013-2018.

The mean maps of daily Absolute Dynamic Topography (ADT; $1/8^\circ$ Mercator projection grid) derived from altimeter and the satellite Sea Surface Temperature (SST; $0.04^\circ \times 0.04^\circ$) distributed by CMEMS, are used in the same periods of drifter data (Figures 1 and 2).

The surface currents in the period 2013-2018 (Figure 2) show larger intensities and a higher mean sea level in the main basin-scale structures of the southern Levantine - the Mersa-Matruh Eddy (MME) and the Cyprus Eddy (CE) - compared to the historical data (Figure 1). The mean location and shape of the MME are steady over time, whereas the CE is mainly elongated zonally according to historical data and more circular (similar extension in latitude and longitude) in recent years. In the western Levantine, the mean location of Ierapetra Eddy (IE) is centred at about 34.5°N and 27°E in the historical data (Figure 1), whereas in the recent years it moved north-westward, allowing the western branch of the Rhodes Gyre (RG) to brush the eastern coasts of the Crete island (Figure 2). The longitudinal extension of the RG is reduced and its western branch is more intense during the period 2013-2018. The increment/reduction of anticyclonic/cyclonic activity in the Levantine Basin in recent years can be related to: 1) a larger inflow of Atlantic Water from the west due to the predominant cyclonic activity in the Ionian Sea during the period considered (Menna et al., 2019) and a consequent sea level rise; 2) an increase of the SST during the period 2013-2018 (not shown) with respect to the historical data.

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OVERTURNING OF THE MEDITERRANEAN THERMOHALINE CIRCULATION

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Abstract

For more than five decades, the Mediterranean Sea has been identified as a region of so-called thermohaline circulation, namely of basin-scale overturning driven by surface heat and freshwater exchanges. The commonly accepted view is that of an interaction of zonal and meridional "conveyor belts" that sink at intermediate or deep convection sites. Here we show from in situ measurements and physical-biogeochemical simulations that most of the net sinking occurs within 50km of the boundary, away from open-sea convection sites. This sinking dominates the export of dissolved organic carbon, hence its central role as a conduit of exchanges between the superficial and deep ocean. We relate this sinking near the boundary to vorticity dynamic and the role of the Earth's rotation in suppressing net vertical motions in the open ocean.

Keywords: *Circulation, Mediterranean Sea, Water convection, Water transport, Organic matter*

The Mediterranean Sea is a semi-enclosed sea connected to the world ocean by a two-way exchange flow at Gibraltar Strait. This flow implies the existence of an overturning cell within the basin to flux mass from surface to intermediate depth. Indeed, the Mediterranean Sea is characterized by a superposition of intermediate and deep, zonal and meridional overturning cells that drive a so-called thermohaline circulation. This circulation has been studied for more than five decades [1] and is thought to be driven by the convection phenomenon, which connects intermediate and deep layers to the surface at a few specific sites [2]. However, despite strong observed vertical exchanges in deep convection areas, idealized studies suggest that no net downward mass flux is associated to them [3]. Instead, they argue for the existence of intense downwelling close to the boundary.

In this work we address where and how the sinking of the Mediterranean Thermohaline Circulation occurs, and what role it has on biogeochemical fluxes. To this end we perform a historical hindcast simulation of the Mediterranean Sea with the physical NEMOMED12 model, which is used to force Eco3M biogeochemical model. We also use glider transport measurements to estimate the sinking rate along a key boundary current. We focus on two key overturning cells of the Mediterranean Sea: the zonal overturning that drives the two-way exchange at Gibraltar and the western meridional overturning associated with the much-studied dense water formation of the northwestern Mediterranean Sea.

All our pieces of evidence show that an intense sinking occurs within 50km of the boundary, away from intermediate and deep convection sites [4], and is associated with large biogeochemical exports. For both overturning cells, all of the sinking simulated by NEMOMED12 model occurs near the boundaries, whereas the open-sea area, including intermediate and deep convection sites, undergoes very limited vertical motion. Key sinking regions include the North African border and Aegean archipelago for the intermediate cell, and the Northern Current for the deep cell, some of which are far away from convection sites. Transport measurements by repeated glider transects along the main Northern Current path confirm an intense sinking, which manifests itself as a deepening and barotropization of the boundary current along its path. Finally, the dissolved organic carbon export occurs predominantly through this sinking along boundaries in Eco3M biogeochemical model. This results puts forward the central role of sinking near boundaries as a conduit of exchanges between the superficial and deep ocean.

Analysis of the vorticity balance in NEMOMED12 physical model provides the rationale for this sinking near boundaries. Indeed, as a result of the Earth's rotation, any vertical motion induces vorticity stretching that must be balanced over the long run. In the interior ocean, the flow is close to geostrophic balance for which only the beta effect permits limited vertical motion where meridional flow occurs. On the contrary, near the coast, the presence of topography and intense boundary currents allows dissipation and friction to balance the vortex stretching, which permits stronger sinking.

We conclude by proposing a revised schematic of the Mediterranean overturning

circulation (Fig. 1, [4]). We argue that the Mediterranean overturning circulation can be comprehensively described by following boundary currents. This conceptually replaces the historical offshore "conveyor belts" by boundary "sinking rings". Although intermediate or deep convection sites indirectly regulate the sinking process, they have no direct contribution to it. At any depth, the availability of topography determines where significant sinking can occur, and key sinking regions are not necessarily in the vicinity of convective areas.

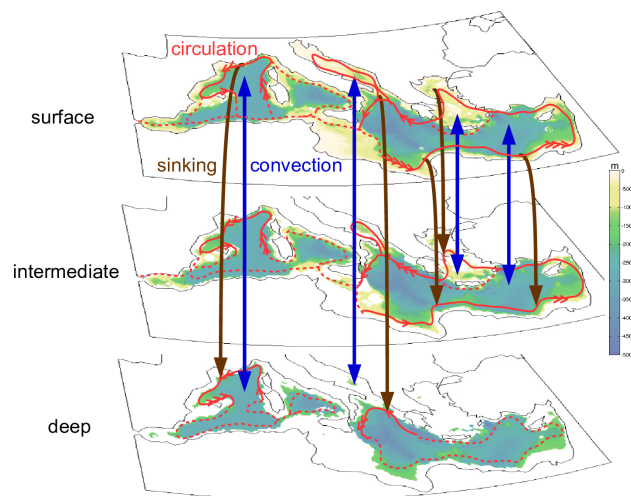


Fig. 1. Revised schematic of the Mediterranean overturning circulation. Sinking occurs along boundaries and is associated with the deepening of boundary currents. Offshore, convection sites undergo intense vertical mixing with no net sinking.

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CIESM Congress Session : Mesoscale variability
Moderator : Rui Caldera, OOM-ARDITI / IDL, Madeira, Portugal

Moderator's Synthesis

It is now well established in the scientific literature that mesoscale systems, in particular eddies, are ubiquitous features in the world's oceans. They are also reported to be the dominant source of kinetic energy in the oceans, which can trap and transport in their cores, over long distances, waters with distinct properties, organisms and particles (including marine litter). Their dynamic nature poses a challenge to sample their core and to map their distribution, and thus understanding their space-time variability requires further studies.

During this session three main themes were addressed: i) case studies of mesoscale processes in the ocean; ii) data and methods used to study mesoscale systems; iii) datasets currently available to map and study mesoscale phenomena i.e. eddies in the Mediterranean Sea.

Due to the size and semi-enclosed nature of the Mediterranean Sea, the dynamics of mesoscale eddies have different spatial-temporal manifestations relative to their Atlantic counterparts. Yet the interaction of the Mediterranean Outflow with the Atlantic Islands and Seamounts is known to induce the formation of relevant mesoscale eddies containing Mediterranean water in the core, i.e. "meddies". Therefore, the study of the dynamics of mesoscale features contained within the Mediterranean Basin can be viewed as important case studies to be replicated and/or continued in the Atlantic Basin, in spite of their distinct spatial / temporal scales. Sophisticated sampling methods like HF-Radars and towed vehicles such as the SEASOR are also fine examples of methodologies that can be used across both Basins to capture and detail the interior of these features. However, due to the altimetry data processing limitations, the methods used to generate the atlas of the mesoscale eddies of the Mediterranean (DYNEDMed-Atlas) are not possible yet to reproduce in the Atlantic. Future cooperations should try to cross-feed interests, teams, methods and datasets, in order to continue to contribute to sample and map the complex dynamics of these very abundant features.



A HIGH-RESOLUTION THREE-DIMENSIONAL HYDRODYNAMIC MODEL OF THE GULF OF GABES, TUNISIA

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Abstract

A high-resolution hydrodynamic model is used to investigate the circulation patterns in the Gulf of Gabes. A part of the Atlantic Tunisian Current (ATC) separates and invades the Tunisian shelf in the Gulf of Gabes and recirculates anticyclonally on the shelf, while the rest becomes a coastal current along the Libyan coast. The ATC signature appears weaker in summer, while in winter it is well developed. On an annual mean scale, the turbulent kinetic energy (EKE) averaged over the whole domain of study represents about 64% of the total kinetic energy suggesting the turbulent nature of the circulation. Comparison of computed and observed lagrangien drifters trajectory shows a good agreement, either in summer and winter periods, although in general, currents are slightly lower than observed

Keywords: *Coastal processes, Gulf of Gabes*

1. Introduction

The gulf of Gabes is located in Southeast Tunisia, between 35°N and 33°N, and extends from Ras Kapoudia, at 35°N parallel level to the Tunisia-Libyan border. The Gulf consists of a very shallow basin with bathymetry depths ranging from 20 to 50 m within a 100 km² area. If the tides in this gulf were extensively studied [1-2], some interrogations about the hydrodynamic circulation remain without convincing answers. Indeed, the main knowledge about the circulation patterns are obtained from some numerical simulations of the circulation in the Central Mediterranean Sea [3-4]. Moreover, there are no datasets that have adequate temporal and spatial resolution to capture the mesoscale in this local area. One of the main objectives of this study is to examine the circulation patterns and its variability with focus on small-scale processes. The spatial and temporal variability of the temperature is interesting to study since the Gulf of Gabes is a basin where sea-atmosphere interactions act par excellence. Being an almost closed and shallow ecosystem, the gulf responds and interacts very quickly with weather conditions. To achieve these goals, a 3D finite-difference hydrodynamic numerical model was applied to the gulf of Gabes.

2. Model set up

The model used in this study is based on the Regional Oceanic Modelling System (ROMS), a three-dimensional primitive equation, finite difference hydrodynamic model. ROMS uses stretched, terrain-following coordinates in the vertical and orthogonal curvilinear coordinates in the horizontal. It is a split-explicit, free-surface oceanic model, where short time steps are used to advance the surface elevation and barotropic momentum equations [5]. The horizontal grid resolution is chosen to be 1/96° (nearly 1 km) for a better representation of the small-scale processes. A grid spacing in sigma coordinates is used in the vertical with 25 vertical levels. The daily mean values of temperature, salinity, total velocity and elevation were transferred from the coarse spaced grid of MED12 [6] to the finely spaced grid of the ROMS open boundaries through an off-line, one-way asynchronous nesting.

3. Results

The model results compare reasonably with existing data and the circulation patterns in seems in agreement with previous regional numerical simulations. The ATC divides into two branches, the first one invades the Tunisian shelf in the Gulf of Gabes and recirculates anticyclonally on the shelf, while the second continues flowing southeastward as an important coastal current and comes close to the Libyan coast, giving rise to a strong coastal jet near the Libyan current. The SST averaged over the gulf is characterised by a strong seasonal signal with an amplitude of 10.3 ° C. As the waters of the Gulf of Gabes are very shallow, they feel very quickly atmospheric effects including wind and heat flow. Indeed, our calculations show that they are extremely cold in winter and heated in summer, much more than elsewhere in the Mediterranean. This implies that these waters will strongly suffer the impact of the climate change. The logarithm of the ratio between EKE and MKE, which provides information on the energy distribution between the mean and fluctuating currents in the study area showed that the EKE values

are up to five times higher than MKE in logarithmic scale. The EKE contribution to TKE is therefore dominant, reaching about 64% in the coastal area on annual scale. This means that the gulf of Gabes is almost controlled by fluctuating currents. We believe that the high values of EKE are mainly due to the baroclinic instabilities of seasonal currents. More specifically, they would be characterized by a permanent conversion of turbulent potential energy available in turbulent kinetic energy. This can be explained by the sudden reversals of the direction of currents in this region. The effect of such inversions, in terms of increasing variability, is amplified by shallow, flat bathymetry and the advection of the unstable ATC on the continental shelf.

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MESOSCALE AND SUBMESOSCALE STRUCTURES OBSERVED DURING HIGH RESOLUTION SURVEYS IN THE WESTERN MEDITERRANEAN BASIN

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Abstract

The Mediterranean Sea is often referred as a “pocket ocean” exhibiting many processes that are primary interest the global ocean circulation [1] given the opportunity to investigate a large panel of oceanic features in a relatively restrained area. Recent field experiments based on the multi-platform integrated monitoring MOOSE [2] or on intensive targeted experiment HYMEX [3] revisited the hydrology and the dynamics of the Western Basin. Such approaches emphasized the ubiquity of the fine scale dynamics in the Mediterranean dynamics. An overview of the observed processes during 5 new fields experiments will be presented and discussed regarding meso- and submeso-scale processes.

Keywords: *Mesoscale phenomena, Western Mediterranean, Fronts*

From 2015 to 2018 five fields experiments have been performed in the Western Mediterranean Basin during winter or early spring (figure 1). Thanks to the intensive use of a towed vehicle undulating in the upper oceanic layer between 0 and 400 meter deep (a SEASOAR), a large amount of very high resolution hydrological transects (cumulating more than 3000 nautical miles) have been undertaken, crossing mesoscales dynamics (slope current and its instabilities, anticyclonic eddies, sub-mesoscales coherent vortices, frontal dynamics convection events, straits outflows) or sub-mesoscales processes like stirring, mixed layer or symmetric instabilities. When available, the data were completed with velocities recorded by vessel mounted ADCP and by surface salinity and temperature recorded by TSG. Some CTD casts have been also performed giving the hydrography of the background and in 2016 a MVP (Moving Vessel Profiler) has been deployed. Freely available, this data set is an unprecedented opportunity to investigate the fine scale processes as the Mediterranean Sea is known for its strong and contrasted dynamics. It should be useful for modellers who reduce the grid size below 400 m and expect to simulate fine scales dynamics or for theoretician who could find some evidence for conceptual approaches.

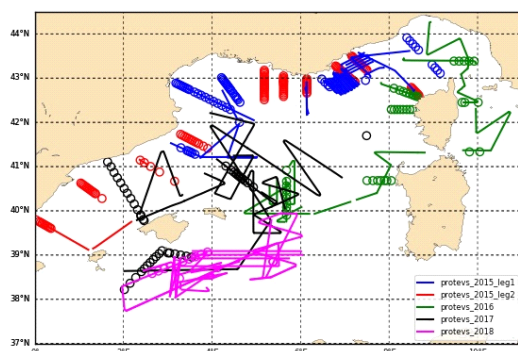


Fig. 1. Overview of the 5 fields experiments. Straight lines represent the SeaSoar transects; circles represents the CTD casts.

When working together, VMADCP and SEASOAR provides a unique synoptic view of a transect. It is then possible to observe with the same horizontal resolution the density and the velocity field in the sub-surface layer, showing even at fine scale (few kilometres) the predominance of the geostrophy. The temperature and salinity field is more patchy than expected but the thermal expansion and the saline contraction coefficient of sea water often compensate and lead to a smoother density (and associated dynamical) field. The structure of observed anticyclonic eddies appears also to be more complex than formerly

described by CTD arrays and are currently composed of different water masses. Submesoscale (ageostrophic) dynamics are highlighted both in the eddy cores (upwelling/downwelling) and along eddy boundaries (likely to be associated to symmetric instabilities). Intra-pycnocline structures subducted or locally formed occurred at eddies boundaries. The fine structure of the NBF (North Balearic Front) showed the interaction between the front and the SCV's generated in the Northern part of the Basin. In the vicinity of the NBF, an offset between a surface layer front and a deep front is noticeable. In the North current, stirring appears in both tracers and velocity field front of Toulon. Particular attention will be paid to the heterogeneity of surface eddies, revealing unexpected (or yet unobserved) particular structure (dual core eddy [4], multi-layered eddy, density compensated structures, ageostrophic dynamics inside or around eddies).

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INTENSE CYCLOGEOSTROPHIC MESOSCALE ANTICYCLONE: IERAPETRA EDDY

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Abstract

The dynamical evolution of the Ierapetra anticyclones (IEs) revealed strong seasonal variability of the eddy intensities that frequently require cyclogeostrophic corrections. The IEs recurrently form and re-intensify in the south east of Crete and might sometimes exhibit strong negative core vorticity ($\zeta = -f$). We investigate with a reduced gravity shallow water model the ocean's response to a transient orographic wind forcing jet that could mimic the strong Etesian forcing in the same area. We recover strong anticyclonic eddies and provide the first dynamical explanation for the formation and the re-intensification of the IEs.

Keywords: Mesoscale phenomena, Wind, Eastern Mediterranean

The dynamical evolution of the IEs, as detected from satellite observations (AVISO/DUACS) and AMEDA eddy detection algorithm [1,2], are found to be among the most intense anticyclones of the Mediterranean Sea. Evidences on the eddy intensity from several oceanographic campaigns (VMADCP measurements) suggest that the mesoscale IEs are probably more intense than we even estimate. The geostrophic Rossby number experiences a strong variability among the years, (from $Ro=0.07$ to $Ro=0.27$) and frequently exceeds $Ro>0.1$ [1]. For such high intensities the ageostrophic corrections cannot be neglected while the estimated maximum values of the core vorticity might sometimes exhibit a negative potential vorticity core ($\zeta = -f$). Moreover, after their formation IEs could re-intensify and double their intensity in less than 4 months. This intensification process is characterized mainly by an increase in the tangential velocities rather than the eddy radius [1]. The position where the IEs form and re-intensify coincides with a region of highly negative wind stress curl induced by the recurrent and strong Etesian summer winds Fig.1(a). The effect of such regional Etesian forcing in the formation and intensification of an Ierapetra anticyclone is investigated with a reduced gravity shallow-water model.

We use ALADIN wind stress data that provide wind stress components in $1/12^\circ$ resolution for the Mediterranean Sea in time intervals of 3h [3]. Analyzing the regional wind stress variations from 1993-2012 in the lee of Crete island, we build an idealized forcing function that could mimic the seasonal Etesian forcing. In a first approximation, an symmetric wind forcing shape ($c=1$) with mean forcing shape characteristics $(W,L)=(40,100)$ km and spatial distribution as described in Eqn.(1) could fit the mean Etesian forcing spatial variations Fig.1(b). Although, the regional wind forcing is better represented with an asymmetric forcing ($c=2$ for $x<0$), due to weaker wind stress shear in the cyclonic side. Interested in the long-term ocean response, we simulate the effect of the transient wind forcing Eqn.(1) of intensity τ_0 and duration T_0 over a 3 month period (summer period). Various wind stress intensities and durations were tested as well as the possible intensification of pre-existing eddies. To track the eddy characteristics of the driven flow we apply AMEDA eddy detection algorithm [2].

$$\tau_y(x, y, t) = \tau_0 e^{-\frac{1}{2} \left(\frac{t-t_0}{T_0} \right)^2} e^{-\frac{1}{2} \left[\left(\frac{x}{cW} \right)^2 + \left(\frac{y-y_0}{L} \right)^2 \right]} \quad (1)$$

The non-linear evolution of the flow revealed the formation of both cyclonic and anticyclonic structures. When a symmetric wind forcing is applied in the ocean, an asymmetry between generated cyclonic and anticyclonic eddies emerges for relatively high values of wind intensity and duration. An example of the ocean response to a symmetric wind forcing shape of intensity $\tau_0 = 0.4 \text{ Nm}^{-2}$ and duration $T_0 = 10$ days is given in Fig.1(c). The asymmetric forcing forms a more circular anticyclone but of similar characteristics with the symmetric case. The intensity of the formed anticyclones was found to linearly depend on the product of the wind forcing intensity and duration. Their size scales with the wind forcing width W . When applied above a pre-existing idealized eddy, we recover the intensification process where the eddy tangential velocity and vorticity increases while the eddy radius stays relatively the same. Hence we provide the first dynamical explanation for the formation and the re-intensification process of the strong IEs in the Levantine basin.

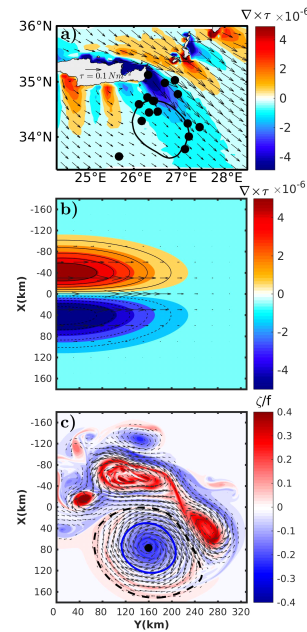


Fig. 1. (a) Climatological wind stress $\langle \tau \rangle$ (vectors) and wind stress curl $\nabla \times \tau$ for the summer months. The mean Ierapetra eddy position (black contour) and the IEs first detection (black circles) are superimposed. (b) Idealized Etesian symmetric wind forcing at time of maximum forcing. (c) Ocean's response illustrated with vorticity fields and velocity components shown 80 days after the maximum forcing occurs. The formed anticyclone is detected with AMEDA (contours).

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ESTIMATION OF SURFACE CIRCULATION STRUCTURES IN THE MALTA SICILY CHANNEL DERIVED FROM HF RADAR

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Abstract

Surface circulation structures were analysed in the Malta-Sicily Channel by means of three different combined datasets: AVISO-MADT, CCMP Wind fields and 13.5 MHz HF Radar. Satellite chlorophyll, sea surface temperature, and numerical and real drifters were used for the validation of the HF Radar array. High frequency motions as well as mesoscale structures, that were not identified previously, were individuated applying the methods described in Kundu, 1976 and Sanderson et al., 1995.

Keywords: *Circulation, Malta Channel, Remote sensing, Coastal processes, Mesoscale phenomena*

Introduction

The Malta-Sicily channel is a passage in the mid-Mediterranean Sea which separates the Malta island with the southern tip of Sicily. The circulation in this area is complex as it is driven by water exchange through straits, wind stress and buoyancy fluxes at the surface due to freshwater input, heat exchanges, and internal dynamical processes. Additionally, complexities are introduced by topography and shape of the coastline. In a simplified way, the general circulation is mainly driven by the slow Mediterranean thermohaline circulation, where water exchanges through straits in the Sicily channel present a double layer system with inflow of colder and fresh water from the Atlantic Ocean (Atlantic water, AW) at the surface and an outflow of warmer and saltier water from the Levantine sea (Levantine water, LW) at the bottom and intermediate layers.

Results

A geostrophic current field in the Sicily channel was computed from AVISO Absolute dynamic topography product, which includes MADT starting from January 1993 to December 2015. Additionally, scatterometer wind fields spanning from January 1988 to December 2011 from the CCMP (Cross-Calibrated Multi-Platform wind vector analysis) were used to see the influence of the wind in Sicily channel. Validation and then analysis of the surface circulation was made using estimates of the velocity field from High frequency radar (13.5 MHz) data spanning from August 2012 to January 2015 (a three array of CODAR HF-radars between Malta and Sicily, under the CALYPSO project), satellite chlorophyll, sea surface temperature, and numerical and real drifters. CCMP v2 scatterometer datasets spanning from August 2012 to January 2015, alongside with the HFR datasets, were used to study high frequency motions as well as mesoscale structures by means of different methods such as Kundu, 1976 and Sanderson et al., 1995.

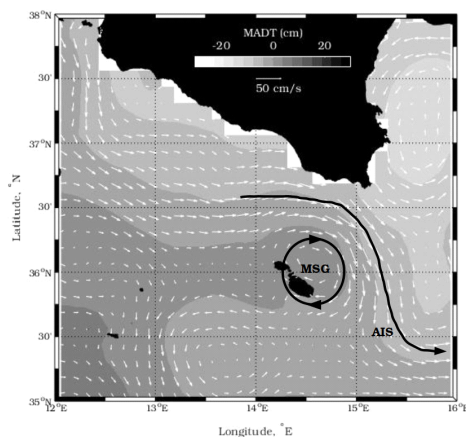


Fig. 1. Interannual map of MADT and mean geostrophic circulation in the Malta-Sicily channel showing the most important structures driving the circulation in the channel

Computing the geostrophic currents and comparing them with previous studies on the surface circulation in the Sicily channel, helped us to identify some of the main structures governing the circulation, such as the Atlantic Ionian Stream (AIS), as described by the studies of Lermusiaux, 1999 and lately by Jojuni et al., 2016. These permanent structures, along with some mesoscales drive the circulation in the Sicilian channel. A mesoscale, which was not present in previous studies, was found to be persistent in the Malta Sicily channel; the anticyclonic Malta Sicily gyre (MSG). This gyre has a radius of ~ 50 km and spins with a velocity of ~ 10 cm/s, during the autumn-winter period. Our studies showed that geostrophic balance is a good approximation to describe the dynamics in the Malta-Sicily channel at more than weekly time scales. These geostrophic currents (AIS and MSG) are responsible for the advection of biogeochemical properties in the area. As winds at longer time scales are mostly SE, there is a reinforcement to the AIS velocity field. Wind stress curl showed coastal Ekman upwelling and downwelling along the Sicilian coast. Here the wind, even if neglected in the geostrophic approximation, helps to build up the pressure gradient needed to balance the Coriolis force at scales longer than a week.

In order to individuate the anticyclonic Malta Sicily gyre, we used Sanderson's method (Sanderson et al., 1995) to find the kinematic properties of the eddy. Our studies revealed that the eddy prevails throughout the winter period in agreement with the qualitative studies carried out, identifying then the anticyclonic mesoscale also in the quantitative sense. Since the phase angle of the complex correlation coefficient is a good measure of the average relative angular displacement (veering) between a pair of two-dimensional vector series (Kundu, 1976), with the analysis of the time series using complex correlation we were able to identify Ekman transport. The correlation was made taking the advantage of the high resolution and the nature of HFR data, using the residual velocity (i.e. removing the geostrophic component of the HFR flow) with the wind. It showed a veering angle of ~ 40 degrees. Corroborating the influence of the wind field, which plays an important role at shorter time scales.

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3D STRUCTURE OF LONG-LIVED EDDIES IN THE MEDITERRANEAN SEA: THE DYNED-ATLAS DATA BASE.

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Abstract

The DYNEDMed-Atlas database provides a unique set of data on surface eddies for a 17 years period (2000-2017) in the Mediterranean Sea. It contains the physical and the dynamical characteristic of mesoscale eddies detected from the cross analysis of AVISO/DUACS altimetry products and Argo profiles. The typical size, the intensity and the trajectory of each detected eddy are calculated. An iterative method is applied on the surface geostrophic velocities to compute the cyclostrophic velocity components. The estimation of the vertical eddy structure is calculated, for more than 100 eddies, from the co-localization of surfacing Argo profiles with the eddy areas. We observed that the long-lived eddies are mainly anticyclonic and located in the eastern basin with a much deeper extend than the ones of the western basin.

Keywords: *Mesoscale phenomena, Remote sensing, Vertical profile, Intermediate waters, Mediterranean Sea*

The regional circulation in the Western and the Eastern basins of the Mediterranean Sea is dominated by large gyres and long-lived eddies. The combination of the high-resolution ($1/8^\circ$) altimetry data-set provided by AVISO/DUACS in the Mediterranean Sea with automatic eddy detection and tracking algorithm allow to quantify the dynamical evolution of large eddies over long time periods [1, 2]. Such mesoscale eddies, having a characteristic radius equal or larger than the local deformation radius, are generally considered to be geostrophic. Nevertheless, there are few cases where the ageostrophic velocity components induced by the local curvature of the streamlines are not negligible. Therefore, we used an iterative method which computes with the best accuracy the ageostrophic corrections to the geostrophic surface velocity of the AVISO/DUACS products [3]. We found that these ageostrophic corrections are needed for most of the mesoscale anticyclones that have a geostrophic vortex Rossby number larger than $Ro > 0.1$ and especially the Alboran and the Ierapetra eddies [2].

However, such analysis based on surface velocities cannot provide any information on the vertical structure of the eddies. We therefore use the Argo profile data-base to estimate the vertical extend of some of detected eddies. Once all the detected eddies were identified, we separate the Argo profiles in two groups: the ones that are located inside an eddy and the one which are outside of all the detected eddies. With the second group we can build the climatological density profiles, of the unperturbed Sea, around a given position and a given date. Hence, the comparison of these climatological profiles with the Argo profiles taken inside the eddies allow us to quantify the maximum depth of the core density anomaly of each long-lived eddy. According to the figure 1, the vertical extend of the core density anomaly of anticyclones (circles) could reach 500m in the Levantine basin while it never exceeds 250m in the Western basin. On the other hand, long-lived cyclones (square) are less numerous and their core density anomaly hardly reach 150m. The lifetime of the eddies sampled by more than ten Argo profile is given by the size of each symbole. Most of the long-lived eddies, those who survive more than six months, are located in the Levantine basin. Their lifetime is correlated to their deep vertical extend.

Hence, thanks to the DYNED-Atlas data base (<https://www1.lmd.polytechnique.fr/dyned/>) we were able to compare, between the Western and the Eastern Mediterranean Sea, the vertical structures of more than an hundred mesoscale eddies. The heat anomalies induced by the long-lived anticyclones, in the Levantine basin, extend much deeper than the seasonal mixed layer.

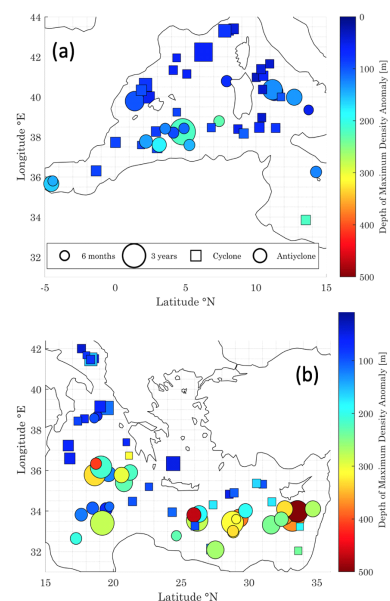


Fig. 1. Maximum depth of the core density anomaly (grayscale) of long-lived (> 6 months) cyclonic (square) and anticyclonic (circle) eddies sampled by more than 10 Argo profiles in the Western (a) and the Eastern (b) basin. The lifetime of each eddy is given by the size of its symbol.

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ISLANDS AS EDDY TRANSFORMATION AND GENERATION HOTSPOTS: CABO VERDE CASE STUDY

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Abstract

Oceanic islands have long been associated with the generation of eddies in their wakes [1], but their interaction with background incoming eddies has seldom been considered. This study focuses on the characterisation of background and locally generated mesoscale eddies in the Cabo Verde Archipelago between 2003-2014. Special attention is given to the interaction of incoming eddies with the islands and their impacts on the local generation of eddies. The archipelago is an ideal location to study such processes due to its: high mountains and exposure to constant north-easterly trade winds; complex island disposition and shape; and the exposure to westward-propagating eddies generated off the African coast. Island-induced wind-shear effects are also considered, and examples of the local biological response presented. This is achieved by combining satellite observations for wind, Sea Surface Height and Chlorophyll a surface concentration. Results show that the intersection of incoming eddies with the islands is recurrent and results in eddy deflection, splitting, merging, intensification and termination (sorted by highest number of occurrences to lowest). Local island-induced disturbances are also significant, mainly due to atmospheric effects. Such processes result in the generation of island-induced eddies and in wind-mediated eddy intensification and confinement, more often observed in the leeward group. Nonetheless, it is strongly suggested that many locally generated eddies are directly or indirectly related to the interaction of background eddies with the islands. Pronounced phytoplankton blooms were observed in both local and background eddies generated off the African coast, challenging the idea that primary productivity in deep oceanic islands is exclusively driven by island-induced mechanisms [2].

Keywords: Eddies; Orographic winds; Cabo Verde

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CIESM Congress Session : Open Sea Processes
Moderator : Paulo Relvas, CCMAR, Univ. of Algarve, Portugal

Moderator's Synthesis

From the research presented in the Open Sea Processes session and from our own experience we do find similarities and differences between the processes in the Mediterranean Sea and the adjacent Atlantic Ocean. Both systems show overturning circulations, although at different scales. Deep and intermediate water formation and vertical displacements are concerns in both systems. Vertical velocities are higher in the Mediterranean and convective processes are claimed to play a significant role there, while wind-driven processes, buoyancy, diapycnal mixing or entrainment are highlighted for the Atlantic. The processes are not mutually exclusive, but the resulting vertical mixing rates are apparently distinct. Mesoscale activity plays a role in the horizontal mixing in both systems, but coastal upwelling and associated offshore export of material are emphasized in the Atlantic. Mesoscale activity is not exclusive of the upper layers and occurs also in the adjacent Atlantic at the Mediterranean water equilibrium level (mainly 800-1000m deep) and represents a key issue in the salt dispersal in the North Atlantic, with climatic consequences.

Underlying all the above mentioned mixing processes, turbulence is present everywhere. We cannot understand how momentum or heat propagates to the deepest layers without assuming turbulent mixing. The same applies to the horizontal dispersal of properties. Turbulence occurs in all scales of space and time. The transference of properties between scales occurs through turbulent mixing. It is recognized that we need to include the smaller scale processes in the larger scale models in order to improve them. Thus, present research lines point to smaller scales. Sub-mesoscale and smaller scales were the object of studies presented in the Open Sea Processes session. In the absence of a theory of the physics of the turbulence, the alternative is to parametrise the process. We have to find turbulent coefficients that properly reproduce the physical problem. However, an accurate parametrisation can be achieved only through a detailed knowledge of the underlying physical processes. To that end, intense observations on dense 3D sampling grids over long periods of time are required. Observation cannot be limited to the surface, through satellites. It is necessary to sample the entire water column, either with long term moorings or process orientated fine scale records. To fulfil that objective, observation methodologies are common to the Mediterranean Sea and adjacent Atlantic Ocean.



IMPACT OF OCEANIC FINE SCALES DURING THE INTENSE CONVECTION EVENT OF WINTER 2012-2013 IN THE NORTH-WESTERN MEDITERRANEAN SEA

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Abstract

Several recent studies reveal the importance of submesoscale. The submesoscale dynamics is strongly ageostrophic, leading to intense vertical velocities and intense vertical buoyancy fluxes. Here, we study the role of (sub)mesoscale structures during deep convection events in the North-Western Mediterranean sea. By using numerical configurations at different spatial resolutions and adapted scale separation methods, the impact of submesoscale features is quantified during the different phases of the intense convection event of winter 2012-2013.

Keywords: North-Western Mediterranean, Open sea

The North-Western Mediterranean sea is one of a few regions in the world's oceans where deep convection may occur. Compared to other deep convection areas, the relative ease of access allows numerous in situ experiments which lead to well documented deep convection events [1]. Furthermore, numerical realistic experiments, at different spatial resolutions, have proven the ability of ocean circulation models to represent the different phases of deep convection events [2].

In this study, we use the Coastal and Regional Ocean COmmunity Model (CROCO, <https://www.croco-ocean.org>). CROCO is a new ocean modeling platform built upon ROMS_AGRIF. Numerical experiments remain in the framework of the hydrostatic assumption. In the recent years, [3], [4] and [5] studied the sensitivity of deep convection modeling to the initial state, to the representation of mesoscale processes and to the air sea exchange. Here, we tackle the influence of submesoscale processes. For that purpose, different configurations at various spatial resolution are set up, from eddy resolving to submesoscale permitting. They cover the entire North-Western Mediterranean sea with a south limit at 39°N. Horizontal resolutions are set between 400 m and 3600 m. All these different configurations are run from 1 August 2012 to 1 May 2013, covering the preconditioning, the stratification breakdown and the restratification phases.

To isolate fine scale contributions, we use a spatio-temporal low-pass filter, following the strategy developed by [6]. Each variable is decomposed into mean, mesoscale and submesoscale contributions. The spatio-temporal filter is designed to remove scales greater than 10 km (about twice the Rossby radius of deformation before stratification breakdown) and longer than four days. For each configuration, submesoscale vertical buoyancy fluxes are computed and averaged in a box included in the convection area. Time series of the averaged fluxes are presented in figure 1 for the configurations at 400 m and 3600 m. Submesoscale buoyancy fluxes are mostly positive and more intense for the configuration at 400 m. For the finest configuration, restratification fluxes occur during the deepening of the mixed layer, partially counteracting the effects of the strong atmospheric fluxes. The different convection events take place at the same time for both configurations. However, restratification submesoscale fluxes are stronger for the finest configuration, leading to shallower mean mixed layer. This latter observation is also due to a smaller spatial extent of the convection area for the configuration at 400 m. Dense water formation volumes are of the same order of magnitude than computed in [3], [4] and [5]. They are however weaker for the finest configuration. In accordance with the results shown in figure 1, submesoscale activity has the effect of limiting deep convection.

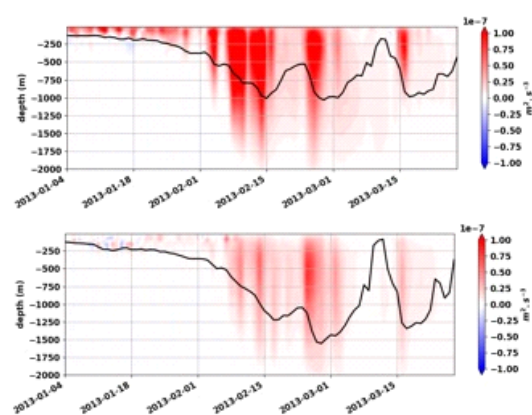


Fig. 1. Spatial average of submesoscale vertical buoyancy fluxes for the configurations at resolution of 400 m (top) and 3600 m (bottom). The black line represents the mean mixed layer depth.

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FORMATION AND DISPERSION OF LEVANTINE INTERMEDIATE WATERS

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Abstract

A high-resolution numerical model has been implemented in the Mediterranean basin to study the interannual variability of the formation of intermediate waters and the dispersion pathways of this water mass to the rest of the basin. Sensitivity studies and detailed validations are discussed. The formation rates and trajectories of particles injected into the formation area are then examined.

Keywords: Intermediate waters, Levantine Basin

The intermediate waters formed in the Eastern Mediterranean basin play a major role at different scales. First of all, they condition the distribution of nutrients throughout the basin and constrain the distribution of trophic regimes. On the other hand, they contribute substantially to the salinity of the North Atlantic intermediate waters and could even be a major actor of convection in the Labrador and Norwegian-Greenland seas.

Intermediate Levantine waters were widely studied until the 1990s from different cruises [1] at a time when numerical models [2] were still far from the realism reached today. Since then, the number of in-situ observations has been greatly reduced. Finally, in the last 5 years, thanks to the ARGO program, the number of profiles available in the region has increased steadily. Our observation is that it is now appropriate to work again on the formation of intermediate waters by taking up the questions that remained unanswered in the 1990s. We would like to better identify the formation areas and in particular to verify if the formation in Rhodes Gyre is also accompanied by formation in the coastal areas from Israel to Turkey. There is also interest in the importance of preconditioning by sustained summer winds. Finally, we would like to better understand the impact of circulation on the scale of the Levantine basin and in particular the interactions between the formation zone and the large anticyclonic structures that accumulate warm and salty surface Levantine waters.

A configuration of the SYMPHONIE hydrodynamic model [3] has been developed for the Mediterranean basin with a resolution varying between 2 and 4 km. The simulation is first compared to the available observations (SST, ARGO T/S profiles) over a period of a few years (Fig. 1). In particular, the time series obtained with ARGO floats are reconstructed with the model outputs. Various sensitivity tests are carried out, for example on the inflow of Atlantic waters at Gibraltar or on air/sea fluxes. Lagrangian tracers are then introduced to highlight the pathways of Levantine waters.

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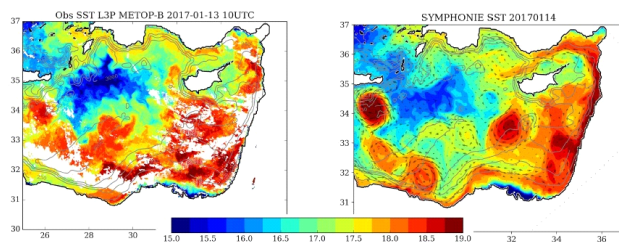


Fig. 1.
Sea surface temperature for January 2017. left : satellite ; right : SYMPHONIE model

INTERMEDIATE DENSE WATER FORMATION AND CURRENT VARIABILITY AT THE DEEPLV MOORED STATION IN THE SOUTHEASTERN LEVANTINE BASIN

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Abstract

We present an eighteen month long (Nov 2016 - June 2018) high-frequency record of velocity, temperature and salinity of the entire water column (1500 m depth) at the DeepLev station, 50 km off-shore Israel. Continuous temperature and salinity records at the LIW core, and down to 400 m depths, show first concrete evidence for LIW formation in this area during February-March 2017 and January-February 2018. Current meters throughout the water column reveal two separate water masses in terms of velocity. The upper 200 meters and the lower 1000 meters (from 400 m depth almost down to the seafloor), are each completely barotropic and decoupled from each other. The upper layer has a strong seasonal cycle, with strong currents in winter reaching 50 cm/s and weak in the summer, whereas the deeper layer shows no seasonal cycle.

Keywords: *Eastern Mediterranean, Levantine Basin, Intermediate waters, Time series, Currents*

A deep-sea station, is vital for better understanding the dynamics of physical and biochemical processes, which requires to resolve variability on timescales ranging from one day and less to decades and longer. It enables to separate real long-term trends in environmental drivers from the natural variability of the system, as well as resolve sporadic events, such as LIW formation, which can easily be missed, without nearly continuous measurements. As far as we know, the dataset presented here is the first continuous record in deep water of the region.

(not shown). By August 2018 the LIW salinity peak retreated back to values between March and November, due to interaction with water above and below. This suggests that the peak in temperature and salinity in late January to mid-February 2018, seen in time series, was of "fresh" LIW, created nearby, and not in the relatively remote Rhodes Gyre.

The main conclusions of this study, some of which are not discussed here, are summarized as follows:

- Concrete evidence for the formation of LIW in southeastern Mediterranean, most probably along the continental slope. LIW formation took place during February-March 2017 and January-February 2018.
- Current meters throughout the water column reveal two distinct layers. The first, down to (at least) 200 m, and the second from 400 m down almost to the seafloor. Currents are constant with depth in each of them. (No measurements were done between the two layers.)
- The currents feature a prominent along-isobath direction as on the continental shelf and slope, and support an average picture of a LEC that continues north along the Israeli continental shelf.
- The currents of the upper water mass feature a strong seasonal cycle, with strong currents in the winter and weak ones during summer. This differs from the seasonal cycle of the continental shelf (and slope), which features strong currents in winter and summer (summer), and weak currents during spring and fall (throughout the rest of the year).
- The currents of the lower water masses do not feature a seasonal cycle.
- A strong near inertial oscillation in velocities, associated with NIWs, affects the entire water column.

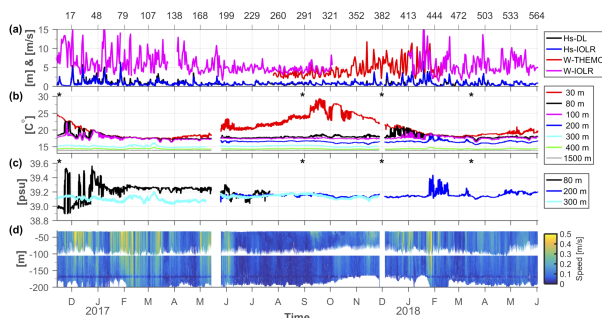


Fig. 1. (a) Daily averaged significant wave height in meters from the DeepLev mooring and the Hadera coastal station. Daily averaged wind speeds from the THEMO mooring and the IOLR coastal weather station are shown in the same panel. (b) Measured temperature from ADCPs, CTDs and Aquadopps. (c) Salinity measured by CTDs. (d) Speed from the top two RDI ADCPs. Bottom horizontal axis is time in month and year. Top horizontal axis is days since first deployment (14-Nov-2016 06:00). Black stars in panels b and c indicate time of ship-based casts.

The figure shows temperature, salinity and upper 200 meter current speed measured from the DeepLev station. The upper layer at 30 m cools during fall, and approaches the 80 and 100 m water temperature, in the beginning of February. It starts warming up again, forming a surface water layer, temperatures separating, in spring. There are strong modulations in the 80 m and 100m temperatures in the winter, which are accompanied by strong changes in salinity. These peaks occur when measurements are just below the thermocline depth, such that a slight slump in thermocline depth, possibly due to a mesoscale structure, gives rise to a large increase in measured temperature and salinity, rather than an abrupt mixing event.

The strong modulations in temperature and salinity at 200 m and below during late winter (early spring), however, do not originate for the same reason. Casts taken during the second fall-winter (2017-18, not shown), show the LIW peak lies as expected at approximately 28.6 kg/m³ [1]. The 200 m DeepLev CTD continuously samples at, or just below, the LIW core. Furthermore, the peak in salinity and temperatures, seen in the time series, in late January to mid-February 2018 is at the same density, pulling the LIW peak to a higher salinity value, which can be seen also in the cast taken 3 weeks later, in mid-March 2018

Research in progress using gliders attempts to understand the mechanism, observe, and quantify LIW formation along the southeastern continental slope of the Mediterranean, which could have consequences on global climate. LIW formed from the LSW, which has been going through rapid warming and salination [1,2], eventually leaves the Mediterranean through the Strait of Gibraltar, where they have role in creating dense water in the Atlantic meridional overturning circulation.

*Eli Biton, Hezi Gildor, Tal Ozer, Ronen Alkalay, Rotem Soffer, Yaron Toledo, Ilana Berman Frank, Yishai Weinstein, Timor Katz, Barak Herut.

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THERMOHALINE EVOLUTION OF THE WESTERN MEDITERRANEAN DEEP WATERS WITHIN THE WMT PERIOD

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Abstract

The thermohaline evolution of the Western Mediterranean deep waters since 2005 is analysed by means of a seasonal hydrographical time series in terms of background diffusion and intermittent water renewals. The contribution to the heat and salt budgets due to ventilation is disentangled from the downwards diffusive fluxes from the intermediate layers. Results show how the intense warming and salinification within the period were modulated by two strong convective periods.

Keywords: Deep waters, Hydrography, Western Mediterranean

The northwestern Mediterranean Sea is known to be an active dense-water formation area. During winter 2005 a large production of anomalous dense waters led to a basin-scale abrupt shift of the historical thermohaline characteristics of the Western Mediterranean deep waters [1]. This new situation, the so-called Western Mediterranean Transition (WMT) [2], induced drastic changes in the stratification of the deep layers by the appearance of a complex thermohaline structure with a hook-shaped signature on the θ - S plane. Since then, the WMT evolution has been monitored through a hydrographic deep station (40° 10.00' N, 04° 34.96' E, 2500 m depth) located NE off Minorca Island within the RADMED programme [3]. The station has been occupied 37 times from 2004 to 2017 (Figure 1).

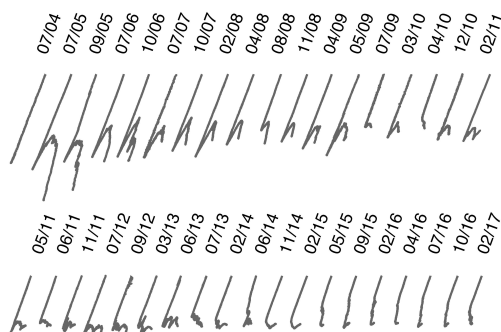


Fig. 1. Detail in T - S diagram shape evolution NE off Minorca below 700 dbar (2004 - 2007)

Using a 1-D diffusion model sensitive to double-diffusive mixing phenomena [e.g. 4], the WMT thermohaline evolution was reproduced by inter-annual deep-water renewals and background diffusion. As an outcome, the contribution to the heat and salt budgets of the deep waters was disentangled in terms of ventilation and diffusive transference from the intermediate layers above.

Results show that since 2005 the deep layers of the Western Mediterranean have undergone significant warming and salinification (0.07 °C and 0.01; 1280 - 2420 dbar), mostly modulated by the dense-water injections of the 2005-2006 and 2011-2013 periods. Diffusion from the intermediate layers played a minor role in this evolution, accounting to around 22% of the heat and salt increments (Figure 2). Heat uptake (0.92 W/m²) of the deep layers within the WMT was remarkable, exceeding estimations for the upper 2000 dbar of the global ocean in the same period.

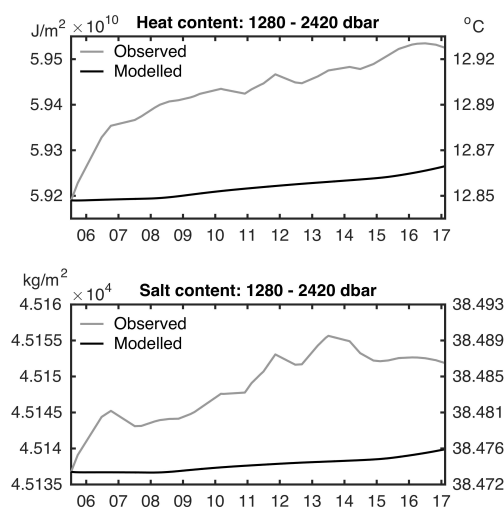


Fig. 2. Heat (upper) and salt (lower) content evolution (2005 - 2017) between 1280-2420 dbar (grey line) and modelled diffusive transference from the intermediate layers (black line). Corresponding potential temperature and salinity changes of the layer are included in the right axes

After 12 years of evolution, the WMT original hydrographic signature was completely eroded by background diffusion and the subsequent injections of dense waters. Nevertheless, the resulted warmer and saltier deep waters are slightly denser and more stratified than prior to 2005. This may have important implications for the ventilation rate of the deep layers since it sets a new density threshold to overcome by the newly formed dense waters in the formation area.

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DIEL AND LUNAR CYCLES OF ZOOPLANKTON VERTICAL MIGRATION IN THE SOUTHERN ADRIATIC SEA AND ITS MODULATION BY PHYSICAL AND BIOGEOCHEMICAL FACTORS

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Abstract

From the eleven-year data record at the Southern Adriatic Observatory (E2M3A), the strength of the backscatter signal from an Acoustic Doppler Current Profiler (ADCP) is studied in relation to zooplankton vertical migration (DVM). The signal represents well the general behaviour of the zooplankton to sink at dawn and to emerge at the sunset. The modulation of the signal along the year is linked in particular to the sun and moon cycles, different environmental conditions and the presence of different zooplankton groups and predators.

Keywords: *Currents, Vertical migration, Zooplankton, Time series, Adriatic Sea*

Introduction

The Southern Adriatic is an area where vertical mixing (upwelling, wintertime convection) has a rather prominent role in homogenizing physical and chemical seawater properties, and controlling the primary production (Gacic et al., 2002). The dynamics of the area is dominated by the presence of a quasi-permanent cyclonic gyre that intensifies in the winter season creating the conditions for the production of dense and oxygenated waters. The oceanographic conditions of the Southern Adriatic are determined by the atmospheric forcing. The area is highly oligotrophic, but hosts a rather complex ecosystem. The Acoustic Doppler Current Profiler (ADCP) is commonly used to monitor currents and flows in the oceans along the water column, but it can be used in inferring biological variables, and in particular, ADCP backscattering signal (S_v) could be related qualitatively to zooplankton biomass.

Results

The correlation between the backscatter signal and distinct zooplankton groups (copepods, euphausiids, ostracods, appendicularians, salps) shows that in different seasons and environmental conditions, different groups are responsible for the strength of the signal. Furthermore, the backscatter signal, interpreted in terms of the qualitative composition of the zooplankton community, provides important information on the behaviour and habits of zooplankton (Ursella et al. 2018). Zooplankton distribution depends on phytoplankton presence and blooms, which on its own is determined by nutrient availability and by sunlight.

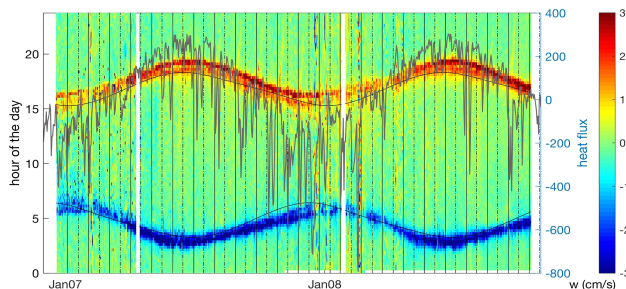


Fig. 1. w as a function of the hour of the day; superimposed the curves of sunrise and sunset (black curves), the time of occurrence of full/new moon (full/dashed line) and the heat fluxes.

High correlation is seen between high values in vertical velocities (w , reaching up to 5 cm/s) and the time of occurrence of sunrise and sunset that varies throughout the year (Fig.1). However, departures from this behaviour are seen in correspondence of full moon times, but also to some extent in correspondence of strong meteorological events or passage of strong eddies (winter period). The effect of the moon is also seen in the vertical distribution of the S_v : during the new moon phase the total amount of scatterers is mainly concentrated in the upper 100 m, while during the full moon it is spread along the vertical. For what concerns wind and cooling events, the convective-mixing brings nutrients to the upper layers and transports plankton to deeper layers, resulting in a smeared S_v signal. However, within 3-4 days the S_v signal is restored to its pattern before the vertical mixing, indicating resistance of zooplankton to be displaced. If an

analysis of w and S_v as a function of the hour of the day is performed at different depths, the behavior is quite distinct from layer to layer, indicating different distribution of plankton communities and distinct DVM patterns. When time-averaged w , relative to sunrise and sunset, is calculated at each depth (Fig.2), the timing of the maximum values of w is not constant with depth, but the descent is anticipated by about 1 h with respect to S_r at 100 m depth and is almost coincident with S_r at 250 m; similarly, the rise begins earlier at depth and later in the upper layers, even if the difference is not prominent as it is during the descent.

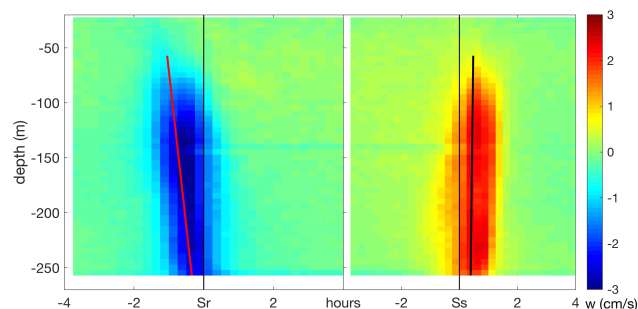


Fig. 2. Averaged vertical profile of w relative to time of sunset/sunrise (S_s/S_r), with linear fit for the maximum value distribution with depth.

This behavior can be interpreted as a synchronized sequence of migrating populations, that transport organics consumed at the shallower nighttime position to the deeper daytime position, and where defecation supplies organic matter to the population below (Ochoa et al. 2013). Finally, the average over depth of w is not equal to zero, but it is slightly negative for most of the study period. This implies a net downward transport of particles towards deeper layers, that might be seen in sediment trap data.

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WHAT IS THE IMPACT OF AN UPWELLING FILAMENT ON THE PHYSICAL-CHEMICAL-BIOLOGICAL INTERACTIONS OFF SW IBERIA?

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Abstract

Upwelling filaments are mesoscale structures of cold water stretching seaward in a tongue-like shape with origin in the coastal upwelling zone. Filaments off the Iberian Peninsula are recurrent and Cape São Vicente in the SW tip of the Iberian Peninsula, represents the root of filaments observed in the satellite imagery during the upwelling season. However, the understanding of their physical and chemical impact on the biological productivity is rather limited. There, a relatively small filament (~ 80 km long) was investigated through remote sensing and in situ multidisciplinary observations during an upwelling favourable wind relaxation event, but just after an intense upwelling period [1, 2]. A total of 42 CTD+Rosette casts up to 400 m depth were distributed on an almost regular grid of 15 km mean spacing guided by satellite SST imagery transmitted to the ship in near-real time. The parameters sampled during the survey included: velocity field sampled along the ship track through a hull-mounted 38 kHz RDI ADCP, meteorological variables, temperature, salinity, chlorophyll a, dissolved oxygen, nitrate, phosphate, silicate, cadmium, lead and zinc. The extent of the impact of the filament was evaluated by quantifying the cross-shelf transports of several properties. The amounts conveyed by the filament were much stronger than those expected by the wind-driven Ekman mechanism, showing that it represents an efficient feature for the exchange of water, dissolved and particulate matter from the productive shelf towards the oligotrophic offshore region. Considering periods of strong upwelling events and with longer duration, exported matter amounts will certainly enhance the biological productivity of these waters, including their fisheries. Data from this filament contribute to understand the physical-chemical-biological interactions of this regional ecosystem.

Keywords: Filaments, upwelling, Iberian Peninsula

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COMITÉ 3

Biogéochimie marine

Président : François Galgani

CIESM Congress Session : Contamination / Traces metals in the marine environment

Moderator : Pedro M. Costa, UCIBIO, Caparica, Portugal

Moderator's Synthesis

Following an introduction of the subject by the undersigned, four speakers presented quite distinct works related to the sources, distribution and fate of trace elements in the Mediterranean Sea, from metals “leaking” from ancient wrecks to relationship between sea floor geodynamics and the distribution of metals. The works, pertaining to environments spread across the Mediterranean basin, show the widespread relevance of the subject in very different areas, enduring very different pressures, natural or anthropogenic. These interesting and well-received talks were complemented with the poster presentations by three young researchers that focused on Atlantic waters. Specifically, these researchers dealt on strategies related to the EU’s Framework directives for the monitoring of waters and distribution of Rare Earth Elements in fish.

The debate that ensued began with a little “tease” from the moderator, who asked the audience for their opinion on whether or not the subject of metal contamination in the seas is still up-to-date, needed and properly addressed. There followed a lively debate where young researchers, presenters included, made their voice well-heard. Through a series of examples, it has been shown that contamination by metals is still a priority subject as in the past, as many areas remain contaminated and that sediments are critical storages of metals that can easily be re-released back to the biota, not only in the Mediterranean but also in the Atlantic coast of Europe and elsewhere. The need to intercalibrate procedures to quantify contamination was consensual, which followed closely the need to promote collaborative efforts to uphold consistent methodologies and exchange perspectives born from distinct scenarios. It was concluded that, despite their many hydrogeographical differences, Atlantic and Mediterranean environments suffer from similar problems arising from strong anthropogenic pressure deriving from human settlement, industry and history.



MERCURY FROM THE WRECKAGE OF A SUNKEN ANCIENT MERCHANTMAN (GNALIC, BIOGRAD NA MORU, CROATIA): A LONG-TERM DANGER TO THE MARINE LIFE

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Abstract

In the cargo of the ship that sank in the sixteenth century near the islet of Gnalic, Croatian Eastern Adriatic, mercury (500 - 1000 kg) was present in various forms: elemental mercury, ore cinnabar (HgS), and vermillion powder (HgS, opaque red pigment). In order to determine the potential impact on the marine life mercury was analysed in different organisms (fishes, shellfishes, molluscs, crabs and echinoderms) collected and caught around the wreck. Elevated to extremely high mercury concentrations in the investigated organisms indicate the high risk of mercury loads to the marine environment and the need to remove it from the archaeological site.

Keywords: *Adriatic Sea, Mercury, Pollution, Fishes, Mollusca*

Introduction

In November 1583 a merchant ship *Gagliana Grossa* transported a variety of merchandise from Venice (Italy) to Constantinople (Istanbul, Turkey) [1]. For an unknown reason (fire or severe weather) the ship with the full cargo sank at twenty-five meters of depth near the islet of Gnalic (Fig. 1). It is assumed that surprisingly large quantity of mercury in the ship's cargo were meant for medical and cosmetic purposes. Also, powdered sulphur in cargo indicates the possibility of its use in the vermillion production process by chemical coupling of Hg and S. The wreck was discovered in 1967, while the study of mercury impact on the environment began in 2013.

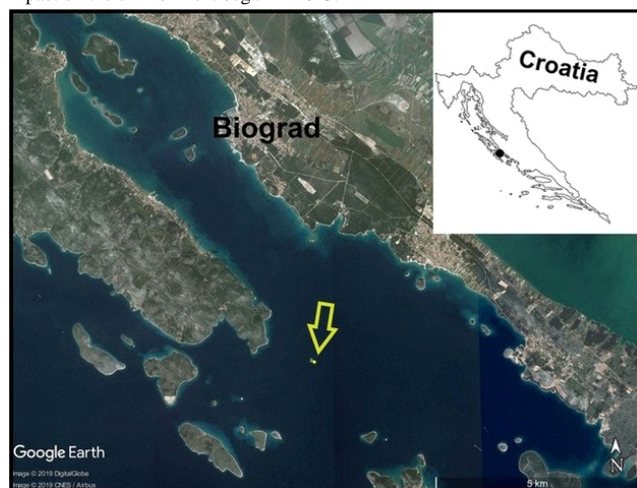


Fig. 1. Study area

Methods

Mercury was analysed in nine organisms (Fig. 2) caught at the site of the archaeological excavation. *Scorpaena scofa*, *Scorpaena notata*, *Scorpaena porcus*, *Sepia officinalis* and *Maja squinado* were caught in the fishing net, while *Echinaster sepositus*, *Holothuria tubulosa*, *Paguristes eremita* and *Murex trunculus* were collected by scuba divers at the sea floor. As a reference, the same species from the other localities that were not burdened with mercury, were taken and analysed. Moreover, the degree of mercury pollution of the examined organisms was determined by comparing the results obtained to the results of organisms from the Kaštela Bay, well known for large quantities of mercury which have been discarded for decades in the sea in the close vicinity of the former chlor-alkali plant [2]. All samples were digested with a mixture of nitric and perchloric acid by a hot plate method. Mercury analyses were performed by cold vapour atomic absorption spectrometry (CVAAS) with detection limit of 0.001 mg kg⁻¹, for solid samples [3].

Results and conclusions

The level of mercury content in organisms clearly shows their contamination, which was noticed in *Scorpaneidae* especially, as they are predators of

sedentary and solitary behaviour. In *Scorpaena notata* (11 cm, 64 g) 170 and 45 mg kg⁻¹ of Hg was found in liver and muscle, respectively. That was two order of magnitude higher compared to the corresponding organism of similar biometric characteristics from Šibenik archipelago (Croatian middle Adriatic). Identical relationship was also found with *Murex trunculus* and *Maja squinado* compared to the same species from unpolluted part of Šibenik Bay. Hg amounts in *Echinaster sepositus* and *Holothuria tubulosa* from Gnalic location were up to 60 times higher compared to those from Dubrovnik pristine localities. It is very significant that the results of mercury analyses in these organisms show even higher values than the values found in various organisms from Kaštela Bay, notorious regarding mercury pollution. As a part of the sunken ship's cargo, mercury has been a threat to the marine environment for centuries. Recently, mercury has been driven even more by archaeological excavations, that have transferred it from the deeper layers of the sea floor toward surface from where Hg is spreading further. That is why removing of mercury from the Gnalic site is an imperative.



Fig. 2. Studied organisms: A *Scorpaena porcus*, B *Scorpaena notata*, C *Sepia officinalis*, D *Scorpaena scofa*, E *Echinaster sepositus*, F *Murex trunculus*, G *Maja squinado*, H *Holothuria tubulosa*, I *Paguristes eremita*

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TRACE METALS DYNAMIC IN TWO SMALL RIVERS DISCHARGING IN TOULON BAY : COMPARISON AND FLUXES DETERMINATION

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Abstract

Coastal environments in Mediterranean Sea are submitted to several nautical activities and are often closed to urbanised zone. The Toulon bay (N-W Mediterranean Sea, France) is a good example of such zone, exhibiting an important gradient of contamination. In such a context METFLUX project aims to identify and evaluate the most important sources of this contamination. Rivers, especially during flood event can lead to a large input of contaminants. To determine the trace metals inputs into Toulon bay, samples were collected during a flood event to measure dissolved and particulate trace metals, organic carbon and nitrogen, major elements. Basic physico-chemical parameters were monitored during the study. From these analyses we notice a rapid response of the system to rain. We also observed differences in dynamic between the two rivers.

Keywords: Trace elements, Coastal systems, North-Western Mediterranean

The Toulon bay (N-W Mediterranean Sea, France) is a semi enclosed bay submitted to several nautical activities (ferries, commercial harbours, 1st Navy harbour) and is closed to an urbanised zone of 0.45M inhabitants (Figure 1).

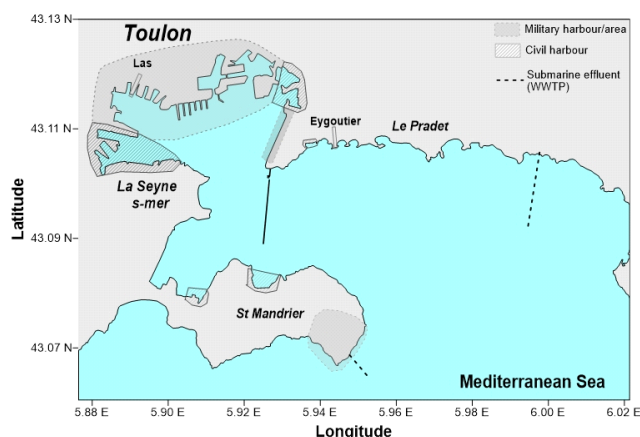


Fig. 1. Map of the studied area. Sampling stations are situated at the outlet of the Eygoutier and Las rivers

Previous studies showed that the surface water exhibits an important gradient of contamination for most of dissolved trace metals (as example Cd, Zn, Cu, Pb, Hg) from enclosed parts to open sea [1]. Potential sources of trace metals are (1) well established: the sediment multi-contamination [2], or (2) to be more studied: harbour (antifouling paints), waste water treatment plant output, atmospheric deposits and rivers (Eygoutier river in the large bay, Las river in the small bay).

This study is part of the METFLUX project (evaluation of trace metals fluxes in a coastal zone – case study of Toulon bay, 2016-2019) supported by the French water agency Rhône-Méditerranée-Corse.

In this study we focused on a flood event occurring in October 2018. To characterise trace metals inputs during a flood event we used composite sampling collected from river with a precleaned LDPE bucket. 60mL of river water, collected each 10 min during 1 h or each 20 min during 2 h, were filtered on field to 0.2 µm for dissolved species (trace metals, DOC, DN, DIC, majors ions). 150 mL of river water, collected each 10min during 1 h or each 20 min during 2 h, were filtered at laboratory on 0.2 µm cellulose acetate filter for particulate trace metals and 0.7 µm glass fiber filter for POC, PN, particulate Hg. Basic physico-chemical parameters were monitored each 10 min (temperature, specific conductivity, turbidity).

Flood event was characterised by a 24 h rain with a cumulative rainfall of 124.9 mm. The maximum flow in the Las and Eygoutier rivers were respectively 25 and 148 m³ s⁻¹ (Figure 2).

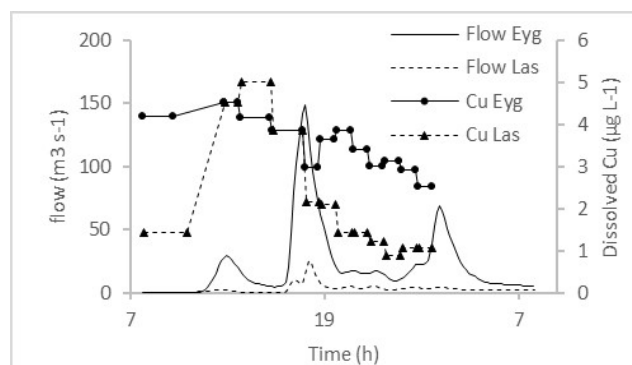


Fig. 2. Eygoutier and Las river flow, Dissolved copper concentration in 1 or 2 h composite samples during flood event of 10/10/2018

The response of the system is very rapid (maximum of flow achieved about one hour after maximum rainfall) as already shown for Mediterranean rivers [3,4]. As an example, Dissolved Cu shows a maximum at the beginning of the flood and then decreased until baseflow concentration, but the dynamic is more important for Las river than Eygoutier. Moreover, trace metals concentrations determined during this flood event were used to calculate annual fluxes. For Eygoutier river we obtain respectively, 0.11, 1.7, 105 and 40 kg y⁻¹ for Cd, Pb, Zn and Cu. For Las river we obtain respectively, 0.14, 2.2, 2.9 and 0.82 kg y⁻¹ for Cd, Pb, Zn and Cu. For Eygoutier river fluxes are significantly higher than previously described [3].

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DISTRIBUTION OF TRACE METALS IN MARINE SEDIMENTS OF COASTAL MEDITERRANEAN AREA: ST-GEORGES BAY (LEBANON)

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Abstract

Trace metals (TM) may reach high levels considered harmful for ecosystems. In this study, we investigate TM contamination in sediment and waters of a coastal Mediterranean site: St-Georges Bay (Lebanon). This site is impacted by several anthropogenic activities transported through Beirut River. Early diagenesis processes highly affect TM mobility in the sediments of this ecosystem.

Keywords: *Sediments, Mediterranean Sea, Trace elements, Metals*

Mediterranean coastal areas are exposed to anthropogenic activities, e.g. sewage outfall and industrial effluents; bringing pollutants such as trace metals (TM) which settled in sediments. Early diagenesis processes influence TM distribution and mobility, which can constitute a potential risk for the surrounding environments. In this context, we studied TM distribution in St-Georges Bay, located in the Eastern Mediterranean Sea (MS) of Beirut-Lebanon. It is characterized by the presence of a seasonal highly contaminated river "Beirut", industrial effluents and a nearby dumpsite that strongly contaminate sediments.

Sediment cores (D0, D1 and D2) were collected by divers. Each core was sliced with 2-cm resolution under inert atmosphere. Then, pore waters were retrieved and filtered. Particulate organic/inorganic carbon were analyzed in sediments. Dissolved organic/inorganic carbon and diagenetic tracers were analyzed in extracted pore waters and overlaying seawater. Dissolved and total contents of minor/major/trace elements were analyzed by HR – ICP/MS.

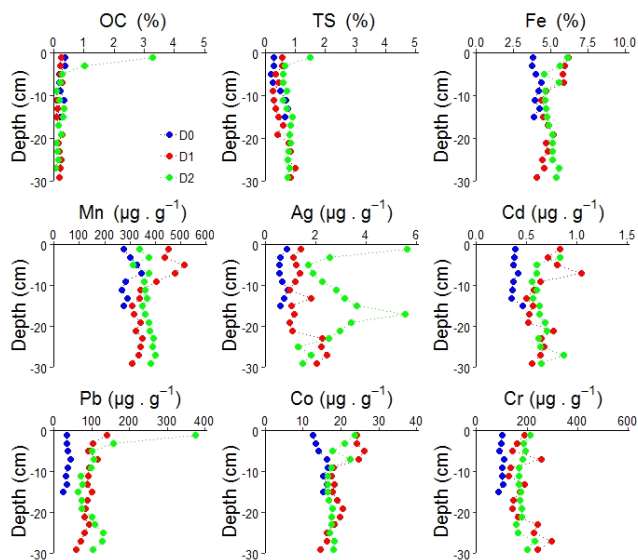


Fig. 1. Organic carbon and trace elements profiles in sediment cores

Obtained results suggest a superficial coastal contamination for the studied TM expect for Ag, probably related to Beirut rivers inputs (Fig.1). Comparing concentrations of these TM to background level in the upper continental crust or to other studies in the MS [1,2], the sediments showed a highly mean content due to intensive industrial activities in the region. Early diagenetic processes clearly mobilize TM (Fig.2), making such sediments a potential source of contaminants for the overlaying seawater column.

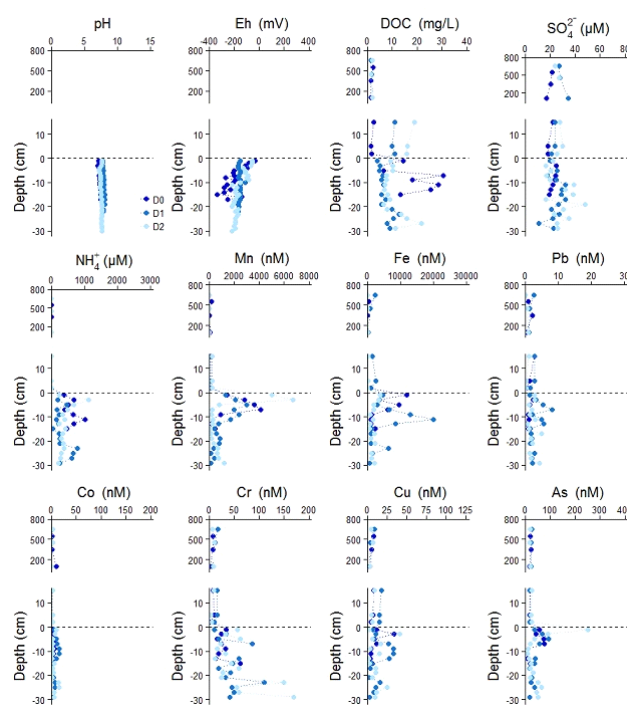


Fig. 2. Diagenetic tracers, dissolved organic carbon and trace elements profiles in column and pore waters.

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TRACE METALS IN THE DEEP SOUTHERN ADRIATIC SEA SEDIMENTS (MEDITERRANEAN SEA)

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Abstract

Anthropogenic trace-metal concentrations were studied in sediments of the South Adriatic basin. This study shows that in some Mediterranean sedimentation systems, the anthropogenic trace metal contamination is affecting not only the coastal areas and continental shelf, but is transferred to some extent also in the adjacent continental slope and deep basin. Complex morphology and sedimentary processes are responsible for the spatial differences in trace metal concentrations between different sub-areas of the South Adriatic. Historical trace metal profiles show trends that were increasing in the 20th century and decreasing in the last 30 years.

Keywords: *Trace elements, South Adriatic Sea, Sediments*

The SW Adriatic Sea shows an extreme seafloor complexity with a series of large scale geomorphic elements, including the Bari Canyon System (BCS) and Dauno seamount, which reflect long-term tectonic deformation [1], and a large variety of erosive and depositional bedforms, which suggest the constructive interaction between distinct bottom water masses [2], effective down to the deep South Adriatic Pit (SAP). Dense water cascading events of North Adriatic Dense Water through the open slope, offshore the Gargano Promontory (OGP), and the BCS were showed to enhance the particle transfer towards the deep basin [3,4]. Additional sediment inputs to the Southern Adriatic come from the Croatian and Albanian continental shelf (eastern margin, EM).

A trace metal mass balance of the western Adriatic Sea has established that the most part of riverine metal supply accumulates on river prodeltas and along the Po River dispersion system [5]. The small unbalance escaping the accumulation on the continental shelf has been attributed to particle transfer toward the deep South Adriatic or out the Otranto Strait. A previous study [6] detected the occurrence of organic contaminants in the South Adriatic related to the influence of cascading events. However, it is still completely unknown if also land-derived trace metals are transferred and to what extent they accumulate in the South Adriatic sea.

Short sediment cores were retrieved in SAP, BCS and OGP. Furthermore, undisturbed surficial sediments were collected in 28 sampling sites distributed in different sedimentary settings of the South Adriatic sea, including the eastern margin (EM) (Fig. 1).

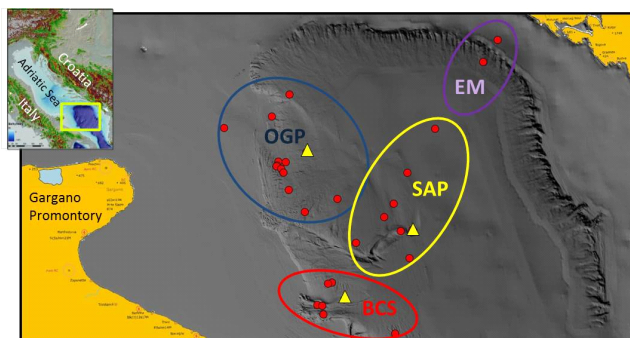


Fig. 1. Study area and location of the sediment cores (triangles) and surficial samples (circles)

The enrichment factors (EF) of trace metals in the surficial sediments showed moderate enrichment of Pb, Zn and Ni (EF ~2 to ~3) and minor enrichment for the other trace metals (EF ~2), suggesting that also the deepest part of the Adriatic basin is affected by (a slight) metal contamination. However, the four sub-areas documented different levels of contamination due to the combined effect of complex morphology, bottom currents and sedimentary processes. Samples collected in BCS and OGP, under the influence of dense shelf water cascading, showed on average higher Zn and Pb concentrations with peak levels recorded in the mud wave field north of the Gondola deformation belt,

downstream of the Gondola slide [*sensu* 2]. Pb and Zn inputs from the eastern side of the Adriatic sea appear negligible. Sediment cores were dated by using ²¹⁰Pb profiles. The preindustrial concentrations of trace metals were detected in the deepest layers of sediment cores and were established as their background levels (BL). The Pb profile of the core collected on the sediment drift at the exit of the Bari canyon showed an increasing pattern from 1930s to 1990s, followed by slightly decreasing trend upwards. Zn showed an increase from 1930s to 1980s, reaching the highest concentration (84 mg kg⁻¹) in 2010, while Cr and Cu were close to the BL (65 mg kg⁻¹). In the other cores, metal profiles were less informative due to the lower sediment accumulation rates.

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TISSUE AND GENDER RELATED DIFFERENCES IN THE ELEMENTAL COMPOSITION OF JUVENILE OCEAN SUNFISH *MOLA MOLA*

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Abstract

Trace elements are potentially critical contaminants of aquatic environments and fish, occupying upper trophic levels, are especially vulnerable to bioaccumulation. Due to public health concerns, however, elemental composition has been mainly studied on commercially-important species [e.g. 1]. The ocean sunfish *Mola mola* attains a low commercial value worldwide [2] and data available on its elemental composition is very limited. In this context, we examined the concentration of 11 trace elements (V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Cd and Pb) in eight tissues [(brain, gills, gelatin (subcutaneous white gelatinous layer), gonads, spleen, liver, white muscle and red muscle)] of twenty-one juvenile specimens (measuring between 37.5 and 85.5 cm total length). Gender-related differences were found, mainly in the gonads and chiefly for essential elements possibly as a result of their importance in embryo development. Zinc and As were the elements observed in greater concentration in body tissues. The considerably high presence of As should be related to the dietary preferences of juvenile *M. mola*. Considerable inter-individual variability in the concentration of each element in a given tissue was observed, especially in the liver, most likely originating from the inclusion of both benthic and pelagic prey in the diet of the analysed fish. Greatest elemental load was found in the liver and gills whereas the lowest load was observed in the white muscle, brain and gelatin. Moreover, a clear distinction in elemental load and elemental composition was observed between white and red muscles, possibly deriving from the different role of these tissues in locomotion and associated divergent metabolism-related physiological adaptations.

Keywords: Ocean sunfish, trace element composition, Southern Portugal

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ACCUMULATION AND ELIMINATION PATTERNS OF LANTHANUM IN WHITE SEA BREAM (*DIPLODUS SARGUS*)

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Abstract

Rare earth elements (REE) play an essential role in the development of innovative environmental technologies, and with this increasing application emission to freshwater and marine systems is expected to increase. Lanthanum (La) is the first element of the lanthanides and, although dissolved La species represent a very small proportion in water and sediment, the trivalent ion La^{3+} is bioavailable and possesses the greatest risk of biological effects. This study aimed to evaluate the uptake, distribution and accumulation of La in gills, blood, liver, kidney and brain of white sea bream (*Diplodus sargus*) over 14 days of exposure followed by 14 days of elimination. Fish were exposed to realistic waterborne La concentrations (60 ng L⁻¹). Prior to La exposure, fish were acclimatized to the experimental conditions and routines for two weeks. Ten fish were sacrificed at each sampling period: at the beginning of the experiment (T0), after 1 (T1), 3 (T3), 7 (T7) and 14 (T14) days of exposure and after 14 (T28) days in clean water. Concentrations of La showed a significantly increase after 1 day of exposure, followed by a sharp decreased at T3 diminishing to levels similar to the control until the end of the experiment. Enzymatic responses in the liver were irregular with increments and reductions along the sampling periods. The observed results could be linked to the La property to block calcium channels or to the replacement of calcium(II) ions in structure of many proteins, which means that these proteins can lose their functions, or, contrariwise, in some cases their function can be activated or increased.

Keywords: *Lanthanum, Diplodus sargus, Bioaccumulation*

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MONITOOL – A NOVEL APPROACH APPLYING METAL-PASSIVE SAMPLERS TO IMPLEMENTATION OF WFD AND MSFD

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Abstract

A large sampling campaign covering the Atlantic region from the Canary Islands to the Scottish Highlands and Islands including the Mediterranean Sea was performed at coastal and estuarine sites. This large operation was done under the European project Monitool. Water was collected for determination of trace elements (Ni, Cd and Pb) and additional interpretative parameters. All partners have followed the same protocol for sampling, sample manipulation and analysis. Additionally, passive samplers (DGT-Diffusive Gradient in Thin Films) have been deployed in the same places for 5 days. The main goal was to compare dissolved metal concentrations obtained from spot sampling with values in DGT. The results obtained show that there is a relation between both methods in some sites. For some cases, the comparison between methods may require the inclusion of interpretative parameters in the correlation analysis. The obtained relations may allow to establish new threshold values for metal contamination in water using the integrative passive sampling technique. This may allow to extent their application of Water Framework Directive and in the Marine Strategy Framework Directive. The first obtained results will be presented for selected target metals.

Keywords: Atlantic region, DGT, ICP-MS and Voltammetry

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Disclaimer:

This project (n° contract: EAPA_565/2016) is co-financed by the European Regional Development Fund through the Interreg Atlantic Area Programme. The present work reflects only the author's view and the funding Programme cannot be held responsible for any use that may be made of the information it contains.

CIESM Congress Session : Contamination / Processes

Moderator : Mário Mil-Homens, IPMA, Lisbon, Portugal

Moderator's Synthesis

The session was followed by about 30 participants . The five speakers covered various issues ranging from biological pump for contaminants, rapid environmental recovery of a site used for sewage sludge disposal, laboratory experiments (marine organisms exposed to pharmaceuticals and the effect of sodium azide onto trace elements mobility during resuspension tests) and responses of authorities to an oil spill accident.

The discussion points that stimulated the most interest were associated with the way:

- to reduce processes of contamination that are responsible for the release of contaminants in the marine environment. The participants suggested that, in addition to citizens' behavioural change towards less consumption, producers should also be held responsible for more environmentally friendly production processes and end products.
 - scientists can generate political action and support implementation of research/management strategies.
- Some of the participants stressed the importance of improving or adapting the quality of communication to make the scientific information transmitted more understandable.



PLANKTON AS BIOLOGICAL PUMP FOR CONTAMINANTS IN MARINE ECOSYSTEMS: A TRANS-MEDITERRANEAN APPROACH (MERITE HIPPOCAMPE CRUISE, APRIL-MAI 2019)

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Abstract

Recent research on the bioaccumulation of organic and trace element contaminants along trophic food webs suggests that plankton plays a central role as a 'biological pump' for pollutants. The MERITE-HIPPOCAMPE project (oceanographic cruise in April-May 2019) aims at studying the interactions between plankton and contaminants (metallic, organic plastics) at atmosphere/water/biota interfaces via a North-South trans-Mediterranean approach in contrasted areas (primary production, fishing zones, ecoregions, polluted bays). The target contaminants are on the lists of priority pollutants and substances of Regional Conventions (OSPAR) and EU directives (WFD, MSF). The expected results are to provide a better understanding of the transfer processes of contaminants from water to the first pelagic trophic levels

Keywords: *Trace elements, Pcb, Pah, Plankton, Mediterranean Sea*

Recent research on the bioaccumulation of organic and trace element contaminants along trophic food webs suggests that plankton plays a central role as a 'biological pump' for pollutants. The MERITE-HIPPOCAMPE project (oceanographic cruise in April-May 2019) aims at studying the interactions between plankton and contaminants (metallic, organic plastics) at atmosphere/water/biota interfaces via a North-South trans-Mediterranean approach in contrasted areas (primary production, fishing zones, ecoregions, polluted bays).

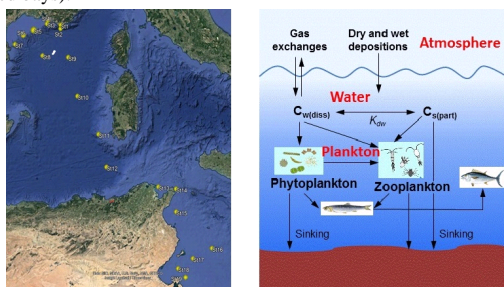


Fig. 1. Left: Position of the 19 sampling stations for the campaign. Coverage includes fishery areas (Gulf of Gabès and of Gulf of Lions), urban bays (Toulon, Marseille, Sfax) and offshore reference stations for West and South basins. Right: Diagram of the role of plankton as "biological pump" for contaminants ($C_{w(diss)}$: concentration of contaminants in seawater dissolved phase; $C_{s(part)}$: concentration of contaminants in seawater particulate phase; K_{dw} : partitioning between dissolved and particulate phases).

The target contaminants are on the lists of priority pollutants and substances of Regional Conventions (OSPAR) and EU directives (WFD, MSF). The expected results will provide a better understanding of the transfer processes of contaminants from water to the first pelagic trophic levels. The methodology used at each station allows conducting intensive and maximized surveys including: 1) deployment of a cluster of sensors for physical, biological and chemical measurements and water column sampling: CTD and range of optical sensors casts with ultraclean Niskin/Go-Flow rosette bottles for depth profiles of chemical contaminants concentrations, nutrients and main physico-chemical parameters, and plankton sampling for biomass, abundance and community structure determinations and 2) intensive plankton sampling in the deep chlorophyll maximum (DCM) and size class fractionations, using *in situ* submersible pumps for bacterioplankton fraction (0.7-60 μm), and deployments of multinet-Hydrobios type for sampling a large amounts plankton by horizontal repeated net tows and cascade on line size class fractionation (60-2000 μm). In addition sampling of contaminants atmospheric wet deposition is carried as well as survey of surface and water column of microplastics. The expected results of this study will provide a better understanding of the transferring processes of metallic and organic contaminants from water to

the first pelagic trophic levels (phyto-, zoo-, and bacterio-plankton) in the Mediterranean Sea. The new knowledge will bring elements to assessment of exploited biological resources chemical contamination, and improve our ability for modeling the fate and impact of contaminants across the Western Mediterranean Basin. Sound scientific understanding of the factors influencing the chemical contaminants uptake by first planktonic trophic level in both southern and northern western Mediterranean will benefit environmental evaluations at basin to coastal scales. The coastal vs more off-shore contaminants bioaccumulation in plankton will also provide new data for ecological status indicators. The MERITE-HIPPOCAMPE project is supported by CNRS/INSU MISTRALS program and its new transverse action Pollution and Contaminants (AT P&C). The project relies on a multidisciplinary and inter-institutional consortium combining French institutes (Ifremer, IRD, CNRS, IRSN, Ecoles des Mines) and Tunisian institutes (INSTM, FSB, CBS). This action is also identified as a major force of the phase 2 of the Joint International Laboratory LMI-COSYSMED (2019-24), enabling the integration of competences and implementation means. This partnership context constitutes a real strength in the perspective of the BLUEMED (H2020) initiative and provides a general framework and an opportunity for collaborative work to be developed in other pilot urbanized and fishing areas of middle/eastern Mediterranean and Black Sea.

– *Complete list of collaborators:* MIO: C. Chevalier, V. Rossi, S. Chifflet, L.-E. Heimbürger-Boavida, C. Guigue, S. Jacquet, A. Dufour, S. Mounier, P. Raimbault, N. Garcia, R. Sempéré, J. Castro Jiménez, V. Fauvelle, B. Misson, M. Quéméneur, L. Cabrol, P. Cuny, O. Pringault, M. Thyssen, D. Banaru, L. Guilloux. IFREMER: J. Knoery, N. Briant, B. Thomas, C. Brach-Papa, C. Ravel, T. Chouvelon, F. Galgani, O. Gerigny, S. Coudray. INSTM: S. Ben Ismail, C. Sammari, M. Brahim, L. Chouba, M. Belhassen, N. Zaaboub, S. Amri, A. Zouari, I. Boudriga, M. Mahfoudi. FSB: N. Daly, N. Makhlof, A. Sakka Hlaili, M. Meddeb. IRSN: O. Radakovitch; CEREGE: T. de Garidel; LISA: K. Desboeufs MT Douai: A. Bourin

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RAPID RECOVERY OF A MARINE SEWAGE SLUDGE DISPOSAL SITE IN ISRAEL FOLLOWING THE CESSATION OF DISCHARGE OPERATIONS

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Abstract

Cessation of activated sewage sludge marine disposal after 29 years induced a rapid recovery of the site located at the Mediterranean coast of Israel. After 5 months with no discharge, the elevated concentrations of organic carbon in the sediments decreased by ca. 2.5 times, and those of Cd, Cu and Zn to almost reference values. Hg concentration reached near reference values after 15 months without discharge. During sludge disposal, the infauna assemblages at the affected stations consisted mostly of opportunistic Polychaeta in the spring and almost no infauna in the fall. After cessation of disposal, the abundance decreased to near reference values in the spring, and the relative contribution of the Capitellidae family dropped from >80% of the total abundance to 38% and 10% in 2017 and 2018, respectively.

Keywords: Pollution, Metals, Organic matter, South-Eastern Mediterranean, Polychaeta

The Dan Region treatment plant in Israel ("Shafdan") has been treating domestic sewage of the Tel-Aviv Metropolitan area since 1987 (140 million m³ y⁻¹ in 2018) and discharged the excess activated sludge (15,000 m³ day⁻¹) at sea through a submerged outfall, 5 km offshore the Mediterranean coast. The marine discharge stopped in January 2017, when a land-based treatment was implemented. Long-term marine monitoring (26 years) found a marked localized, seasonally dependent impact on sediment quality and benthic assemblages [1,2]. Elevated concentrations of organic carbon (C_{org}), and sludge associated metals (Hg, Cd, Cu, Zn) were detected mainly up to 5 km northward of the outfall. At the affected stations, the infauna exhibited seasonal "boom and bust" cycle, with high abundance of eutrophication-tolerant opportunistic Polychaeta in the spring and almost no infauna in the fall. Reduction of metal loads in the sewage, in compliance with the discharge permit, was effective in reducing their concentrations in the sewage sludge and hence in the sediments, and improving its quality, although C_{org} loads were not reduced (Figs. 1-2). No evidence of multiannual sludge accumulation was found, only temporal variability related to environmental forcing [1,2]. Four surveys were conducted at the site during 2017 - 2018; 5, 10, 17 and 22 months following the cessation of the discharge in January 2017. After 5 months with no discharge, the concentrations of C_{org} decreased by ca. 2.5 times, and remained similar since, slightly higher than the background concentration (Fig. 1). Hg concentration was still elevated in 2017 and decreased to near reference values in 2018. Cd, Cu and Zn concentrations decreased after 5 months without discharge, and remained near the reference values in the subsequent surveys (Fig. 2).

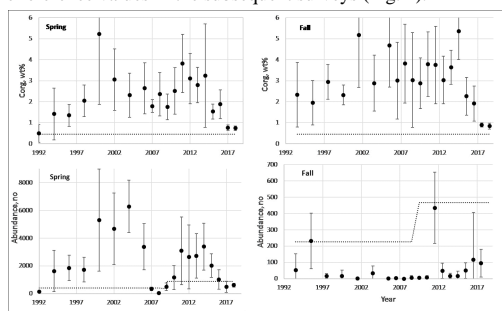


Fig. 1. Temporal evolution of average concentration of C_{org} and infaunal abundance in spring and fall at the affected area. Reference conditions are shown as dotted lines. Note different abundance scales for spring and fall.

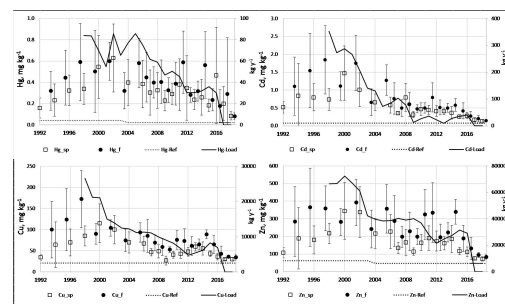


Fig. 2. Temporal dependence of average concentrations of Hg, Cd, Cu, Zn at the affected stations (spring, open squares and fall, black circles). Metals' load (kg y⁻¹) (black line) and reference concentrations (dotted line) are depicted as well.

While the C_{org} and metal concentrations decreased sharply following the cessation of disposal, the infaunal abundance in the fall of 2017 was still much lower than the reference values, indicating no recovery after 10 months. In the spring of 2017 and 2018, the abundance was within reference values, but a decreasing trend in abundance was observed since 2015, while discharge still took place (Fig.1). However, during sludge disposal, the infauna at the affected stations in the spring consisted mostly (>80%) of Capitellidae family. Its relative contribution to the infauna dropped to 38% in 2017, and to 10% in 2018, indicating a certain recovery. However, in order to follow patterns of ecological succession during the site rehabilitation, monitoring should include infauna identification to species level.

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EFFECT OF SODIUM AZIDE (NaN₃) ONTO TRACE ELEMENTS' MOBILITY DURING LABORATORY RESUSPENSION EXPERIMENT

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Abstract

The intrinsic effect of NaN₃ onto trace element's mobility was studied during a laboratory resuspension when sediment was mixed with seawater. It was shown that NaN₃ influenced the TME's transfers between sediment and seawater. As a conclusion NaN₃ should not be used in experiment when sediment is mixed with seawater.

Keywords: *Mediterranean Sea, Adsorption, Behaviour*

Dissolved trace metallic elements (TME) can bind to a solid phase (sediments, colloids) (Cappuyns and Swennen, 2005) which will eventually settle down to sediments (Pia Di Nanno et al., 2007; Ye et al., 2013). Nevertheless, sediment can be resuspended and become a major source of contamination. In order to evaluate the biotic and abiotic contributions in the remobilization processes, a microbial community inhibitor which do not contaminate in TME, do not complex them and not modify the organic matter is needed. In this context sodium azide (NaN₃), a strong poison commonly used in biogeochemistry, is often used to prepare abiotic controls in sediment resuspension experiments (e.g. Cabrol et al., 2017; Shipley et al., 2011; Zouch et al., 2018). Nevertheless, the intrinsic effect of NaN₃ onto TME transfer between water and sediment was never studied.

To understand the intrinsic effect of NaN₃ onto TME mobility, a laboratory resuspension experiment was performed consisting in mixing in trace-metal clean teflon bottles sediment (collected with a grab) to seawater collected at the same site (Toulon Bay, NW Mediterranean Sea, France). Sediment were autoclaved and seawater was filtered under 0.2µm in order to sterilized both media and inhibit biotically mediated transfers. NaN₃ was added to seawater at concentrations ranging from 1 to 50mM along with a NaN₃-free control. Then sediment was added to the seawater with a ratio of 50g/L and the mixture was submitted to head-over-shaking during 2 weeks.

Samples were collected after 1 day and 2 weeks of contact times. They were filtered on 0.2µm (Sartorius) before being analyzed. TME concentration was assessed by HR ICP-MS, dissolved organic carbon (DOC) concentration was obtained with a TOC-VCSH (Shimadzu) and particulate organic carbon (POC) concentration was acquired by a NC Soil Analyzer Flash 200 (Thermo Fisher Scientific). Furthermore, pH and Eh were measured at the beginning and at each sampling dates.

The obtained results demonstrated that NaN₃ significantly modified TME transfers, the remobilization amplitude being dependant on NaN₃ concentration. For example, after two weeks of contact time dissolved lead concentration were lower when NaN₃ concentration increased whereas dissolved Cu concentration increased with NaN₃. This difference of behaviour between Cu and Pb could be explained by their respective affinities with the dissolved phase, associated DOC transfers and pH/Eh modifications. The influence of their adsorption/desorption kinetics (Dang et al., 2015; Monnin et al., 2018) also partly explained our observations.

As a conclusion, NaN₃ should not be used in experiment, when sediment is mixed with seawater, to explain TME transfers as it has itself a strong impact onto the mobility of TME.

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THE VIRGINIA OIL SPILL IN PROVENCE: A TALE OF INAPPROPRIATE OVER-CLEANING

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Abstract

The Virginia oil spill (October 2018) was a minor one: 600 m³ of fuel released. Oil was washed up on the coasts of Provence (France). Apart from the core area of the Port-Cros National Park, thanks to the timely intervention of its Scientific Council and its director, the rest of the area was extensively and disproportionately cleaned up, which aggravated the damage caused by oil pollution.

Keywords: *Pollution, Mediterranean Sea, Biodiversity, Petroleum, Supralittoral*

For the public at large, oil spills are one of the most serious forms of impact of man on the marine environment. Several major oil spills (up to several thousand tonnes of oil released) have marked our memories, e.g. Torrey Canyon (1967), Amoco Cadiz (1978), Exxon Valdez (1989), Haven (1991), Erika (1999), Prestige (2002) and Deepwater Horizon (2010). Despite their spectacular appearance, oil spills are not the most worrying kind of impact on the marine environment, especially in the Mediterranean. Overfishing, biological invasions, coastal urbanization and the destruction of the dune-beach-banquette ecosystem constitute far more serious threats [1]. In addition, oil spills may cause grave environmental damage, but the cleaning of beaches and rocky shores usually greatly increases the impact on ecosystems, turning a short-term into a long-term impact [2-3].

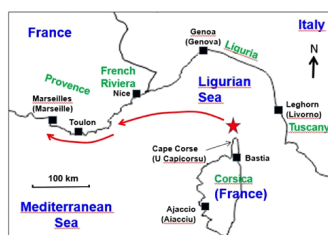


Fig. 1. The north-western Mediterranean Sea. Star: the site of the collision between the Ulysse and the CSL Virginia. Arrows: schematic pathway of the oil slicks towards eastern Provence, then western Provence.

On October 7th, 2018, the ro-ro ferry Ulysse collided with the containership CSL Virginia, anchored 28 km north-west of the Cape Corse (Corsica) (Fig. 1). Some 600 m³ of fuel leaked out from the fuel tanks of the Virginia. Between the 8th and the 15th of October, spill response vessels recovered over 1 000 m³ of oily water. Strong winds, blowing westwards, pushed oil sticks towards the coasts of Provence, where the Northern Current carried them. On October 16th, oil began to wash up on the shores, in the form of tar balls and scattered patches (Fig. 1). Compared to the major oil spills mentioned above, the Virginia oil spill was of a very modest scale. Part of the areas fouled belongs to the core area (Archipelagos of Port-Cros and Porquerolles) or to the transitional area (Aire Maritime Adjacente) of the Port-Cros National Park (PCNP). The Scientific Council of the PCNP and its director issued (23rd October 2018) a warning against the risks, for the environment and the ecosystems, of an over-reaction and the use of heavy and intensive cleaning methods on the rocks and beaches; they recommended e.g. (i) no use of chemicals (e.g. dispersants); (ii) no hot water high pressure washing (HWPW), with the exception of rocky areas accessible to pedestrians, close to the beaches; (iii) no cleaning in areas of high ecological sensitivity such as *Lithophyllum byssoides* rims; (iv) on beaches, taking care to remove as little sand as possible and leave as much wood as possible on the spot; (v) *Posidonia oceanica* banquettes of dead leaves should be preserved, with manual removal limited to surface layers exhibiting oil. Unfortunately, the French authorities followed the recommendations of the ships' insurers and entrusted to a private company, internationally

recognized for its competence, the task of removing all traces of oil. While the territory of the core area of the PCNP was relatively spared from disproportionate cleaning, thanks to the interventions of the Scientific Council and the PCNP's director, this was not the case for the rest of the area, which was intensively and disproportionately cleaned up, both in areas accessible to tourists in summer and in inaccessible areas. Rocks were stripped of the whole of the mediolittoral and supralittoral ecosystem (Cyanobacteria, lichens, *Littorina*, *Euraphia*, *Chthamalus*, *Patella*, etc.) via HWPW, *P. oceanica* banquettes were totally removed, regardless of whether or not oil patches were present, etc. (Fig. 2). These banquettes are of paramount importance for coastal ecosystems and provide a wide range of ecosystem services. This clean-up operation considerably aggravated the damage caused by oil pollution. The interest of the insurers, objectively supported by local elected officials and media pressure, was to remove all visible traces of the oil spill, in order to limit claims for compensation for economic damage (loss of profit). A further aim of this cleaning strategy was to remove visible traces of pollution in order to avoid any request for compensation relating to the necessary monitoring of ecosystems after such an event. The result is that a very minor oil spill, occurring 9 months before the next tourist season, was transformed by the polluters themselves (via the insurers), by carrying out a disproportionately large-scale cleanup operation, into a major ecological damage, the natural restoration of which will take at least 10 years.

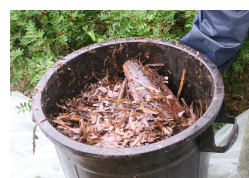


Fig. 2. The dead leaves of the *Posidonia oceanica* banquette are removed, placed in a trash can and transported to a garbage dump. One of the authors (CFB) manually verified that these leaves, like those of the other trash cans transported on the day of the observation, did not contain any trace of oil.

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CIESM Congress Session : Biogeochemistry & cycles / State & processes

Moderator : Marisa Almeida, CIIMAR, Univ. of Porto, Portugal

Moderator's Synthesis

All major biogeochemical cycles (e.g. carbon, nitrogen, oxygen, phosphorus) are important to, and are influenced by, the microbial (bacterioplankton and phytoplankton) components of aquatic environments (which can contribute ca. 50% to global primary production). Carbon, nitrogen, oxygen, phosphorus are essential elements. Monitoring these compounds will allow to track environmental changes in the long term, while studying their processes will help identify their sources and inputs. Biogeochemical cycles of carbon can indicate, for instance, possible effects of ocean acidification. So, methodologies to access biogeochemical cycles of essential elements, namely on carbon dynamics, are much needed. In addition, other contaminants like metals (some are micronutrients while others are toxic) should be considered, so as to better understand their role in biogeochemical processes.

It is essential that physical and biochemical variables be measured simultaneously in order to allow proper integration. Furthermore monitoring of diverse oceans and seas, where processes can be quite different, will allow comparison and a deeper understanding of environmental state and biogeochemical cycle. In that sense, Mediterranean Sea can represent several small Oceans within its borders, encompassing distinct areas with totally different behaviours. Studies on the Mediterranean Sea can be used as a proxy for Atlantic Ocean monitoring schemes and understanding.



MECHANISMS OF C EXPORT IN THE DEEP SOUTHEASTERN LEVANTINE BASIN

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Abstract

We present C export data from the DeepLev observatory at the southeastern Levant, 50 km west of Haifa, water depth of 1,500 m. Using sediment trap and ²³⁴Th deficit data, we show that C export in the deep Levant is mainly controlled by coastal discharge or shelf resuspension (winter peaks) rather than by marine primary production. This is demonstrated by larger POC fluxes in deep water, by tight correlation of POC with total mass flux and by deep water ²³⁴Th deficits. ²³⁴Th deficit data are decoupled from sediment trap flux patterns. It is suggested that the traps capture the larger grain-size fraction, related to terrestrial discharge or large shelf resuspension, while the ²³⁴Th method preferentially represents the finer size fraction, possibly related to dust deposition, wave resuspension or deep/intermediate water formation.

Keywords: Carbon, Levantine Basin, Radionuclides, Sediments, Deep sea basins

About 10-30% of the net primary production, produced in the oceans photic zone, is exported downwards by the biological pump [1]. This pump is the main buffering agent of atmospheric CO₂, and it forms an important foundation for most of the heterotrophic life in the deep-sea. Carbon export in the Mediterranean Sea is relatively low (1-13% of PP, [2,3]), while there is hardly any data from the eastern Levantine basin. Modelling suggests that in the highly oligotrophic eastern Mediterranean Sea (hereafter: EMS), particulate flux constitutes just 10% of total export, with the predominant carbon exported as dissolved organic carbon [3,4].

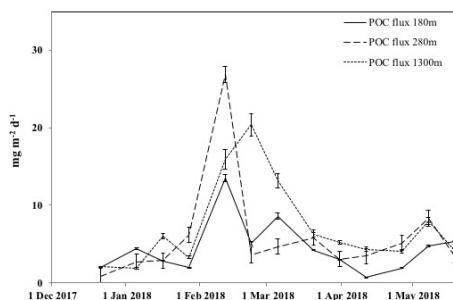


Fig. 1. POC fluxes, measured in the automated McLane traps, Dec 2017 – May 2018.

POC fluxes were measured for 18 months by automated and single bottle sediment traps at the recently-deployed DeepLev observatory (50 km from Haifa, 1,500 m depth) and compared with water column profiles of ²³⁴Th. While POC export in the basin is generally low (0.05-1 mmoleC m⁻²d⁻¹ at the base of the photic zone during Dec 2017 – May 2018), fluxes are quite variable, and the export pattern is mainly controlled by coastal discharge or shelf-resuspension by waves (winter peaks) rather than by marine primary production. This is demonstrated by correlation with waves and with onshore stream discharge, and supported by larger POC fluxes measured by deep water and twilight zone traps (Fig. 1), by tight correlation of POC with total mass flux, by lowering POC percentage of the total mass flux during winter peak events and by deep water ²³⁴Th deficits (Fig. 2). ²³⁴Th often shows large deep water deficits (e.g. Dec 2017, Fig. 2), which are not matched by large fluxes in the traps.

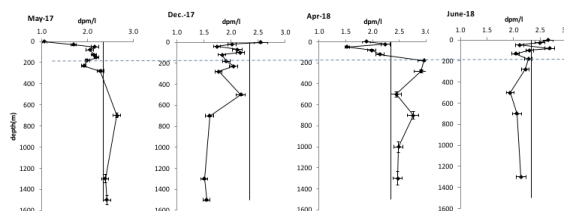


Fig. 2. ²³⁴Th profiles (dpm/l) taken during 4 visits to the DeepLev site. Also shown is the reference ²³⁸U activity. Base of euphotic zone (~180 m) is shown as a dashed line.

This hints that the two methods do not necessarily document the same processes. It is suggested that while the traps capture the larger grain-size fraction, which is transported by terrestrial discharge or large shelf resuspension, the ²³⁴Th method preferentially represents the finer size fraction, which could be related to dust deposition, wave resuspension, deep/intermediate water formation, or could document slow settling at the end of the rainy season.

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DISSOLVED ORGANIC MATTER DYNAMICS IN THE ADRIATIC SEA

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Abstract

Vertical distribution of Dissolved Organic Carbon (DOC) and Fluorescent Dissolved Organic Matter (FDOM) was studied in the Southern Adriatic Sea in December 2015 and April 2016 (Eurofleets2-ESAW cruises). DOC showed a clear seasonality with the highest values in the mixed layer in December and a downward export due to vertical mixing in April. In the bottom layer (800-1200 m) DOC values in April were up to 13 μM higher than in December, even if no increase in oxygen was observed. The application of PARAFAC to the 330 excitation emission matrices (EEMs) allowed for the validation of a 6-component model, indicating the occurrence of 3 terrestrial and 1 marine humic-like components, 1 protein-like and 1 PAH-like components. Fluorescence indicates removal in the upper layers and a transformation of the DOM pool in the deep waters.

Keywords: *Organic matter, Geochemical cycles, Warming, Adriatic Sea*

Dissolved Organic Matter (DOM) represents the largest pool of reduced carbon on the Earth and the main source of energy for the heterotrophic prokaryotes [1]. The Adriatic Sea is a semi-enclosed basin strongly influenced by many factors such as river discharge, winds regime, and large-scale circulation patterns (e.g., BiOS-Bimodal Oscillating System). It is the major source of dense water for the Eastern Mediterranean Sea [2]. The main goals of this study are: 1) to report the first information about Fluorescent Dissolved Organic matter (FDOM) in the Middle and Southern Adriatic Sea; 2) to assess the seasonal variability of dissolved organic carbon (DOC) distribution in the Adriatic in relation to large-scale and long-term changes in water masses circulation and properties. Samples were collected from the surface to the bottom along 2 sections, located in the Middle and Southern Adriatic Sea, during 2 cruises (Fig. 1): ESAW 1 (December 12th to 15th 2015) and ESAW 2 (April 5th to 9th 2016) in the framework of the research project funded under the Eurofleets 2 EU-FP7.

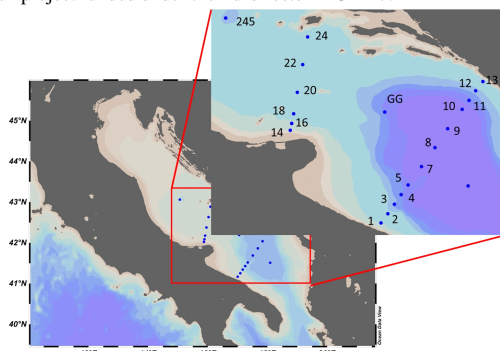


Fig. 1. Study area and sampling stations.

In December, DOC ranged between 44 and 84 μM with maximum values in the surface layer in correspondence with the riverine input and at station 10 (Fig. 2). At station 10, values of $\sim 65 \mu\text{M}$ are observed down to 300 m, indicating the DOC vertical re-distribution by mesoscale features. The lowest values (44 μM) were observed in the core of the Levantine Intermediate Water (LIW) (400-600 m), in agreement with previous observations [4]. In April, the highest values (77-82 μM) were observed in the surface layer, close to the Italian coast, and at stations 7 and 8. Vertical mixing can explain the high values observed in the upper 400 m. The lowest values (48-50 μM) were still observed in LIW core. In the bottom layer (800-1200 m) DOC values were up to 13 μM higher than in December. Usually, an increase in DOC values in the deep layer of this area is observed after the arrival of newly formed dense water from the North Adriatic, but neither physical nor oxygen changes clearly supported this interpretation during winter 2016. The application of PARAFAC to the 330 excitation emission matrices (EEMs) allowed for the validation of a 6-component model. In order to identify these components, their spectra were compared with matching spectra obtained from OpenFluor database [5], with spectra reported in the literature and with spectra of commercial humic and fulvic

acids and proteins. Four components were identified as humic-like of both marine (C1) and terrestrial (C2, C3 and C5) origin; one component (C4) was identified as protein-like; the last component (C6) was identified as PAH-like.

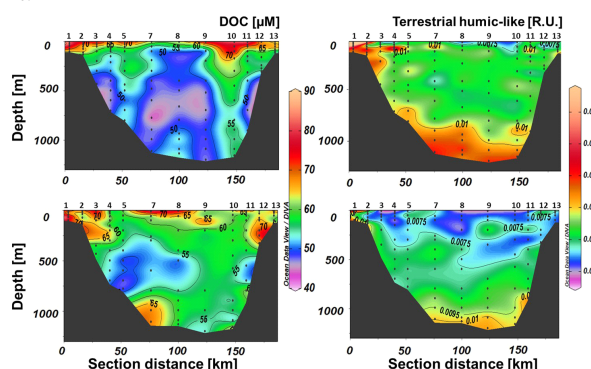


Fig. 2. Vertical distribution of terrestrial humic-like component (C3) and DOC in December 2015 (upper panels) and April 2016 (lower panels).

The vertical distribution of the terrestrial humic-like component (C3) is reported as representative of the other humic-like components (Fig. 2). FDOM was lower in April than in December along the whole water column. In both periods the highest values were close to the Italian coast (stations 1 and 2), in contrast the minimum was in the upper 50 m in December and in the upper 500 m in April due to photobleaching processes. Deep waters were characterized by markedly higher fluorescence in December than in April, suggesting the removal of FDOM between the two periods. Interestingly, a comparison with data collected in the same area 10 years before reveals an increase of $\sim 10 \mu\text{M}$ in DOC concentration in the surface layer (0-50 m). DOC accumulation can be explained by a combination of factors such as the increase in temperature and in salinity (due to the phase of BiOS) and the enhanced riverine input.

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OBSERVING WINTER MIXING AND RESULTING SPRING BLOOM IN THE MEDITERRANEAN. AN INSIGHT FROM THE PHYSICAL FORCINGS TO THE BIOGEOCHEMICAL CONSEQUENCES

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Abstract

To better characterize and understand dense water formation in the northwestern Mediterranean and its biogeochemical consequences, a major experiment, DEWEX (DEep Water EXperiment), was carried out in 2012-2013. This one-year experiment combined data from oceanographic vessels, satellite images, and various instrumented autonomous platforms. These efforts provided a unique and comprehensive data set that allows for an accurate description of the seasonal cycle of atmospheric, oceanic and biogeochemical components

Keywords: *Deep waters, Gulf of Lyon, Geochemical cycles, Nutrients, Water convection*

One of the general characteristics of the Mediterranean is its oligotrophy that affects biological productivity. However, there are some areas where particular oceanographic and atmospheric conditions generate intense vertical mixing in the water column in winter. These convective areas are located in the northern half of the Mediterranean (Gulf of Lion, Adriatic Sea, Aegean Sea, Levantine Basin). Dense water formation has important implications for the hydrodynamics, biogeochemistry and vitality of Mediterranean ecosystems. This process regulates the characteristics of the intermediate and deep water masses that contribute to the general circulation [1]. It also injects massive amounts of nutrients into the surface layer [2], triggering large spring planktonic blooms, while also exporting organic matter and oxygen to the deep layers [3] (Figure 1).

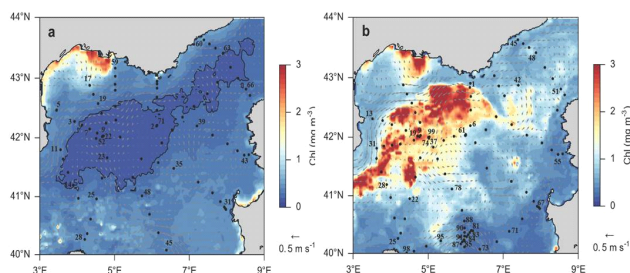


Fig. 1. Average surface chlorophyll and geostrophic circulation for (a) 03-21 February 2013 and (b) 05-24 April 2013

A major experiment, DEWEX (DEep Water EXperiment), was carried out in 2012-2013 in the framework of the HYMEX, MERMEX, and NAOS projects [4]. This one-year experiment combined data from oceanographic vessels (6 cruises), satellite images (altimetry, surface temperature, and ocean colour), and various instrumented autonomous platforms (gliders, moorings, drifters, and profiling floats). These efforts provided a unique and comprehensive dataset that allows for an accurate description of the seasonal cycle of atmospheric, oceanic and biogeochemical components. This is a unique case study for the modelling community. The results allowed a better understanding of the quantitative and qualitative dimensions of dense water formation and also revealed important dynamic processes at small scale.

The measurements revealed that convection during the winter of 2013 was particularly intense. The mixing reached the bottom at a depth of 2500 m and formed a significant amount of dense water, increasing the temperature, salinity, oxygen and density of the bottom waters. A major phytoplankton spring bloom was triggered by a large amount of nutrients introduced in the surface layer during winter. The combination of in-situ measurements, satellite measurements and modelled data made it possible to confirm that the extent of the area affected by convection strongly influences the intensity of the spring bloom, whereas the depth reached by the convection is a key factor controlling the diversity and

activity of the bloom and then the matter flux entering the trophic chain [5]. Indeed, the size of the convection ultimately determines the amount of nutrients injected into the surface layers. The convection depth modifies the elemental stoichiometry of the mineral compartment thus favouring siliceous organisms (i.e. diatoms) if the convection is deep (Figure 2).

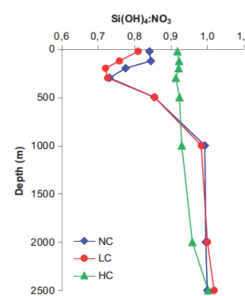


Fig. 2. Vertical S:N (mol:mol) ratio profiles in three "areas" (NC: No Convection, LC: Low Convection, HC: High [deep] Convection)

The Mediterranean is particularly sensitive to climate change. The increase in surface layer temperature affects vertical stratification but is counterbalanced by evaporation, resulting in an increase in salinity. Thus, the Mediterranean could continue to produce dense water but through different mechanisms, which could dramatically affect the characteristics of water bodies, nutrient balances and ecosystem functioning, notably through stoichiometry equilibrium.

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HOW IS EMODNET CHEMISTRY EVOLVING: USE CASES

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Abstract

EMODnet Chemistry is one of the seven thematic portals started by DG MARE in 2009 to unlock and provide open access to chemical data and data products. It recently developed important use cases to answer needs of MSFD data reporting, EEA, and EC (through its MSFD WGs and JRC). In particular, EMODnet Chemistry gathers MSFD monitoring data, providing INSPIRE compliance according to Article 19 (3). EEA officially announced the suspension of WISE data flow for Marine Waters, suggesting the use of EMODnet Chemistry and ICES systems; standardized, harmonized, and validated datasets of MSFD D5 and D8 for all European seas were delivered to EEA for its thematic assessments under the State of the Environment reports (SoEr). A subset of the pan-European litter database has been delivered to form the knowledge base for EU Baselines computation.

Keywords: *Marine litter, Eutrophication, Marine policy, Mediterranean Sea, Black Sea*

EMODnet Chemistry started its 3rd phase in March 2017, with the overall objective of assembling, processing and making accessible chemical measurements and derived data products concerning eutrophication, ocean acidification and contaminants. The scope has been extended to marine litter collected on beaches, in fishermen's nets, or in specific surveys. The geographic coverage is also broadened, including now six major European sea regions: Norwegian Sea and Barents Sea, Baltic Sea, N.E. Atlantic (Celtic Seas, Iberian coast and Bay of Biscay and Macaronesia), Greater North Sea, Mediterranean Sea and Black Sea. EMODnet Chemistry consortium brings together 45 participants from 27 countries (20 EU member states) along European seas, mostly national marine monitoring agencies and major marine research institutes. In addition, the consortium includes 3 international organisations, ICES – International Council for the Exploration of the Sea, BSCS - Black Sea Commission Secretariat, and UNEP/MAP - United Nation Environment Programme / Coordinating Unit for the Mediterranean Action Plan. The Chemistry portal and related activities build on products and services developed within the previous phases, aim for complete interoperability with services developed by the other thematic groups and with the INSPIRE Directive and are open to receive data provided through EMODnet ingestion facility.

During the last biennium, EMODnet Chemistry reached a number of important milestones marking a significant change for EMODnet Chemistry visibility and consideration:

1. The EMODnet Chemistry portal has tested the application of INSPIRE Data Specifications to model nutrient data in the Mediterranean Sea. The use case builds on the Technical Guidelines related to Environmental Monitoring Facilities (EMF) and Oceanographic Geographical Features (OF) themes and to the Observations and Measurement (O&M) data model. It was developed in collaboration with the SeaDataCloud and MEDCIS projects. The mapping between SeaDataCloud metadata and INSPIRE elements demonstrated the completeness of EMODnet Chemistry metadata with respect to INSPIRE requirements and the feasibility to map EMODnet to INSPIRE models, showing how EMODnet platform could be used to expose monitoring data following Art.19(3), i.e. compliant with INSPIRE.

2. EEA decided to cancel the WISE-SoE data call and to follow-up on the use of EMODnet Chemistry and ICES systems for three EEA indicators (i.e. Hazardous substances in marine organisms, Nutrients in TCM waters and Chlorophyll in TCM waters). EIONET National Focal Points have been encouraged to make contact with their EMODnet chemistry national partner(s) to make available their MSFD monitoring data. This opportunity will demonstrate the robustness and comprehensiveness of EMODnet to support the long term availability of data and to provide qualified and updated information by complementing data available at ICES reported by OSPAR and HELCOM. Additional up-to-date information are expected to complement data provided by EMODnet Chemistry partnership as a result of the positive synergy. This step will contribute in streamlining data flow at EU level.

3. MSFD TG ML endorsed EMODnet Chemistry data format proposal for gathering and managing data sets on marine micro-litter on a European scale. This is done adopting and adapting SeaDataNet standards (CDI metadata format and ODV data format) and tools (NEMO, MIKADO). Additionally, EMODnet Chemistry formats for gathering beach litter and sea floor litter data were tailor made based on existing standards (OSPAR, ICES, TG ML, UNEP/MAP, MEDITS). For beach litter the format has been used to handle marine litter data

gathered from Member States for ML Baselines. The definition of the best possible data management strategy and the identification of the most valuable methodology have been pursued, with the main goal of delivering a single database able to handle marine litter data at pan-European scale (1). With the development of the Marine Litter Database, EMODnet Chemistry has supported the analysis of the litter baselines performed by JRC with a subset of the pan-European database. This baselines dataset, including only official monitoring data collected by Member States authorities, contains data from 22 European countries and 4 marine regions, with a total 3 063 surveys on 389 European beaches over the period 2012 to 2016.

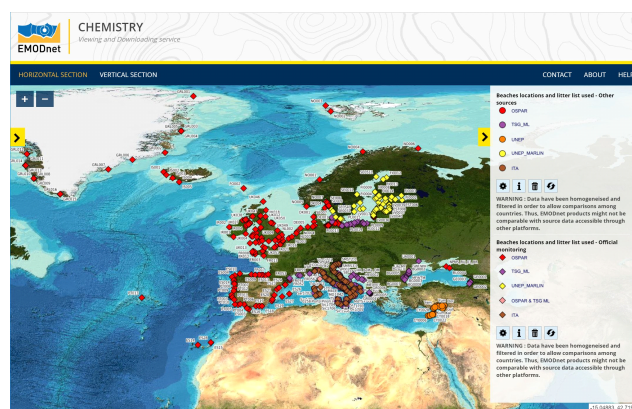


Fig. 1. Spatial distribution of beach litter surveys, highlighting the differences on the reference list used

4. EMODnet Chemistry started a close cooperation with Copernicus to contribute with oxygen, chlorophyll-a, and nutrients aggregated, validated and harmonized data collection products to CMEMS INSTAC. A Memorandum of Understanding concerning cooperation on in-situ biogeochemical marine data between Copernicus Marine Environment Monitoring Service (CMEMS) and EMODnet Chemistry is agreed. As part of this synergy, CMEMS INSTAC will promote and encourage potentially additional data providers from Europe to include their datasets in EMODnet Chemistry.

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CORRELATION PROFILE BETWEEN TRACE METALS IN SEDIMENT AND PHYSICOCHEMICAL PARAMETERS OF SEAWATER ON THE MONTENEGRIN COAST

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Abstract

Quality of the water was monitored by analyzing both physicochemical parameters in water (temperature, salinity, DO, pH and nutrient content) and trace metals (Cr, Cu, Pb, Ni, Fe, Mn, Zn and Hg) in sediment on the Montenegrin coast, during fall 2018. Another aim of the study was to find out whether any relationship existed between heavy metals concentration and physicochemical parameters by the calculation of correlation factors among them. Water and sediment samples were collected at 3 stations along the Montenegrin coast. Based on the obtained data we can conclude that significant amounts of trace metals are deposited in Montenegrin sediments and that there is a significant positive correlation among certain metals, as well as between some metals in sediment and physicochemical parameters of the water.

Keywords: Coastal waters, Sediments, Trace elements, Adriatic Sea

Introduction

Contamination of the natural environment with trace metals is a global problem. Trace elements from natural and anthropogenic sources continually enter the aquatic ecosystem where they pose a serious threat due to their toxicity, long-term stability and bioaccumulation [1]. Trace metals can be released from sediments into water above through natural or anthropogenic processes, causing potential danger to the ecosystem. Hydrographic medium conditions such as pH, oxidation state and redox potential [2] significantly affect metal solubility. The pH value of water [3] affects the metal toxicity in several ways, while the initial specificity and bioavailability of the metal may vary between the pH values of 4-8 [4]. In general, trace metal bioavailability and toxicity are dependent on temperature, dissolved oxygen concentration, salinity, conductivity and pH.

Material and Methods

The sediment samples were collected at three different sites along the Montenegrin coastline during the autumn of 2018 as it is shown in Figure 1. The sites Port of Kotor and Port of Tivat in the semi-enclosed Boka Kotorska Bay, as well as the site Port of Bar on the coastline of open sea, are situated in the proximity of different geochemical, hydrological and human impacts.



Fig. 1. Map of investigated area

Collected sediment samples were homogenized, frozen at -18 °C, freeze-dried at -40 °C for 48 h (CHRIST, Alpha 2-4 LD plus, Germany), ground to a fine powder and sieved through a less than 63 µm stainless steel mesh wire, for trace element analysis. The mineralized samples were analysed for Cr, Ni, Fe, Cu, Mn, Pb, Zn by flame-furnace atomic absorption spectrometer (Shimadzu AA 7000, F-AAS), while Hg content was measured following a CV-AAS procedure, by using Shimadzu Hydride System coupled to the atomic absorption spectrometer. The applied methods for the trace metal determination are specified in the Laboratory Procedure Book, IAEA (International Atomic Energy Agency), Marine Environment Laboratory, Monaco 2009. The basic

hydrographic parameters were collected using the multiparameter probe and CT data loggers. Nutrient contents were measured by UV/VIS spectrophotometer (Analytik Jena Specord 250 Plus).

Results and Discussion

During sediment collection the depth waters had temperatures of 19.4-21.9°C, pH of 8.1-8.21, salinity of 28.8-38.4 PSU and DO concentrations of 6.36-7.01 mg/L. The nutrients had a maximum data of 0.72 µg/l NO₂⁻, 3.69 µg/l NO₃⁻, 0.43 µg/l PO₄⁻ and 0.95 µg/l NH₄⁺. The maximum measured metal concentrations were 267 mg/kg Cr, 57.12 mg/kg Cu, 38130 mg/kg Fe, 742 mg/kg Mn, 172 mg/kg Ni, 58.8 mg/kg Pb, 183 mg/kg Zn and 4.52 mg/kg Hg. The metal distribution in sediments follows the order: Fe > Mn > Cr > Zn > Ni > Cu > Hg. Based on the data obtained we can see a correlation between the physicochemical parameters (pH and salinity) of water with metal concentrations. This is important for our study since pH and salinity are the vital factors in metal solubility and control metal speciation and thus their distribution within dissolved fractions [5]. The Cu, Fe and Hg concentrations in sediment were positively correlated with water pH (r = 0.83; r = 0.89, r = 0.98, p < 0.05). Salinity also influences the solubility of Mn and Zn (r = 0.955, p < 0.05 for Mn and r = 0.808, p < 0.05 for Zn). The present study shows that certain trace metals in sediments were significantly correlated. Very high positive correlations (p < 0.05) in the sediments were found for Fe with Cu, Ni with Cr, Cu and Fe, Pb with Cr, Cu, Ni, Hg with Cu and Hg with Fe.

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CIESM Congress Session : Biogeochemistry & cycles / Trends & changes

Moderator : François Galgani, IFREMER, Bastia, France

Moderator's Synthesis

The session was dedicated to the evaluation of bio geochemical parameters, their trends, and the understanding of changes occurring in their associated processes. The five different presentations described the changes in geochemical indicators such as dissolved organic carbon, along a 28 year- time series, and hydrological parameters and inorganic nitrogen in the last 45 years. Changes in the cycling of nutrients, phytoplankton, in the inputs of phosphates at sea and in atmospheric CO were also addressed.

Experiments were conducted in various places of the Mediterranean Sea, including the strait of Gibraltar and the Adriatic Sea. They were also associated with specific processes such as the formation of deep sea water, the inputs from rivers and acidification. The results highlighted the importance of long-term research on organic matter, especially DOC, total inorganic nitrogen (TIN), orthophosphate (PO₄) and chlorophyll concentrations but also oxygen in deep waters of CO in atmospheric compartments.

The discussion started on the results presented and was very active. Besides, various aspects of long term data management were discussed, including the quality of data, how to manage old and recent data in datasets, and inter-comparison or inter-calibration. Harmonization of processes was also debated, focusing on the role of large data management collection schemes and the way to manage quality insurance and harmonize results. The importance of large scale data systems such as EMODnet was finally discussed.



LONG-TERM INVESTIGATIONS OF ORGANIC MATTER IN THE NORTHERN ADRIATIC SEA AS AN INDICATION OF GLOBAL CHANGES

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Abstract

An unique time series of organic matter (OM) content (dissolved organic carbon, DOC and its surface active fraction, SAS) collected between 1989 and 2017 with monthly or bimonthly temporal resolution along the transect Po River delta - Rovinj in the northern Adriatic (NA) will be presented and discussed according to available physico-chemical and biological conditions. Organic matter shows very pronounced changes in its amount and properties. In the investigated years the periods of high and low carbon content change is noticed with evident changes in reactivity regarding to presence of surface active organic material. Obtained results highlight the importance of long-term research on organic matter, especially DOC and its SAS fraction as possible indicators of changes in the NA ecosystem.

Keywords: Organic matter, Adriatic Sea, Electrochemistry, Monitoring, Global change

In this paper an unique time series of organic matter content (dissolved organic carbon, DOC and its surface active fraction, SAS) that were collected between 1989 and 2017 with monthly or bimonthly temporal resolution along the transect Po River delta - Rovinj (Figure 1) in the northern Adriatic (NA) will be presented.

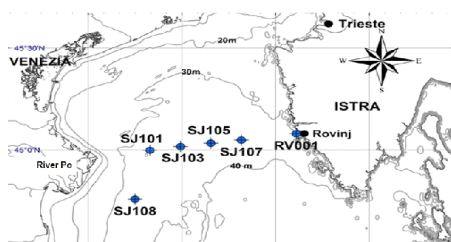


Fig. 1. Sampling stations along the transect Po River delta - Rovinj: SJ108 (44°45'24"N, 12°45'0"E); SJ101 (44°59'53"N, 12°49'48"E); SJ103 (45°1'0"N, 12°59'35"E); SJ105 (45°1'59"N, 13°9'18"E); SJ107 (45°2'52"N, 13°19'0"E); ZI032 (45°4'6"N, 13°30'54"E) and RV001 (45°4'48"N, 13°36'36"E).

The organic matter shows very pronounced changes in its amount and properties. During the investigated years the periods of high and low carbon content change may be noticed [1], with evident changes in reactivity regarding to presence of different surface active organic material which can be taken as a rough tracer for different phytoplankton composition and activities [2, 3]. Organic matter reactivity, is based on adsorption properties (hydrophobic-hydrophilic) measured by electrochemical methods, and expressed by so-called normalized surface activity (NPA = SAS / DOC), (Figure 2) [2, 3]. NPA for natural samples is always compared with model substances.

The OM changes indicate altering episodes of eutrophication and oligotrophication, embedded to an overall oligotrophication trend in the considered period [1]. Observed changes on a long-term scale can be discussed as a consequence of (a) annual fluctuations of freshwater input, mainly driven by the Po River, and (b) water circulation and alteration of water masses in the Adriatic Sea, due to changes in the Adriatic-Ionian Bimodal Oscillating System (BiOS) [1,4,5].

The BiOS is responsible for advection of either highly saline ultraoligotrophic Levantine Intermediate Water from the Eastern Mediterranean or nutrient-rich less saline Western Mediterranean waters into Adriatic, that according to our findings reflects on OM amounts (DOC, SAS) and properties.

Changes in the content and properties of organic matter in the NA coincide with other research that highlight significant changes in the NA ecosystem (amount of nutrients, composition and activities of phytoplanktonic organisms, Istrian coastal counter-current development, etc.) [1,6]. This study highlights the importance of long-term research of organic matter,

especially DOC and its SAS fraction as possible indicators of changes in the NA ecosystem.

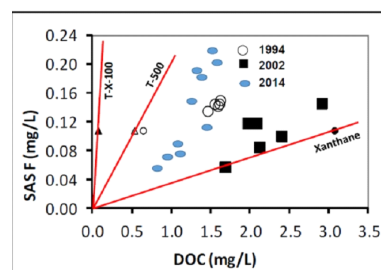


Fig. 2. Correlation of SAS_{diss}/DOC concentrations obtained for the surface seawater samples collected at stations 107, and 108 (Figure 1) in the NA in 1994, 2002, and 2014. Lines correspond to different model substances that were used as representatives for hydrophobic and hydrophilic SAS in natural samples (Triton-X-100, polysaccharide T-500 and xanthane).

Acknowledgement: Financial support of Croatian Science Foundation projects SPHERE and MARRES, is highly acknowledged.

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OCEANOGRAPHIC CONDITIONS RELATED TO THE EXTREME WARM SPRING-SUMMER OF 2016 AND 2017 IN THE NORTHERN ADRIATIC

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Abstract

Temperature, salinity, total inorganic nitrogen (TIN), orthophosphate (PO₄) and chlorophyll *a* concentrations in the surface, and oxygen saturation in the bottom layer of two stations in the northern Adriatic (NA) were measured in 2016 and 2017, and compared with the long-term data (1972-2015).

Keywords: Air-sea interactions, Temperature, Salinity, Nutrients, Adriatic Sea

The oceanographic conditions in the NA mostly depend on: a) air-sea heat and water fluxes, b) Po River freshwater input, and c) advection from the middle/south Adriatic, possibly related to the intensity of motions within the Ionian-gyre (BIOS; [1]). Extremely warm weather recorded in 2016 and particularly in 2017 in Croatian region, during spring and summer. In order to verify if this atmospheric event had a significant impact on the NA, oceanographic parameters, measured in 2016 and 2017 at two stations were compared with long-term data (1972-2015). While the western station (SJ101-12 Nm off the Po River delta, Italy) is under a prevailing influence of eutrophied Po River waters, the eastern station (SJ107-12 Nm off the Istrian coast, Croatia) is predominantly oligotrophic due to advection of higher salinity waters from the middle Adriatic. Sea surface temperatures were at both stations generally higher than the average, particularly in summer 2017 (Figs.1 and 2).

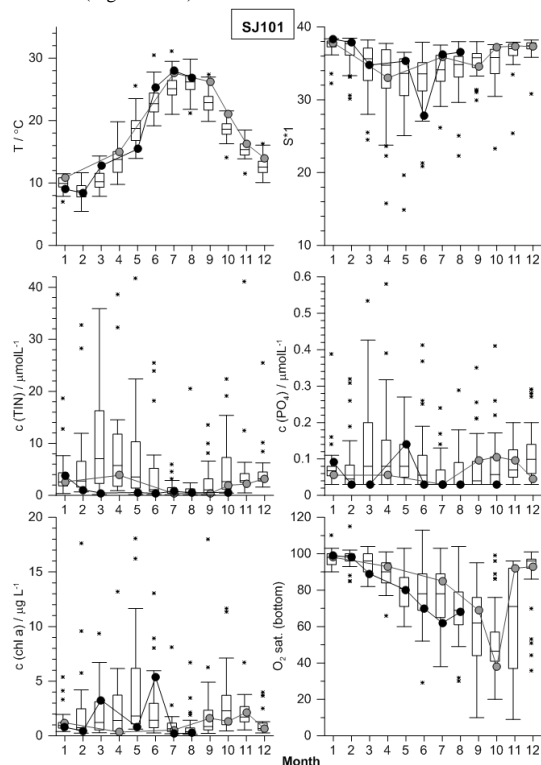


Fig. 1. 1972-2015 long-term data (Box-Whisker plot), 2016 (grey) and 2017 (black) monthly values of oceanographic parameters at the station SJ101. Surface salinity at SJ107 was higher than usual in the almost all the measured cases (Fig. 2). This occurred less frequently at SJ101, although still dominantly. As expected, the nutrient concentrations were correlated to the described oceanographic conditions (Figs. 1 and 2). At SJ101 the TIN concentrations were mostly remarkably below the averages, while at the SJ107, the differences were reduced, although still significant. The PO₄ values at this station were near the analytical limit, as typical. Some increased values were observed in the fall 2016 at SJ101 (Fig. 1). The chl *a*

concentrations were close or below the long-term average, with occasional higher values correlated with nutrient concentration increases, e.g. in June (SJ101) and November (SJ107) of 2016. Interestingly, during spring and summer 2017, as well as in October 2016 the bottom oxygen saturation ratios at SJ101 were lower than the averages (Fig. 1).

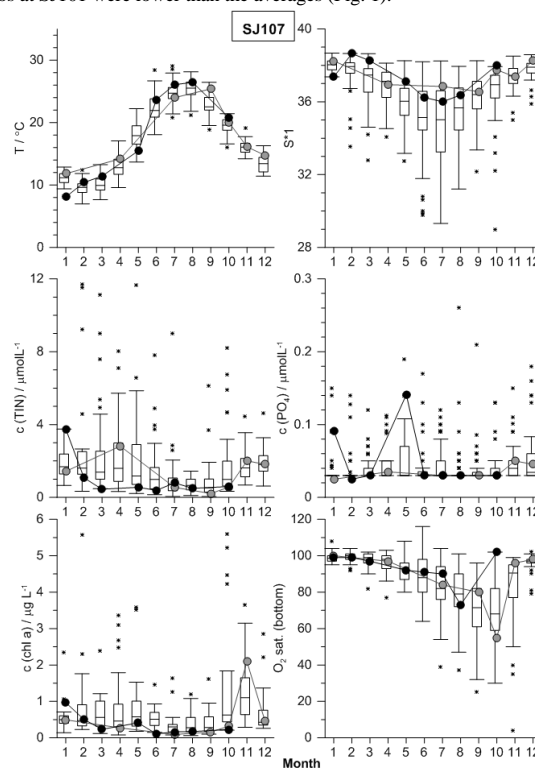


Fig. 2. 1972-2015 long-term data (Box-Whisker plot), 2016 (grey) and 2017 (black) monthly values of oceanographic parameters at the station SJ107.

Conclusions Oceanographic conditions in the NA during 2016 and 2017 were affected by increased air-sea heat fluxes and advection of high salinity waters from the middle/south Adriatic, concurrently with reduced Po river influence, particularly in spring and summer. Consequently, surface higher salinity, reduced nutrient concentrations and modest phytoplankton blooms, especially in spring, were observed.

Acknowledgements This publication has been produced within the frame of the project Ecological response of northern Adriatic to climatic changes and anthropogenic impact (EcoRENA).

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RESEARCH AND PRODUCTS DERIVED FROM THE MONITORING PROGRAM RADMED (SPANISH MEDITERRANEAN WATERS)

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Abstract

The Mediterranean Sea can be especially vulnerable to climate change effects due to its reduced dimensions. For example, an increase of the water column stratification could inhibit winter mixing and reduce the frequency and intensity of convection processes which inject nutrients to the photic layer and are responsible for the ventilation of deep waters. In this context, the long term monitoring of the Mediterranean waters is a basic task. In this work time series from 1992 to 2017 of physical, and biochemical variables obtained from RADMED project are analyzed and average distributions of nutrients, phytoplankton, temperature and salinity are described, and when possible long term trends are calculated

Keywords: *Time series, Temperature, Phytoplankton, Nutrients, Western Mediterranean*

Introduction

The RADMED project [1] is a monitoring program that covers the waters from the eastern side of the Gibraltar Strait to the Catalan and Balearic Seas. It was initiated in 2007, merging some previous programs, some of them initiated in 1992. Four times per year several sections are sampled routinely, from Cabo Pino (close to Straits of Gibraltar) to Barcelona, including Balearic channels. Coastal, shelf and deep stations are monitored, from 20 to 2500 m depth, so all water masses from western Mediterranean are sampled regularly. Samples for the analysis of nutrients (nitrate, nitrite, phosphate and silicate) and chlorophyll concentrations, micro-, pico and nanoplankton and zooplankton composition and abundance are taken, as well as data for temperature, salinity and dissolved oxygen concentration.

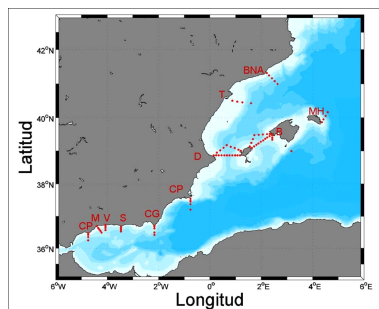


Fig. 1. RADMED stations map. Red dots indicate the stations sampled in a seasonal basis

Results

In this work time series of all the physical and biochemical variables routinely sampled in RADMED cruises are analyzed from 2007 to 2017 (in some cases from 1992). The average distributions of the different parameters, ranges of variability and long term trend of the parameters analyzed could be considered as indicative of the environmental state of the sea. The capability of the time series generated under RADMED for the calculation of mean values for the properties of the Spanish Mediterranean water masses and the study of the interannual and decadal variability of such properties when possible is shown in this work.

In the case of physical properties, RADMED data have been merged with the historical data from the MEDAR/MEDATLAS data base, so the study of temperature and salinity trends extend from 1900 to 2015 [2] Derived of the analysis of these long time series an increase of the temperature and salinity of the intermediate and deep layers of the Western Mediterranean is detected. The temperature and salinity trends for 1943-2017 period and for the intermediate layer are 0.002°C/yr and 0.001 yr⁻¹ respectively. Deep layers warmed and increased their salinity at a rate of 0.004 °C/yr and 0.001 yr⁻¹.

In the case of biochemical variables the analyses show a clear trophic gradient in the RADMED area. Nutrient and chlorophyll concentrations and

the intensity of the deep chlorophyll maximum decrease northeastward [3] The deep chlorophyll maximum depth increases to the northeast. The Balearic and Catalan Sea show a clear seasonal pattern with maximum surface concentrations for nutrients and chlorophyll in winter/spring, associated to winter mixing. On the contrary, the Alboran Sea does not show such a clear seasonal cycle, probably because of the existence of permanent upwelling processes acting along the whole year. The Atlantic Water occupying the upper part of the water column shows a Redfield N:P ratio close to or lower than 16, indicating no phosphorus limitation. Finally, chlorophyll concentrations seem to have increased from 1992 to 2015 in the Alboran Sea, while no long term changes could be established for the rest of the variables and geographical areas.

Also time series of micro- pico and nanoplankton are analyzed [4]. The results obtained suggest that there are three main areas in the Spanish Mediterranean waters:

- (1) The most productive waters located in the western part of the Alboran Sea where primary production and the presence of large cells such as diatoms are influenced by winter mixing, but also by other fertilizing processes linked to the dynamics of the Strait of Gibraltar and the cyclonic circulation areas
- (2) The poorest waters are those located to the south of the Balearic Islands and Cape Palos where small flagellates dominate during all the seasons.
- (3) The third area would be the Catalan Sea, where the described oligotrophy could be partially relaxed by strong wind episodes, being winter mixing stronger than at the Balearic Sea.

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VARIATIONS IN RIVERS INPUTS IN THE LAST DECADES INDUCED SIGNIFICANT CHANGES IN THE BIOGEOCHEMISTRY OF THE MEDITERRANEAN SEA

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Abstract

The biogeochemistry of the Mediterranean Sea (MS) is strongly linked to the input of nutrients from external sources, such as the Gibraltar strait which has long been considered as the major source. Recent studies have shown that other sources may play a significant role, such as rivers and runoffs which substantially changed over the last decades. The consequences of these variations on the MS biogeochemistry remain poorly investigated. This study aims at filling this gap through a modelling study. One of the main result is that PO₄ concentrations in the surface layer have decreased in the last decades, especially in the eastern basin (EMB), resulting in higher dissolved organic carbon concentrations. This study also provides a new potential explanation for the shift between the top of the nitracline and the phosphacline in the EMB.

Keywords: *Models, Phosphorus, River input, Mediterranean Sea*

The MS is an oligotrophic sea where phosphate (PO₄) availability mostly controls phytoplankton growth and bacterial production [1]. It has four main potential external sources of nutrients, namely the Gibraltar strait, the Dardanelle strait, rivers and runoff and atmosphere (dry and wet deposition). The former has long been considered as the major source for surface water [2].

However, recent studies have shown that N and P concentrations are also sensitive to nutrient inputs by rivers [3] which have experienced strong variations in the last decades due to human activity [4]. N input increased between the 1960's and the 1980's and then remained high while P input increased between the 1960's and the 1980's and then rapidly dropped back to its 1960's value. The decrease in P reflects the adoption of new regulations by the surrounding countries of the MS, such as the prohibition of phosphorus detergents, and the improvement of wastewater treatment plants [4].

The consequences of these variations on the MS biogeochemistry remain poorly investigated, especially at the scale of the whole basin. In this study, we use a mechanistic with flexible stoichiometry biogeochemical model Eco3M-Med [5; 6] coupled with the 3D physical model NEMO-MED12 [7] to analyse at basin scale the effect of these variations on the biogeochemistry over the 1985-2010 period.

This shift has already been observed [8; 9], but we provide here a new explanation for it.

As a conclusion, changes in river inputs may affect not only coastal areas and the direct vicinity of river mouths, but also offshore areas as shown here for the EMB. Moreover, this study clearly stands for the use of realistic scenarios of river inputs along with climate scenarios for coupled physical-biogeochemical forecasts in the MS.

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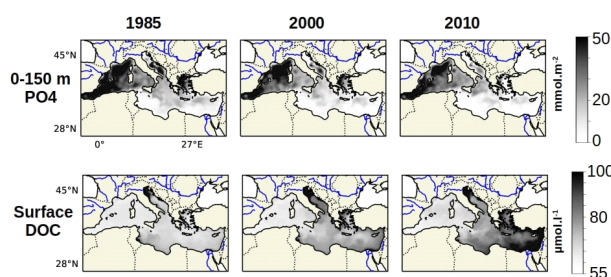


Fig. 1. Evolution of (top) 0-150 m mean PO₄ and surface DOC concentrations (bottom) in the MS between 1985 and 2010.

This study first shows that the strong decrease in PO₄ rivers inputs induces a diminution of PO₄ in the sub-surface layer, especially in the EMB (Fig. 1 top). As a result, mean annual surface DOC concentrations gradually increased in the EMB from 80 μmol.l⁻¹ in 1985 to 100 μmol.l⁻¹ in 2010, as far as we know this feature has not been documented so far (Fig. 1 bottom).

Another result concerns the top of the phosphacline which deepened in the EMB from 50 m in 1985 to more than 100 m in 2010. Since the nitracline remained at about the same position, a shift appeared between both nutriclines.

TEMPORAL VARIABILITY OF THE CARBONATE SYSTEM IN THE SOUTHERN ADRIATIC SEA

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Abstract

The increasing CO₂ concentration in the atmosphere determines a process called ocean acidification. This is a process on a global scale, especially pronounced in areas where deep water formation takes place, and where low seawater temperatures enhance the solubility of atmospheric CO₂. For this reason, it is important to investigate the responses to climate changes in the Southern Adriatic Sea, where the physical pump contributes to transport anthropogenic CO₂ into the deep Eastern Mediterranean Sea.

Keywords: Carbon, South Adriatic Sea

The Southern Adriatic Sea (SAd) is an area characterized by the presence of a quasi-permanent cyclonic gyre that intensifies in the winter season, thus creating the preconditioning to dense and oxygenated water formation. During the winter vertical convection, the South Adriatic Dense Water (SAdDW) is formed and then exported through the Strait of Otranto, contributing to the Eastern Mediterranean Deep Water (EMDW) (Cardin *et al.* 2011). For a better understanding of the physical pump which regulates the transfer processes of CO₂, a high-frequency CO₂ partial pressure (*p*CO₂) and pH automatic sampling system has been set up on the surface buoy of the Sailor E2M3A Observing Site, moored in the centre of the Southern Adriatic basin.

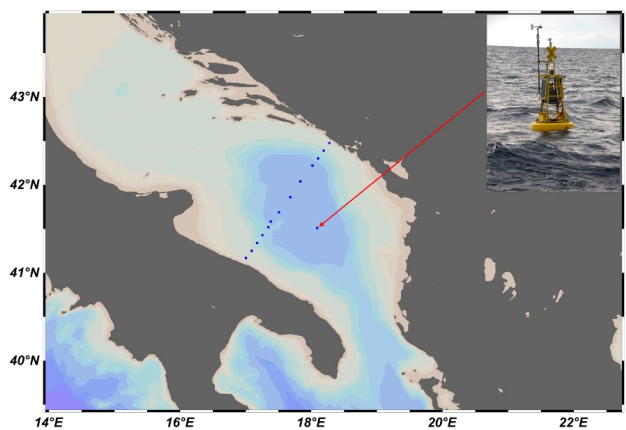


Fig. 1. Map of the E2M3A buoy and of the sampling stations along a transect from Bari to Dubrovnik.

The variability of the carbonate system of the SAd in response to seasonal changes, has been analysed from 2013 to 2017 using both data from automatic monitoring sensors (on the E2M3A buoy) and data from nine oceanographic cruises. During the cruises a partial or complete section of the SAd from Bari (Italy) to Dubrovnik (Croatia) has been sampled. The cruises were undertaken as part of several projects. Samples for dissolved oxygen (DO), total alkalinity (*A*_T), spectrophotometric pH_T and inorganic nutrients (nitrates + nitrates NO_x, phosphates PO₄, ammonia NH₄ and silicate Si(OH)₄) have been taken. Total dissolved inorganic carbon (TCO₂) and *p*CO₂, have been calculated based on *A*_T, pH_T, phosphorus and silicate concentration, pressure, temperature and salinity with the CO2Sys software (Pierrot *et al.*, 2006). To evaluate the influence of biological processes the apparent oxygen utilization (AOU) has been calculated as the difference between the equilibrium saturation of oxygen's concentration in water with the same physical and chemical properties and the measured concentration of DO. In the five years analysed, four principal water masses have been identified. The eastern South Adriatic Surface Water, characterized by high salinity and an AOU ≈ 0 μmol kg⁻¹; the western South Adriatic Surface Water with low salinity and an AOU ≈ 0 μmol kg⁻¹; the Levantine Intermediate Water, LIW, (salinity > 38.8) at a depth between 300 and 500 m and with an AOU between 30 and 60 μmol kg⁻¹, and the SAdDW,

characterized by high potential density (σ_θ>29.2), a depth higher than 880 m and AOU between 25 and 70 μmol kg⁻¹.

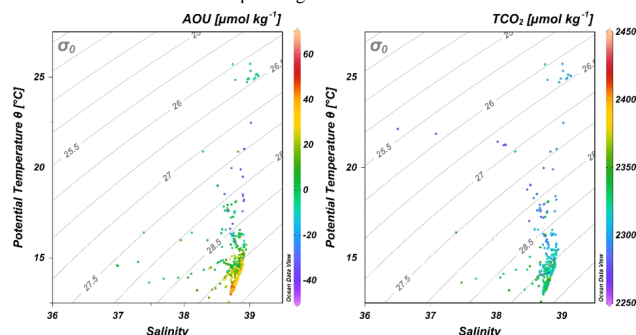


Fig. 2. Temperature-salinity diagrams showing the presence of different water masses.

To eliminate the effect of temperature, pH_T was recalculated at a constant temperature of 14.81°C, which is the mean potential temperature of all the cruises; this highlighted that biological processes prevail in western surface waters, which were also the waters with higher *A*_T, and lower *p*CO₂. Higher *p*CO₂ values (between 305 and 410 μatm) were found in LIW and SAdDW, in correspondence of lower pH_{T14.81°C}. SAdDW and LIW were also the waters with higher TCO₂ concentrations, between 2260 and 2370 μmol kg⁻¹, confirming the importance of convective processes as a sink mechanism of CO₂. Within the study period, the concentration of TCO₂ was variable at the surface and increased with depth, becoming almost constant below ~400m. The linear regression between TCO₂ and AOU was significantly positive (*p* < 0.001). Comparing pH_{T14.81°C} and AOU an inverse linear regression was obtained, highlighting that there is a strong influence of biological processes on these two parameters. The correlation between NO_x and PO₄ in the LIW and in the SAdDW had a ratio of 17 and 15 respectively, close to the theoretical Redfield value (16). NO_x, PO₄ and Si(OH)₄ concentrations increased with depth. This study highlighted that the SAd is a remineralization basin: SAdDW has higher AOU, lower pH_T and higher TCO₂; while the western surface waters are the most productive waters with a lower AOU, higher pH_T and lower TCO₂; and that continuous monitoring, both with discrete samplings than with automatic sensors, is important to study the temporal variability of the carbonate system.

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CIESM Congress Session : Ecotoxicology
Moderator : Mário Pacheco, Univ. of Aveiro, Portugal

Moderator's Synthesis

The session was highly attended and included 14 presentations (7 speakers and 7 invited posters), which reflected the intense and prolific research that has been carried out in the field of ecotoxicology. The presentations covered both Atlantic and Mediterranean contexts and a variety of contaminants of concern (e.g. metals, rare earth elements, nanoparticles, pesticides), involving a wide range of bioindicators, diagnosis tools and approaches (with a higher incidence on experimental ecotoxicology comparing to monitoring ecotoxicology). In the introductory presentation, some key issues on ecotoxicology research were raised, with emphasis on the available tools, and specifically the biological effects techniques (the so-called biomarkers), and bioindicator species. It was stated that a wide range of relevant and sufficiently developed techniques are available, but an apprehension was expressed concerning the risk that ecotoxicologists be nowadays too fascinated or distracted by new techniques, privileging novelty over reproducibility and underestimating the need to establish the links between biomarkers and impacts at the population, community or ecosystem levels. In the same direction, the profusion of bioindicators was identified as a factor that can hamper the deepening of knowledge.

A short but constructive discussion reinforced the need to: (i) focus on a well-defined set of biomarkers and work on the standardization/harmonization of methodologies and approaches (e.g. external ring-trials, inter-laboratory calibration and quality assurance) within regional (or sub-regional) scales; (ii) improve the knowledge on the interference of confounding factors (biotic and abiotic); (iii) develop systematized approaches to select suitable bioindicator species. These priorities should be assumed as conceptual and communicational challenges, but also as a path to meet the expectations of public authorities and decision-makers, providing conclusive and convincing data for setting management measures in Atlantic and Mediterranean worlds. CIESM can be the right arena to catalyse this process.



REVIEW ARTICLE: DISPOSAL OF PHARMACEUTICAL DRUGS ON ENVIRONMENTAL TOXICITY

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Abstract

The disposal of pharmaceutical material and products begins with the arrival of the drug's expiry date. Moreover, most consumers dispose of their expired medication just as they dispose of any of their other waste; by placing it in a trash bag and throwing it away, where it either is burned or fills a landfill site. Consequently, traces of pharmaceutical products have been found in marine organisms including fish. Such disposal methods result in increasing toxicity to the environment and ends up affecting members of the ecosystem(s). Steps and approaches must be taken in order to decrease the amount of pharmaceutical waste reaching the environment and insure the consumers are aware of disposal methods.

Keywords: *Ecotoxicology, Worldwide, Pollution, Plastics, Bio-accumulation*

Currently, there is an existing dilemma as to whether the drug expiry date printed on a medicine's label is always truthful, or whether it is used as a marketing opportunity for pharmaceutical manufacturers ¹, where if a drug is said to expire earlier than it actually does, it is thrown away faster, and thus repurchased more rapidly. However, the expiry date of a drug does not necessarily mean that the drug has broken down or has become toxic/dangerous to consume, in most cases, it merely means that the concentration of the active substance has been reduced, even if by minuscule amounts.

It is a common misconception, for most of the drugs, that once the drug has reached its expiry date, that it had reached toxicity and is unsafe and dangerous to consume. For most of the drugs in tablet and capsule forms (otherwise known as solid-dosage forms), this is simply untrue. This would prove right, however, in some cases of emulsions, syrups, creams, ointments, suspensions and injectible forms (IV, IM) (liquid and semi-solid dosage forms).

At the same time, most drug consumers are unaware of such facts and end up disposing their expired medication as soon as the expiry date comes to arrive. While consuming a drug past its expiry date is not always safe, in most cases, it causes no harm and poses no risk to the consumer. Meanwhile, safe drug disposal policies and movements do exist, but are mostly not sought after by consumers to dispose of their waste, or are not enforced in the region. This means that if the drug is thrown amongst other waste, it ends up amongst the landfill sites where it may cause harm. Pharmaceutical products are usually coated and covered by large amounts of non-biodegradable plastics and aluminum foils, which contributes more and more to the world-wide issue of single-use plastic overload.

Moreover, less shelf life means more disposal rates, more plastic and aluminum filling landfill sites. It is also to be noted that pharmaceutical materials do have drastic effects on the environment if not disposed of properly (which is surprising, universal). For instance, traces of drugs from human prescriptions have been found in plants, fish, and other animals that drink or swim in lakes, streams, and oceans ². Such traces pose a risk; as the presence of pharmaceutical substances in drinking water and animals may lead to the ingestion of the substance, which could lead to drug toxicity, as well as allergic reactions and side effects of the substance showing up in humans.

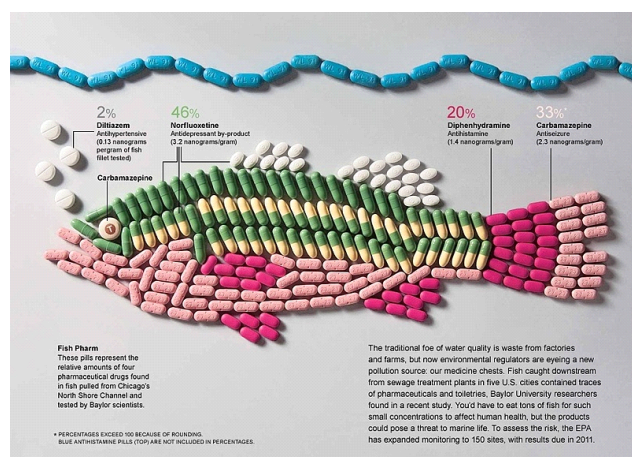


Fig. 1. The figure above shows the percentage of traces of pharmaceutical ingredients found in fish samples collected from Chicago's North Shore Channel.

Correct methods and sources of disposal must be implemented, as well as educating consumers on the dangers surrounding incorrect disposal of pharmaceutical waste, as well as informing the consumers of which drugs remain safe and potent after their expiry date, and which do not. In addition, governments must take into account urging pharmaceutical companies to run stability studies in order to ensure that the expiry dates present on the label are the longest a drug can last without being toxic and maintaining its potency.

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FATTY ACID COMPOSITION OF *LIZA RAMADA* AS A BIOMARKER FOR COASTAL ANTHROPOGENIC POLLUTION

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Abstract

This work aimed to assess the change on fatty acid composition in the *Liza ramada* tissue collected from two sites in Mahdia coast (S1: offshore and S2: in the harbor) exposed to different degree of anthropogenic pollution. Our results revealed an alteration in the fatty acid composition as evidence by a decrease of polyunsaturated fatty acids (PUFA) mainly docosahexaenoic (DHA) and eicosapentaenoic (EPA) and an increase of saturated fatty acids (SFA) in S2 as compared to S1. The determination of the oxidation ratio confirmed the obtained variation of fatty acids in both sampled sites. This investigation represents a first approach for the use of fatty acid composition as a useful parameter using *Liza ramada* as model species.

Keywords: Bio-indicators, Tunisian Plateau

Introduction: Fatty acids (FAs) considered as major cell constituents, playing numerous vital roles in biological systems [1]. Recently, FAs have been used as health biomarkers [2]. Moreover, changes in FAs composition and have been investigated as a biochemical response to better understand the effect of anthropogenic pollution in aquatic ecosystems [2]. This work aimed to evaluate the total lipid content, general FAs composition and the oxidation ratio in *Liza ramada* tissue in order to assess the possible use of FAs as a biochemical response of anthropogenic pollution.

Material and methods: *Liza ramada* was collected from two sites (S1: offshore, S2: in the harbor) in Mahdia coast (Tunisia) and transferred in the laboratory in ice tanks. Fish were washed and dissected. Tissues of each specimen (1g) were destined to lipid extraction using chloroform/methanol buffer. FAs methyl esters were determined using gas chromatography (CPG). Results were calculated basing on standard solution (SUPELCO) and expressed as percent of the total FAs. The oxidation ratio was obtained according to Bejaoui et al [3].

Results and discussion: Changes in lipid metabolism and FAs composition in aquatic organisms can be defensive strategies under anthropogenic pollution [4]. Our results showed a significant decrease in lipid content in fish sampled from S2 as compared to S1. Also, there was a tendency for a decrease in PUFA and increase in SFA ($p < 0.05$). While no significant difference was observed between sites for monounsaturated fatty acids (MUFA). Regarding FAs, the most important increases were recorded in C16:0, C18:0 and PUFA n-6 for S2 than S1. Such rises could be associated with membrane variability regulation and to toxicity responses as reported previously by Silva et al [5]. In our study, the amount of PUFA n-3, DHA and EPA appeared to be the most affected FAs by the anthropogenic pollution. This decrease can probably relate to the increase of peroxidation level or decreasing membrane permeability [6]. Furthermore, the oxidation ratio showed a clear decrease in fish tissue from S2 as compared to S1, confirming the alteration of fish tissue collected from the harbor site. Our present study suggested the use of FAs composition as an original tool to assess the ecological risk of coastal environments using *Liza ramada* as bioindicator organisms.

Tab. 1. Fatty acid composition of *Liza ramada* collected from two sites impacted with different degree of anthropogenic pollution.

FAs (%)	S1 (offshore site)	S2 (harbor site)
C14:0	5.80±0.11	5.10±0.15
C15:0	0.46±0.06	0.70±0.01**
C16:0	15.5±0.44	22.90±0.19***
C17:0	0.50±0.01	ND
C18:0	3.80±0.14	7.04±0.40***
C20:0	0.19±0.01	ND
ΣSFA	26.33±0.16	35.74±0.35***
C14:1	0.15±0.01	ND
C15:1	0.08±0.01	ND
C16:1	0.87±0.01	0.60±0.23
C18:1	18.90±0.10	22.00±0.34
C20:1	0.60±0.08	1.51±0.01
ΣMUFA	20.60±0.10	24.11±0.35
C18:2n-6	5.32±0.02	9.79±0.17**
C20:2n-6	0.28±0.01	0.27±0.01
C20:3n-6	0.62±0.04	ND
C20:4n-6	1.04±0.03	0.89±0.03
ΣPUFA n-6	7.26±0.04	10.95±0.20**
C18:3n-3	0.96±0.01	1.78±0.07*
C20:5n-3	5.39±0.07	2.80±0.14***
C22:5n-3	0.40±0.04	0.93±0.04***
C22:6n-3	13.09±0.16	8.08±0.31**
ΣPUFA n-3	19.85±0.24	13.51±0.55***
ΣPUFA	27.10±0.28	24.46±0.75*
OR	0.84±0.24	0.35±0.16***

PUFA: polyunsaturated fatty acids; SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; OR: oxidation ratio.
The difference between sites was assessed using Tukey (HSD) test at 5% (* <0.05 ; ** <0.01 ; *** <0.001).

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EFFECT LEAD EXPOSURE IN *MACTRA CORALLINA* GILLS: OXIDATIVE STRESS RESPONSES AND HISTOPATHOLOGICAL STUDIES

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Abstract

The present investigation was performed to assess the effect of lead graded doses exposure (1mg/L, 2.5mg/L and 5mg/L) on oxidative stress, metallothionein up regulation and histopathological injury in the gills of *Mactra corallina*. Our result revealed an increase in malondialdehyde (MDA) and metallothionein (MTs) levels. Alteration on antioxidants defense systems were confirmed by an increase of catalase (CAT), a decrease of superoxide dismutase (SOD) and glutathione peroxidase (GPx) and by a decline in non-enzymatic antioxidants defense systems in all treated groups. Our biochemical findings were supported by the histopathological studies, resulting by several alterations in the treated gills as compared to the control.

Keywords: *Tunisian Plateau, Ecotoxicology, Bivalves, Lead*

Introduction

Lead chloride (PbCl₂) is one the most toxic heavy metals, which is widely dispersed in the aquatic ecosystem [1]. PbCl₂ can accumulate in aquatic organisms and causes various damage especially in the in faunal bivalves [1]. The principal mechanism of PbCl₂ toxicity is associated to the generation of reactive oxygen species (ROS) and alterations of antioxidant defense systems [2]. Previous studies have demonstrated that bivalves such as *Mactra corallina* (*M. corallina*) used as biomonitoring for metal pollution and ecotoxicology studies [3]. The present study was aimed to investigate the antioxidant status, MT induction, and histopathological damage in *M. corallina* gills flowing exposure to PbCl₂ graded doses.

Materials and methods

The experiment condition was maintained for a period of 5 days under PbCl₂ graded concentrations as following: CT(control); D1 (1mg/L); D2 (2.5mg/L) and D3 (5mg/L). After the exposure days, some portion of gills were homogenized in Tris-HCl buffer (20mM; pH=7.4) at cold. Supernatants were stored at -80°C until the analysis of oxidative stress biomarkers. Other portion were fixed in the formal buffer and embalmed in the paraffin for histopathological analysis.

Results and discussion

An unavoidable consequence of the Pb exposure is the generation of ROS, which was confirmed by the simultaneous increase of MDA level in all treated PbCl₂ groups. Excessive efflux of free radicals has been reported to mediate genotoxicity and cell death [4]. The gills defense system against oxidative stress is sustained by several mechanisms comprising enzymatic and non-enzymatic antioxidants. In the present work, SOD, GPx activities as well as NPSH, Vit C, and GSH levels were found to decreases after exposure to PbCl₂ graded dose. Such decline could be also explained by the increased flux of oxygen radicals (e.g. MDA) which may inhibit the antioxidants systems as previously reported by [2]. However, CAT activity increased considerably in all treated gills as compared to the control. Such result may be considered as an adaptive response against the ROS overproduction. Beside the alteration of antioxidant systems, PbCl₂ exposure has occurred in a significant rise of the gills MT levels in *M. corallina* treated groups with 2.5 and 5mg/L that may reveal the induction of this protein as a detoxification mechanisms against the concomitant PbCl₂ toxicity. Gills of all experimental conditions were characterized by frontal, intermediate, abfrontal zones with ciliary discs, haemolymphatic sinus and connective tissues. Alterations in histological structure of gills filaments were observed in all treated groups with PbCl₂ graded doses which were characterized by a dilatation of the haemolymphatic sinus, degradation cilia and increasing number of granulocytes (figure1). Our findings corroborates with previous reports which have demonstrated that metals exposure induced antioxidants dysfunction and histological injuries in bivalves [1].

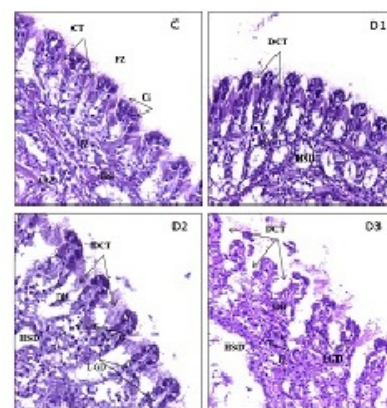


Fig. 1. Histological structure of treated (D1, D2 and D3) and control (C) gills exposed to PbCl₂ graded doses during 5 days.

CT: connective tissue, FZ: frontal zone, IZ: Intermediate zone, ABZ: abfrontal zone, HS: hemolymphatic sinus, Ci: cilia, DCT: deterioration of cilia, DH: dilatation of hemolymphatic sinus, DCT: degradation of the connective tissue, HSD: haemolymphatic sinus degradation, LGD: lipofusion granules degradation.

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ASSESSMENT OF BLACK SEA CUCUMBER EFFICIENCY AGAINST SYNTHETIC TEXTILE DYES INDUCED ENDOCRINE DISORDERS, BIOCHEMICAL AND GENETIC ALTERATIONS IN NILE TILAPIA

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Abstract

Textile dyes effluents have a potential role of aquatic life pollution causing alterations in the function of pituitary cells. Textile dyes affect synthesis of sex steroid hormones leading to endocrine disruption. The impact of some textile dyes ("reactive yellow 18" and "reactive blue 4") was investigated against water and health of Nile Tilapia. Results revealed higher toxicity of water quality of solely dyes based aquaria compared to aquaria treated with sea cucumber. Also a significant increase in micronucleus formation resulted from treatments with textile dyes and alteration in gene expression of reproduction genes. So, using sea cucumber as dietary supplements could reduce adverse impacts of FSH, LH and aromatase genes by textile dyes.

Keywords: *Ecotoxicology, Diet, Red Sea, Pollution, Fishes*

Recently, textile industry is considered from the most important and rapidly growing industrial sectors all over the world which consumes large amount of water. Textile dyes effluents affected greatly the aquatic life [1]. The marine environment is characterized by its enormous biodiversity, making it an excellent source of natural and bioactive compounds that have many medical, protective and curative effects. Marine natural products are considered as vital source for overcoming the toxicity produced by several mutagens [1]. Therefore, the aim of this study was to investigate the effect of different textile dyes such as: "reactive yellow 18" and "reactive blue 4" on water quality and the health of Nile Tilapia, biochemical and genetic status. The protective effect of sea cucumber against textile dyes toxicity was assessed using different techniques including: activity of Superoxide dismutase (SOD) and Catalase (CAT) [3,4], Micronucleus test and gene expression of reproduction active genes (Follicle Stimulating Hormone, FSH-Luteinizing Hormone, LH and Aromatase, CYP19A1) by using Real-Time PCR [5]. The animals were divided into several groups as follows: Control group, textile dyes alone or with different concentrations of sea cucumber including: 100 mg, 200 mg and 300 mg/kg of bodyweight doses for 4 weeks.

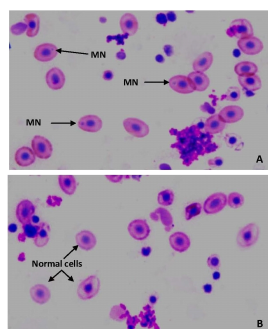


Fig. 1. (A) Formation of micronucleus in Nile tilapia exposed to textile dyes. (B) Represents Nile tilapia with normal cells control.

The results showed that water quality of solely dyes based aquaria has revealed higher toxicity compared to aquaria treated with sea cucumber in different concentrations. The treatments with textile dyes caused significant increase in the micronucleus formation (Fig. 1), alteration in the gene expression of reproduction genes compared to control and treated animals with sea cucumber. Moreover, biochemical analysis has demonstrated that both of SOD and CAT activity increased significantly in the liver of the animals exposed to dyes concentrations without sea cucumber additives. However, when fish were treated with sea cucumber, the toxic effect of textile dyes was reduced and the enzymes activity rate had reached the normal level. Finally, it can be concluded that adding of sea cucumber as dietary supplements may reduce the adverse effects of FSH, LH and aromatase genes by textile dyes, reducing the incidence of endocrine disruptions.

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OXIDATIVE STRESS BIOMARKERS AND TRACE METALS BIOACCUMULATION IN NATIVE AND INVASIVE MUSSELS FROM THE GULF OF TUNIS: A COMPARATIVE STUDY

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Abstract

The purpose of this study was to compare the sensitivity of native (*Mytilus galloprovincialis*) and invasive (*Brachidontes pharaonis*) bivalves species to marine environmental pollution. Metal levels, metallothionein (MT) content and oxidative stress parameters were assessed in mussel gills collected from Rades harbor (Gulf of Tunis). Our results revealed that the order of magnitude of metal accumulation in both studied species was Zn>Cu>Pb>Cd, with highest concentrations recorded in *B. pharaonis*. Furthermore, gills of the exotic species showed the disruption of oxidative stress biomarkers (malondialdehyde, advanced oxidation protein product and metallothionein) exceeding as compared to the native counterparts.

Keywords: Bivalves, Invasive species, Ecotoxicology, Tunisian Plateau

Aquatic ecosystems are often exposed to the influences of anthropogenic activities and xenobiotics. Heavy metals as a widespread environmental pollutant, may act as a selective drive for invaders compared with their native counterparts. However, this empirical statement is not generally established and has yielded opposing results [1]. To the best of our knowledge, this study is the first to investigate the trace metals bioaccumulation effects on the oxidative stress biomarker responses in gill of the native mussel *Mytilus galloprovincialis* and the invasive one *Brachidontes pharaonis* which was recently detected in Tunisia [2].

Specimens were collected during summer 2017 from the Northern Tunisian coast (Rades Harbor, Gulf of Tunis). Metals were analyzed in the freeze-dried organs by atomic absorption spectrophotometry (AAS) according to Ennouri et al. [3]. The Malondialdehyde (MDA) occurred by lipid peroxidation was measured spectrophotometrically according to Draper and Hadley [4]. The advanced oxidation protein product (AOPP) levels were determined according to the method of Kayali et al. [5]. Metallothionein (MT) determination was evaluated according to Viarengo et al. [6] modified by Petrovic et al. [7].

Results showed notable differences in Zn, Cu, Pb, Cd accumulation between the two species (Tab. 1). These differences may be due to the ability of each species to accumulate and to eliminate metals. A predominance of Zn particularly in the invasive species may reflect the anthropogenic pollution of the harbor by this metal.

Tab. 1. Metal concentrations in the gills of *Mytilus galloprovincialis* and *Brachidontes pharaonis*. Results were expressed in µg/g of dry weight of sample.

	Cd	Pb	Cu	Zn
<i>M. galloprovincialis</i>	1.61±0.04	4.03±0.14	0.08±0.01	37.46±0.15
<i>B. pharaonis</i>	4.56±0.08	14.5±0.18	0.13±0.05	38.15±0.21

The invasive mussels revealed higher levels of lipid peroxidation and protein oxidation as evidenced by the enhanced MDA and AOPP levels, respectively. Such findings pointed out that lipids and proteins, major compounds of cell membranes, were alerted by ROS overproduction. In addition, *B. pharaonis* exhibited lower MT level indicating the important role of MT to protect gill cells against oxidative stress injuries by quenching metals (Tab. 2). Overall, our results demonstrated that the native species coped much better than the invasive one with environmental pollution.

Tab. 2. Malondialdehyde, advanced oxidation protein product and metallothionein levels in the gills of *Mytilus galloprovincialis* and *Brachidontes pharaonis*.

	<i>Mytilus galloprovincialis</i>	<i>Brachidontes pharaonis</i>
MDA (nmol/mg protein)	0.08±0.02	0.14±0.01***
AOPP (µmol/mg protein)	9.77±1.93	15.08±1.79***
MT (µmol GSH/g tissu)	10.13±0.6	7.2±1.3***

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CHROMIUM (VI) INDUCES OXIDATIVE STRESS IN GILL AND DIGESTIVE GLAND OF *VENUS VERRUCOSA*

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Abstract

Chromium is known for its wide toxic manifestations. This experiment pertains to evaluate the toxic effects of dichromate of potassium ($K_2Cr_2O_2$) graded doses on oxidative stress biomarkers in the gill and digestive gland of *Venus verrucosa* (*V. verrucosa*). Results showed an increase in hydrogen peroxide (H_2O_2), malondialdehyde (MDA), glutathione (GSH) and vitamin C (Vit C) levels, as well as an alteration of the antioxidant status (superoxide dismutase (SOD), glutathione peroxidase (GPx)) in all treated groups as compared to the controls. Furthermore, our findings indicated that gill structure of *Venus verrucosa* showed more stress effects in exposure successive concentrations of $K_2Cr_2O_2$.

Keywords: *Ecotoxicology, Bivalves, Physiology, Redox, Tunisian Plateau*

Introduction

In aquatic environments, bivalve species are subject to several anthropogenic pressures, leading to their exposure to high levels of toxic elements, such as heavy metals [1]. Among them, chromium (VI) is one of the common pollutants of aquatic ecosystems that discharged from several industrial operations [2]. One aspect of chromium toxicity is the generation of reactive oxygen species (ROS) that cause an oxidative deterioration of biological macromolecules and enzymes [3]. To the best of our knowledge, the present study is the first study report providing an assessment of biochemical parameters of oxidative stress in gill and digestive gland of *Venus verrucosa* exposed to graded doses of chromium (VI)

Materials and methods

Specimens of *V. verrucosa* were obtained from marine farm of bivalves' society (F.M.B) located in Bizerte lagoon. In the laboratory, Clams were kept for one week in clear seawater containing aeration system under controlled conditions. After acclimation, clams were randomly divided into four groups of 25 individuals and transferred to 50 L experimental aquaria in triplicates (n=6 clams per replicate for each condition) and exposed to graded $K_2Cr_2O_2$ doses at $0 \mu g.L^{-1}$ (C), $1 \mu g.L^{-1}$ (D1), $10 \mu g.L^{-1}$ (D2) and $100 \mu g.L^{-1}$ (D3) of $K_2Cr_2O_2$ respectively, during 7 days. At the end of the experimental period, clams of each group were dissected on ice in order to get the gills and digestive glands that were homogenized in cold condition with Tris-HCL buffer (20 M, pH: 7.4). The obtained supernatants were stored in liquid nitrogen at $-80^\circ C$ in order to determine the biomarkers of stress response. Statistical analysis was performed using STATISTICA 8 (StatSoft Inc.) and the significant differences between control and treated groups were assessed at 5%.

Results and discussions

In the current study, (MDA) level was notably increased in gill and digestive gland in all $K_2Cr_2O_2$ exposed groups in dose dependent manner (Table1). This suggests that oxidative stress increases as a repercussion of ROS over production in lipid membranes due probably to the progressive rise in $K_2Cr_2O_2$ accumulation. Furthermore, a significant production of H_2O_2 was observed, suggesting the deterioration of both tissues. To overcome the damaged redox status *V. verrucosa* has used their antioxidant systems, which work together, to decrease the production of ROS. In the current study, we established that of SOD and GPx activities and GSH and Vit C levels increased in the gills and digestive glands of *V. verrucosa* after 7 days of $K_2Cr_2O_2$ -exposure indicating the activation of detoxification mechanism in the both tissues to chromium toxicity. Moreover, a compensatory adaptive mechanisms between different biochemical biomarkers in gills cells as well as digestive gland may be occurred. Additionally, gill showed redox status disruption exceeding as compared to digestive gland. This elucidates that this tissue has weak capacity in detoxification process of free radicals since their surface is characterized by it faster saturation due to its direct contact with metal [4]. Our results are in harmonies with previous findings for bivalves under short-term exposure to heavy metals [4].

Tab. 1. Malondialdehyde (MDA), hydrogen peroxide (H_2O_2) levels and antioxidants responses of control and treated gills (G) and digestive gland (DG) with $K_2Cr_2O_2$ -graded concentration. Malondialdehyde (MDA), hydrogen peroxide (H_2O_2) levels and antioxidants responses of control and treated gills (G) and digestive gland (DG) with $K_2Cr_2O_2$ -graded concentration. Values are presented as means \pm SD. Treated groups VS controls: * <0.05 ; ** <0.01 and *** <0.001 . D1: $1 \mu g/L$ $K_2Cr_2O_2$; D2: $10 \mu g/L$ $K_2Cr_2O_2$; D3: $100 \mu g/L$ $K_2Cr_2O_2$.

		MDA ($\mu mol/mg$ pr)	H_2O_2 ($mmol/mg$ pr)	SOD ($nmol$ GSH/ min/mg pr)	GPx ($nmol$ GSH/ min/mg pr)	GSH ($\mu g/mg$ pr)	Vit C ($nmol/mg$ pr)
G	C	37.22 \pm 3.12	2.41 \pm 0.51	13.97 \pm 3.80	3.52 \pm 0.42	0.72 \pm 0.05	23.33 \pm 1.23
	D1	44.93 \pm 7.54**	2.53 \pm 0.99*	15.02 \pm 2.83***	4.66 \pm 0.35**	0.75 \pm 0.06	23.25 \pm 2.37
	D2	53.71 \pm 9.79***	2.77 \pm 0.87**	18.78 \pm 0.93***	6.98 \pm 0.05***	0.77 \pm 0.02***	31.50 \pm 0.98***
	D3	72.59 \pm 8.87***	3.29 \pm 0.91***	26.60 \pm 0.77***	8.99 \pm 0.02***	0.89 \pm 0.03***	36.64 \pm 0.08***
DG	C	33.11 \pm 2.21	1.24 \pm 0.33	15.00 \pm 1.52	3.00 \pm 0.75	0.82 \pm 0.04	14.67 \pm 0.96
	D1	37.37 \pm 7.05	1.42 \pm 0.19*	14.99 \pm 0.97	3.01 \pm 0.00	0.82 \pm 0.03	14.70 \pm 0.74
	D2	52.88 \pm 9.27***	1.66 \pm 0.48**	18.22 \pm 0.52***	5.65 \pm 0.01**	0.82 \pm 0.01	16.09 \pm 0.43***
	D3	68.07 \pm 8.55***	1.90 \pm 0.21**	19.94 \pm 0.33***	7.33 \pm 0.56***	0.86 \pm 0.01***	18.30 \pm 0.36***

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FATTY ACID PROFILING: A SENSITIVE TOOL TO ASSESS MERCURY CONTAMINATION IN THE SEA CUCUMBER *HOLOTHURIA FORSKALI*

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Abstract

This study assessed the Hg impact on the fatty acid (FA) composition in the sea cucumber *Holothuria forskali* body wall. Specimens were exposed to HgCl₂ graded doses (40, 80 and 160 µg L⁻¹) for 96 h. At the end of the trial, the body wall Hg-burden exhibited significant dose dependent increases reflecting the bio-accumulative ability of this tissue. A decrease in linoleic, arachidonic and eicosapentaenoic acid levels and an increase of docosahexaenoic acid were mainly observed at the nominal tested dose. Our findings highlighted the usefulness of the FA composition as an early sensitive bioindicators of Hg intoxication in holothurians.

Keywords: Bio-indicators, Echinodermata, Ecotoxicology, Mediterranean Sea

Mercury pollution is featuring as one of the major threat for marine ecosystem, biota and human health. Despite their great ecological and economic importance, little is known about the impact of Hg contamination on Holothurians. In a previous study [1], we have studied the responsiveness of sea cucumber to Hg exposure through a set of standard biomarkers as oxidative stress parameters. Here we investigated, for the first time, the influence of Hg intoxication on the fatty acid composition of *Holothuria forskali* in order to verify their usefulness as a biomarker of mercury intoxication in holothurians. To do this, we exposed specimens of *H. forskali* to 40, 80 and 160 µg L⁻¹ of mercuric chloride (HgCl₂) for 96 hours. At the end of the trial, total Hg was analyzed using Direct Mercury Analyzer (DMA 80). Lipids were extracted according to the method of Folch et al. [3] and then trans-esterified using the method of Cecchi et al. [4]. Fatty acid methyl esters (FAMES) were analyzed in gas chromatograph. As given in figure 1, body wall Hg-burden exhibited significant dose-dependent increases reflecting the bio-accumulative ability of this tissue.

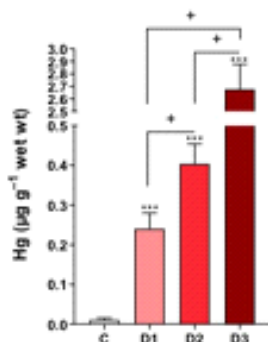


Fig. 1. Total mean mercury concentrations in the body wall of unexposed (C) and exposed *Holothuria forskali* to different concentrations of HgCl₂ (D1=40 µg L⁻¹, D2=80 µg L⁻¹ and D3=160 µg L⁻¹) for 96 h. *** p < 0.001: treated groups vs. control group; + p < 0.001: treated groups vs. each other.

An evident toxic effect of Hg on the *H. forskali* body wall's lipid fraction was detected in all treated groups and prominently at the nominal tested dose (Table 1). The simultaneous increase of saturated fatty acids (SFA) and decrease of polyunsaturated fatty acids (PUFA) can be attributed to the lipid peroxidation mechanism and/or to cellular adaptive response by the triggering of defense and reparation mechanisms to alleviate membrane damage as suggested by Rocchetta et al. [5]. Indeed, the recorded drastic diminution of the PUFA (n-6) group in particular arachidonic acid (C20:4n-6) and its precursor linoleic acid (LA, C18:2n-6) reflects an increased metabolic demand for the regulation of cell membrane fluidity and/or for the activation of eicosanoid synthesis through arachidonic cascade pathway.

Our assumption was further confirmed by the similar trend observed for the eicosapentaenoic acid (C20:5n-3) which is another eicosanoids precursor also known as an excellent energy source. The ability of *H. forskali* to cope with Hg insults through the modulation and the adjustment of its lipid metabolism was further reflected by the increment of the docosahexaenoic acid (C22:6n-3) level. This FA, which has been proven to be potent antioxidant agent and to have primordial role in membrane architecture, seems to be selectively retained or biosynthesized in treated *H. forskali*.

Tab. 1. Fatty acid profile of *Holothuria forskali* body wall in response to different HgCl₂ exposures: D1 (40 µg L⁻¹), D2 (80 µg L⁻¹) and D3 (160 µg L⁻¹) plus control (C). Data are expressed as % of total fatty acids (mean ± S.D.). Means followed by different letters in same line are significantly different (p < 0.05). SFA: saturated fatty acid, MUFA: monounsaturated fatty acid, PUFA: polyunsaturated fatty acid.

FA	C	D1	D2	D3
C18:2n-6	14.68 ±2.74 ^a	0.72 ±0.07 ^b	8.64 ±0.08 ^c	7.77 ±0.90 ^d
C20:4n-6	2.06 ±0.78 ^a	0.71 ±0.13 ^b	0.81 ±0.04 ^b	2.62 ±0.55 ^a
C20:5n-3	1.17 ±0.15 ^a	0.24 ±0.05 ^b	0.36 ±0.14 ^b	1.67 ±0.28 ^a
C22:6n-3	1.13 ±0.34 ^a	4.78 ±0.53 ^b	3.43 ±0.33 ^b	3.34 ±0.60 ^b
ΣSFA	26.61 ±5.27 ^a	59.24 ±5.07 ^b	40.50 ±2.35 ^c	35.45 ±3.08 ^c
ΣMUFA	15.02 ±3.36 ^a	18.14 ±2.38 ^{ab}	20.97 ±1.88 ^b	29.02 ±2.85 ^c
ΣPUFA	58.37 ±17.63 ^a	22.62 ±2.69 ^b	38.53 ±1.53 ^c	35.53 ±1.43 ^c
ΣPUFA (n-3)	8.84 ±0.64 ^a	8.04 ±1.09 ^b	13.26 ±1.48 ^b	10.96 ±1.23 ^b
ΣPUFA (n-6)	44.18 ±6.08 ^a	9.64 ±2.67 ^b	19.25 ±0.35 ^c	18.02 ±0.55 ^c

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HAEMOCYTOLOGICAL ALTERATIONS IN FISH FOLLOWING EXPOSURE TO INORGANIC (TITANIUM DIOXIDE NANOPARTICLES) AND ORGANIC (OXYBENZONE) UV FILTERS AS SUNSCREEN INGREDIENTS

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Abstract

The use of sunscreens has been growing due to the awareness of the risks associated with solar radiation exposure. Sunscreens have in its composition UV filters, which have the ability to protect against radiation. Previous studies stressed that the occurrence of sunscreen ingredients in coastal waters may pose risk to marine biota [1]. In fact, in the Mediterranean Sea, the levels of sunscreen ingredients found in the marine system are being toxic to the biota [2]. Hence, the main goal of this study was to evaluate the potential toxicity of the most used UV filters [titanium dioxide nanoparticles (TiO₂ Np) and oxybenzone (BP-3)] in a marine fish (*Scophthalmus maximus*). Fish were exposed via intraperitoneal injection to 3.0 µg.g⁻¹ body weight of each compound and their mixture. Blood was collected 72 and 168 h post-injection to assess red blood cell count (RBC), haemoglobin (Hb), and mean corpuscular haemoglobin (MCH), as well as nuclear morphology based erythrocytic parameters [erythrocytic nuclear abnormalities (ENA) assay and the erythrocytic maturity index (EMI)]. The results showed that BP-3, tested individually, decreased both Hb and MCH after 72 h, while after 168h, it increased RBC. These alterations reflect an impairment of the Hb synthesis followed by a compensatory response translated in the RBC rise. After 168 h, the ENA frequency increased in BP-3 exposed fish, denoting a DNA damaging potential. Overall, it was demonstrated the ability of BP-3 to induce haemocytological alterations including genotoxicity, whereas no toxicity was observed for TiO₂ Np and for the mixture.

Keywords: UV filters; marine fish; Portuguese Coast

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ACCUMULATION, ELIMINATION AND OXIDATIVE STRESS IN GLASS EELS (ANGUILLA ANGUILLA) EXPOSED TO LANTHANUM UNDER A WARMING SCENARIO

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Abstract

Rare earth elements (REE) comprise elements from lanthanum to lutetium, including yttrium and scandium. They are considered emergent contaminants of great economic interest and concern as they are crucial for numerous groundbreaking environmental technologies and high-technology products [1]. Transfer to aquatic ecosystems is expected to increase, however, little information is known about their potential impacts in marine biota. Considering the endangered conservation status and the economic relevance [2] of the European eel (*Anguilla anguilla*) and the vulnerability of early fish life stages to contaminants, we exposed glass eels, through water, to an ocean warming scenario (OW; $\Delta +4^{\circ}\text{C}$; 18°C and 22°C) and to an environmentally relevant concentration (360 ng.L⁻¹) of lanthanum (La), one of the most abundant REEs, for 5 days (plus 5 days of depuration). The major aim of this study was to assess the accumulation and elimination of La in eel's body parts (head, viscera and body) and evaluate lipid peroxidation, heat-shock proteins (HSP), DNA damage (body) and the quantification of acetylcholinesterase (AChE, head).

The results revealed that La-exposed glass eels under OW accumulated significantly higher concentrations than control organisms. This accumulation was tissue-dependent and peaked in the first days in contact with the contaminant. Accumulation was higher in the viscera, followed by the skinless body and ultimately in the head, possibly as a protective mechanism to cope with La neurotoxicity. Heat shock response was thermo-regulated with exposed glass eels to OW+La producing significantly higher HSP. Evidence of lipid and DNA damage was found, supported by alterations in AChE levels in the head. Further investigation is needed towards understanding the biological effects of REEs.

Keywords: Lanthanum, Ocean Warming, Glass eels, Portugal

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EFFECTS OF PRIMEXTRA® GOLD TZ ON BIOCHEMICAL PROFILE OF *CERASTODERMA EDULE*

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Abstract

In the last 30 years an intensive usage of fertilizers and pesticides has been reported in the Mediterranean region, in some cases reaching EU contamination limits. Considering this chemical application near ecological coastal wetlands, monitoring programs to recover the aquatic systems (e.g. Mondego estuary, Figueira da Foz – Portugal), have been developed. According to information from agricultural cooperatives of the Mondego valley, Primextra® Gold TZ is the most used herbicide in corn crops fields [1]. Biomarkers, as fatty acids (FAs), has been described as potentially powerful tools to determine and evaluate the exposure to and the effects of contaminants. The ecological relevance of bivalve species, as well as their ability to filter and ingest great amounts of water and particles, allied to the ease handling and maintenance have made them widely used in ecotoxicological bioassays [2]. Thus, this work aims to understand the effect of Primextra® Gold TZ at lethal and biochemical level, evaluating the fatty acids profiles composition of *Cerastoderma edule*, large (L) and small (S) size classes.

Organisms were sampled in the Mondego estuary and after 48h of depuration, organisms were exposed to a range of concentrations of Primextra® Gold TZ, during 96h. Results show, that considering two size classes, the larger organisms are more tolerant to herbicide action than the smaller ones ($EC_{50L} = 28.78 \text{ mg/L}$ (24.73-33.24), $EC_{50S} = 27.25 \text{ mg/L}$ (21.06-30.35)). Comparing FA contents in the field and after exposure to the toxicant, it was observed an increased in saturated FA to both size classes and of highly unsaturated FA to small size class.

Keywords: Bivalve species, Fatty acids, Mondego Estuary

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HAZARDOUS AND NOXIOUS SUBSTANCES: COORDINATED MULTIBIOMARKER RESPONSES TO ASSESS CHRONIC EXPOSURE AND EFFECTS IN A MARINE DECAPOD

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Abstract

Hazardous and Noxious Substances (HNS) are a group of substances highly transported through maritime routes, which if spilled into the sea have high potential to cause health hazards to humans and marine animals, to damage amenities or interfere with other legitimate uses of the sea [1]. Inclusion of multibiomarker approaches in integrated chemical and biological effects monitoring and assessment has been recognised as cost-effective approach to ensure environmental health. Here, we present a method, accounting for coordinated multibiomarker responses, to diagnose exposure and to follow-up long-term responses of the marine model *Carcinus maenas* to the HNS acrylonitrile (ACN) and aniline (ANL) [2]. Adult male crabs were exposed to low and high post-spill levels of ACN or ANL for 21d. Bioaccumulation, feeding behaviour, and biomarkers related to the mode-of-action of the HNS were evaluated over time. The results identified distinct temporal patterns of response to low and high exposure concentrations. A set of interactive multibiomarker predictors was identified for each HNS. ACN caused peripheral neurotoxic effects coupled with enhanced biotransformation and significant oxidative damage particularly in gills. ANL elicited alterations in central neurotransmission affecting ventilation coupled with very low levels of oxidative damage in gills. Overall, chronic toxicity data was found determinant to improve HNS hazard assessment. Accounting for coordinated multibiomarker responses brought otherwise overlooked information the effects of ACN and ANL.

Keywords: Northern Portugal, Environmental Health, Biomarkers

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CHANGES ON ANTIOXIDANT ENZYMATIC ACTIVITY OF A MARINE BIVALVE SPECIES AS CONSEQUENCE OF COPPER EXPOSURE

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Abstract

Nowadays, anthropogenic activities are the main source of pollution and everyday contaminants are discharged in aquatic systems, like estuaries, affecting not only the water quality but also the living organisms. Copper has a great importance in aquatic systems pollution, due to the frequency, quantity and impact of its input in these systems. Copper sulphate, a copper-based formulation, is widely used in agricultural practices to control pests. To evaluate the pollution and recover aquatic systems, namely the Mondego Estuary, monitoring programs have been developed in this Mediterranean area. Biomarkers showed to be useful and efficient tools for early detection of exposure to chemical contaminants [1, 2]. The main aim of this study is to determine the effects of copper in the antioxidant defence system of an important commercial bivalve species, *Cerastoderma edule* in two size classes. Organisms were collected in the Mondego estuary and submitted to a depuration time of 48 hours, after which the organisms were exposed to a range of concentrations of copper sulphate, during 96h. The results showed that the larger organisms are more sensitive to copper sulphate than the smaller ones ($LC_{50}L = 0.818$ (0.595- 0.987) mg/L; $LC_{50}S = 1.129$ (0.968 - 1.289) mg/L). Behavioural activity of the organisms was observed during the exposure time and at the end of the bioassay. It was evaluated antioxidant enzymes activity as well as the lipid peroxidation. According to the results, copper exposure caused changes on the behavioural and enzymatic activity. Moreover, an occurrence of lipid peroxidation as consequence of the exposure to the chemical is observed in the big size class.

Keywords: *Cerastoderma edule*; Enzymatic activity; Mondego Estuary

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COMET ASSAY IN THE GONADS OF *CARCINUS MAENAS* MALES: DIAGNOSING EXPOSURE TO ENVIRONMENTAL CONTAMINATION

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Abstract

Exposure to man-made chemicals can influence sperm quality of aquatic organisms, interfering with their reproductive success. Among the effects caused, genotoxic damage is of particular concern due to the restricted anti-oxidant capacity of sperm cells and ability for DNA repair. To investigate its potential to indicate exposure to aquatic chemicals, DNA damage was assessed using the Comet Assay in gonads of crabs from two Northern Portuguese estuaries with different pollution levels. Crabs were sampled in Minho estuary (low impacted) and in Lima estuary (moderately polluted) [1]. The latter is impacted by industrial activities, including a harbour and a shipyard. Other biomarkers determined in the gonads of the crabs were the activity of biotransformation enzyme glutathione S-transferase (GST) and cholinesterase (ChE) enzymes as indicative of neurotoxic damage. Established biomarkers used in biomonitoring programmes with *Carcinus maenas* were also determined in the digestive gland (biotransformation, antioxidant defences, oxidative damage), muscle and thoracic ganglion (acetylcholinesterase) [2]. The remaining soft tissues, and sediment samples, were used for chemical analyses of metals. Significant DNA damage and alterations of ChE and GST activities were found in the gonads of crabs from the Lima estuary, compared to Minho. Multibiomarker interactions indicative of exposure to chemical stress were also described. Altogether, the data points to the usefulness of gonad biomarkers for monitoring and risk assessment using *C. maenas*.

Keywords: Northern Portugal, Environmental Health, Integrated Monitoring

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NEUROTOXIC EFFECTS OF MERCURY IN WILD FISH (CHELON AURATUS) AT A HISTORICALLY CONTAMINATED COASTAL LAGOON (AVEIRO, PORTUGAL) AS UNVEILED BY BRAIN BIOCHEMICAL ALTERATIONS

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Abstract

The high propensity of mercury (Hg) to be bioaccumulated in fish brain has been described lately [1], following the profound knowledge on Hg neurotoxicity in mammals [2]. There are also some insights about the effects of Hg in fish brain as mostly provided by laboratory experiments, but the neurotoxicity of Hg in wild fish has been seldom investigated. The present study was carried out at a Portuguese coastal system (Aveiro lagoon) historically contaminated by Hg, including a confined area - Laranjo basin (LAR). Fish (*Chelon auratus*) were caught at LAR and at a reference area (São Jacinto; SJ). Biochemical alterations (i.e., antioxidant protection and neurotransmission) in fish brain were evaluated on winter and summer, together with the bioaccumulation of Hg [i.e., total Hg (tHg), methylmercury (MeHg) and inorganic Hg (iHg)].

The brain of *C. auratus* from LAR showed a higher accumulation of MeHg and iHg than the brain of SJ fish, in both seasons. A winter-summer variation was found for LAR site, with winter levels of tHg and MeHg in the brain being higher than those accumulated in summer, suggesting an enhanced risk in winter. Accordingly, spatial differences were mainly found in winter for biochemical changes, namely with brain of fish from LAR depicting and higher activity of superoxide dismutase and a decrease of glutamine synthetase, probably denoting an enhancement of brain antioxidant defences and alterations on the glutamate homeostasis due to Hg. In summer, higher levels of total glutathione were recorded in the brain of fish from LAR. The neurotoxicity of Hg in wild fish was underpinned at Aveiro lagoon, pointing out the relevance of considering alterations at this level in fish inhabiting historically contaminated areas, namely well-known Hg hotspots at the Mediterranean Sea.

Keywords: Mercury neurotoxicity; Fish; Aveiro lagoon (Portugal)

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CIESM Congress Session : Marine Litter / Methods and Assessments

Moderator : Joana Raimundo, IPMA, Lisbon, Portugal

Moderator's Synthesis

The session was attended by about 50 participants. All six presentations pointed to the importance of marine litter as a contaminant in the marine environment. Several topics were identified such as the quantity of marine litter in beaches, ways to identify marine litter sources, the impact of fisheries and new technologies to prevent net losses and a possible automatic parametrisation for the monitoring of microplastics in beaches.

During the debate all attendants agreed on the importance to establish harmonized and standardized methodologies to be used in monitoring programs and to assess impacts. The importance of the implementation of the MSFD, the threshold values and the way it is going to be implemented (sub-regional or regional level) was also stressed. In the end, it was pointed that few studies are being developed involving Mediterranean and Atlantic regions. It was considered relevant to have a more detailed knowledge of marine litter exchange between the two environments.



AUTOMATIC PARAMETRISATION OF BEACHED MICROPLASTICS

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Abstract

Four sandy beaches on the island of Malta were regularly sampled for Large MicroPlastic (LMP) particles having a diameter between 1mm and 5mm, at stations located at the waterline, and 10m inshore. The extracted LMPs were characterised (dimensions, surface roughness, colour) by microscopic analyses, as well as by a developed algorithm. Two-thirds of the isolated particles were smooth and the majority of these belonged to the grey-white colour category suggesting that these were preproduction pellets. Roughly six times as many particles were recorded within the inshore sampling stations as the particles recorded at the waterline stations. The automated image processing algorithm performed well when the dimension and colour parameter values it delivered were compared with those obtained by microscopic analyses.

Keywords: *Plastics, Mediterranean Sea*

The presence of MicroPlastics (MPs) in the marine environment is the result of two introduction pathways: as primary MPs in the form of virgin plastic pellets and powders, and as secondary MPs through the fragmentation of litter (Primpke et al., 2017). Despite this consensus in recognising the importance of MP monitoring protocols, there is no universal methodology of high validity of analysing isolated MPs. The simplest MP analysis protocol involves examination with the naked eye or with a microscope, without further analyses. This results in error margins as high as 70% when the same samples were re-analysed using spectroscopic techniques (Loder et al., 2015). Human observer interpretation bias is inevitable in such visual analysis, especially when determining subjective attributes such as colour (O'Neill and Smith, 2014). For instance, the assigned colour might change according to the prevailing lighting conditions being used by the observer. Therefore, there is much scope for the formulation of an alternative MP analysis technique.

This study investigated the use of image processing techniques to automatically extract the required parameters for LMPs exceeding 1mm in diameter. Apart from making the process less time-consuming, an automated method removes the subjectivity and allows more accurate spatial and temporal comparisons to be made. The proposed algorithm was tested on a large number of LMP samples collected over several weeks from four different beaches along the Maltese coastline.

Microplastic samples were collected from popular beaches. Apart from being distributed along different swathes of the north-western and north-eastern coastline, these beaches are subjected to different wind and wave exposure conditions by virtue of differences in aspect, fetch, bathymetry, and beach profile. This allowed for an exploratory correlation of microplastic density with the meteorological conditions that prevailed on the days preceding sampling. Sampling was carried out every two weeks between August and November 2017. Each sample was collected early in the morning when no people were present and prior to beach-grooming activities by the authorities. Sampling was carried out at three replicates to the waterline (0m) and at another three replicates located 10m inshore. Sand contained within a volume of 50cm × 50cm × 10cm was sifted to collect LMP particles with a diameter that exceeded 1mm.

Digital images of the LMPs were obtained through scanning on a flatbed scanner at a high resolution. One of the preliminary steps of the algorithm developed in this study was to identify every LMP as an individual entity. In order for real length measurements of the LMPs to be obtained, a calibration coefficient to convert pixel length measurements into spatial coordinates was inferred by scanning a custom pattern at the same resolution.

Since the particles were scanned against a black background, an adaptive thresholding method was used to obtain a binary image that represented a mask. The next step involved the morphological closing of the binary image through the use of a disk template. The algorithm progressed by identifying the boundaries of objects within the processed binary mask. Here, the exterior of each object was traced to identify the coordinates of a polygon that encloses each microplastic particle. For every identified LMP, the best ellipsoid was fitted through a least squares method. The major and minor axis of the ellipse

were extracted and converted to length measurements by using the calibration coefficient. The difference between the boundary and the best-fitting ellipsoid around each object was then used to obtain a measure of roughness.

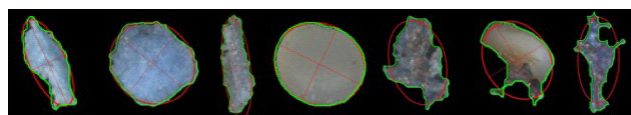


Fig. 1. Detected LMPs, their identified boundaries and the corresponding fitted ellipsoids.

The red, green, and blue components of pixels enclosed within each boundary were obtained and the mean intensities for each colour were computed from the corresponding histograms. The values were then compared to tuples in a list that stored the information of standard colours.

In order to assess the performance of the developed algorithm, individual plastic particles were also viewed under a stereomicroscope, which was used to characterise manually the LMPs through human observation and to capture micrographs of the same particles complete with a scale bar. The algorithm performed very well in determining the dimensions and colour of the LMP particles as emerging from an analysis of the correlation values for the two (algorithm-derived and human observation-derived) datasets. The contribution beyond the current state-of-the-art of marine environmental monitoring proposed by this study is along the same lines as that proposed by Deidun et al. (2018) for automated coastal litter monitoring by aerial drones in that the algorithm can be incorporated as a routine protocol within photo-capturing smart phone apps.

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MARINE LITTER ON MONTENEGRIN BEACHES (SOUTH ADRIATIC SEA)

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Abstract

In this paper composition and abundance of marine litter on Montenegrin coast during autumn and winter season 2018 are given. Results showed that abundance is similar on all investigated beaches and that all beaches belong to „dirty” group. The most dominant litter group was plastic. Spatial and seasonal differences in marine litter were not statistically significant.

Keywords: *Marine litter, Pollution, Adriatic Sea*

Introduction

Marine litter is defined as any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment [1]. It represents quite a big problem over the world, and the Mediterranean is recognized as one of the most affected areas [2]. Although it was believed that tourism has the biggest impact on litter generation, it was concluded that in the Adriatic Sea bigger influence have winds, sea currents, fishing activities, aquaculture and river inflow [3]. The aim of this study is assessing the amounts and composition of marine macro-litter on Montenegrin beaches.

Material and Methods

Collection of marine litter was performed on three beaches (Blatna beach, Becicka beach and Velika Beach), during autumn and winter season 2018. Two sampling units (transect, 100m * 10m) were monitored on each beach. Methodology of sampling and marine litter categorization is done according to [4]. The number of items per 100 m stretch was calculated, including density of litter items per m², and Clean Coastal Index (CCI) [4]. Statistical analyses were done in Microsoft Office Excel 2010 and 2013.

Results and Discussion

During the research, a total of 3334 marine litter items were collected, with total weight of 79 kg. Abundance of litter was quite the same for all three beaches, 0.571 items/m² (571 items/100m) on Blatna beach, 0.564 items/m² (564 items/100m) on Becicka beach and 0.531 items/m² (531 items/100m) on Velika beach. CCI was also quite the same 11.42, 11.28 and 10.62, respectively, indicating that all beaches belong to „dirty” group. The similar results are given for Montenegrin beach called „Kamenovo”, while some lower values were reported for Igalo beach [4]. The dominant type of litter belonged to plastic (72.56%) followed by metal (10.83%). In other studies it is also reported that plastic has the biggest contribution in total marine litter [4], [5]. Statistical analysis did not show any differences in number of items, neither spatial (ANOVA, $p=0.982$), nor seasonal (t test, $p=0.599$). Among top 10 items, cigarette butts and filters accounted the highest percentage (19.95%), followed by plastic pieces larger than 2.5 cm and smaller than 50 cm (8.04%) and crisps packets/sweets wrappers (7.47%). Among top 10 item groups most dominant were also metal bottle cups, lids and pull tabs, food containers incl. fast food containers, plastic cups/lids from drinks, cups and cup lids, paper fragments, polystyrene pieces larger than 2.5 cm and smaller than 50 cm, sanitary towels/panty liners/backing strips. Most of those items were also listed as top 10 items on Adriatic beaches [4]. Results of this study showed that Montenegrin beaches are highly polluted with macro-litter, especially plastic, what implies that future steps must be directed towards establishment of management measures related to marine litter problem.

Acknowledgement This work has been supported by the IPA Adriatic Cross Border “Welcome” project (WatEr Landscapes sustainability through reuse of Marine litter), No 192.

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DISTRIBUTION AND AMOUNT OF MARINE LITTER DERIVED BY FISH AGGREGATING DEVICES (FADS) FISHERY IN THE MEDITERRANEAN SEA

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Abstract

Fishermen of Majorca, Sicily, Tunisia and Malta anchor a large numbers of Fish Aggregating Devices (FADs) every year at sea. These are built with palm leaves, plastic floating objects, polypropylene cables and anchor blocks. Through a bibliographic research, in this study estimates of total number of FADs and the abandoned litter in localized marine areas was reconstructed. From 1961 to 2017 1596518 FADs were lost at sea. The wider fishing areas are in Tunisia and Malta. In Tunisia and Sicily the greater amount of litter was estimated. A smaller amount of litter was assess in Majorca and Malta where FADs fishery is regulated. It is desirable reducing significantly the FADs number and using environmentally friendly materials.

Keywords: *Marine litter, Mediterranean Sea, Fisheries, Plastics*

Introduction

The Mediterranean FADs (Fish Aggregating Devices) fishery, having the dolphinfish (*Coryphaena hippurus*) as target species, is practiced annually in autumn and in later summer. The FADs structure is very similar throughout the Mediterranean: palm leaves or plastic sheets used to shade; plastic bottles or polystyrene slabs used like floats; polyethylene cables and large blocks used to anchor the FADs [1,2]. In a overview published in 2000 about Mediterranean FADs fishery the authors reported the use of 65376 FADs a year [3]. In December FADs are abandoned and the action of the swells destroys them. This high annual number of lost FADs represents a source of marine litter. The aim of this study was to estimate the amount and distribution of this marine debris along the areas where FADs fishery is practiced.

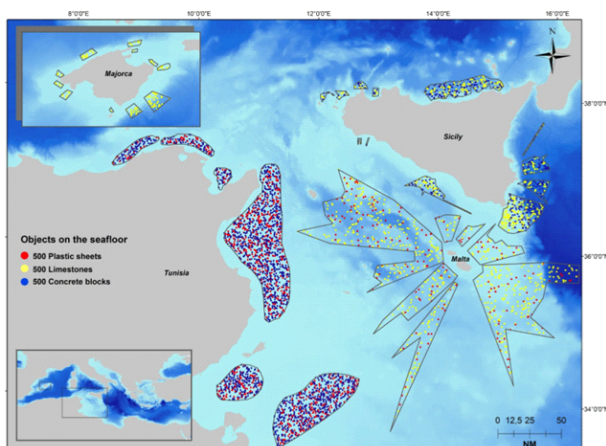


Fig. 1. Boundaries of the Mediterranean FADs Fishery areas

Methods

A historical reconstruction of the Mediterranean areas where FADs are deployed, their number and the materials used was made through the study of scientific publications, technical reports and gray literature. The collection of each contribution was made through the principal scientific search sources (Scopus, Web of science, Scholar). A matrix has been constructed for each study area reporting the total number of anchor block and plastic objects and the kilometers of anchor cable. The maps reported in the contributions were scanned and then were georeferenced and digitized using the ArcMap 10.3 software, in order to create a map of the all Mediterranean FADs areas (features of polygonal type). The average depth was calculated (Spatial Analyst tool) for each fishing area by using of a Mediterranean bathymetry raster, in order to estimate the average cable length used for anchoring the FADs. Results The bibliographic research has highlighted the presence of 5 scientific publications, 6 technical reports and 1 doctoral thesis useful for the data collection related to

the period from 1961 to 2017. In these years it has been estimated that 1596518 FADs were abandoned at sea. Tunisia and Malta have the wider fishing areas, mainly in the Strait of Sicily characterized by shallow waters (70-400 m). The fishing areas in Sicily have a smaller extension but are characterized by greater depths (from 400-1000 m). In Majorca the fishing areas are small and with shallow waters (Fig. 1). In Tunisia the highest number of anchor blocks and plastic objects released to sea were estimated. In Sicilian waters the highest number of kilometers of plastic cable was released to sea. In Majorca smaller numbers of FADs litter were estimated compared with the other areas (Table 1).

Tab. 1. Estimates of FADs litter from 1961 to 2017 per area and per litter tipology

FADs area	Anchor blocks	Cable lenght (km)	Plastic objects
Majorca	53555	4793	21666
Sicily	359900	430944	5578450
Malta	277580	132836	240604
Tunisia	905483	76242	27617232

Discussion

The FADs litter in the Mediterranean has been studied only in areas near Malta and only for the limestone slabs [4]. Although this study minimizes the impact of the stones on the seabed it not considers the huge lost amount of sunk and floating plastic. This phenomenon is prevalent in Sicily and Tunisia where FADs fishery is only recently regulated. In Malta and in Majorca there are regulations that limit the number of FADs and delimit the anchorage areas. However, the regulations do not focus on the environmental issues of FADs litter. FADs should be significantly decreased in their number also because there is no relationship between the number of FADs and associated biomass [5] and the use of sustainable materials should be encouraged.

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HOW DIFFERENT CLASSIFICATION METHODS MAY HELP TO IDENTIFY THE MAIN LITTER SOURCES

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Abstract

The abundance and composition of the sea-floor marine litter collected in the North-Central Adriatic Sea during four survey years (2013-2016) are reported, focusing on the use of different items classifications to understand which one may provide more information to better identify the marine debris sources. Litter was classified using three methods, from the general materials' classification to the finest possible. The average density of litter collected in the overall sampling period was 83.53 ± 14.43 kg/km². The highest concentration of litter was found in stations close to the coast and plastic litter was always dominant within the whole sampling area. The finest classification method, although it requires more effort, seems to be the most effective to better understand all the possible marine debris origins.

Keywords: Marine litter, Adriatic Sea, Marine policy, Sampling methods, Monitoring

The impacts of marine litter and their consequences have been widely described and nowadays it is considered a widespread world pollution problem as well as an important threat to environment and wildlife. The European Marine Strategy Framework Directive considers marine litter among the 11 qualitative descriptors to define the good environmental status (GES) of the European seas. Marine debris comprises many different materials among which plastic litter was already known as a special issue since 1980s, being the most represented category due to its resistance to degradation and persistence in the environment. In 1992–98 it was estimated that plastic items accounted over 70% of the total litter in the European marine regions and fishing activity is reported as the most important source of plastic debris at sea [1,2,3,4]. The abundance and composition of marine litter collected on the sea-floor of Adriatic Sea during 4 survey years (2013-2016) are reported here, focusing on the use of 3 different items classifications (C1, C2, C3) to understand which one may provide more information to better identify the marine debris sources. The Adriatic Sea is subject to a heavy anthropic pressure due to intense coastal urbanization, especially along the Italian side, tourism, dense shipping traffic and to other maritime activities [4]. Litter samples were collected, during Solemon Project surveys [4], using a modified Italian beam trawl named “rapido” [4]. A total of 67 stations were sampled each year, distributed over the area following a depth-stratified random design (strata: 0-30 m, 30-50 m, 50-100 m) [4]. At each haul, the litter items were collected, counted, weighted and classified firstly (C1) following six major categories (Figure 1A) according to the nature of the material [5], subsequently (C2) plastic litter was divided into 4 sub-categories (Figure 1B), finally (C3) all items were finely classified basing on the object's typology, resulting in forty different sub-categories (Figure 2A). The mean density of total litter collected over all the sampling years throughout the surveyed area amounted to 83.53 ± 14.43 kg/km². The highest concentration of total litter was found in stations close to the coast with a mean weight of 98.21 ± 18.68 kg/km², while the lowest one was recorded between 50 and 100 m depth (54.13 ± 13.39 kg/km²). Plastic was the most abundant category (42.37 ± 8.57 kg/km²; 51%) followed by metal (20.31 ± 6.74 kg/km²; 24%), other litter (7.44 ± 2.15 kg/km²; 9%), glass (5.61 ± 1.17 kg/km²; 7%), natural material (4.61 ± 1.94 kg/km²; 5%) and rubber (2.99 ± 1.03 kg/km²; 4%; Figure 1A)

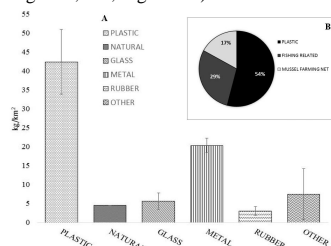


Fig. 1. A, C1 classification: average abundance (\pm SE) of the 5 marine litter categories recorded on the seabed during the four survey years; B, C2

classification: percentage composition of the plastic marine litter sub-categories.

Fishing and aquaculture related plastic represented 29% and 17% respectively of all plastic litter (Figure 1B). At the third classification level (C3) it resulted that, for instance, all fishing and aquaculture related items corresponded to 40% of the overall collected litter and consisted of fishing related metal objects (e.g. fishing leads, tow cables; 41%), nets (32%), mussel farming nets (21%) and, in smaller percentage, fishing lines and fishing related rubbers (Figure 2B).

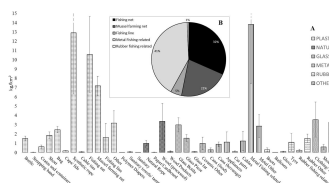


Fig. 2. A, C3 classification: average abundance (\pm SE) of the forty marine litter sub-categories; B, percentage composition of all the fishing and aquaculture related items recorded on the seabed during the four survey years.

Considering the three classification methods, it is clear that more detailed is the classification more information can be collected on the litter main sources. Although this can require more effort in terms of man work and time, nowadays it still represents the only way to collect reliable data useful to better address actions aimed to reduce the occurrence of litter at sea.

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MODELING PLASTIC WASTE FLOWS IN THE MEDITERRANEAN ENVIRONMENT : FROM RIVERS TO THE SEA

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Abstract

The plastic issue in the Mediterranean environment represents a major concern but the quantification of sources and the particles distribution at Sea are still poorly known. Our modeling approach consists, first, in developing a statistical model to quantify the rivers emissions of plastic particles to the Sea. It is based on the delineation of the Mediterranean watersheds, plastic measurements in world rivers and geospatial data as population densities, waste management, river runoff. Then, this model of plastic inputs is used to initiate numerical simulations of ocean circulation to analyze the plastics dispersion through the currents coupling with waves.

Keywords: *Plastics, Pollution, Mediterranean Sea, Circulation, Models*

Introduction and method The Mediterranean Sea is one of the most polluted zones of the world with more than a million debris of plastic floating per km². Plastic concentrations found at the surface of the Mediterranean Sea can reach concentrations measured in the center of the ocean gyres like the great pacific garbage patch (Cozar et al. 2015). Nevertheless, while garbage patches have been observed in the oceans, there is still no accumulation zone clearly identified in the Med Sea. The Mediterranean Sea is therefore a hotspot for plastic pollution due to its semi-enclosed structure. Moreover, the high coastal population densities of the Mediterranean region apply a strong anthropogenic pressure on this environment and the strong river flows contribute to high plastic inputs from inland.

In order to better understand the impact of plastic pollution on marine ecosystems and potentially on human health, it becomes necessary to quantify the plastics sources and analyze their dispersion offshore. In this way, our project aims to develop a model, integrating the increasing number of observations in rivers and at sea, in order to quantify the plastic inputs and interpret the debris distribution at the surface of the Sea. Our approach start with an empirical model for river plastic emission developed at the global scale (Schmidt et al. 2018). It involves collecting anthropogenic factors like population densities or waste management and hydrological parameters as catchment boundaries, rivers network or runoff (Ludwig et al. 2009). The correlation between plastic inputs with other characteristics as suspended matter yields (Sadaoui et al. 2017), vegetation density, land use or dam retention is also tested. Comparing these data per catchment to plastic concentration in rivers available in the literature thanks to a multiple regression permitted to approximate the plastic inputs from each catchment to the Mediterranean Sea.

circulation commonly used for sediment transport, phytoplankton dynamics or organic carbon export is able to integrate plastic particles characteristics such as different sizes, shapes or densities. Moreover, simulations done overall Mediterranean Sea can be use now (resolution between 1 and 6 kilometers). This modeling approach needs to integrate current hypothesis on plastic particles transport to bring knowledge on the fate of plastics in the Mediterranean compartments (beaching, sedimentation on the seabed, cascading, water column distribution or surface drift). To validate the scenarios, it will be necessary to compare the simulations to the increasing number of field observations and measurements.

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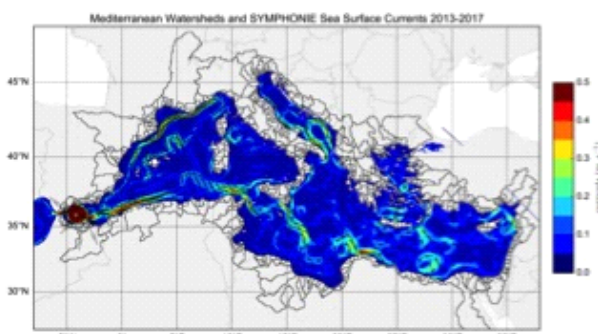


Fig. 1. Mediterranean Watersheds delineation and 5-year (2013-2017) average of SYMPHONIE Sea Surface Currents

The plastic particles dispersion through the currents is obtained offline using the outputs of the 3-D hydrodynamic model SYMPHONIE developed at the aerology laboratory of Toulouse (Marsaleix et al., 2008). This model of ocean

NEW APPROACHES AND TECHNOLOGIES TO PREVENT MARINE LITTER FOR FISHERIES – THE NetTag PROJECT

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Abstract

New approaches and technologies are needed to prevent and reduce plastic pollution of marine ecosystems. Unfortunately, the Ocean is the ultimate destination of man-made wastes, including chemical contaminants, toxic residues and mostly plastic debris. We recently started a new international project, NetTag, which aims to reduce and prevent marine litter derived from fisheries by working directly with fishers through an integrative preventive approach: 1) reducing lost gear by using new technologies (acoustic system), which will help fishers to localize and recover their lost gears; and 2) promoting better practices on-board regarding management of fishing waste, through awareness actions organized by fishers associations for fishers. NetTag will develop new technologies to track fishing gears in case gears got lost, and thus promoting a reduction of lost gears in the ocean. The technology will include low cost, miniature and environmental-friendly acoustic tags and acoustic transceivers [2] for uniquely localization (with fisher's personal ID) of lost gear and an automated-short-range robotic recovery system. Participant fishers will, then, evaluate the new technology in a dedicated demonstrative field action. In parallel, we will assess the reduction of environmental impact of lost gears as a new pollutant by preventing gears loss. Awareness actions, developed by fishers for fishers, will be an innovative strategy to engage the fishing industry, increasing fishers' willingness to act [1] and adopt better practices on-board to reduce marine litter from fishing vessels. We will also evaluate the cost-efficiency of the proposed solutions, estimating the economic viability of their implementation for reduction marine litter derived from fisheries. NetTag, based on synergistic activities between fishers and scientists to pilot innovative solutions, will reduce and prevent marine litter derived from fisheries.

Keywords: acoustic tags; fisheries; awareness actions

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CIESM Congress Session : Microplastics
Moderator : Paula Sobral, New Univ. of Lisbon, Portugal

Moderator's Synthesis

In the microplastics session discussions were mostly centered on the amounts of microplastics found on Mediterranean beaches, on the ingestion by semi-pelagic fish and deep-water species and on the effects of ingestion on mussels. Microplastic quantities were found to be higher than those in the Atlantic and mostly related to human activity in nearby sites, Great concern was expressed regarding the absolute need for quality control and quality assessment during procedures to identify particles and fibers as the smallest ones may contaminate samples due to their presence and ease of transport through the air, especially with respect to fibers. Also visual sorting of non-natural particles is prone to mistakes and should be followed by a thorough analysis of the particles in question. This was clearly demonstrated in one of the presentations where after the FTIR analysis was performed on 336 visually sorted fibers more than 90% of microfibers were found to be natural, therefore not plastic.

Microplastic ingestion by wild mussels and histological alterations reported in the digestive gland are consistent with previous studies performed in the Atlantic and elsewhere. The need for indicator species was expressed with fish or shrimp as possible candidates. The amounts of MP in the bogue guts were similar to the ones for mackerel in the Eastern Atlantic, and they seem to be density-dependent. MP in all the deep-water shrimp examined proves that both particles and fibers are present in the Mediterranean seabed and are promptly eaten by the shrimp. This concerns contamination of the human diet all over the world.

Discussions in the general debate were dense and lively, denoting great interest from the audience, which reflects the worldwide concerns regarding plastics in the oceans food web, the need to know how much is out there and what are the impacts on the environment and on human health.



QUANTITY AND TYPE OF MICRO PLASTIC FROM NORTH AFRICAN COASTS OF THE MEDITERRANEAN SEA : FIRST DOCUMENTED EVIDENCE

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Abstract

The presence of microplastics has been evaluated for the first time in Algeria. Four sandy beach sites were sampled to investigate the occurrence and distribution of (MPs) at the surface waters from the Gulf of Annaba. Microplastics were detected in all water samples. The number of MPs was in the range of 1858.736 P/Km² - 47546.012 P/Km² of surface waters.

Keywords: *Pollution, Algerian Sea*

1. Introduction Microplastics are defined as small plastic particles with an upper size limit of 5mm (GESAMP, 2015). As most plastics were designed to be non-biodegradable, they only break down into smaller sizes and exist in the natural environment for hundreds or even thousands of years. These pollutants were found to be present in freshwater to marine ecosystems contaminating both water and sediment columns. Their presence in coastal zones and open oceans gained attention owing to their ecological threats to the marine life upon ingestion or entanglement.

2. Materials and Methods Study area is Located in the extreme eastern section of the Algerian coast. Four sampling stations having different contamination levels were chosen in this study. The samplings were conducted over one year (2017-2018) during summer–autumn 2017, and winter 2018 at four stations located in the gulf of Annaba.

Tab. 1. Location and description of the sampled sites in the Gulf of Annaba, northeastern Algeria

Study site coordinates)	Type and sources of pollution
Cape Rosa Beach (36°56'50"N, 08°36'70"E)	No anthropogenic pollution.
Chapuis Beach (36°55'09"N, 07°45'16"E)	Household wastewaters mainly sewages.
Joinville Beach (36°52'14"N, 07°46'10"E)	Mixture of household and industrial wastewaters directly discharged near Annaba Port and originated from fertilizer industries. Industrial discharges of the port and wastewaters of 13 sewers of the city of Annaba.
Sidi Salem Beach (36°52'03"N, 07°46'29"E)	Agricultural, industrial and domestic wastewaters from the west valley of the city of Annaba.

Surface water microplastics sampling were conducted using a common methodology (Kovac Viršek et al., 2016). They used methods for identification and quantification for microplastics in the marine environment (Hidalgo-Ruz et al., 2012).



Fig. 1. Map of the five sampling stations and of the main processes governing the marine dynamics inside the Annaba Gulf (northeastern Algeria) (in Belabed et al., 2013b).

3. Results and Discussion : Microplastics were detected in all water samples. Concentrations range from 1858.736 P/Km² - 47546.012 P/Km². The highest MPs concentration was observed at Joinville station. The lowest average MPs concentration was found at Cap Rosa. In each station, coloured particles were found. The majority of fibres are clear followed by white, blue, red, green and black, whilst, fragments were dominated by blue, green, black and red. The foams are white, the films are transparent. On the other hand the pellets are orange, with particle sizes ranging from 0.3 to 5 mm.

4. Conclusion : Our research highlighted the existence of microplastics in all of the four sampling sites. As MP abundances in the environment increase, further studies are planned to quantify the presence of MPs in all Algerian coast, biota, notably fish and filter feeders such as bivalves, and assess their toxicological impact. Data presented in this study provide baseline information of the distribution and types of MPs in the gulf of Annaba.

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MICROPLASTIC INGESTION IN THE *GOURMET* CRUSTACEAN *ARISTEUS ANTENNATUS* (RISSE, 1816)

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Abstract

We investigated microplastics (MPs) ingestion in the deep-water shrimp *Aristeus antennatus* (Risso, 1816), which is internationally appreciated as *gourmet* food. Combining MPs extraction protocol and FT-IR characterization, we investigated 63 stomachs of *A. antennatus* captured by means of trawl survey from 7 sites around the island of Sardinia, CW Mediterranean. Overall 66.7% of individuals showed MPs particles in their stomachs, with a minimum of 1 to a maximum of 3 particles stomach⁻¹. The average abundance was 1.11 ± 0.12 particles stomach⁻¹, with polyester fibers constituting the most abundant fraction of MPs, followed by polyethylene fragments. Our results show that *A. antennatus* ingestion is not limited to MPs fiber balls but to a wider range of particles, greatly enhancing occurrence reported up to now in scientific literature.

Keywords: *Plastics, Decapoda, Deep sea processes, Continental margin, Western Mediterranean*

The use of synthetic plastic literally exploded during 1950-60' and, nowadays, plays such an integral role in daily life that a mark can be recorded in the timeline of human race: the "Plastic Era". Tons of plastic litter enter and persist in the marine environment through a number of pathways [1] and this is globally recognized as one of the most concerning threats to oceans' wildlife. In particular, the ingestion of fragments of plastic smaller than 5 mm, known as microplastics (MPs), has been reported for a wide variety of organisms, covering all geographic and bathymetric boundaries [2,3]. However, the spatial occurrence and effects of MPs on wild populations remain quite unknown. Present study targets an economically and ecologically key species dwelling in deep-sea habitats of the Mediterranean Sea: the deep-water shrimp *Aristeus antennatus* (Risso, 1816). This species is internationally appreciated as gourmet food and consist of some of the most valuable fisheries resource in European Atlantic and Mediterranean waters, with landings worth cumulatively hundreds of millions of Euros [4]. *A. antennatus* is commercially trawled in Mediterranean deep waters from 40m down to over 800m depths. Samples were collected in the framework of the MEDiterranean International Trawl Survey (MEDITS) conducted around the island of Sardinia (Geographical Sub Area 11) in 2017. A total of 64 samples of stomachs were collected for *A. antennatus*, over a depth range comprised between 470 and 655 m, across 7 sites (Fig. 1).

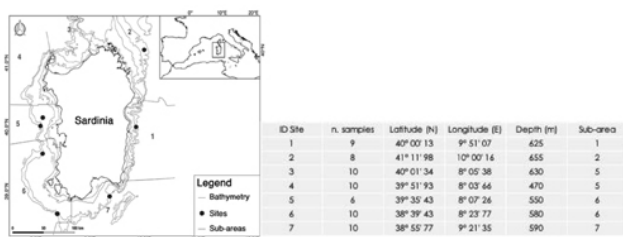


Fig. 1. Map of the investigated area and sites code, number of samples collected in each site, geographical coordinates, depth and code of the geographical sub-region.

Our investigation, differently to other data available in literature [5] was based on an extraction protocol specifically devoted to MPs detection in biological tissues [6] rather than visual inspection of stomach contents. Once extracted and sorted, the polymer composition was identified using Fourier transformed infrared spectroscopy technique (FT-IR). In addition, n. 10 blank control samples were processed to detect eventual contamination throughout the steps of the protocol in different days, showing the absence of environmental contamination. Overall, 275 particles have been identified in *A. antennatus* stomachs, of which 70 were identified as polymers. All sites showed the presence of, at least, one individual with MPs in the stomachs; thus, occurrence in sites was 100%. A total of 42 stomachs out of 63 were positive to MPs, with an occurrence of 66.7%. Average MPs abundance was: 1.11 ± 0.12 items stomach⁻¹ (mean \pm std. error). The maximum number of particles per

stomach was 3 (observed in 15% of positive stomachs), while the majority of samples showed the presence of 1-2 particles (cumulatively 85%). Fibers of polyester were the most abundant category of MPs, followed by fragments of polyethylene and polypropylene. Statistical analyses based on uni-variate PERMANOVA routine were conducted to test for significant differences in MPs frequency and abundance among different locations investigated, using the factors 'site' and 'geographical sub-area' (see Fig.1), singularly, as unique source of variation. The test showed no significant difference for both investigated factors. In addition, there wasn't any evidence of a relation between individual size and the number of particles ingested. MPs ingestion was confirmed to cover a wide spatial range over a deep bathymetry (470-655 m), pointing out the ubiquitous presence of these pollutants. *A. antennatus*' close trophic relation with the sea bottom might enhance MPs exposure and ultimately lead to accidental ingestion. Our results based, on an efficient and reliable extraction protocol shows higher occurrence values compared to the only study present in scientific literature based on visual sorting of stomachs contents [5]. In addition, our results emphasize that MPs ingestion is not limited to polyester fibers balls but to a wider range of polymers.

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BOOPS BOOPS AS A BIOINDICATOR OF MICROPLASTIC POLLUTION ALONG THE SPANISH CATALAN COAST

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Abstract

Microplastics (< 5 mm) are a growing cause of concern for the marine environment, particularly in the Mediterranean Sea which is considered one of the most polluted seas worldwide. According to the Marine Strategy Framework Directive (MSFD), indicator species are a useful tool to determine the Good Environmental Status (GES) of the marine ecosystem. In this study, the gastrointestinal tracts of *Boops boops* from three areas off the Catalan coast (Spain) subject to different degree of industrialization were analysed to assess microplastic pollution. As expected, the highest occurrence of microplastics was found in the most industrialized area, located off Barcelona.

Keywords: *Bio-indicators, Mediterranean Sea, Pollution, Plastics, Fishes*

Microplastics (< 5 mm in size) represent a considerable portion of the marine litter that may pose a threat to the marine environment [1]. Different methods have been used to assess the extent of microplastic pollution. Among them, the use of bioindicators has proved particularly effective [2]. The MSFD monitoring guidelines for the Mediterranean Sea include the analysis of fish gastrointestinal tract as a method to assess microplastic pollution [4]. *Boops boops* (Linnaeus, 1758) has been proposed as a suitable indicator species due to its ubiquitous distribution in the Mediterranean, its large size of the gut, its high commercial value and the high occurrence of microplastics in its digestive tract [2][3]. This study aims to assess microplastic pollution along the Spanish Catalan coast through microplastic quantification in the gastrointestinal tract of *Boops boops*.

A total of 102 specimens were sampled from three areas off the Spanish Catalan coast, selected following a gradient of industrialization and urbanization: 1) the highly anthropized area off Barcelona (n = 34); 2) an intermediate-anthropized area, off Blanes (n = 34), and 3) a Marine Protected Area, off Cap de Creus (n = 34) (Fig. 1). The stomach and intestine of each fish were analysed to detect, quantify and identify microplastics as described in [5] with few modifications. A Kruskal Wallis test was applied to determine differences in microplastic abundance among areas.

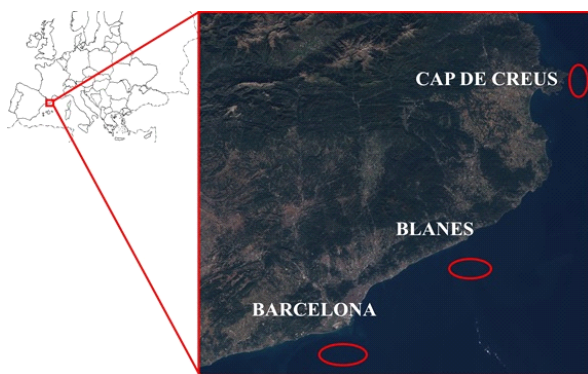


Fig. 1. Study area showing the three sampling sites: Cap de Creus MPA, Blanes and Barcelona.

46 % of all fish had microplastics in the digestive tract. Microplastic abundance ranged from 1.5 to 2.3 items/individual. The majority of ingested microplastics were fragments of different colour and size, and polypropylene was the most common polymer type, followed by polyethylene and polystyrene. As expected, the highest abundance and frequency of occurrence of ingested microplastics were detected in the most industrialized area of Barcelona (Table 1). *Boops boops* is thus confirmed to be a suitable bioindicator to assess spatial variations in microplastic pollution in coastal areas.

Tab. 1. Frequency of occurrence and abundance of ingested microplastics in *Boops boops* from the three sampling areas. Microplastic (MP) abundance is expressed as mean \pm SE.

Location	Barcelona	Blanes	Cap de Creus MPA
Number of individuals examined	34	34	34
Number of individuals containing microplastics	22	12	13
MP frequency of occurrence (%)	64.71	35.29	38.24
MP number of items	57	17	18
MP size range (longest side, μ m)	50 - 2960	66 - 3300	88 - 4700
MP abundance			
a) Number of items per individual in all individuals examined	1.68 \pm 0.31	0.50 \pm 0.14	0.53 \pm 0.14
b) Number of items per individual in individuals containing microplastics	2.59 \pm 0.35	1.42 \pm 0.23	1.38 \pm 0.18
c) Number of items per gram weight in individuals containing microplastics	0.83 \pm 0.15 ^a	0.20 \pm 0.05 ^b	0.16 \pm 0.02 ^b

^{a,b}Indicate significant difference among fish sampling areas (Kruskal-Wallis rank sum test).

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HISTOLOGICAL ALTERATION OF MUSSEL *MYTILUS GALLOPROVINCIALIS* DIGESTIVE GLAND INDUCED BY MICROPLASTICS

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Abstract

The aim of this study was to describe the presence and effect of microplastic particles on digestive gland of Mediterranean mussel *Mytilus galloprovincialis* Lamarck, 1819 from native environments. Microplastic fragments and pellets were noticed in digestive glands of mussels from all investigated sites. Mussels exhibited a higher atrophy of digestive gland tissue with abundant content of lipofuscin granules. Future work will focus on investigating aquaculture areas in the Northern Adriatic Sea.

Keywords: *Adriatic Sea, Plastics, Bivalves*

The marine environment is polluted by anthropogenic marine debris that consist synthetic polymers – plastic of all shapes, colors and sizes (1). Researchers have reported that model microplastic particles can be ingested and taken up into the marine organism cells and tissues (2,3). However, data on microplastic particles, and their presence and potential impact on invertebrates from natural environment, especially mussels, are very limited (4).

Mussels were sampled in April 2015, from two sampling sites: the site exposed to anthropogenic impact (ACI Marina Pula, 44°87'55"N; 13°84'67"E) and a control site (St Catherine Island, 45°07'67"N 13°62'96"E) without human influence along Rovinj coastal area, Northern Adriatic Sea, Croatia. Dissected mussel tissues were cryopreserved, cutted with a cryostat and stained with haematoxylin and eosin (H&E). Microplastic uptake into the digestive gland was analyzed by polarized light microscopy. Mussel health status was investigated incorporating histological alterations and semiquantitative assessment of lipofuscin granule content and digestive gland atrophy.

The majority of plastic particles in the mussel digestive gland were fragments (Fig 1.) and pellets (Fig 2.) between 2 and 80 µm in all mussel samples.

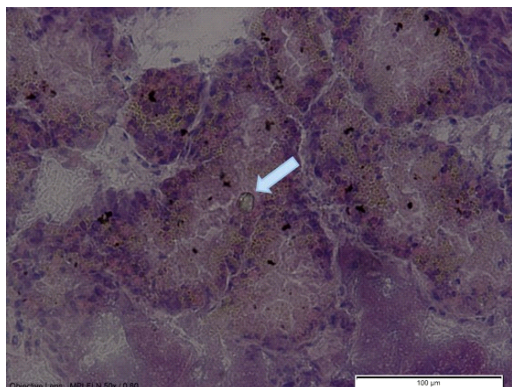


Fig. 1. Microplastic fragment (arrow) in H&E stained digestive gland section of the Mediterranean mussel seen by light microscopy. Image shows normal digestive tubules with high lipofuscin granule content.

Histological observation showed atrophy between digestive gland tubules, abundant content of lipofuscin granules in digestive tubules (cells displayed > 70% of intense lipofuscin) and high number of heterophagosomes (Fig 2).



Fig. 2. Microplastic pellet (arrow) in H&E stained digestive gland section of the Mediterranean mussel in polarized light. Image shows tubule with vacuoles of heterophagosomes (hp), high amount of lipofuscin granules (lf) in digestive gland tubule and tissue atrophy (at).

This study provides the evidence that microplastic was taken up by wild mussels sampled at polluted sampling site and site without anthropogenic activity. Thus, since mussels are filter feeders they are susceptible of microplastic by direct uptake and further accumulation in digestive gland which might negatively affect their health status. Recommendations are aimed at investigating the mussel health status from nearby aquaculture areas in Northern Adriatic Sea.

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TEXTILE MICROFIBERS IN MEDITERRANEAN SURFACE WATERS

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Abstract

We report the results of a microfiber pollution survey performed in Mediterranean waters in 2017. Microfibers were found in all surface water samples collected with a mean concentration of 5.1 ± 2.3 fibers/liter. According to FTIR analysis (n=336), most of these fibers were made of non-synthetic materials such as cotton, cellulose and wool. Only 6.85% of the fibers analyzed were actually synthetic, with polyester being the most abundant polymer.

Keywords: *Plastics, Mediterranean Sea, Pollution, Surface waters*

Microfibers are emerging pollutants with widespread distribution in the marine environment [1,2]. Ingestion of fibers by marine organisms is being increasingly reported by studies worldwide and understanding their concentrations and composition in the natural environment is integral to assess their potential environmental impact [2]. Here we present the results of a microfiber pollution survey performed during two sampling expeditions (Ichnussa2017 and INFRA-Oce17) carried out in the central-western Mediterranean Sea between October and November 2017 on board the Italian research vessel “Minerva Uno”.

A total of 108 samples were collected at 36 different sampling stations (Fig. 1). At each station three-replicates bulk-water samples were collected using a 10-liter stainless steel bucket, triple rinsed in seawater prior to use. The bucket was lowered over the side of the ship using a sisal rope (brown natural fiber) until it reached the water. Once full, it was hauled aboard and the water poured into 10-liters containers for subsequent filtration. In the lab, samples were gravity-filtered through 20 mm mesh filters (Ø 55 mm), triple rinsed with pre-filtered water prior to use. Samples were then labeled, placed in petri dishes and stored at -5°C in the freezer for subsequent analysis. In the laboratory, all samples were examined at the stereo-microscope and all fibers were counted by the same individual using standardized criteria [1].

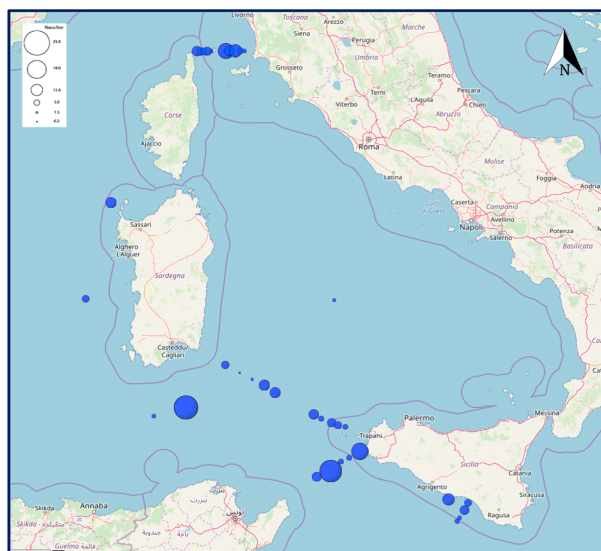


Fig. 1. Map of the study area showing the location of all sampling stations and the mean fiber concentrations (expressed in fibers/liter), obtained by averaging the values measured in the three replicates collected at each station. The size of the circles is proportional to the concentration values on a logarithmic scale.

A subsample of these fibers (n=336, i.e. ~10 fibers per sample) were randomly selected for polymer identification using a LUMOS standalone FT-IR microscope (Bruker Optik GmbH). ATR spectra of single fibers were recorded and compared with commercially available standard libraries. Only matches $\geq 70\%$ with reference spectra were accepted as verified polymers. Prior to each scan, fiber length and diameter were also digitally measured using the OPUS in-house software.

Contamination control was obtained by performing two different kind of blanks during sampling operations. Aerial controls were made by exposing clean filters to open air both outdoor, on the main deck during sampling, as well as indoor while processing the samples. Milli-Q procedural blanks instead, were made by filtering 10 liters of ultrapure milli-Q water, using the same equipment used for sampling. In total 35 procedural blanks were done during the cruise and the contamination levels obtained in blank samples were subtracted from seawater samples in order to obtain the final concentration values reported below.

A total of 5466 fibers were counted in all samples (mean 151.8 ± 68.9 fibers per sample). By averaging the concentrations obtained in the three-replicate samples collected at each station, we obtained an overall mean concentration of 5.1 ± 2.3 fibers/liter across the study area. Fibers concentrations showed a relatively high spatial variability, but no clear trend in relation to distance with land (Fig. 1). Maximum concentrations (12.2 fibers/liter) were observed in the Sardinian Channel, while the lowest concentration (2.1 fibers/liter) was found in a sample collected in the Western Tyrrhenian Sea (Fig. 1).

FTIR analysis (n=336) revealed that most of these fibers were made of non-synthetic materials, with the majority being made of cotton (47.3%), wool (5.4%) or other cellulosic materials (40.5%). Only 6.85% of the characterized fibers were actually synthetic, with polyester being the most abundant polymer (4.2%), followed by nylon, polypropylene and acrylic. Half of the collected fibers (50.1%) were clear in color (white, grey, transparent), followed by dark/black (22.1%), blue (21.75%), red (3.8%), orange/yellow (2%) and green (0.2%). Mean fiber length was 1.79 ± 1.82 mm (Max: 14.62 mm; Min: 0.14 mm) while mean fiber diameter was 22.6 ± 18.4 μ m (Max: 200 μ m; Min: 5 μ m).

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CIESM Congress Session : Biogeochemistry & cycles / Coast & shelves

Moderator : François Galgani, IFREMER, Bastia, France

Moderator's Synthesis

The session was dedicated to cycling processes occurring in coastal waters and on shelves. Five different presentations were given, describing various aspects of chemical contamination, the characterization of contaminants, the development of relevant methods, the speciation and partition of selected chemicals and the biogeochemical processes in coastal areas, including the vertical mixing of waters. Topics such as interactions between cobalt complexes with humic acids, and the development of a new approach to better understand speciation, with copper in an estuary as an example, were discussed. The quantification and the influence of the presence of iron minerals in sediments on sulfate-coupled anaerobic oxidation of methane was also described in detail. More globally, the use of a coupled hydrodynamic-biogeochemical model to assess the mobility and the cycle of nitrogen pools in waters connecting a lake to the sea, and the description of a coupled physical-biogeochemical model to evaluate the dissolved oxygen budget in a western Mediterranean sea were presented. Another short presentation on the partition of Platine group elements in the Tagus system, using voltammetry in surface sediments was given, focusing on transfer from the urban area of Lisbon into the estuary, the speciation of Pt and Rh and the hydrodynamic modeling of metals recirculation and potential exchange with the ocean.

Overall, the session was very active with questions to all presenters, and relevant discussions on technical, chemical and biogeochemical aspects of contamination. Typically, the development of modelling tools is important to predict speciation, contamination scenarios from local to larger scale, namely the coastal areas, and will support a better understanding of the cycling of contaminants in the Mediterranean Sea.



CHARACTERIZATION OF COBALT(II)-4-NITROCATECHOL AND COBALT(II)-HUMIC ACID COMPLEXES IN SEAWATER MODEL SOLUTION

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Abstract

Cobalt(II) is an essential element present in seawater mostly in organic complexes. Electrochemical characterization of cobalt (II) complexes with 4-nitrocatechol and humic acid in NaCl using square wave and cyclic voltammetry, was performed. First reduction peak of Co(II)-4-nitrocatechol was recorded at E_p -0.8 V while the second one at -1.1 V. At the same potential was registered reduction peak of Co(II)-humic acid complex. That suggests that nitro group is the binding functional group for cobalt with the humic acid ligand. Investigated cobalt(II)-complexes reduction were recorded in the pH range from 5 to 9.5.

Keywords: *Electrochemistry, Adriatic Sea*

Cobalt (II) as an essential element and important for biochemical processes in the marine environment, is bioavailable in its dissolved form. It is known that in seawater cobalt is partially, but strongly complexed to natural organic ligands. It has an important influence on the growth of coccolithophores, diatoms and cyanobacteria. Dissolved cobalt(II) is very important element for all marine organisms (biochemical and physiological functioning). Despite its abundance in the environment, dissolved Co^{2+} in the oceans is present at low concentrations, $<10^{-9}$ mol dm^{-3} , mostly in organic complexes. [1] By its complexing with 4-nitrocatechol and humic acid, complex components of the natural organic matter present in seawater, cobalt(II) forms soluble complexes in aqueous solutions. [2] Electrochemical characterization of cobalt (II) complexes with 4-nitrocatechol and humic acid in aqueous solution (0.55 mol dm^{-3} NaCl) using square wave and cyclic voltammetry, was performed. Cobalt(II) concentrations varied from 1 to 5 $\times 10^{-5}$ mol dm^{-3} , 4-nitrocatechol from 1-5 $\times 10^{-5}$ and humic acid from 0.1 to 0.9 mg dm^{-3} . First reduction peak of Co(II)-4-nitrocatechol was recorded at E_p -0.8 V while the second one at -1.1 V. At the same potential was registered reduction peak of Co(II)-humic acid complex (Figure 1. A and B). That suggests that nitro group is the binding functional group for cobalt with the humic acid ligand. (Figure 1).

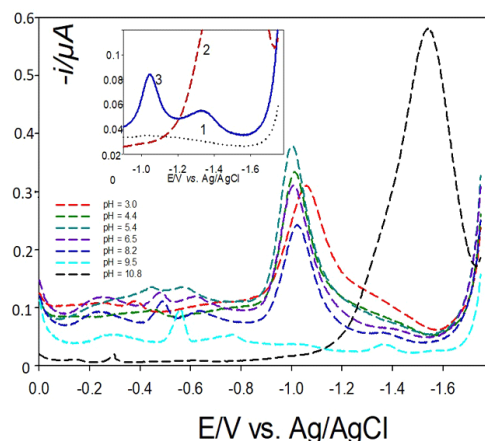


Fig. 1. Dependence of Co(II)- complexes on pH. A) $C_{Co} = 4 \times 10^{-5}$ mol dm^{-3} , $Y_{humic\ acid} = 0.9$ mg dm^{-3} . Inset: SW voltammograms of humic acid, cobalt, Co(II)-humic acid complex in 0.55 mol dm^{-3} NaCl; pH 8.2

Investigated cobalt(II)-complexes reduction were recorded in the pH range from 5 to 9.5. Reduction currents reached maximum at \approx pH 6.5. Further investigations were performed at pH of the seawater. The reduction mechanism of both complexes was investigated by square-wave voltammetry with variation of parameters: frequency, amplitude and step increment. Based on the theory of the reduction current and potential dependencies on SW frequency, it was confirmed that the redox process of both Co(II)-complexes is irreversible. SW amplitude showed exponential increase characteristic for irreversible redox process with the reactant

adsorption. [3] CV voltammograms recorded irreversible cathodic peaks. Using NTA as competing ligand, a stoichiometry of the Co(II)-4-nitrocatechol complex (at \approx -0.8 V) was presumed to be 1:1, 1:2 and 1:3. EDTA was used as competing ligand for titration with humic acid and a stoichiometry of the Co(II)-humic acid complex (at \approx -1.1 V) was presumed to be 1:2 [4]. UV/VIS spectra were recorded under the same conditions experimental conditions. Titration data (changes in complete spectra) were processed by multivariate non-linear least-square fitting program [5]. Obtained results show that 4-nitrocatechol and humic acid form soluble Co^{2+} complexes in the pH range from 5 to 9 that remain in the solution for a sufficient period of time to be available for phytoplankton.

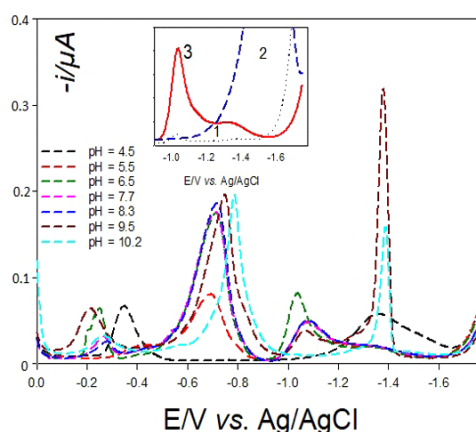


Fig. 2. B) $C_{Co} = 4 \times 10^{-5}$ mol dm^{-3} , $C_{cat} = 1 \times 10^{-5}$ mol dm^{-3} . Inset: SW voltammograms of 4-nitrocatechol, cobalt, Co(II)-4-nitrocatechol complexes in 0.55 mol dm^{-3} NaCl ; pH 8.2

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COPPER SPECIATION IN THE KRKA RIVER ESTUARY (CROATIA)

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Abstract

Determination of trace-metal organic interactions in natural water is still very challenging task. Currently, the most used methodology is the competitive ligand equilibrium adsorptive cathodic stripping voltammetry (CLE-AdCSV). The technique relies on the competitive effect of added ligand (AL) which forms know complex with target metal. Methodology is mostly used at one concentration of AL, despite multi-detection window approach was recommended because it is time and sample volume consuming. In this study we are proposing a revised approach, called "segmented multi-detection window" (SMDW). The proposed method was first verified on model titrations, and thereafter experimentally tested on copper speciation analysis in the vertical salinity gradient and surface microlayer, in the Krka River estuary (Croatia).

Keywords: Estuaries, Vertical profile, Trace elements, Electrochemistry, Adriatic Sea

Characterization and discrimination of trace metal-organic ligand complexes in natural waters commonly rely on determination of their conditional stability constants (K'_{MLi}) and concentrations of corresponding discrete ligand classes ($[L_i]_T$). Electrochemical techniques are the main tool in these studies. Among them competitive ligand equilibrium adsorptive cathodic stripping voltammetry (CLE-AdCSV) is most widely used. It is based on the re-distribution of metal between the natural organic ligands present in the sample and added competitive ligand (AL) which forms the electroactive complex with known stability constant. The newly formed complex is accumulated by adsorption onto the electrode surface (Hg drop) and then stripped by reduction scan. Previous studies have shown that complexation parameters are partially dependent on AL concentration and in order to attain more reliable results it was recommended to conduct multiple individual titrations at different concentrations of AL (MultiDetection Window – MDW) and their modeling (fitting) as a single set of data.[1] Disadvantages of this approach are the longer time needed to perform multiple titrations and requirement for larger sample volume. In order to overcome these shortcomings, we have proposed and tested a revised method called "Segmented MultiDetection Window" (SMDW) which consists in multiple change of AL concentrations (2-4) along only one titration experiment. Support for modeling and processing of these titration curves is incorporated within the already existing ProMCC program.[2] The proposed method was first verified on model titrations encompassing one and two ligand systems (example shown in Figure 1), and thereafter experimentally tested on copper (Cu) speciation analysis in the vertical salinity gradient and surface microlayer, in the pristine Krka River estuary (Croatia).

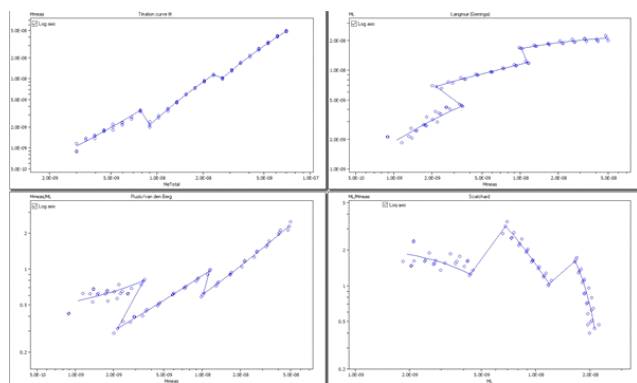


Fig. 1. SMDW titration set for 2-L model at decreasing AL concentration. Circles- titration points, Line - fitted curve.

SMDW approach gave complexation parameters comparable to the "classical" approach (Figure 2), indicating that the proposed methodology is very robust and can be used successfully for this type of studies, with less sample consumption and a shorter total time analysis.

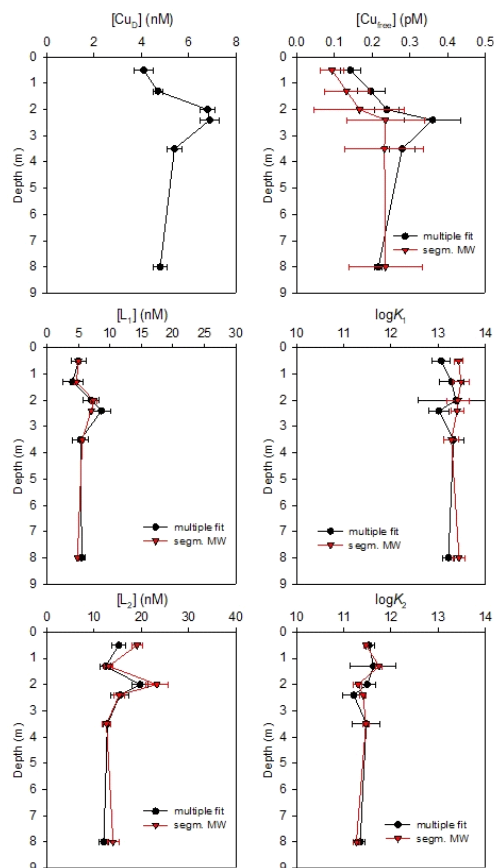


Fig. 2. Comparison of the new "Segmented" MultiDetection window (SMDW) method and the classic "multiple-fit" method in two sample detection windows.

Acknowledgement: This research was realized within the MEBTRACE project (IP-2014-09-7530), financially supported by the Croatian Science Foundation.

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A MODELLING APPROACH TO INVESTIGATE THE BIOGEOCHEMICAL CYCLE OF NITROGEN AND THE SPATIAL DISPERSION IN AN ESTUARINE SYSTEM

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Abstract

Idku Lake is directly connected to Abu Qir bay via a natural outlet. Over years, the lake has received rising levels of nitrogen loads from agricultural drains, which in turn affected the water quality inside the lake and the adjacent water of the bay. A coupled hydrodynamic-biogeochemical model was developed to investigate the mobility and the biogeochemical cycle of nitrogen pools that dispersed from the lake to the bay. The simulation has shown that, most of nitrogen components that derived from the lake outlet, were diluted with the bay water and transported over the open boundaries of the model. In addition, there was no retention of nitrogen within the model domain, due to the low residence time of water masses in Abu Qir bay.

Keywords: *Nutrients, South-Eastern Mediterranean, Nile Delta, Coastal models*

Introduction

The Egyptian Mediterranean coast hosts five lakes which are called (the Northern Lakes), these lakes receive their water mainly from agricultural drainage systems. Idku Lake is one of the northern lakes, located in the north west of Nile Delta, and is connected to Abu Qir bay directly via an outlet (Figure 1). Historically, nitrogen levels have increased significantly inside the lake, affecting the water quality of the lake and the coastal water of Abu Qir bay [1, 2]. The aim of the present work is to investigate the fate of nitrogen compounds that dispersed from the lake into the bay.

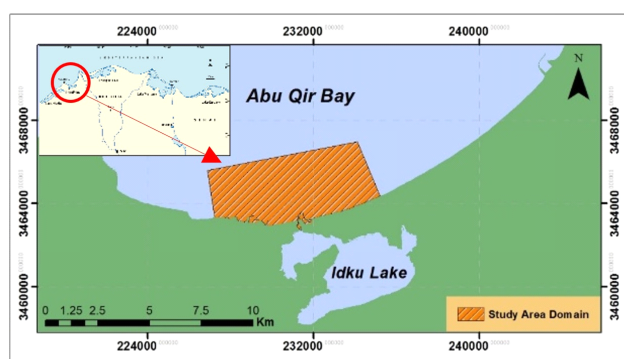


Fig. 1. Map illustrating the study area

Materials and Methods

A coupled highly resolved hydrodynamic-biogeochemical model was developed on the basis of Delft3D over the period from November 2015 to May 2016. The model comprised most of the nitrogen cycle components and processes, as well as the hydrodynamics controlling factors within the model domain including (water levels at the bay and the Lake Outlet, wind direction and speed, bottom roughness, and water viscosity). The hydrodynamic model grid was highly resolved with a grid cell resolution of (33 * 30 m) and (12 * 14 m) around the outlet.

Results and Discussion

Based on the simulation, it was observed that nitrogen dispersion in the bay has varied temporarily, depending on its concentrations inside the lake as well as the physical parameters that regulate the flow and circulation patterns of water masses in Abu Qir bay (ex: water levels and winds). Thereafter, most of those nitrogen fluxes were diluted by the bay water and dispersed over the open boundaries of the model.

Regarding the biogeochemical cycle, dissolved oxygen levels have played a key

role in the cycle processes. As the study area is a shallow coastal area, and the water column is turbulent oxygenated, this resulted in stimulating the nitrification rate and inhibiting the denitrification process. In addition, phytoplankton had a major role in transferring high loads of nitrogen fluxes to sediments. That's because after nitrogen algal assimilation and mortality, nitrogen fluxes in algal cells were converted to detrital nitrogen, and consequently transferred to sediments by algal sedimentation. Furthermore, the sedimentary nitrogen fluxes were transferred back to the water column through the mineralization process. Overall, as shown in (Figure 2), TN outflow has exceeded the inflow over the model domain entirely. Indicating to no retention of nitrogen, and the study area is more exporting of nitrogen loads to the open boundaries, than sequestering nitrogen fluxes.

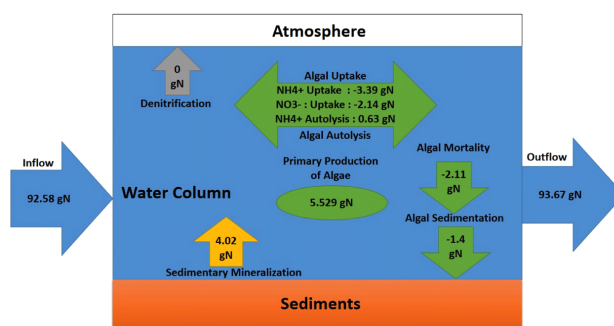


Fig. 2. Schematic overview of the systematic nitrogen transformations over the model domain. Note: Negative fluxes (gN) refers to the loss of N-fluxes by processes, while the positive fluxes refers to the gain of N-fluxes

Acknowledgements: The authors of this work are grateful to the Egyptian Science & Technology Development fund (STDF) for funding this work, under the project number (25445).

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BUDGET OF DISSOLVED OXYGEN IN THE WESTERN MEDITERRANEAN SEA DURING THE DEEP CONVECTIVE YEAR 2012-2013

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Abstract

A coupled physical-biogeochemical model is used to perform a dissolved oxygen budget in the western Mediterranean sea over the period September 2012-September 2013. We estimate that 18 mol m⁻² of atmospheric O₂ was absorbed in the deep convection region during the intense vertical mixing process. The model shows that atmospheric dissolved oxygen ingested was transferred under the euphotic layer reaching the deep layer of the zone (> 800 m). It was then gradually exported to the south and west of the western Mediterranean basin, notably, through the spreading of dense waters recently formed.

Keywords: *Oxygen, Western Mediterranean, Water convection*

The aim of the DEWEX project was to investigate the impact of deep convection on biogeochemical fluxes in the northwestern Mediterranean. Three cruises and deployments of Argo floats allowed intensive observation of this region before, during and just after the intense deep convection episode of January-March 2013. In particular, observations suggest a rapid intake of atmospheric dissolved oxygen during the intense vertical mixing period, which greatly influenced the O₂ content in the entire water column [1]. However, these observations, which remain punctual in time and space, do not make it possible to quantify the contribution of ingassing/outgassing, biological production/consumption and lateral import/export in the variation of O₂ inventory during and after the convective episode, as well as to understand the post-convection fate of atmospheric oxygen ingested.

We use a coupled physical-biogeochemical model [2] to perform a dissolved oxygen budget in the north-western Mediterranean convection area over the period September 2012-September 2013. Overall, the model correctly reproduces the spatial distribution and temporal evolution of the oxygen concentration observed during and between the three cruises. In particular, during the winter period, the model simulates the homogenization of the water column between 41.5 and 42.3°N, the heart of the convection zone (Figure 1).

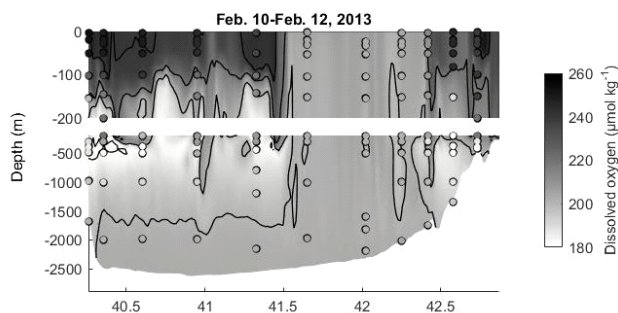


Fig. 1. Vertical section of dissolved oxygen concentration (μmol kg⁻¹) observed (circles) and simulated (background colors) across the deep convection area over the Dewex Leg1 cruise period (10-12 February 2013) in the northwestern Mediterranean sea.

We analyze and quantify the air-to-sea fluxes as well as the hydrodynamic and biogeochemical fluxes of O₂ in the water column. The results show that the annual budget was driven by the deep convection process. We estimate that 18 mol m⁻² of atmospheric O₂ was absorbed in the deep convection region during the convection process (20 mol m⁻² over the one-year period, Figure 2). The model shows that the atmospheric dissolved oxygen ingested during the convective period and, in a minor extent, the biologically produced oxygen, were transferred under the euphotic layer reaching the deep layer of the zone (> 800 m). It was then gradually exported, from winter to summer, to the south and west of the western Mediterranean basin, notably through the spreading of

dense waters recently formed.

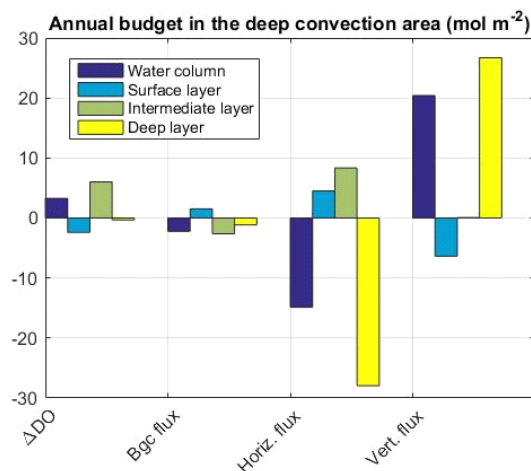


Fig. 2. Annual budget of dissolved oxygen (mol m⁻²) in the northwestern deep convection area: variation of oxygen inventory, biogeochemical and hydrodynamical fluxes influencing oxygen inventory in the water column (dark blue), surface (surface-150m, light blue), intermediate (150-800m) and deep (800m-bottom) layers.

Projections predict a decline in deep convection in this region by the end of the century [3]. This could have significant consequences on the uptake of O₂ in the Mediterranean sea and the O₂ exchanges with the Atlantic Ocean that seem necessary to better quantify in a context of expansion of low-oxygen zones.

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IRON INFLUENCE ON SULFATE-COUPLED ANAEROBIC OXIDATION OF METHANE IN SEDIMENTS OF THE EASTERN MEDITERRANEAN CONTINENTAL SHELF AND THE YARQON ESTUARY

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Abstract

This study presents incubation experiments of sediments from the sulfate-methane transition zone (SMTZ) of two marine diffusive controlled environments: The oligotrophic Eastern Mediterranean Continental Shelf and the organic rich Yarqon Estuary. The experiments were designed to quantify iron reduction process in this zone and the influence of the presence of iron minerals in sediments on sulfate-coupled anaerobic oxidation of methane (AOM) in the SMTZ. The results shed insights into the relationship between iron reduction, sulfate reduction, AOM and methanogenesis processes in the SMTZ zone.

Keywords: *Geochemical cycles, Eastern Mediterranean, Continental shelf*

Microorganisms perform microbial respiration of organic debris in sediments, coupled to the reduction of electron acceptors along a cascade of decreasing free energy yield [1]. The sediments can be divided into different zones according to the electron acceptors and the main process occurring in each zone. This study focuses on the sulfate-methane transition zone (SMTZ). In this zone methane which produced in the deep methanogenesis zone, diffuses upwards, and comes in contact with sulfate. Microbial anaerobic methane oxidation (AOM) by sulfate reduction was found to be the dominant process in this depth. However, recent studies in estuarine sediments and marine seep sediments showed that sulfate reduction, iron reduction, AOM, and methanogenesis can coexist in the same depth ([2], [3]), and that also iron oxides are involved in sulfate-driven AOM in seep sediments [3].

Here, we aimed to explore the iron reduction process and the influence of the presence of iron minerals in the sediments on sulfate-coupled anaerobic oxidation of methane in the SMTZ. Sediments cores were taken from two marine diffusive controlled environments: (1) the oligotrophic Eastern Mediterranean Continental Shelf (2) the organic rich Yarqon Estuary. Pore water was extracted by centrifugation from the cores and geochemical profiles of Fe(II), sulfate, sulfide, dissolved inorganic carbon (DIC), $\delta^{13}\text{C}_{\text{DIC}}$ and CH_4 were performed in order to identify the SMTZ in each core (Fig.1). Long term incubation experiments with sediments from the SMTZ in both environments were performed as well. In order to keep track of AOM processes, labeled methane ($^{13}\text{CH}_4$) was added to all bottles, and the bottles were manipulated differently to explore the factors influencing the anaerobic processes. The bottles were sampled along half to one and a half year, and the samples were measured for the concentration of Fe (II), sulfate, sulfide, DIC, $\delta^{13}\text{C}_{\text{DIC}}$ and $\delta^{34}\text{S}_{\text{SO}_4}$.

Results

The SMTZ was observed in the Eastern Mediterranean Continental Shelf between 132 to 142 cm depth, and in the Yarqon Estuary between 5 to 22 cm depth, where methane concentrations were rising and sulfate concentrations were decreasing (Fig. 1).

The experiments results show that iron reduction occurs in the SMTZ of both environments, although it is not the main process in this zone. In the shallow sea sediments, low reactive iron oxides like hematite can lead to the occurrence of iron reduction simultaneously to sulfate driven AOM and possibly partial inhibition of sulfate driven AOM. In the Yarqon Estuary, due to the high amount of organic matter and high amounts of microorganisms, sulfate reduction with organic matter seems to be the main process in the SMTZ, and iron oxides presence doesn't seem to effect it. This process inhibits low reactive iron oxides reduction, methanogenesis and AOM, but not high reactive iron oxides (like amorphous iron) reduction which occurs simultaneously to the sulfate reduction. When the sulfate is depleted, low reactive iron minerals reduction and methanogenesis start to occur in the sediment.

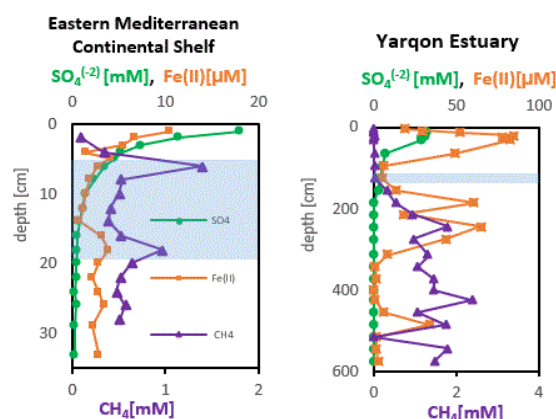


Fig. 1. Geochemical profiles of Fe(II), sulfate and methane concentrations from the Eastern Mediterranean Continental Shelf and the Yarqon Estuary. Sediments for the incubation experiments were taken from the area marked in blue (which was characterized as the SMTZ in each core).

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ANTHROPOGENIC SIGNATURE OF PLATINUM-GROUP ELEMENTS IN THE TAGUS RIVER ESTUARY (SW EUROPE): OCCURRENCE, TRANSPORT AND GEOCHEMICAL IMPLICATIONS IN A HYDRODYNAMIC ESTUARY

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Abstract

Platinum-group elements (PGEs) are technology-critical elements of environmental emerging concern with a large variety of applications and increasing global demand. Consequentially, PGEs concentration has increased in several environmental compartments [1]. This study presents the recent data acquired in Tagus River estuary and provides new insights on the occurrence and transport from urban areas to the estuary, and geochemical implications as well. Using voltammetric analysis [2], platinum (Pt) and rhodium (Rh) spatial distribution was assessed in surface sediments (n=72). Concentrations ranged between 0.18–5.1 ng Pt g⁻¹ and 0.019–1.5 ng Rh g⁻¹. Estimated reference levels in the estuary were 0.55 ng Pt g⁻¹ and 0.27 ng Rh g⁻¹. Concentrations were higher in the surroundings of Vasco da Gama bridge and industrial areas, pointing to PGEs sources in automotive catalytic converters (ACC) and industrial catalysts, respectively. The industrial imprint was also evaluated using sediment cores collected at two industrial sites. Concentrations slightly varied in depth at the chlor-alkali unit (North channel), continuously operating almost for a century. In contrast, at the dismantled industrial complex site (southern bank) an increase on PGEs concentration was found in deeper layers, coincident with the peak activities in the early 1970s. Focusing on the PGEs transfer from the urban area into the estuary, the speciation of Pt and Rh was evaluated using a multi-method approach under relevant environmental conditions. Road dust truly dissolved concentrations of Pt and Rh were approximately 10 and 40 % of total dissolved concentrations, respectively, suggesting the presence of colloidal- or insoluble (nano)particles. Concentrations and partition of Pt and Rh were assessed in water column samples collected at the entrance and mouth of the estuary during a tidal cycle. All data will complement the hydrodynamic model of Tagus River estuary in order to assess metals recirculation within the estuary and/or potential exchange to the Atlantic Ocean. The development of such modelling tools is important to predict contamination scenarios to a larger scale, namely in the Mediterranean Sea.

Keywords: Platinum-group elements; Biogeochemistry; Tagus River estuary (Portugal)

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COMITÉ 4
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**Microbiologie et Biotechnologie marines**

*Président* : Frank Oliver Glöckner



## **CIESM Congress Session : Ocean health**

**Moderator : Vitor Vasconcelos, Univ. of Porto / CIIMAR, Porto, Portugal**

### *Moderator's Synthesis*

This session highlighted some aspects related to ocean health and its impacts. Global changes and eutrophication have changed the intensity and diversity of toxic blooms, leading to the occurrence of emerging toxins. Tetrodotoxin, ciguatoxins and palitoxins are those that may cause more hazards in the Mediterranean and the north Atlantic. Pulsed, wind-driven circulation may also control neashore algal blooms in the Mediterranean Sea. Cyanobacteria such as *Prochlorococcus* and *Synechococcus* - both very important genera in the production of oxygen in the ocean - may also be impacted not just by global changes but also by biological means such as airborne bacteria and virus, following Saharan-dust deposition.

The increased need of freshwater is leading to the increase of marine water desalination with expected impacts in coastal waters. The impacts of hypersaline waters in coastal environments may impact different trophic levels from bacterioplankton to invertebrates and fish. The occurrence of increased parasite incidence in fish may also be a consequence of global changes. The use of the filter feeding anemone *Aiptasia pallida* as a model to detect marine pathogens is an interesting approach that can be extended to other similar invertebrates. Continuous observation of the ocean, using physical, chemical and biological data is a necessary condition to better assess Ocean health and its implication in human health.



# PULSED, WIND-DRIVEN CONTROL OF NEASHORE ALGAL BLOOMS IN THE MEDITERRANEAN SEA

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## Abstract

We analyze the short-term variability of nearshore waters at Palma beach (Mallorca) and its influence on the occurrence of high biomass phytoplankton accumulations. Results from an observational study carried out during 2018 reveal that flow patterns in the nearshore are driven by the interaction between alongshore submarine groundwater discharges (SGD) and wind-driven currents. The dynamic equilibrium between both forcings determines either retention of SGD and plankton in the nearshore or its spread over a wider region. This interaction is regulated by the diel wind cycle, which is a major driver of phytoplankton variability. We identify pulsed breeze-driven mechanism regulating phytoplankton communities and HAB occurrence in nearshore waters of the Mediterranean Sea.

**Keywords:** *Phytoplankton, Mediterranean Sea, Wind, Nutrients*

Intensive agriculture and urbanization of coastal watersheds has resulted in a remarkable increase of nutrient sources along the Mediterranean coasts. Submarine groundwater discharges (SGD) from coastal aquifers constitute an important source of nutrients and other elements to the nearshore environment, often fueling high biomass dinoflagellate blooms in this region that are perceived during summer [1]. While general factors influencing nearshore microalgal growth and accumulation are known<sup>1</sup>, the predictability of short-term bloom dynamics has been elusive.

One of the major challenges to understanding the underlying controls of nearshore HABs is to understand the physical-chemical environment in which these phenomena take place. Wind is known to be a major driver of coastal circulation and nearshore processes in the Mediterranean Sea [2]. Indeed, has been regarded as a major factor modulating nearshore HABs [3]. Coupling between breeze driven currents and diurnal vertical migration may contribute to cell accumulation along the coast. Cell abundances also show a shorter time variability, attending to rapidly changing wind conditions.

Previous studies in the NW Mediterranean have shown persistent exponential phytoplankton biomass increases and HAB producing dinoflagellate accumulations in the nearshore related with shore directed winds [4]. Here, we analyze the short-term dynamics of the nearshore environment and its influence on the observed phytoplankton biomass accumulation at Palma beach (Mallorca). The study area is characterized by a microtidal environment, low-energy wave conditions, and a shallow bathymetry.

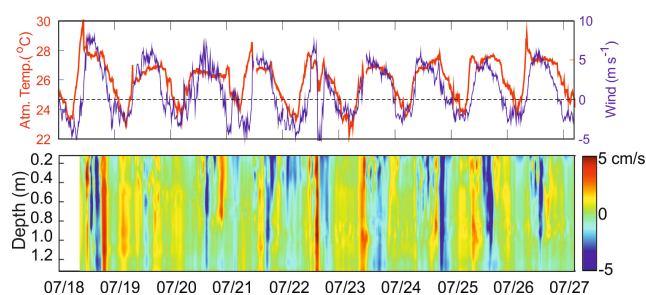


Fig. 1. Top. Variations in cross-shore wind intensity and atmospheric temperature. Bottom. Cross-shore current velocity. Blue-orange colors indicate onshore-offshore directed flow.

Chlorophyll concentrations in the nearshore present marked diurnal variability with values  $< 2 \text{ mg m}^{-3}$  at night and concentrations exceeding  $8 \text{ mg m}^{-3}$  in the afternoon. These values rapidly decline in the offshore direction reaching values  $< 1 \text{ mg m}^{-3}$  at 600 m off the coast. These findings suggest that both sea breezes and SGD may play an important role in the nearshore blooms observed in the Mediterranean Sea.

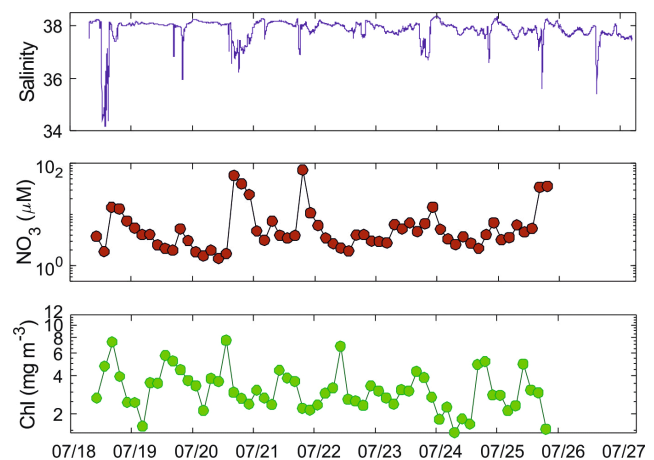


Fig. 2. Salinity, nitrate and chlorophyll variations at a sampling point located at 25m from the shoreline. Note that Chl y-axis is scaled exponentially.

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# ECTOPARASITES OF *BATHYTOSHIA CENTROURA* (MITCHILL, 1815) IN TUNISIAN WATERS

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## Abstract

The aim of this work was to assess the parasite fauna of *Bathytoshia centroura* captured in Tunisian waters. In fact, this study allowed us to identify four Copepod species (*Eudactylinella alba*, *Nemesis* sp., *Pseudocharopinus bicaudatus*, and *Pseudocharopinus concavus*) and two Monogenean species namely *Monocotyle myliobatis* and *Hypanocotyle* sp. This last species is a new for Science. *Nemesis* sp. presented the highest prevalence (16.27%) and *Pseudocharopinus bicaudatus* presented the lowest one (2.32%). This is the first record of *Nemesis* sp on *B. centroura* in Tunisia. We report for the first time the presence of *Pseudocharopinus bicaudatus* and *Pseudocharopinus concavus* on this host species.

**Keywords:** Parasitism, Copepoda, Elasmobranchii, South-Central Mediterranean

## Introduction

*Bathytoshia centroura* (Mitchill, 1815) is a cosmopolitan fish species of important commercial value, distributed along the Tunisian coast. However, investigations into its parasites in Tunisian waters are rare [1, 2]. Thus, the aim of this study is to provide new data on the ectoparasitic species that infest this host species off the Tunisian coast, as well as to provide data on the host-parasite associations of this species.

## Material and Methods

Between 2013 and 2015, 129 specimens of *B. centroura* were examined for parasitic species. Samples were collected along the Tunisian coast (Figure 1).

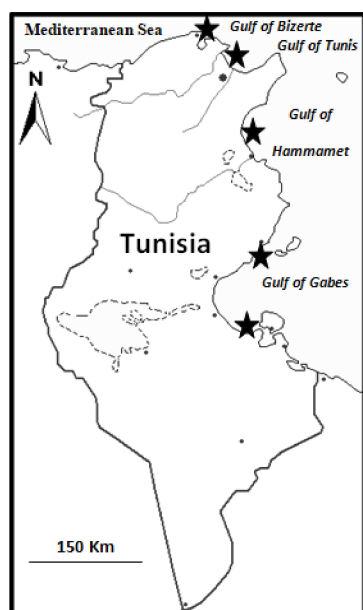


Fig. 1. Sampling sites, indicated by black stars.

All body parts (skin, fins, gills, mouth, cloaca) were carefully examined. Gills were removed and placed in Petri dishes containing seawater. Each holobranch was individually examined. Copepods parasitic species identification was based on morphological features following [3], and [4]. Monogenean species were identified following [5] and [6]. Rates of infestation were evaluated using prevalence, mean intensity and abundance according to [7]. Prevalence is the number of hosts infected with one or more individuals of a particular parasite species divided by the number of hosts examined for that parasite species. Mean intensity is the average intensity of a particular species of parasite among the infected members of a particular host species. Abundance is the number of individuals of a particular parasite in/on a single host regardless of whether or not the host is infected.

## Results and Discussion

Our survey allowed us to identify four copepod species (*Eudactylinella alba*, *Nemesis* sp., *Pseudocharopinus bicaudatus*, and *Pseudocharopinus concavus*) and two Monogenean species (*Hypanocotyle* sp. and *Monocotyle myliobatis*) (Table 1).

Tab. 1. Ectoparasite species with their rates of infestation. P (%): Prevalence; MI: Mean intensity; A: abundance.

|            | Parasite species                   | P (%) | MI   | A    |
|------------|------------------------------------|-------|------|------|
| Copepods   | <i>Eudactylinella alba</i>         | 3.10  | 1    | 0.03 |
|            | <i>Nemesis</i> sp.                 | 16.27 | 1.6  | 0.26 |
|            | <i>Pseudocharopinus bicaudatus</i> | 2.32  | 1    | 0.02 |
|            | <i>Pseudocharopinus concavus</i>   | 4.65  | 1    | 0.04 |
| Monogenean | <i>Hypanocotyle</i> sp.            | 3.10  | 1.5  | 0.04 |
|            | <i>Monocotyle myliobatis</i>       | 5.42  | 1.57 | 0.08 |

This analysis allowed us to identify a new species of Monogenean (*Hypanocotyle* sp.) and to report for the first time the presence of *Monocotyle myliobatis*, *Pseudocharopinus bicaudatus* and *Pseudocharopinus concavus* on *B. centroura*. This is the first record of *Nemesis* sp on *B. centroura* in Tunisia. Moreover, we noted that *Nemesis* sp. presented the highest rates of infestation (P=16.27%; MI=1.6 and A=0.26) while *Pseudocharopinus bicaudatus* presented the lowest rates of infestation (P=2.32 %; MI=1 and A=0.02).

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# AIRBORNE VIRUSES AFFECT *PROCHLOROCOCCUS* DISTRIBUTION IN OLIGOTROPHIC MARINE REGIONS

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## Abstract

Here, we investigated the role of aerosols-derived viruses in diminishing the biomass of one of the most ecologically-important microorganism in the oceans; the cyanobacteria *Prochlorococcus*. We show that *Prochlorococcus* cells can be infected by airborne viruses following Saharan-dust deposition. This process may presumably govern the abundance of *Prochlorococcus* throughout the Mediterranean Sea. Enhanced desertification will likely increase the transport of airborne microbes, including viruses, to oligotrophic marine systems, thereby affect atmospheric CO<sub>2</sub> drawdown and climate change.

**Keywords:** *Bacteria, Mediterranean Sea*

## Introduction

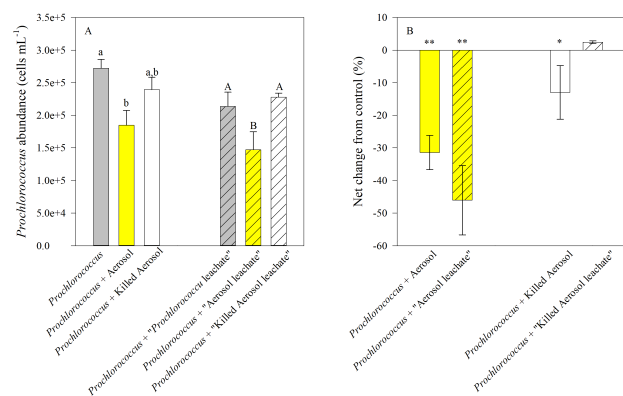
Aerosols are regularly transported across the oceans supplying nutrients and trace-metals to the surface water [1]. Aerosols also contain a wide array of different airborne microorganisms and viruses that can be transported for thousands of kilometers away from their place of origin within a few days [2].

## Methods

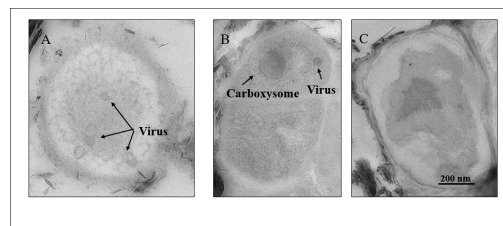
The impact of airborne viruses on *Prochlorococcus* abundance was examined under laboratory-controlled conditions using exponentially growing *Prochlorococcus* MED4 cultures maintained in 100 mL sterile culture flasks in triplicates. The following additions were carried out: [1] No addition (*i.e.*, pure culture,  $\sim 2 \times 10^5$  cells mL<sup>-1</sup>); [2] 1.5 mg L<sup>-1</sup> aerosol addition; and [3] 1.5 mg L<sup>-1</sup> UV-killed aerosol addition. The bottles were incubated for 24 h under low light in a temperature-controlled room. At the conclusion of the experiment, each bottle was filtered using a sterile 0.2- $\mu$ m filter and the leachate (dissolved fraction which includes the <0.2- $\mu$ m particles including viruses) was collected and transferred to a fresh *Prochlorococcus* MED4 culture at a 1:9 filtrate to media ratio (*v:v*). The bottles (containing fresh cultures + relevant leachate) were incubated for another 24 h under the same conditions described above. *Prochlorococcus* abundance was quantified using flow-cytometry at the start and conclusion of each experiment.

## Results and Discussion

We show that *Prochlorococcus* cells can be infected by non-chemical constituents in airborne particles, presumably viruses, resulting in low relative abundance when aerosols are deposit at high levels into the Mediterranean surface water (Figures 1,2). Amendments of aerosol particles or aerosol leachate (<0.2- $\mu$ m) to surface seawater or *Prochlorococcus* cultures resulted in a significant decline in cell biomass (<90%), while UV-sterilized aerosols used as control elicited a much weaker response (Figure 1 A,B). Viruses-infected *Prochlorococcus* MED4 were observed using transmission-electron-microscopy only in cells cultured with ambient aerosol and not in those treated with the UV-sterilized aerosol (Figure 2 A-C). Thus, we suggested that the dominance of *Synechococcus* over *Prochlorococcus* throughout the surface Mediterranean-Sea and the typical spatial trends in chlorophyll-*a* are regulated/governed by airborne viral lysis of *Prochlorococcus*. Predictions for enhanced desertification may intensify the transport of airborne viruses to LNLC marine systems.



**Fig. 1. The effect of 'live' or 'UV-killed' aerosol addition on *Prochlorococcus* MED4 abundance.**(A) Changes in the abundance of *Prochlorococcus* MED4 cultures following 1.5 mg L<sup>-1</sup> aerosol addition; (B) The net % change relative to the unamended controls.



**Fig. 2. (A,B) TEM images showing viral-infected *Prochlorococcus* MED4 cells following aerosol addition; and (C) An uninfected cell.**Striped columns represent the addition of filtered (0.2- $\mu$ m) culture ('control', 'live-aerosol' or 'UV-killed aerosol') to fresh *Prochlorococcus* culture (10% filtrate and 90% fresh culture).

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# INSIGHTS INTO INNATE IMMUNITY FUNCTIONAL CONSERVATION FROM A SEA ANEMONE - VIBRIO PATHOGEN MODEL SYSTEM

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## Abstract

Environmental disturbances driven by climate change, such as sea level rise, ocean acidification and overheating of shallow tropical waters, drive major changes in the ecology of marine microbes worldwide, which represents an imminent risk for human health. We used a pandemic *Vibrio parahaemolyticus* serotype - the leading cause of gastroenteritis in human via contaminated seafood, and the sea anemone *Aiptasia pallida* – an emerging model for innate immunity, to investigate functional conservation through 550 million years of evolution. Transcriptomics after 1, 3, 6 and 12 hours of pathogen exposure reveal ancestral defense mechanisms in the anemone that push back the presumed origin of certain innate immunity genes.

**Keywords:** *Bacteria, Cnidaria, Worldwide*

## Introduction

The interactions between the ocean and human health are complex and remain vastly unexplored. Environmental disturbances driven by climate change, such as sea level rise, ocean acidification and overheating of the tropics, have severe consequences on the health of the oceans. Warming waters alone are predicted to drive major changes in the ecology of marine microbes (Cohen RE et al.; 2018). Those microbial shifts at the basis of the marine food chain can have rippling effects on the health of people worldwide. The most studied marine bacteria are the *Vibrios* species including *Vibrio vulnificus*, *Vibrio alginolyticus* and *Vibrio parahaemolyticus* that are responsible for increasing rate of acute and chronic human diseases. For example, *Vibrio parahaemolyticus*, a gram-negative bacteria has been responsible for several pandemic gastroenteritis via consumption of contaminated seafood. The innate immunity is the first line of defense in case of infection in vertebrates and invertebrates. Cnidarians (including corals and sea anemone) are evolutionarily early-diverged metazoans that have only the innate immune system as protective mechanism against infectious agents. This study was conducted to answer a simple question: which of the known or unknown innate immune genes of the anemone *Aiptasia pallida* have conserved functions in response to pathogen infections?

## Materials and methods

*Aiptasia pallida*'s is an emerging model system with its genome and transcriptome sequenced allowing for transcriptomics on the innate immune response in host-pathogen interactions. We incubated clonal anemones (strain CC7, Pringle Lab) with the human pathogen *Vibrio parahaemolyticus* O3:K6 (strain RIMD2210633, Lan et al.; 2009) at 10<sup>8</sup> cfu/mL. Samples were taken at 1, 3, 6, 12 hours of exposure for RNA extraction and subsequent RNASeq analysis.

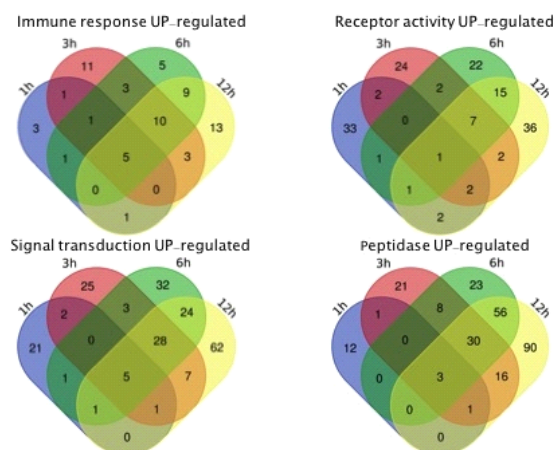


Fig. 1. Venn diagram of *Aiptasia*'s differentially up-regulated expressed contigs representing the immune response, the receptor activity, the signal transduction, and the peptidase Gene Ontology annotations detected after 1, 3, 6 and 12 hours of exposure to *Vibrio parahaemolyticus*.

## Results

Evidence of sensorial activities can be identified in the response of the anemone after 1 hour, followed by an increase in the innate immune gene regulation detected after 3 hours. This increase coincides with the expression of virulence factors in infectious vibrio in other studies.

The functional analyses highlight the involvement of TNF receptors and the apoptotic pathway through activation of NF-kappaB and JUN. Lysosomal activity coupled with highly expressed endopeptidase were also detected after 12 hours. Apoptotic activity was exemplified by the increasing over-expression of caspases with time.

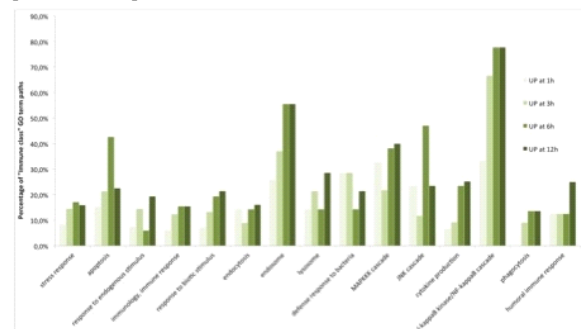


Fig. 2. Changes in *Aiptasia*'s immune class GO term percentages with time of exposure to *Vibrio parahaemolyticus*.

**Conclusion** The anemone/vibrio innate immune response model was validated through identification of well-known members of vertebrate innate immunity, and represents a valuable tool to identify novel genes involved in the defense against Gram-negative pathogen.

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**CIESM Congress Session : Phytoplankton / Bacterioplankton**  
**Moderator : Carla Gameiro, MARE, Univ. of Lisbon, Portugal**

*Moderator's Synthesis*



# PHYTOPLANKTON AND BACTERIAL RESPONSE TO DESERT DUST DEPOSITION IN THE COASTAL WATERS OF THE SOUTHEASTERN MEDITERRANEAN SEA: A FOUR-YEAR *IN-SITU* SURVEY

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## Abstract

We investigated the *in-situ* temporal dynamics of phytoplankton and bacteria in the surface coastal waters of the SE Mediterranean Sea during dust deposition events ( $Al > 2000 \text{ ng m}^{-3}$ ,  $n=29$ ) and during “typical” days ( $Al < 2000 \text{ ng m}^{-3}$ ,  $n=89$ ) between 2013-2017. We show that dust addition affects metabolic rate measurements (primary and bacterial production,  $N_2$  fixation) more than phytoplankton or heterotrophic bacterial abundance/biomass. Further, heterotrophic bacteria (biomass and activity) show a faster and stronger response to dust deposition than autotrophic-related variables (chlorophyll *a*, primary production). We conjecture that this can cause a food-web cascade where heterotrophic metabolism will become more significant than autotrophic processes in areas subjected to high rates of dust deposition such as the SE Mediterranean Sea.

**Keywords:** *Bacteria, Mediterranean Sea, Coastal waters, Phytoplankton*

## Introduction

Atmospheric dust/aerosol deposition is an important source of external nutrients for the surface of the ocean, fueling primary and bacterial production [1,2]. Such depositions are especially important in Low Nutrients Low Chlorophyll (LNLC) marine environments such as the southeastern Mediterranean Sea.

## Material and Methods

This study shows high-resolution observational data gathered *in-situ* over a period of four years on bacterial and phytoplankton abundance and activity during typical background atmospheric conditions ( $n=89$ ) and during intense dust storm events ( $n=29$ ) in the LNLC coastal waters of the southeastern Mediterranean Sea.

## Results and Discussion

Chlorophyll *a* (an estimate for phytoplankton biomass) and bacterial abundance showed moderate changes in response to dust deposition/events ( $-10\%$  and  $+20\%$ , respectively, Figure 1A,B), while primary production, bacterial production, and  $N_2$  fixation rates were all significantly and positively affected by deposition ( $+25$  to  $+40\%$ ;  $p < 0.05$ , Figure 2A-C). The rapid changes in bacterial and/or phytoplankton rate parameters suggest that the released micro/macronutrients from atmospheric deposition are tunneled directly in metabolic processes and, to a lesser extent, for biomass accumulation. The predicted expansion of LNLC areas in oceans in the future, and the projected increase in dust emission due to desertification, may affect the production of marine microbial communities in the surface of the ocean, yet only moderately affect their biomass or standing stock. Such alterations may impact carbon sequestration to the deep ocean.

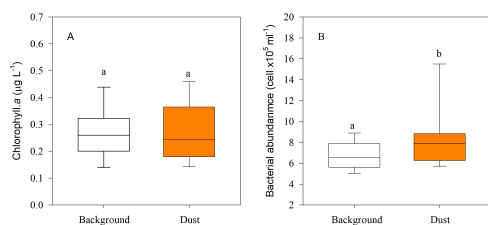


Fig. 1. Box-whisker plots showing the surface ( $\sim 1 \text{ m}$ ) chlorophyll *a* (A) and bacterial abundance (B) during “typical” days (white) and during dust storms (orange).

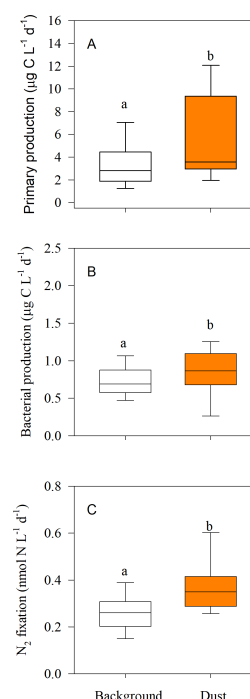


Fig. 2. Box-whisker plots showing the primary production (A), bacterial production (B) and  $N_2$  fixation (C) during “typical” days (white) and during dust storms (orange).

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# DINOFLAGELLATE RESTING CYSTS FROM SURFACE SEDIMENTS OF THE NORTH-EASTERN ADRIATIC AND THEIR POTENTIAL SPREADING PATTERNS

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## Abstract

Dinoflagellate resting cysts from surface sediments of the North-Eastern Adriatic were studied and their potential spreading pattern hypothesised. Each taxa was associated with one of the two potential spreading pattern, natural or anthropogenic.

**Keywords:** *Dinoflagellates, Phytoplankton, NIS, Circulation, Adriatic Sea*

Benthic cysts play a vital role in dinoflagellates' ecology as they allow survival through adverse environmental conditions (nutrient depletion, temperature decrease, high turbulence). Ballast waters (BW) are a proven vector of spreading phytoplankton species over large distances across oceans. The Adriatic (Fig.1.), a basin located in the northernmost part of the Mediterranean, is an important inter/national seaway subjected to intense maritime traffic, and its ports, potential hotspots of non-indigenous species (NIS) introductions.

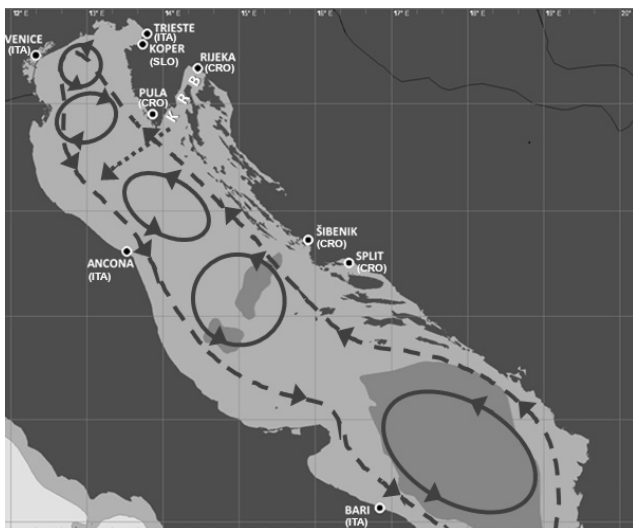


Fig. 1. Map of the Adriatic with investigated ports and Kvarner and Rijeka Bay (KRB) and schematics of Adriatic surface circulation pattern [2]; general circulation (dashed line), gyres (solid), Bora induced current in KRB (dotted).

In 2014 and 2015, a study of dinoflagellate cysts was included in Port Baseline Surveys (PBS), conducted in 9 Adriatic ports (Fig. 1.). Here we present an inventory of dinoflagellate cysts observed in the ports of Pula and Rijeka, and Kvarner and Rijeka Bay (KRB) [North-Eastern Adriatic (NEA)], during surveys in 2011 (May, August), 2014 (September, December) and 2015 (February, April, May, July, November) [1,2]. Only taxa determined to the species level are discussed.

Dinoflagellate cyst inventory (Tab. 1.) includes 20 taxa. Upon investigation of their presence in other 7 ports [1] and available literature [references in 1], we hypothesised their introduction to be either natural - by circulation pattern - or anthropogenic - by BW. Accordingly, we allocated each taxa to one of the following six groups (Tab. 1.). (1) Inconclusive - cysts are widespread across the Adriatic. (2) Natural - from NE region (including ports of Trieste and/or Koper) as cysts were observed in KRB; points to recent spread as not observed in ports of Pula nor Rijeka. (3) Natural - from NE region or the port of Split as cysts were observed in NEA. (4) Either – natural, into port of Rijeka over the KRB from NE region or anthropogenic, followed by spreading from port of Rijeka over KRB further into NE region, as cysts were observed in KRB and port of Rijeka. (5) Anthropogenic - as cysts were absent from KRB where would potentially remain during natural spread. (6) Almost certainly anthropogenic - as no observation anywhere else in the Adriatic was reported.

Tab. 1. Check-list of observed taxa in the ports of Pula (P) and Rijeka (R), and Kvarner and Rijeka Bay (B) with indication of potential toxicity (large T). Taxa were checked for presence in literature (LIT.) in Adriatic regions (Reg.) in vegetative stage (veg.), and as cysts observed in other ports. Regions, with endorsing ports, are abbreviated as follows: north-western (NW) - Venice (V), mid-western (MW) - Ancona (A), south-western (SW) - Bari (B), north-eastern (NE) - Trieste (T) and Koper (K), mid-eastern (ME) - Split (S) and Sibenik (Si), and south-eastern (SE) - no PBS data. Grey field indicates presence. According to hypothesised introduction, each taxa is allocated to one of six groups (G).

| TAXA                                 | LIT. |      | PBS   |   |   |    |                                   | TAXA | LIT. |      | PBS   |   |   |  |  |
|--------------------------------------|------|------|-------|---|---|----|-----------------------------------|------|------|------|-------|---|---|--|--|
|                                      | veg. |      | cysts |   |   |    |                                   |      | veg. |      | cysts |   |   |  |  |
|                                      | G    | Reg. | Reg.  | P | B | R  | G                                 |      | Reg. | Reg. | P     | B | R |  |  |
| <i>Alexandrium affine</i>            | 6    |      |       |   |   |    | <i>Protoceratium reticulatum</i>  | 4    | NW   | NE   | T     | K |   |  |  |
| <i>A. minutum / affine / tamutum</i> | 5    | NW   | NE    | V | T | K  | <i>Protoperidinium claudicans</i> | 4    | SW   |      |       | S |   |  |  |
| <i>A. tamarense / catenella</i>      | 5    | NW   | NE    |   | T | K  | <i>Protoperidinium compressum</i> | 3    | NW   | NE   |       |   |   |  |  |
| <i>Gonyaulax scrippsae</i>           | 4    | MW   |       |   | S | Si | <i>Protoperidinium conicum</i>    | 5    | NW   | NE   |       | T | K |  |  |
| <i>Gonyaulax spinifera</i>           | 4    | MW   | ME    |   | S | Si | <i>Protoperidinium oblongum</i>   | 5    | MW   | ME   |       | S |   |  |  |
| <i>Gyrodinium impudicum</i>          | 4    |      | NE    |   | T | K  | <i>Pyrodinium cf. bahamense</i>   | 6    | MW   |      |       |   |   |  |  |
| <i>Lingulodinium polyedra</i>        | 1    | NW   | NE    | V | T | K  | <i>Pyrophacus steinii (cf.)</i>   | 4    |      | NE   |       |   |   |  |  |
| <i>Polykrikos hartmanii</i>          | 6    |      |       |   |   |    | <i>Scrippsiella acuminata</i>     | 4    | SW   | SE   |       |   |   |  |  |
| <i>P. schwartzi / kofoidii</i>       | 2    | NW   | NE    |   | T | K  | <i>Scrippsiella crystallina</i>   | 2    | NW   | NE   |       | T | K |  |  |
| <i>Preperidinium meunieri</i>        | 6    |      |       |   | S |    | <i>Scrippsiella lachrymosa</i>    | 2    | NW   | NE   |       | T | K |  |  |

## Conclusion

*Alexandrium affine* and *Pyrodinium cf. bahamense*, two NIS and potentially toxic taxa were observed in the investigated area (the latter was reported before in MW region). Further 2 taxa were identified as NIS, *Polykrikos hartmanii* and *Preperidinium meunieri*, and 7 as potentially toxic. As such, NEA poses threat to the remainder of the Adriatic. BW facilitate spreading of potentially harmful species to more distant areas where natural spread would be doubtful.

## Acknowledgements

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# MICROBIAL SUCCESSION DURING THE REGIME SHIFT IN A MARINE MEROMICTIC LAKE (ROGOZNICA LAKE, ADRIATIC COAST)

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## Abstract

Water column of marine Rogoznica Lake (Croatia) is usually stratified into oxic mixolimnion and euxinic monimolimnion. On rare occasions the Lake exhibits holomixis during which these layers overturn, accompanied by oxidation of sulfide and development of colloidal sulfur, leading to establishment of euxinic conditions. Here we investigated microbial communities during stratified and holomictic conditions. An almost complete change in the structure of the prokaryotic communities was observed during holomixia. *Chromatiaceae* were replaced by *Thioglobaceae* family (SUP05 cluster), while the abundance of *Planctomycetacia* and *Chlorobia* increased. Phylum *Epsilonbacteraeota*, as well as *Nanoarchaeota* appeared. Drastic change of environmental conditions also decreased microbial diversity and the abundance as a response to this stressful event.

**Keywords:** Stressors, Adriatic Sea, Bacteria, Anoxic basin, Vertical profile

## Introduction

Rogoznica Lake (Dragon's Eye), is a small (10,276 m<sup>2</sup>, max. depth, 15 m) karstic, marine meromictic lake located on the eastern Adriatic coast (Croatia) (43°32'N 15°58'E). Water column of the Lake is stratified into oxic mixolimnion and euxinic monimolimnion that are separated by the transition zone-chemocline. Mixing between these layers is rare and primarily depends on meteorological conditions. During that process high H<sub>2</sub>S concentrations reach the mixolimnion, oxidation of which causes oxygen depletion and precipitation of colloidal sulfur (S<sup>0</sup>) [1].

## Materials and Methods

Samples for the investigation of microbial communities were collected seasonally during stratified period in 2015 from the chemocline and monimolimnion, while the samples during holomictic conditions were obtained on October 24th 2016 from various depths across the vertical profile of the Lake. Extracted DNA was sequenced on *Illumina MiSeq* platform and the abundance was determined by qPCR.

## Results and Discussion

Sequencing of 16S rRNA gene revealed a clear vertical structure of the microbial community during stratification (Fig. 1a), with *Gammaproteobacteria* (average, 16.1 ± 2.5%) dominating the chemocline and *Deltaproteobacteria* (average 14 ± 2.1%) and *Bacteroidetes* (average, 22.9 ± 0.9%) dominating the monimolimnion.

These communities were seasonally stable in terms of their structure and the abundance. Moreover, diversity in the monimolimnion was one of the highest recorded in meromictic lakes (Shannon-Wiener average, 7.08 ± 0.18) which is contributed to a high proportion of unclassified bacteria (average, 40.5 ± 4.6%). However, holomictic conditions led to an almost complete change in the community structure (Fig.1b). *Chromatiaceae* were replaced by *Thioglobaceae* family (SUP05 cluster) (average, 16.7 ± 10.2%), while the abundance of *Planctomycetacia* (average, 11.9 ± 33%) and *Chlorobia* (average, 11.6 ± 12.4%) increased. *Epsilonbacteraeota* (average, 11.8 ± 7.5), as well as *Nanoarchaeota* (average, 3.3 ± 3.6%) which were not detected during the stratification, appeared. Holomictic conditions significantly decreased microbial diversity (Shannon-Wiener average, 4.1 ± 0.58) and the abundance (for an order of magnitude).

Coexistence of *Epsilonbacteraeota* (mainly *Arcobacteraceae*) and *Chlorobiaceae*, although recorded [2], is not usual in anoxic marine environments [3]. This can be contributed to precipitation of colloidal sulfur, that reduced water transparency and enabled development of chemolithotrophs and only highly specialized phototrophs such as *Chlorobiaceae*. Taking into account environmental conditions during holomictic event and dominant taxa, it can be suggested that the chemolithotrophic oxidation of H<sub>2</sub>S is coupled to denitrification. These reactions seem to be conducted by *Arcobacter* and *Sulfurovaceae* as well as by *Thioglobaceae* (SUP05 clade), and *Thiovulaceae* [4] families. Sharp and drastic change in environmental conditions during holomictic event had multiple impacts on microbial communities in Rogoznica Lake in terms of their structure, diversity and abundance. This is tightly associated to environmental stress, that is expected to become more frequent.

## Acknowledgement

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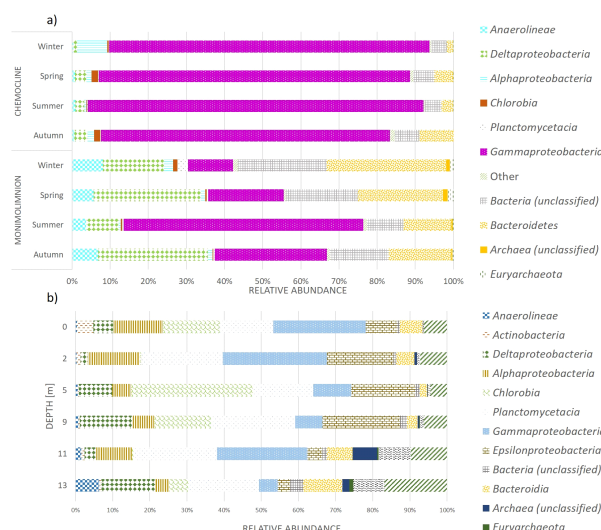


Fig. 1. Taxonomic structure of the dominant taxa at various water depths in Rogoznica Lake during stratified (a) and holomictic (b) conditions. Taxa with the relative abundance <1% is presented as "other".



# THE EFFECT OF ENVIRONMENTAL FACTORS ON COLONIZATION OF DIATOMS ON ARTIFICIAL SUBSTRATE (GLASS) IN THE MARINE LAKE (THE SOUTHEASTERN ADRIATIC SEA COAST)

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## Abstract

The taxonomy, ecology and colonization features of periphytic diatoms were studied in the marine lake Mrtvo more (Island of Lokrum, Croatia) using glass slides as an artificial substratum on a weekly basis from April to October 2016, a period when this area is under significant anthropogenic influence by swimmers. The objectives of this study were to determine the weekly difference in abundance and composition of benthic diatom community and the effect of temperature, salinity, TIN – total inorganic nitrogen, phosphate ( $\text{PO}_4^{3-}$ ), silicate ( $\text{SiO}_4^{4-}$ ), oxygen saturation ( $\text{O}_2/\text{O}_2'$ ) and chlorophyll *a* concentrations on diatom colonization rate of artificial substrate exposure. Our data provide an important step for further investigations of the development of the biofilm under different environmental conditions.

**Keywords:** *Adriatic Sea, North-Eastern Mediterranean, Diatoms, Biodiversity*

## Introduction

Any permanently exposed, non-defended surface will eventually become fouled (Wahl 1989). Among the early settlers, microalgae play a key role in the biofilm development and are able to settle on even the most fouling resistant surfaces (Molino & Wetherbee 2008). In this study, the initial colonization of diatoms in the periphytic community and development of diatom assemblages on a immersed artificial substrate with various physico-chemical properties were examined in a shallow marine lake.

## Materials and methods

The experiment was carried out for 25 weeks from April to October 2016. Through a six-months survey, artificial substrates (glass slides) were horizontally placed on the bottom, 1 m beneath the water surface at one station (42°37'21"S; 18° 7'14"E) in the oligotrophic round shaped marine lake named Mrtvo more (Croatian: „Dead Sea“) situated on the southern part of the island of Lokrum near Dubrovnik (South Adriatic), Croatia. Every week another microscope slide was taken out and gently plunged into filtered seawater. Detail diatom analysis was performed on permanent slides of processed material (hydrogen peroxide treated) with Nikon E600 microscope at a magnification of 1000 x. In order to determine the relationships between diatom community and environmental variables, water samples for analysis of physicochemical variables were taken weekly from April to October of 2016 on the same place where diatom sampling was carried out.

## Results

Water temperature ranged from 18.3°C (May) to 27.3°C (July); salinity from 26.6 (October) to 37.0 (August);  $\text{O}_2/\text{O}_2'$  from 0.58 (September) to 1.3 (June); TIN from 0.96 (May) to 10.2 (September)  $\mu\text{M}$ ;  $\text{PO}_4^{3-}$  from 0.11 (May) to 0.58 (July); and  $\text{SiO}_4^{4-}$  from 3.923 (May) to 13.02 (July)  $\mu\text{M}$ . Decreased nutrient concentrations was noted during spring. From the end of June (coincidence with the beginning of swimming season in Mrtvo more for 2016) till the middle of July Mrtvo more had mesotrophic state, while from the end of July till middle of September, the Lake was eutrophic. The Mrtvo more hosts a diatom flora with high total species richness (286 diatom taxa belonging to 72 genera). An increase in species diversity index from middle of July was noted and the maximum occurred in August 2016 (Figs 1, 2).

## Discussion

The results of this study indicate the affinity of diatoms as a major fouling community to a studied artificial material and show the outcome of glass debris in the marine environment. Additionally, results reveal in particular diatom colonization rate of artificial substrate during the period of significant anthropogenic influence. Strong relationships between environmental variables and diatom assemblages were found and shifts in dominance at the species level were visible. Species within a genus *Cocconeis* clearly differ in their response to nutrient supply, leading to an altered community composition, which may be detected only if the species level is considered. Further studies are needed in order to verify this conclusion.

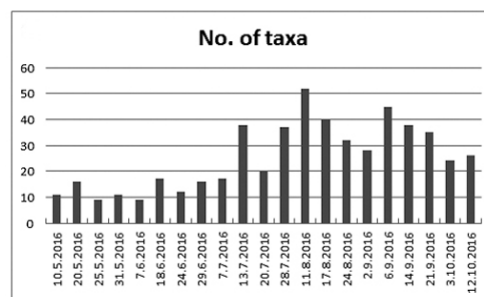


Fig. 1. Number of diatom taxa in the Mrtvo more in 2016.

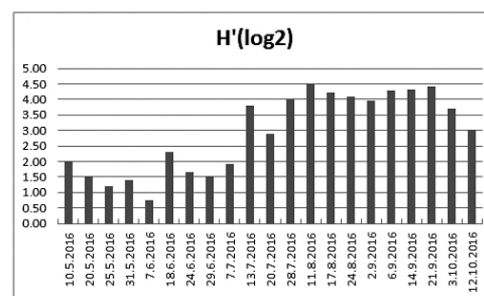


Fig. 2. Number of cells/cm<sup>2</sup> in the Mrtvo more in 2016.

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# DUST-BORNE MICROBES AFFECT ULVA'S (CHLOROPHYTA) EPIBIONTS AND PHYSIOLOGY

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## Abstract

*Ulva Ohnoi*, as many macroalgae, host a high diversity of epiphytic microbial symbionts. We investigated the role of airborne microbes delivered with Saharan dust on *U. Ohnoi* physiology. To this end, we experimentally examined *U. Ohnoi* growth rates, physiological state and characterized its microbial epibionts abundance, activity and diversity following dust (containing nutrients and airborne microorganisms) or UV-killed dust (only nutrients) amendments to filtered seawater. We show that viable airborne microbes can replace the Ulva's natural microbial epibionts communities, keeping the macroalgae alive and active. These results highlight the role of viable prokaryotes delivered with dust to marine life, especially in areas subjected to high annual dust deposition such as the Mediterranean Sea.

**Keywords:** *Atmospheric input, Eastern Mediterranean*

The macroalgae *Ulva Ohnoi* play a pivotal role in the ecology of coastal environments [1]. Recent studies, however, pointed that *U. Ohnoi* is in fact a holobiont comprised of macroalgae and epiphytic microbial symbionts in a tight association with one another. The physiology and activity of *U. Ohnoi* depend, to a great extent, on its bacterial epibionts [2]. Aerosols and dust are regularly transported across the oceans and were previously recognized as an important source of micro/macronutrients [3], as well as of viable airborne microbes [4]. In this study, we investigated the impact of desert dust, and particularly the impact of airborne microbes in the dust, on *U. Ohnoi*'s epibionts and physiology. Thus, we grew *U. Ohnoi* in sterile seawater (0.2 µm) either with or without its natural microbial epibionts (antibiotic-treated). Bottles were also supplemented with ~1.5 mg/L of Saharan dust (containing nutrients and airborne microorganisms) or UV-killed dust (only leaches nutrients) amendments [4], and the *U. Ohnoi* physiological state and the epibionts activity and diversity was recorded. Our results show that 1) *U. Ohnoi* was tightly associated with its microbial epibionts – once removed by antibiotics, the macroalgae did not grow and its photosynthesis was impaired (Figure 1A,B); and 2) Leached dust-borne microbes can replace the *U. Ohnoi* epibionts (Figure 1C,D), resulting in 'healthy' macroalgae-bacterial holobiont complex.

letters above the columns represent significant differences (one-way ANOVA and a Fisher LSD means comparison test,  $p < 0.05$ ) for mean values between additions.

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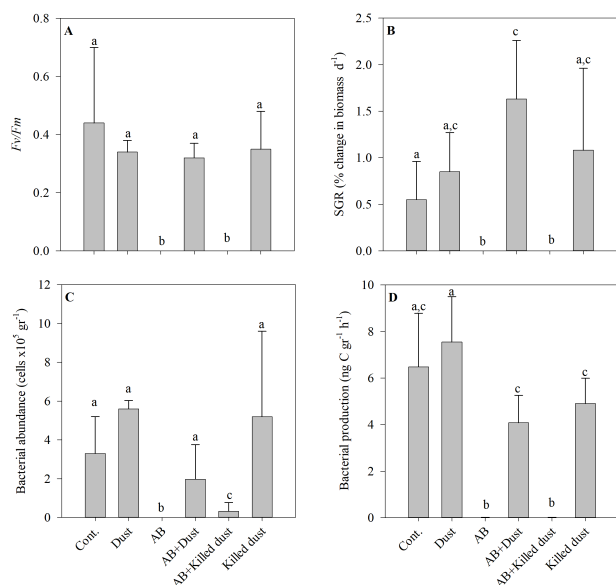


Fig. 1. *U. Ohnoi* specific growth rate (A), microbial epibionts abundance (B), *Fv/Fm* (C) and bacterial production (D) following the addition of dust; antibiotics (AB); AB+dust; AB+Killed dust; Killed dust; and unamended control. Results presented are the averages and standard deviation of 3 independent triplicates measured at the conclusion of the experiment. The

# MECHANISMS OF PHYTOPLANKTON SUCCESSION IN THE NE BLACK SEA

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## Abstract

In the NE Black Sea small diatoms prevail in the spring when nitrogen (N) and phosphorus (P) are abundant. *E. huxleyi* tends to dominate in late spring and early summer when N is scarce, with N:P lower than the Redfield ratio. Large diatoms dominate in summer and its prefer lower P concentrations and high N:P ratios. Domination of *E. huxleyi* was in the presence of SE winds, diatoms dominate when NE winds prevail.

**Keywords:** *Phytoplankton, Nutrients, Wind, Black Sea*

**Introduction.** The phytoplankton community structure undergoes annual cycles and is strongly determined by nutrients availability and stoichiometry. These variables are largely influenced by water movements (advection and vertical mixing), which depends on the intensity and direction of winds [1]. However, the processes controlling phytoplankton community structures are not fully understood. In this work, we used long-term data to investigate the mechanisms that regulate the shifts in dominance in the phytoplankton of the NE Black Sea.

**Materials and Methods.** Data collected in the northeastern Black Sea between 2002 to 2017 were used. Sampling, hydrophysical measurements, nutrient and phytoplankton analyses and statistical tests were conducted as described in [2]. We also conducted enrichment experiments according to the methods in [3].

**Results.** Small diatoms of the genera *Pseudo-nitzschia* mainly prevail in the spring; the coccolithophorid *Emiliania huxleyi* dominates in late spring and early summer; the large diatoms *Pseudosolenia calcar-avis* and *Proboscia alata* dominate in the summer and autumn. Small diatoms prevail when nutrients are abundant and the N:P ratio is close to the Redfield ratio. *E. huxleyi* blooms were observed when the thermocline is close to the surface and N concentration is low, with N:P and Si:N ratios, respectively, lower and higher than the Redfield ratio. Large diatoms dominate when the seasonal thermocline is deeper, P concentration is low and Si:P and N:P ratios are high (above the Redfield ratio). *E. huxleyi* maximum abundance occurs in the presence of SE winds, whereas diatom blooms are usually associated with the occurrence of NE winds. N and P enrichment of natural populations (bringing N:P close to the Redfield ratio) causes the increase of the abundance of small diatoms. The addition of P alone and therefore a decrease in the N:P ratio increases the *E. huxleyi* abundance [3].

**Discussion.** The following succession in the phytoplankton communities of the north-eastern Black Sea was observed in the 2002-2017 period: small diatoms (spring) → coccolithophores (late spring, early summer) → large diatoms (summer, autumn) (Fig 1). Such succession is the result of the concatenated effect of meteorology (especially winds and water temperature) and nutrient concentration on the abundance of phytoplankton species. Algal species differ for their mode of nutrient acquisition, growth response to nutrient availability, for their elemental stoichiometry and nutrient demands (Giordano 2013). It is therefore not surprising that the variations of dominant species follow the nutritional changes in the environment and their matching to the requirements of the different algae. The interaction of species and their ability to compete for a given resource, in a nutritional varying environment, then determines the final structure of the community.

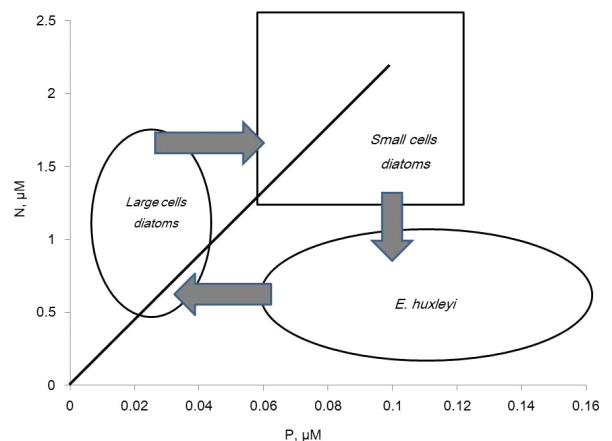


Fig. 1. Conceptual scheme of annual phytoplankton succession. The arrows indicate the main trajectory of phytoplankton succession. The solid line shows the Redfield ratio.

The effect of meteorological conditions, however, is not to be underestimated: it is the end of winter convective mixing that allows the spring bloom of diatoms. The onset of south-eastern winds and the increased irradiance in the late spring and early summer lead to the formation of sharp thermoclines, located close to the surface. In this condition, nitrogen becomes scarce in the upper mixed layer; this favors the development of *E. huxleyi* blooms. In the summer, the strengthening of the north-eastern winds leads to the deepening of the thermocline to nitrogen-rich water layers and to the promotion of large diatoms abundance. Our results allow us to predict the structure of phytoplankton in Northeastern Black Sea, under different nutrients conditions. Given the similarity of dominant phytoplankton groups in the Northeastern Black Sea with those of temperate and subarctic zones, our results may also be used to increase our comprehension of annual phytoplankton dynamics in these regions.

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## USING OCEAN COLOUR REMOTE SENSING TO IDENTIFY SUITABLE LOCATIONS FOR MARINE AQUACULTURE: THE PORTUGUESE MAINLAND COAST STUDY CASE

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### Abstract

Remote sensing has been increasingly applied to marine aquaculture in the past decade, allowing for multi-parameter synoptic, high-resolution and continuous data. Ocean colour remote sensing (OCRS), for instance, can be used, on the one hand, to warn aquaculture sites of the potential development of harmful algal blooms (HABs) or, on the other hand, to identify high-productivity zones for aquaculture site selection [1]. OCRS may also help by assessing phytoplankton bloom phenology (i.e. the annual cycle of phytoplankton biomass). By combining the information acquired from OCRS with local and regional physical data, OCRS can help to identify suitable zones for aquaculture, depending on the farmed species. This information can then be evaluated and, consequently, passed upon stakeholders, thus contributing to a more efficient and sustainable aquaculture.

The goal of this work is to assess the feasibility of using OCRS to identify suitable locations for marine aquaculture along a dynamic coast. In this work, the Portuguese coast will be used as a case study. 1998-2018 remote sensing chlorophyll a with a 1km spatial resolution data was acquired from ESA Ocean Colour Climate Change Initiative [2], as a proxy of phytoplankton biomass. The use of higher spatial resolution (300 m) data from recent ESA Sentinel-3 satellite is also explored. Phytoplankton biomass and bloom phenology will be used to identify the most productive coastal locations. Subsequently, the suitability of these locations will be assessed by using remote sensing and in situ data on several relevant variables for marine aquaculture, such as temperature, hydrodynamics and HABs incidence. Initial results from this work will be presented, discussed and compared with the actual spatial distribution of marine aquaculture sites in Portugal. The potential contribute of OCRS for marine aquaculture is also discussed.

*Keywords: Ocean colour remote sensing; Marine aquaculture; Portugal*

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**CIESM Congress Session : Blue biotechnology**  
**Moderator : Milton da Costa, Univ. of Coimbra, Portugal**

*Moderator's Synthesis*

Session 29 started with about 35 persons attending. None of the presentation went over the limit of 2 or 5 minutes. The talks were very well presented by all speakers and contained interesting information on several areas of research, ranging from work with bacteria to algae and fish.

The moderator started the discussion on the metabolism leading to the formation of butanol from bacteria grown on brown Sargassum waste with high output. The interesting work on marine oil pollution was also discussed with reference to the organism that is responsible for the process. The discussion of probiotic bacteria of the Nile Tilapia lead to a lively discussion of the species inhabiting these intestines that are active against fish pathogens. It seems that the authors have found some candidates that have probiotic activity.

The talk on the structural diversity of enterocin genes in *E. faecium* was also discussed at length. The poster on the utilization of emerging marine bioproducts, was general presentation of the variety of products that can be obtained in the near future; suggestions of additional products lead to a discussion among the participants. ?



# IN VITRO EVALUATION OF PROBIOTIC BACTERIA ISOLATED FROM NILE TILAPIA FISH INTESTINE AGAINST SOME FISH BACTERIAL PATHOGENS

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## Abstract

The intestine of fish is a complex ecosystem containing a wide variety of microorganisms. In the present study, the intestines of Nile Tilapia (*Oreochromis niloticus*) fish were screened for bacteria with probiotic properties. Characterization of the selected probiotic isolates includes Gram staining, catalase, hemolytic activity, pH, sodium chloride and bile salt tolerance and further molecular characterization using 16S rRNA gene sequencing. Evaluation of their probiotic activity against *Staphylococcus aureus* and *Vibrio cholera* were examined using well diffusion method. Based on the obtained results, MT2 which was confirmed by 16S rRNA gene sequencing to be *Lactobacillus sakei* is an ideal in-vitro probiotic candidate and require further in vivo experimental evaluation.

**Keywords:** *Aquaculture, Nile Delta*

Aquatic animals are exposed to severe conditions as a result of water quality deterioration. In recent decades, many studies evaluated the use of probiotic bacteria in the field of disease prevention and control (1) instead of using antibiotics which lead to arising of antibiotic-resistant bacteria and contaminating the aquaculture ecosystem (2,4). In this study, probiotic bacteria were screened from the intestine of Nile Tilapia (*Oreochromis niloticus*), fish, and candidate isolates were assessed for their bactericidal activity (1). Fifty-two bacterial isolates were recovered from the intestine of Nile Tilapia (*Oreochromis niloticus*) fish which were collected from Manzala Lake at Port-Saied Governorate in Egypt from October 2015 to September 2016. A total of 2 from 52 bacterial candidates denoted as (MT2 and MT3) were selected for further characterization of their probiotic activity (1, 3). The antibacterial activity of these isolates against *Staphylococcus aureus* and *Vibrio cholera* were examined using well diffusion method (1).

**Results** showed that cell-free supernatant (CFS) of the two bacterial candidates have good inhibitory activities against both pathogens. The MT1 isolate showed the highest inhibitory activity against *S. aureus* and *Vibrio cholera* (30.0 mm-mm) followed by MT2 and MT3 (28.0 mm- 22.0 mm), then (26.2 mm- 24.0 mm) respectively. While cell-free supernatant treated with (1N NaOH and 20.2 catalase enzyme) for all three candidates did not affect *Vibrio cholera*. All two isolates were tolerant to acid, bile salt and NaCl in different concentrations. 16S rRNA gene sequences confirmed that MT2 was *Lactobacillus sakei* while both MT3 were *Staphylococcus hominis* as shown in figure 1 and 2.

**In conclusion**, two candidate probiotic bacteria (MT2, MT3) were assessed for their antibacterial activity. MT2 exhibited the best probiotic potentials where its antibacterial activity was as a result of being a bacteriocin-producing bacterium.

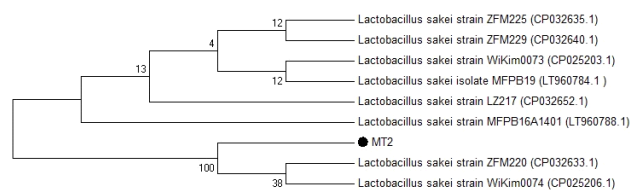


Fig. 1. Neighbor-joining phylogenetic tree based on 16S rRNA sequences showing the position of MT2 isolate. Number of nodes of levels of bootstrap support (%) from a 1,000 record resample dataset, bar 0.0001% expected nucleotide substitution per position

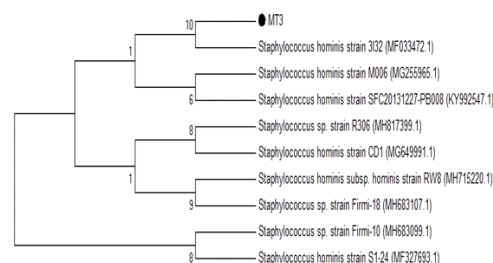


Fig. 2. Neighbor-joining phylogenetic tree based on 16S rRNA sequences showing the position of MT3 isolates. Number of nodes of levels of bootstrap support (%) from a 1,000 record resample dataset, bar 0.0001% expected nucleotide substitution per position

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# PHYLOGENETIC DIVERSITY OF THE STRUCTURAL ENTEROCIN GENES IN *E. FAECIUM* OF MARINE FARMED FISH

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## Abstract

Bioactive *Enterococci* species have been previously isolated and characterized from both farmed fish intestinal content and skin of marine waters farmed fish in Tunisia for sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*) and *E. faecium* represent the most identified species. In present study we highlighted the presence of one or more enterocin structural gene(s) in the whole bioactive isolates of *E. faecium* species identified. The structural gene of enterocin B was the most frequently occurring gene in the isolates of *E. faecium*, harbored more than two types of enterocine genes.

**Keywords:** *Bacteria, Aquaculture, Gulf of Tunis*

## Introduction

The use of probiotics in human and animal nutrition still with high interest as alternative to extensive use of antibiotic and drugs to control pathogens and enterococcal bacteriocins, or enterocins, have been widely investigated for their bioactivity against food-borne pathogens in field of fish farming [1].

## Materials and Methods

The *E. faecium* bioactive Lactic acid bacteria were isolated from fresh fish: Gilthead sea bream (*Sparus aurata*) and European sea bass (*Dicentrarchus labrax*). The identification of the isolated strains by genetic tools was obtained by sequencing 16S rDNA. Potential producer strains were screened against a range of indicators pathogenic strains (39 strains). Detection of bacteriocin activity in enterococci strains was initially screened by means of a standardized agar disk diffusion method. The detection of known enterocin gene was performed by PCR using the primers for EntA, EntB, EntL50, EntP previously described by [2] EntP2, EntQ, EntL50 [3] ORF [4], AS-48 [5] and Mun1 [6] targeting the class II enterocins produced by enterococci, namely: enterocin A, enterocin B, enterocin L50, enterocin P, enterocin Q, enterocin L50, mundticin KS, enterocin AS-48 and enterocin CRL35.

## Results and discussion

The genes of enterocin B were the most frequently detected structural genes among the PCR positive strains (25 strains) and secondly the structural gene of enterocin P, represented by entP, entP2, entP1P2 and entP1P3 genes (Table 1). The combination of two different enterocins was the most commonly frequent (twenty strains). Whereas three different enterocins were detected in seven of the *E. faecium* tested and the combination of enterocin A and B are the most commonly detected in all *E. faecium* strains. In conclusion, a high-frequency and variability of enterocin structural genes exists among *E. faecium* bioactive isolated from farmed fish origin what offers a big possibility to find effective bacteriocin-producing strains for their application in aquaculture and/or biopreservation of fish products.

Tab. 1. Genes encoding bacteriocins detected in the *E. faecium* isolates.

| Bacteriocin genes detected | Number of isolates for each gene |
|----------------------------|----------------------------------|
| Ent B                      | 4 strains of <i>E. faecium</i>   |
| Ent P                      | 1 strain of <i>E. faecium</i>    |
| Ent L50                    | 3 strains of <i>E. faecium</i>   |
| Ent B / A                  | 7 strains of <i>E. faecium</i>   |
| Ent B / P                  | 3 strains of <i>E. faecium</i>   |
| Ent L50 / P                | 4 strains of <i>E. faecium</i>   |
| Ent B / L50 / P            | 2 strains of <i>E. faecium</i>   |
| Ent B / A / P              | 5 strains of <i>E. faecium</i>   |

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# ENHANCEMENT OF THE BIODEGRADATION OF HIGH MOLECULAR WEIGHT POLYAROMATIC HYDROCARBONS BY NANO-MAGNETIZED HALOTOLERANT BACTERIA

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## Abstract

Microbial cells of halotolerant Gram +ve *Micrococcus lutes* Sh1 were coated by magnetic MFe<sub>3</sub>O<sub>4</sub> nanoparticles (MNPs) that have reasonable adsorption capacity towards pyrene (Pyr) (7.66  $\mu$ mole/g). The transmission electron microscope (TEM) analysis showed that the MNPs were efficiently assembled and adsorbed on the bacterial cells. The coated cells not only showed higher biodegradation capabilities towards Pyr, but could be also reused for four successive cycles, characterized by high storage and operational stabilities and have the advantage of magnetic separation.

**Keywords:** *Petroleum, Pollution, Bacteria, Biotechnologies, Mediterranean Sea*

**Introduction:** Because of the hydrophobicity and low water solubility of the recalcitrant and persistent; carcinogenic, teratogenic, mutagenic and toxic high molecular weight polycyclic aromatic hydrocarbons (HMwt. PAHs), they pose serious risks to the marine environment. They bind tightly to suspended particles, accumulate in sediments and become concentrated in marine food webs. Consequently, affect the marine ecosystem for a long period and negatively impact the marine algae, which are consumed by higher trophic organisms [1]. Biodegradation can be safely applied to remediate polluted marine ecosystem. However, the major drawbacks of bioremediation are not only being a lengthy process, but the microbial stability, reusability and separation after the process completion are also drawbacks that should be solved [2]. This work aims to solve these problems by applying the large surface to volume ratio and low toxic MFe<sub>3</sub>O<sub>4</sub> NPs.

**Experimental work:** The previously prepared MFe<sub>3</sub>O<sub>4</sub>NPs [3] were used to decorate a halotolerant Gram +ve *Micrococcus lutes* Sh1 isolated from Egyptian Mediterranean polluted sea water (183 mg/L total petroleum hydrocarbons content, BOD  $\approx$  312 mg/L and COD  $\approx$  1,901 mg/L). A comparative kinetic study was performed to follow up the biodegradation (BD) of 1000 mg/L Pyr in batch aqueous systems over a period of 10 days at room temperature and 150 rpm, using free and coated cells. High Performance Liquid Chromatography (HPLC) and Gas Chromatography-Mass Spectroscopy (GC-MS) were applied for quantitatively estimate Pyr-BD and primarily elucidate Pyr-BD pathway, respectively.

**Results and discussion:** The Pyr-BD pathway involved phenanthrene, naphthalene and *o*-phthalate metabolic pathways. Whereas, it was initiated by dioxygenation at the C4 and C5 positions (K region) producing: pyrene-*cis*-4,5-dihydrodiol, re-aromatized to form 4,5-dihydroxy-pyrene by dihydrodiol dehydrogenase. That was subsequently cleaved to phenanthrene-4,5-dicarboxylic acid by intradiol dioxygenase. Then loss of a carboxyl group by decarboxylase occurred producing 4-phenanthroic acid. That was oxidized by ring-hydroxylating dioxygenase producing 3,4-phenanthrene dihydrodiol-4-carboxylic acid. Then further transformed to 3,4-dihydroxyphenanthrene by dehydrogenase/decarboxylase. Which was metabolized to 1-hydroxy-2-naphthoic acid. That was further mineralized through two different pathways. The 1<sup>st</sup>; 1-hydroxy-2-naphthoic acid was oxidized to 1,2-dihydroxy naphthalene, then metabolized to salicylic acid. The 2<sup>nd</sup>; ring cleavage of 1-hydroxy-2-naphthoic acid occurred and furtherly metabolized to 2-*o*-phthalic acid and 3,4-dihydroxybenzoic acid. In both catechol was further produced which was degraded via the *ortho*-cleaving enzyme; catechol-1,2-dioxygenase to *cis,cis*-muconic acid then 3-oxoadipate which would enter into the bacterial TCA cycle. Because of the large specific surface area of the prepared MNPs ( $\approx$ 110.5 m<sup>2</sup>/g), good pore size 3.2 nm, pore volume 0.198 cm<sup>3</sup>/g, high surface energy and low average particle size 5-8 nm, they showed reasonable adsorption capacity towards Pyr (7.66  $\mu$ mole/g) via  $\pi$  complexation bonding and were efficiently assembled on the surface of the bacterial cell of average size (1.08  $\mu$ m) (Figure 1a). They were not washed out and due to their superparamagnetic properties (Ms 16 emu/g), the MFe<sub>3</sub>O<sub>4</sub>-coated cells were easily separated by an external magnetic field (Figure 1b), recycled and reused for four successive cycles without losing its BD-efficiency. The MNPs expressed non-toxic effect on Sh1. Approximately complete removal of Pyr was achieved and the initial Pyr-BD rate was doubled using coated cells ( $r = 12.5$  mg/L/h). The batch Pyr-BD process followed first order kinetic ( $R^2 > 0.92$ ), with rate constant ( $k =$

0.837 and 0.609 d<sup>-1</sup>) and half-life ( $t_{1/2} = 19$  and 27 h) for coated and free cells, respectively. The coated cells could be stored for 30 days at 4°C without losing its Pyr-BD activity. Not only this, but it could be also used over 960 h without losing its Pyr-BD efficiency. While the free cells could be used only once, lost half of its activity after storage for 30 days at 4°C and could be only separated by centrifugation or filtration. The overall operating and capital cost of immobilized cell-system were estimated to be lowered by 18 and 7 %, respectively.

**Conclusions:** Applying a magnetized-nano-biocatalyst for the bioremediation of polluted seawater is very promising in batch and continuous processes. It has the advantages of magnetic separation, easy recovery, high storage and operational stabilities. It can be reused for successive times, overcome the toxicity and inhibition effects of the byproducts, appears not to experience a mass transfer problem, and increases the rate of biodegradation of the recalcitrant high molecular weight PAHs, with relatively lower overall operating and capital cost than that of the free-microbial system.

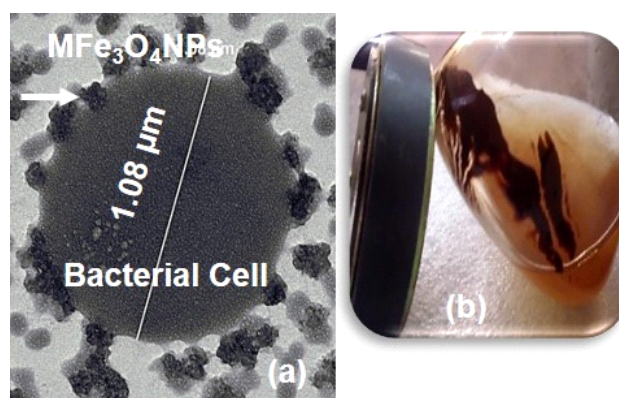


Fig. 1. (a) TEM image of MFe<sub>3</sub>O<sub>4</sub> NPs coated bacterial cell (b) Separation of nano-magnetized bacteria by application of external magnetic field.

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# BIOBUTANOL PRODUCTION FROM THE BROWN MACROALGAE *SARGASSUM* SP.

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## Abstract

Macroalgae, an abundant and carbon-neutral renewable resource, with several species rich in carbohydrates are suitable for biobutanol production. Biobutanol has recently emerged as a potential alternative liquid fuel for gasoline and diesel due to its advantages. In this study the brown macroalgae (*Sargassum* sp.) was used as carbon source for biobutanol production. Acid hydrolysis is the most common method to release out sugars from substrates. So, sulfuric acid (6 % (v/v)) is used in this study followed by thermal pretreatment at 121°C for 20 minutes using 90 g/L of hydrolyzed (*Sargassum* sp.). The resulting sugars (33.46 g/L) were further fermented anaerobically by bacterial isolate (*Clostridium* sp.HC-11)) producing biobutanol of 17g/L equivalent to 0.20g/g macroalgae.

**Keywords:** *Algae, Red Sea*

## Introduction

Butanol is considered a promising renewable energy source and a future biofuel having potential to replace gasoline. Butanol has more advantageous fuel properties than ethanol such as, higher energy content, less sensitivity to temperature, less corrosivity and the absence of any required modification in combustion engine [1]. Recently, macroalgae is considered as suitable substrate for biofuel production. This is because macroalgae have fast growth rates with up to 4–6 harvest cycles per year, can be grown in the sea thus eliminating issues relating to land use and irrigation water. Furthermore, macroalgae is preferable to microalgae (also a third generation biofuel feedstock) for biofuel production because its plant-like characteristics make it easier to harvest, and its high concentration of carbohydrates more than microalgae which make it a potentially better biofuel production feedstock. Since macroalgae are composed of a mix of different sugars, these organisms are expected to efficiently convert most sugars into an ABE mixture [2]. The conversion of hydrolysed sugars released from macroalgae to acetone, butanol and ethanol (ABE) was carried out through anaerobic fermentation process by using different species of *Clostridium* bacteria.

## Materials and methods

**Collection and pre-treatment of substrate.** The substrate selected in this study was brown macroalgae (*Sargassum* sp.) collected from Red sea in Hurgadaa Egypt. *Sargassum* sp. was washed with running water to remove salts and undesired materials, air-dried, then chipped and sieved to constant size (0.8-1 mm). The grinded substrate was stored in clean plastic containers at room temperature until analysis and treatment were performed. Hemicellulose, cellulose, and lignin concentrations in the collected substrate were determined in Agricultural Research Center, Giza, Egypt, according to method reported by [3]. Total reducing sugars were determined by 3, 5-dinitro salicylic acid DNS method and glucose was used as standard. The samples were stored at -18° C until analysis was performed.

**Chemical hydrolysis of *Sargassum* sp.** Different substrate concentrations (10-100 grams) of *Sargassum* sp. were put into 2500 ml Erlenmeyer flask with 1000 ml of sulfuric acid at different concentrations (1-10% v/v). The flasks were autoclaved at 121°C for 20 min then the flasks were filtrated. The concentration of reducing sugars in supernatant was determined to obtain the optimum substrate and acid concentrations using the high performance liquid chromatography (HPLC).

## Results and discussion

**1-Effect of different acid concentrations on hydrolysis.** The acid concentrations have significant effect on total reducing sugars. The H ion concentration is an important factor for reducing sugars formation, because protons in acid molecule will participate in decomposition reaction as a catalyst. The dilute sulphuric acid 6% can efficiently improve hydrolyze hemicelluloses into monomer sugars (arabinose, glucose, xylose, etc.) and soluble oligomers [4]. Increasing the acid concentrations greater than 6% have no effect on the amount of total reducing sugars obtained this is in agreement [5] who studied the effect of acid concentration from (1-5% v/v).

**2- Effect of different substrate concentrations on hydrolysis.** Different substrate concentrations of *Sargassum* sp. were used from (10 to 100 grams). It was found that 90 g/ L of substrate was the optimum concentration which released the maximum total reducing sugars. These in agreement with [6] who found that the acid could not hydrolyse the substrate efficiently at high concentration.

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Fig. 1. Preparation of wild microalgae.

# ESTIMATION OF THE *MYTILUS GALLOPROVINCIALIS* (LAMARCK, 1819) QUALITY FROM THE ROMANIAN BLACK SEA COAST FOR PHARMACEUTICAL PURPOSE

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## Abstract

The purpose of this research was to determine the biochemical composition and some contaminants such as: heavy metals, organochlorine pesticides (OCPs) content and microbiological indicators in mussel, *Mytilus galloprovincialis* (Lamarck, 1819) from the Romanian Black Sea coast in the aim to assess its quality for pharmaceutical (cosmeceutics) industry. This important bio resource is currently used in Romania only for human food.

**Keywords:** *Black Sea, Bivalves, Biotechnologies*

## Introduction

Bivalve, *M. galloprovincialis* is considered one of the most characteristic and important benthic invertebrates of the Black Sea [1], being a source of food for benthic fish, a natural resource for human nutrition and raw material for obtaining biologically active substances by biotechnology [2]. The study of its quality (condition) is particularly important both for its health and potential users (consumers).

Mussel samples were collected from the Southern part area of the Romanian Black Sea coast, Vama Veche, in August 2018. This station is considered to be an area less affected by pollution and anthropogenic impact being an marine protected area.

## Materials and Methods

The biochemical composition was analyzed using a UV-VIS Analytic Jena specord according to "Les notes techniques de l'URAPC"- NT/URAPC/ 96-01-02-03, IFREMER, 1996 [3].

The heavy metals were analyzed using graphite furnace-atomic absorption spectrometers, type SOLAAR M6 Dual Thermo Electron-UNICAM.

The analytical determination of the OCPs content were made by the gas-chromatographic method with a Perkin Elmer gas chromatograph CLARUS 500, equipped with electron capture detector.

The microbiological aspects were assessed by "most probable number" (MPN) method which was used to analyze the concentrations of total coliforms (TC), *Escherichia coli*, and enterococci (FS).

## Results and Discussions

From the biochemical point of view, the following parameters were investigated: dry weight (DW:18.56%), moisture (81.44%), organic substance (17.52% DW), ash-mineral substance (1.04% DW), water-soluble proteins (54.14% DW), total carbohydrates (20.91% DW), total lipids (10.24 % DW).

The high content of organic components, especially proteins, confirms the high nutritional value and the use in obtaining biologically active substances with subsequent practical applications (marine biotechnology, cosmeceutic products).

Mussels are a real source of fatty acids [4], amino acids [5] and collagen [6] which are important compounds for obtaining of the cosmeceutics from marine origin.

Concentrations of heavy metals in *M. galloprovincialis* were within the range of normal variation and decreased in the order of: Cu (10.19 µg/g DW) > Cd (3.02 µg/g DW) > Ni (2.04 µg/g DW) > Cr (0.67 µg/g DW) > Pb (0.31 µg/g DW). Although the cadmium concentration it slightly increased, it does not exceed the maximum allowable limit for human consumption (EC 1881/2006). Also, the lead concentration measured in mussels is well below the maximum allowable limit.

Concentrations of organochlorine pesticides (OCPs) varied between the detection limit and 1.9111 µg/g DW: HCB 0.0164 µg/g DW, Lindane 0.0004 µg/g DW, Heptachlor 0.0411 µg/g DW, Aldrin 0.0129 µg/g DW, p,p'DDE 0.0002 µg/g DW, Dieldrin 0.0003 µg/g DW, Endrin 0.4441 µg/g DW, p,p'DDD 0.0686 µg/g DW, p,p'DDT 1.9111 µg/g DW. Some of OCPs (p,p' DDE, p,p'DDD, p,p' DDT) levels are higher than maximum admissible level for human consumption.

The determined organochlorine pesticide values have generally been within

the range of values and can significantly depend on the age and/or condition of the organisms [7].

The microbiological quality (total coliforms TC, *E. coli*, and enterococci FS) of *M. galloprovincialis* has been assessed in the light of national and European quality standards for mollusc waters (Council Directive 2006/113/EC transposed by GD 201/2002). The level of bacterial indicator concentrations recorded in the meat of these molluscs of commercial interest on the Romanian Black Sea coast during August 2018 was below the norms accepted (<300 CF/100 g) ranging from 0 to 100 MPN/100 g.

## Conclusions

1. Values of the most pollution indicators have indicated an appropriate quality of *M. galloprovincialis* in terms of pollution for human consumption and pharmaceutical (cosmeceutics) use.

2. The biochemical parameters show a high content in proteins and it confirm the mussels valorizations for pharmaceutical (cosmeceutics) industry.

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## EMERGING MARINE BIOPRODUCTS AND BLUE BIOTECHNOLOGY: EXPLORING THE POTENTIAL OF MARINE INVERTEBRATES

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### Abstract

The European Blue Growth agenda, of Marine Biotechnology is keystone, aims at merging the scientific and industrial communities to generate health and welfare from the sustainable exploitation of marine resources. Not surprisingly, the oceans' immense biodiversity offers a range of novel solutions that expand beyond biomaterials and foodstuff well into drug discovery for the production of cost-effective and safe pharmaceuticals, pesticides and many other applications. Such biodiversity carries, nonetheless, as many challenges as it offers assets. Consequently, there is a growing need to turn the discovery of novel bioactive compounds from marine organisms from random to systematic. At the SeaTox Lab, we aim at developing frontier multidisciplinary approaches aiming at bioproduct discovery, especially from marine invertebrates, which stand as the most diversified animal group on our planet, albeit still little explored. Specifically, we take marine Polychaeta as major, and most promising, case-study for the discovery of novel biomaterials and bioactive compounds with biotechnological potential, such as toxins, photoactive pigments and mucins, to quote a few [1,2]. Our strategy combines traditional ecology, systematics and toxicology with state-of-the-art molecular biology and bioinformatics, with the objectives of: i) understanding the evolutionary ecology of venom-producing marine invertebrates to locate new species of interest along the animal tree of life, ii) identifying and characterizing new bioproducts and devise potential applications; iii) discover safe and eco-friendly processes to harvest, purify and synthesize new compounds of interest, and iv) understand how these compounds interact with human health. Ultimately, the information provided will assist the development of an industry-directed database of Portuguese marine bioactives, which will now only transfer knowledge from science to stakeholders but also raise awareness to the importance of preserving our unique biodiversity resulting from the Atlantic-Mediterranean confluence.

*Keywords: drug discovery; marine bioactives; Portuguese coast*

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## COMITÉ 5

### **Ressources vivantes et écosystèmes marins**

*Co-Présidents* : Jamila Ben Souissi, Salud Deudero  
et Natalya Milchakova



## **CIESM Congress Session : Bioinvasions / Biogeography**

**Moderator : João Canning Clode, MARE, Madeira, Portugal**

### *Moderator's Synthesis*

The main goal of this session was to identify common ground in the interplay between biological invasions and biogeography both at the Mediterranean and Northeastern Atlantic and promote future synergies focusing in these two biogeographical regions.

At first, a bioinvasion perspective from island ecosystems was presented, particularly the Macaronesia region which is composed by the archipelagos of Azores, Madeira, Canary Islands and Cape Verde. Shipping has been identified as the major vector for introducing non-indigenous species (NIS) at a global scale, and Macaronesia is no exception. However, other emerging vectors have been responsible for introducing NIS worldwide and in recent years particular attention has been given to marine debris in Madeira islands.

The session proceeded with several new NIS records being reported for the Mediterranean including the wood borer *Limnoria tripunctata* and the foraminifera *Amphistegina lobifera* as well as a general overview of exotic fishes in the region. Interestingly, the last oral communication of the session covered an often-overlooked long-distance dispersal and bioinvasion vector: live passage through digestive tracts of animals, particularly ichthyochory (fish gut passage). The session ended with two poster presentations, the first focused on experimental stress trials with the scyphozoan *Aurelia solida* while the second reported the first arrival of the marine brachyuran crab *Pyromaia tuberculata* in Europe, with a first detection in the Tagus estuary, Portugal.

These excellent six communications provided background information for a vivid discussion, namely the need for a more consistent and standard terminology in invasion science. Finally, most bioinvasions and biogeography assessments at a European scale are based on literature research. There is an urgent need to conduct standardized field surveys in European seas to investigate large scale patterns of biological invasions in marine ecosystems in this region. The CIESM community could play here a key role as a platform to initiate this debate.



# FIRST RECORD OF THE WOOD BORER *LIMNORIA TRIPUNCTATA* MENZIES 1951, IN THE EGYPTIAN MEDITERRANEAN SEA

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## Abstract

It is the first record of the wood borer isopod *Limnoria tripunctata* Menzies 1951 (Crustacea, Limnoriidae) in the Egyptian Mediterranean Sea. On October, 2018; samples were collected from wooden structures of a fishing boat working in the Eastern harbour of Alexandria, Egypt. A total number of  $44.5 \times 10^6$  isopods/cubic meter of wood was estimated. Remarks on the recorded species are provided.

**Keywords:** *Crustacea, Coastal waters, Levantine Basin, Gibraltar Strait*

## Introduction

Limnoriidae is isopodan family which feed on plant material, wood and seaweed, into which they bore. Members of this family could tunnel inside wood, and utilize it as the main carbon source by digesting lignocellulose [1, 2] causing huge destruction to the wooden structures. Damage of wooden man-made structures is well considered and documented [3]. In Egypt, species of wood-boring isopods (*Limnoria lignorum* & *Sphaeroma serratum*) were recorded from Port Said Harbour [4].

## Material and methods

On 21<sup>st</sup> of October 2018, a wooden structure of a fishing boat working in the Eastern harbour of Alexandria, Egypt, was examined for wood borers. A random sample of wood (8 cm<sup>3</sup>) was inspected to identify the borer [1, 5] and the extent of the infection.

## Results & discussion

A total of 356 individuals of *Limnoria tripunctata* (Fig. 1B) were sorted from tunnels of infected wood (Fig.1A). Table 1 demonstrates the categories, the number of individuals, the length range, and the wet weight. This species is characterized by the proximal area of pleotelson in dorsal surface, with a single median tubercle followed distally by a pair of tubercles (fig.2B); maxilliped with triangulate epipod; moreover, second antenna with flagellum having five articles. In 1999, only one individual of this species was recorded among fouling community in the Eastern Harbour of Alexandria [6]. However, the present record is the first as wood borer in Egypt. *Limnoria tripunctata* can be distinguished by the three small tubercles of pleotelson while the pleotelson of *L. lignorum* (Rathke) lacks tubercles and has an anteriorly situated middorsal longitudinal carina that bifurcates posteriorly [1].

The type locality of *Limnoria tripunctata* was from San Diego County, Mission Bay, California [1]. Now its distribution area includes: Atlantic Ocean [7], Mediterranean Sea including Italian [8], Libyan [9], Egyptian [present investigation], as well as Aegean and Levantine Sea coasts of Turkey [10], which indicates that the Strait of Gibraltar is its main route to enter the Mediterranean Sea. However, the present record would confirm the rapid expansion of the species in the Mediterranean basin and its spread eastwards. Moreover, it is important to monitor the distribution and destructive activity of this organism in the Egyptian waters.

Tab. 1. *Limnoria tripunctata* extracted from a random (8 cm<sup>3</sup>) piece of wood.

| Categories       | No. of indiv. | Length range | Wet weight (gm) |
|------------------|---------------|--------------|-----------------|
| Ovigerous female | 34            | 2.8-4.1 mm   | 0.0273          |
| Mature           | 141           | 2.6-3.6 mm   | 0.068           |
| Immature         | 181           | 0.8-2.5 mm   | 0.0159          |
| Total            | 356           |              | 0.1112          |

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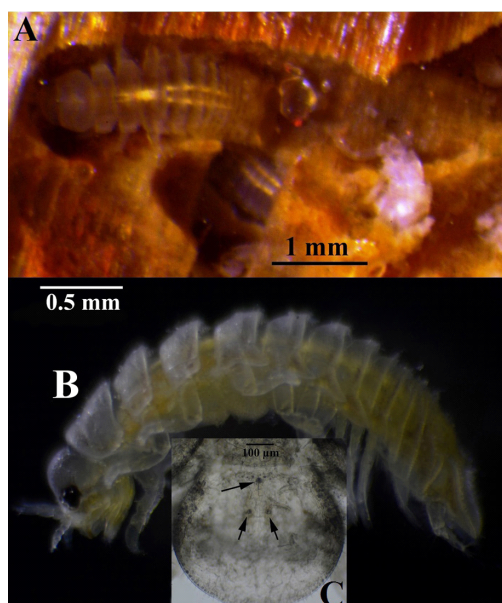


Fig. 1. Tunnels of *L. tripunctata* inside boat's wood (A), *L. tripunctata* (B), and the three tubercles of pleotelson (C).

# CIESM ATLAS OF EXOTIC FISHES INTO THE MEDITERRANEAN — 2019 UPDATE

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## Abstract

The phenomenon of fish invasion into the Mediterranean is continuing with no sign of ceasing. This contribution of CIESM Atlas on Exotic Fishes in the Mediterranean presents new data acquired since our 2016 update which is currently visible on CIESM website.

**Keywords:** *NIS, Invasive species, Fishes, Erythrean species, Mediterranean Sea*

Eleven species were recorded for the first time in the Mediterranean (Table 1a) during the last three years. This high number is due to increased reporting of information received from fishers or ordinary citizens, cooperating with scientists. Many established exotic species expanded their distribution range in the Mediterranean. For eight of these species, this extension has been very wide during the last three years (Table 1b). In this period, several reports of allegedly records of new exotic fish species in the Mediterranean were based on misidentifications; others on unsubstantiated sources (Table 2).

Tab. 1. a) Exotic fish species first recorded in the Mediterranean in last three years; b) Exotic fish species that extended significantly their distribution in the Mediterranean since 2016.

a)

| Species                                              | Source       | Year published record |
|------------------------------------------------------|--------------|-----------------------|
| <i>Ablennes hians</i> (Valenciennes, 1846)           | Indo-Pacific | 2019                  |
| <i>Holacanthus africanus</i> Cadenat, 1951           | Atlantic     | 2017                  |
| <i>Priacanthus prolixus</i> Starnes, 1988            | Indo-Pacific | 2017                  |
| <i>Dipterygonotus balteatus</i> (Valenciennes, 1830) | Indo-Pacific | 2018                  |
| <i>Dentex canariensis</i> Steindachner, 1881         | Atlantic     | 2017                  |
| <i>Abudefduf sexfasciatus</i> (Lacépède, 1801)       | Indo-Pacific | 2018                  |
| <i>Chrysiptera hemicyanea</i> (Weber, 1913)          | Aquarium     | 2018                  |
| <i>Chaetodon auriga</i> Forsskål, 1775               | Aquarium     | 2018                  |
| <i>Chlorurus rhakoura</i> Randall & Anderson, 1997   | Shipping     | 2017                  |
| <i>Acanthurus sohal</i> Forsskål, 1775               | Aquarium     | 2018                  |
| <i>Paracanthus hepatus</i> (Linnaeus, 1766)          | Aquarium     | 2017                  |

b)

| Species                                                   | New subregion                |
|-----------------------------------------------------------|------------------------------|
| <i>Etrumeus golanii</i> DiBattista, Randall & Bowen, 2013 | W Mediterranean              |
| <i>Bregmamaceros nectabanus</i> Whitley, 1941             | Levantine Sea                |
| <i>Fistularia petimba</i> Lacépède, 1803                  | Levantine Sea                |
| <i>Pterois miles</i> (Bennett, 1828)                      | Strait of Sicily, Ionian Sea |
| <i>Upeneus pori</i> Ben-Tuvia & Golani, 1989              | Strait of Sicily             |
| <i>Lagocephalus sceleratus</i> (Gmelin, 1789)             | W Mediterranean, Adriatic    |
| <i>Lagocephalus suezensis</i> Clark & Gohar, 1953         | Gulf of Sirte                |
| <i>Siganus luridus</i> (Rüppell, 1828)                    | Strait of Sicily, Adriatic   |
| <i>Siganus rivulatus</i> Forsskål, 1775                   | Strait of Sicily             |
| <i>Cyclichthys spilostylus</i> (Lies & Randall, 1982)     | Levantine Sea                |

The CIESM Atlas of Exotic Fishes was published in 2002, as a hard-copy book [1] and a year later as an online version. Both original versions included 90 species recognized as exotic in the Mediterranean. The online version has been updated periodically with new species [2] and this information has been presented at successive CIESM congresses [3-7]. The influx of new fish species into the Mediterranean and the widening of their distribution range have been consistent, and even accelerated, during this period. A second edition of the Atlas is in the final stage of writing. It will map and document the arrival of new species and update all others. This new edition of the CIESM Atlas of Exotic Fishes will be published in late 2019 or early 2020.

Tab. 2. Correction of misidentified exotic fish species in the Mediterranean since 2016.

| Species                                                | Remarks                                                    |
|--------------------------------------------------------|------------------------------------------------------------|
| <i>Himantura leopard</i> Manjaji-Matsumoto & Last 2008 | Possible misidentification of <i>H. uarnak</i>             |
| <i>Hydrolagus mirabilis</i> (Collet, 1904)             | Possible misidentification of <i>Chimaera monstrosa</i>    |
| <i>Encrasicholina punctifer</i> (Fowler, 1938)         | Misidentification of <i>E. gloria</i>                      |
| <i>Pterois volitans</i> (Linnaeus, 1758)               | Possible misidentification of <i>P. miles</i>              |
| <i>Trachurus delclivis</i> (Jenys, 1841)               | Misidentification of <i>Xanthochromis</i> sp.              |
| <i>Leiognathus berbis</i> Valenciennes, 1835           | Possible misidentification of <i>Equulites klunzingeri</i> |
| <i>Caesio varilineata</i> Carpenter, 1987              | The source of specimens is questionable                    |
| <i>Argyrops filamentosus</i> (Valenciennes, 1830)      | Possible misidentification of Med. indigenous sparid       |
| <i>Pomacanthus asfur</i> (Forsskål, 1775)              | Misidentification of <i>P. maculosus</i>                   |
| <i>Siganus virgatus</i> (Valenciennes, 1835)           | Questionable source                                        |

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# A 70-YEAR LONG LESSEPSIAN COLONIZATION: THE CONQUEST OF MALTA BY *AMPHISTEGINA LOBIFERA*

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## Abstract

The highly invasive *Amphistegina lobifera* (Larsen, 1976), a non-indigenous benthic foraminifera coming from the Red Sea through the Suez Canal, has colonized the Eastern Mediterranean during the last decades and in 2006 it was recorded for the first time from the Maltese Islands (Central Mediterranean). Here, we report new data from a sediment core collected in May 2018 near the northern coast of Malta. Results show that *A. lobifera* reached Malta between 1950 and 1955; then it progressively increased in abundance with time, probably favoured by the rising of Mediterranean SST during the last 40 years.

**Keywords:** Alien species, Foraminifera, Lessepsian migrants, Mediterranean Sea

## Introduction

The Indo-Pacific foraminifera *Amphistegina lobifera* was observed for the first time in the Maltese Islands in 2006 [1]. However, its real first occurrence in the area is still unknown. This study aims to date the first occurrence of *A. lobifera* in Malta through a <sup>210</sup>Pb-dated sediment core. Additionally, the history of its invasion is also reconstructed, taking into account the SST trends reported from the western Mediterranean region.

## Material and Methods

On 8<sup>th</sup> May 2018, one sediment core was collected at 16 m depth in Marsamxett Harbour, Malta (Lat. 35°54'16.7''N; Long. 14°30'27.5''E). The core, 41 cm long and mostly composed of fine-grained sediments, was longitudinally sectioned in two halves and then crosscut into 41 samples, each of them being 1 cm thick. Samples were prepared for both micropaleontological and radiometric analyses (<sup>210</sup>Pb decay). Sediment samples were dried, weighed (about 7 grams) and then washed on a 63 mm sieve. Washed residues were analysed at the stereomicroscope, in order to calculate, along the core record, the absolute abundance of *A. lobifera* as number of individuals recorded per gram of dry sediment (N g<sup>-1</sup>). <sup>210</sup>Pb activity (t<sub>1/2</sub> = 22.3 years) was measured via alpha counting of its daughter isotope <sup>210</sup>Po, assuming secular equilibrium between the two isotopes. Sedimentation rates for the last decades were calculated based on the decreasing concentration of excess <sup>210</sup>Pb, following the Constant Flux – Constant Sedimentation model [2].

## Results and Discussion

*Amphistegina lobifera* is continuously present from cm 0-1 below the sea floor (bsf) to cm 14-15 bsf, with a characteristic decreasing abundance trend going back in time (Fig. 1). It is highly abundant (from 3.95 to 1.11 N g<sup>-1</sup>) in the upper part of the core down to cm 6-7 bsf, and then it abruptly decreases in abundance down to cm 14-15 bsf, where its lowest occurrence is recorded (0.28 N g<sup>-1</sup>).

The <sup>210</sup>Pb activity is detected through the typical activity-depth profile, showing higher concentration at the core top that rapidly decreases down to the bottom. The derived age model shows a constant sediment accumulation rate (SAR) of about 0.22 cm yr<sup>-1</sup>, hence constraining the studied record chronologically. According to this model, each centimetre of sediment corresponds to a time interval of about 5 years.

The combination of micropaleontological and radiometric analyses shows that the first occurrence of *A. lobifera* in Malta can be backdated to A.D. 1950-1955, sixty years earlier than its first finding in 2006 (Fig. 1). During the first two decades (1955 to 1975), it is present with very low abundances, probably in response to environmental conditions still not completely favourable for the growth of dense populations. Starting from the 1980s, its abundance shows a first increase, followed by a second more rapid increase in the mid-1990s (Fig. 1). The maximum peak of abundance is recorded at cm 3 bsf, corresponding to A.D. 2006, the same year when the species was first recorded in four different sites in Malta, Comino and Gozo [1]. The increased abundance of *A. lobifera* (Fig. 1), especially since the 1980s, perfectly mirrors the Sea Surface Temperature (SST) increasing trend registered in the Western Mediterranean [3]. This result supports the assumptions of geographical distribution models of *A. lobifera* [4].

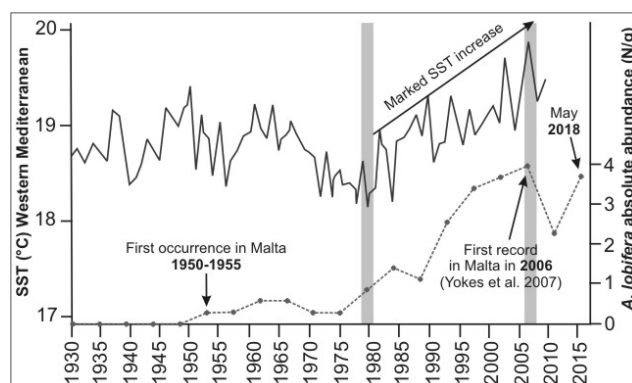


Fig. 1. Absolute abundance of *A. lobifera* plotted against the SST of the Western Mediterranean during the last century (modified after [3]).

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# OCEAN-HITCHHIKERS: THE BIOGEOGRAPHY AND PHYSIOLOGY OF ZOOCHOROUS DISPERSAL AND BIOINVASIONS

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## Abstract

Shipping has long been considered the primary vector for the introduction of non-indigenous species, although, often the specific vector was not evident. Here we investigated a newly-identified long-distance dispersal and bioinvasion vector—live passage through digestive tracts of animals (zoochory). For centuries, zoochory has escaped the attention of marine scientists—studied at small scales or in freshwater habitats. We studied ichthyochory (fish gut passage) using contemporary field research, historical analyses of preserved fish, and spatio-temporal analyses, and found evidence for the transport and spread of dozens of benthic species. Thus, we suggest that ingestion of marine benthos by non-indigenous fish, followed by defecation of viable individuals, comprise a main introduction vector of these organisms into novel environments.

**Keywords:** *NIS, Migration, Zoobenthos, Alien species, Mediterranean Sea*

Dispersal of organisms by 'hitchhiking' in the digestive tract of another species is well-known in terrestrial and freshwater habitats [1]. Seed dispersal via ingestion by vertebrates (mostly birds and mammals), termed endozoochory, is the most common seed dispersal mechanism in trees. In marine environments, little is known about the role of zoochory as a vector of species dispersal and introduction.

We studied the live passage of algae and zoobenthic taxa via the gut of two invasive Indo-Pacific herbivorous rabbitfish—*Siganus luridus* and *S. rivulatus* (first observed in the Mediterranean Sea in 1924 and 1955, respectively). These fish are now found in the entire Levantine basin, and have spread westward and northward into the Ionian, Tyrrhenian, Aegean and Adriatic Seas. As voracious grazers, the rabbitfish have decimated the native algal canopy in the invaded environments, leading to profound ecological phase shift to turf barrens [2]. Faecal pellet analysis of rabbitfish collected off the coast of Haifa (South-Eastern Mediterranean Sea) during 2015-2018 revealed a high abundance and diversity of viable organisms, predominantly non-indigenous foraminifera species [3]. These foraminifera species are holobenthic—permanent bottom-dwellers in sediments, on rocks, or as epiphytes on macroalgae—lacking planktonic stage. Negative geotaxis assay of foraminifera in the rabbitfish faeces (movement detection on vertical surfaces) was used to isolate living individuals. Historical data obtained from museum specimens of siganid fish collected in the Gulf-of-Suez and Cyprus (1967-1975), revealed 34 species of benthic foraminifera species in the preserved rabbitfish guts, ten of which are known as Lessepsian migrants [3]. Comparing the Mediterranean distribution of *S. luridus* with that of *Amphistegina lobifera*, one of the most abundant Indo-Pacific benthic foraminiferan, revealed congruent propagation patterns with a lag time averaging 6.8 years between the first observation of the rabbitfish to that of the foraminifera (figure 1).

Viable macroalgae and motile ostracods, bivalves, gastropods, copepods, amphipods, ophiuroids and cnidarians were also found in the rabbitfish faeces. Current efforts are made to identify this rich diversity of rabbitfish-hitchhiking species by molecular barcoding. Excluding macroalgae, the majority of the hitchhiking species that we found in the rabbitfish faeces are calcareous, e.g., foraminifera, bivalves and gastropods. It was therefore a puzzle, to how these organisms—considered as highly vulnerable to even the slightest change in ocean pH—survived the passage through the acidic gut phase. We hypothesize that the high carbonate content that we measured in the rabbitfish gut (20% in the foregut, 40% and 42% in the mid and foregut) can buffer the gut microenvironmental pH, allowing conducive conditions for calcareous organisms. Further research is required to understand the physiological mechanism of hitchhiker endurance.

Overall, our findings suggest that endozoochory—gut passage—has a major role in structuring marine benthic communities and may accelerate 'invasional meltdown', where one group of non-indigenous species facilitates another's group invasion. More studies are needed to evaluate the impact of this newly identified vector on both historical and modern marine biogeographies, and its potential role in mediating species introductions and spread.

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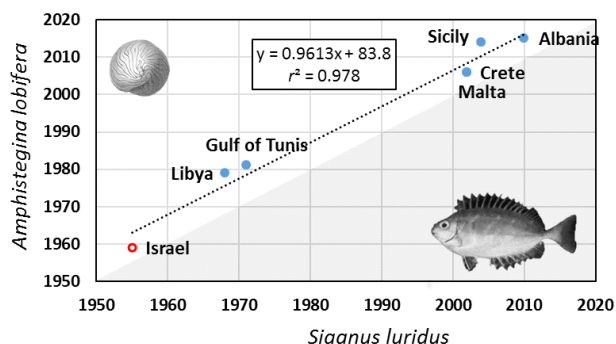


Fig. 1. Correlation between first record years of the non-indigenous Indo-Pacific foraminifera *Amphistegina lobifera* and the Lessepsian invader *Siganus luridus* in Israel, Lybia, Gulf of Tunis, Crete, Malta, Sicily and Albania.

## **AURELIA SOLIDA (BROWNE 1905) ASEXUAL REPRODUCTION UNDER SALINITY AND TEMPERATURE REGIMES**

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### **Abstract**

Jellyfish outbreaks are conspicuous and natural events in marine ecosystems, with substantial impact on the structure and dynamics of marine ecosystems, as well as on different economic sectors of human activities, such as fisheries, tourist activities and power plant industries [1]. Understanding the life cycle strategies of jellyfish species is critical to mitigate the impact these organisms may have on local populations, biodiversity, and ultimately on the functioning of food webs as well the potential establishment of Non-Indigenous Species (NIS). The scyphozoan *Aurelia solida* has been recorded in various areas (Azores and Madeira archipelagos in the Atlantic Ocean, the Gulf of Trieste in the North Adriatic Sea, the Bizerte Lagoon in Tunisia, Red Sea and the Maldives islands) [2] presenting different environmental conditions (e.g. temperature, salinity, food, seasonal variation). While previous studies have shown temperature effects on different *Aurelia* cryptic species, little is known about possible combined effects with salinity. In this context, survival, budding and strobilation activities of *Aurelia solida* polyps, originated from the Adriatic Sea, were studied under different temperatures (12, 16, 20, 24, 28 °C) and salinities (20, 25, 30, 35, 37, 40) regimes. Our findings indicate that survival of polyps did not differ across the different conditions (excepted at 28°C and 20 salinity with 100% mortality), showing a high tolerance of *Aurelia solida*. Our results also showed a significant impact of both temperature and salinity in its reproduction capacity. Unexpectedly, polyps budding activity was enhanced in lower temperature (20°C) than the same species population established in the Red Sea. Moreover, strobilation was enhanced at 16°C while polyps showed positive response to lower salinities (< 37) suggesting a good adaptability to estuarine environments.

**Keywords:** Scyphozoa, polyps, non-indigenous species, Adriatic Sea

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## THE MARINE BRACHYURAN CRAB *PYROMAIA TUBERCULATA* (LOCKINGTON, 1877) REACHED EUROPE

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### Abstract

*Pyromaia tuberculata* is native of the North-Eastern Pacific Ocean and currently established in distant regions in the Pacific Ocean and South-Western Atlantic. Outside its native range, this species has become established in organically polluted enclosed waters such as bays. The Tagus estuary, with a broad shallow bay, is one of the largest estuaries in the west coast of Europe, located in western mainland Portugal, bordering the city of Lisbon. In this study, sediment samples were collected in the estuary between 2015 and 2017 with a Smith-McIntyre grab and a beam trawl. *P. tuberculata* was first found in 2016 and again in 2017. Six adult specimens including one ovigerous female were collected and morphologically identified. A portion of tissue was used for DNA extraction, amplification of the genetic marker Cytochrome c oxidase subunit I (COI-5P) and subsequent sequencing. Both morphological and genetic approaches resulted in an accurate identification of the species.

Since the species has pelagic larval stages, it is likely that ballast water is the vector of introduction in Europe. The constant presence of adults including the ovigerous female over the 2-year sampling period suggests that the species has become established in the Tagus estuary. Moreover, the short life cycle (six months), allowing producing at least two generations per year with females reaching maturity within six months after settlement, favours population establishment. In spite of being referred as invasive, there are no records of adverse effects of *P. tuberculata* to the environment and socioeconomy in regions outside its native range. However, it is important to consider its inclusion in European monitoring programmes of non-indigenous species, in order to improve knowledge on its biology and behaviour.

Keywords: DNA barcoding, Europe, new record, non-indigenous species



**CIESM Congress Session : Bioinvasions / Ecology**  
**Moderator : Paula Chainho, MARE, Univ. of Lisbon, Portugal**

*Moderator's Synthesis*

This session included presentations on the biology and ecology of non-indigenous species and impacts on ecosystems associated to biological invasions, including marine protected areas. The presentations stimulated an enthusiastic debate on the importance of knowledge on the biology and ecology of invasive species to conduct risk assessments and estimate and prevent possible impacts on recipient ecosystems. The unpredictability of most of the impacts caused by invasive species was enhanced, as well as the low success of available mitigations measures, such as the direct removal of non-indigenous species as a population control measure. The participants also highlighted that receiving ecosystems also change along time, increasing the unpredictability of impacts and changes on ecosystem services. Outreach activities were indicated as the most efficient measure to prevent future introductions and related impacts, stressing the importance of getting stakeholders involved in prevention and mitigations strategies, through improved governance processes.



# MORPHOMETRIC FEATURES OF THE SHELL POPULATION OF *BRACHIDONTES PHARAONIS* (FISCHER, 1876) (BIVALVIA: MYTILIDAE) FROM ALEXANDRIA COAST OF EGYPT.

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## Abstract

The shell size of *Brachidontes pharaonis* (Fischer, 1876) on Alexandria Coast ranged from 0.5 mm to > 36.0 mm, with the most abundant size group of 4.0-8.0 mm shell length. The smallest individuals (0.5-4.0 mm) were observed in high percentage (20%) during autumn. Large size groups (> 12-16 mm) were presented with lower values during all seasons. All morphometric relations showed a strong positive linear correlations between SL and H/W with monthly negative allometric relationship. While positive allometric relation were found during April, August, and from October to February in SL/Tw relationship. The highest value of CI was observed in May and October and the lower was in September for both sexes.

**Keywords:** *Biometrics, Bivalves, Eastern Mediterranean, Invasive species*

## Introduction:

The mussel *Brachidontes pharaonis* has colonized the Mediterranean Sea in 1869, and remained rare before 1995. It is widely reported from the Western Pacific Ocean, Indian Ocean and the Red Sea. The objective of this study was to describe the morphometric features of the shell populations of *B. pharaonis* from Alexandria Coast of Egypt after the recently vast propagation by this mussel species.

## Materials and methods:

Monthly samples of *B. pharaonis* were collected from different sites along the coast of Alexandria City that extended between 31.16, 31.14 latitudes and 29.59, 29.57 longitudes covering about 16 km of the coastal area by SCUBA diving from March 2016 to February 2017. Measurements of the shells were taken as shell length SL mm, shell height H mm, shell width W mm by using digital Vernier Caliper (0.01 mm accuracy), total wet weight Tw g, shell weight Sw g and wet weight g of flesh Ww using a digital balance to the nearest 0.01 g. The allometric relationships were established through regression analysis. Condition index was calculated as  $CI = (\text{dry flesh weight} / \text{dry shell weight}) \times 100$ . All statistical analysis and regression were done using SPSS V.15 and Microsoft Excel 2013 to test the differences.

## Results:

Shell size distribution of *B. pharaonis* of the total population through the period of study as in Fig (1). SL groups ranged from 0.5-4.0 mm to > 36 mm. Individuals of sizes 4.0-8.0 mm SL represented by higher percent as 27.3% followed by sizes 0.5-4.0 mm and 8.0-12.0 mm SL which are represented by 15.4% and 15.5%, respectively. Larger sizes were found with lower percentages as in Fig (1).

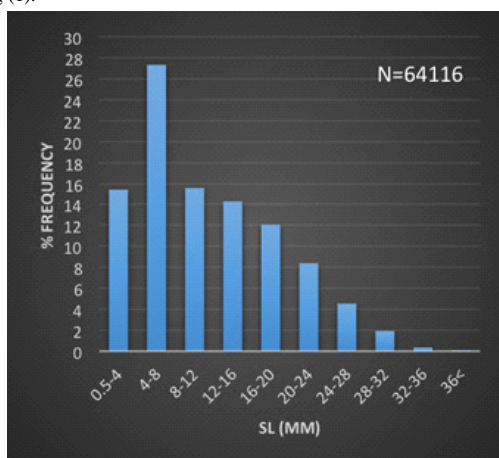


Fig. 1. Shell size distribution of the total population of *B. pharaonis*.

The morphometric relationships for SL-H/ W and for length-weight relationship showed a strong positive correlations. The monthly values of (b) for all relationships are presented in Fig (2). Higher values of CI were observed in May and October and the lower were in September for both sexes.



Fig. 2. The monthly distribution of (b) values for length-height/width and length-total weight relationships.

## Discussion:

The present results prove that the population of shell size of *B. pharaonis* was represented by the small SL sizes from 0.5 mm to less than 20 mm which agree in other areas as reported by. This may be related to the mode of continuous spawning of this species all year round [1]. The linear patterns of SL variables with H & W showed a negative allometric relation as in other locations, while with weight, a non-linear patterns were observed and b values ranged from 2.8257 to 3.0607 which could be attributed to its reproductive cycle. Similar observations were found in Gulf of Suez and Red Sea [2] as well as in Sicily [3]. The results of CI correlated to its spawning cycle as reported by [1].

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# ALGAL SUBSTRATUM PREFERENCES OF THE ALIEN FORAMINIFERAN *AMPHISTEGINA LOBIFERA* IN SHALLOW WATER

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## Abstract

The Lessepsian foraminiferan *Amphistegina lobifera* is particularly numerous on algae in shallow water. We sampled foraminiferans from three algae (*Cystoseira* spp., *Padina pavonica* and *Halopteris* sp.) within the 0.75 - 2.0 m depth zone from five different sites around the island of Malta. There was a significant difference in the population density of live *Amphistegina* between the algae studied with *Halopteris* being preferred to *Padina* and with very sparse populations on *Cystoseira*.

**Keywords:** *Alien species, Behaviour, Foraminifera, Malta Channel*

## Introduction

The symbiont bearing foraminiferan *Amphistegina lobifera* is a Lessepsian immigrant in the Mediterranean Sea where it now occurs in Tunisia, Egypt, Libya, Turkey, Greece, Malta, Italy, Israel and Lebanon [1]. This foram has been very successful in some areas (e.g. Turkey and Greece) where it can constitute 80-90% of total foraminiferal abundance [2], reducing the native foraminiferal diversity by up to 30% [3]. In shallow water, *A. lobifera* is particularly abundant on algae, but casual observations suggested preference for particular types. Field studies were carried out to test this hypothesis.

## Methods

Five replicate samples of each of three different algae (*Cystoseira* spp., *Padina pavonica* and *Halopteris* sp.) were obtained from the 0.75 - 2.0 m depth zone from five sites in Malta (Anchor Bay, Bahar ic-Caghaq, Fond Ghadir, Ghar Lapsi, Marsaskala) (Fig. 1), using a 10 cm x 10 cm quadrat. Sampling was undertaken between August and November 2017. With one exception, the algae chosen were present at all sites (*Padina* was not found at Fond Ghadir) and were the dominant species in the sampled areas. In the laboratory, any *Amphistegina lobifera* present on the algal thalli were removed and stained in 0.25 g/L Rose Bengal in 70% ethanol for 48 hours. Individuals were then separated into three categories: living, uncertain and dead. The living forams stained pink whilst the dead ones retained their original colour; those with an in-between colour were classified as 'uncertain'.

## Results and Discussion

Living *A. lobifera* accounted for 80-93 % of the amphisteginids present on the algal thalli. The mean abundances of living specimens recorded from the different algae are presented in Table 1. There was a statistically significant difference in abundance of living *A. lobifera* between the different algae (Kruskal-Wallis H-test;  $p < 0.004$ ), with *Halopteris* being preferred to *Padina* at all sites, and *Cystoseira* hardly having any forams at all.

In shallow water, amphisteginids are prone to dislodgment by wave action, especially when they are still juvenile (<500 µm diameter) [4], while high light intensities can cause bleaching of their photosynthetic symbionts [5]. Both factors may contribute to the observed preference for *Halopteris* sp. since the thallus of this species consists of very dense lateral branches and axillary hairs, making it ideal for secure attachment and also serving to reduce light penetration. *Padina pavonica* was the next preferred species. Most forams on this alga were found on the underside of the thalli, suggesting that the broad thallus can act as a 'shield' from wave action while also having a shading effect. *Cystoseira* spp. was the least preferred algal species at the studied depths, most likely due to the larger spacing between the branches of the thallus. At greater depths the situation may be different due to decreased water movement and reduced need to shelter from sunlight.

Tab. 1. Mean (±SD) number of live *Amphistegina lobifera* standardised per m<sup>2</sup> on different algae from five sites round the island of Malta. Five replicate samples were collected from each site.

| Site            | <i>Cystoseira</i> spp. | <i>Padina pavonica</i> | <i>Halopteris</i> sp. |
|-----------------|------------------------|------------------------|-----------------------|
| Anchor Bay      | 0                      | 820 ± 415              | 4380 ± 3174           |
| Bahar ic-Caghaq | 20 ± 40                | 1780 ± 572             | 6040 ± 3073           |
| Fond Ghadir     | 20 ± 40                | N.A.                   | 9580 ± 3074           |
| Ghar Lapsi      | 0                      | 1400 ± 539             | 8120 ± 3066           |
| Marsaskala      | 0                      | 4540 ± 1016            | 9680 ± 1287           |

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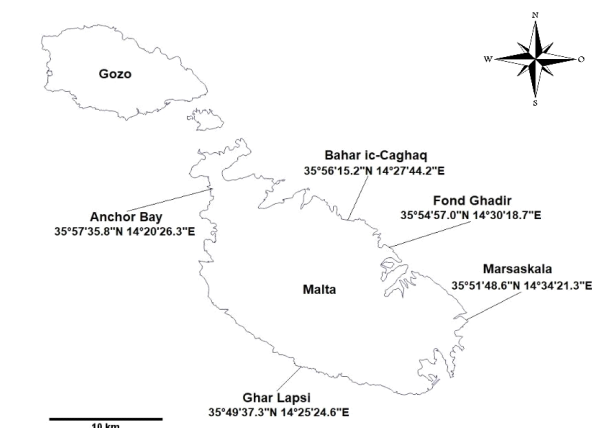


Fig. 1. Map showing the location and the GPS coordinates of the sites chosen for sampling.

# SEASONAL CHANGES IN POPULATIONS OF *CAULERPA TAXIFOLIA* VAR. *DISTICHOPHYLLA* IN THE MALTESE ISLANDS

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## Abstract

*Caulerpa taxifolia* var. *distichophylla*, an alien alga in the Mediterranean Sea, was first recorded from the Maltese Islands in 2013. Initial observations suggested that it underwent complete frond regression in winter, possibly due to the colder temperatures. Since then it has spread rapidly and has become abundant in the infralittoral in some localities. The present two-year study on the Maltese populations indicates that the alga is able to resist low seawater temperatures during the winter and is not regressing completely, potentially increasing its ecological impact.

**Keywords:** *Mediterranean Sea, Phytobenthos, Alien species, Population Dynamics, Malta Channel*

## Introduction

In the Mediterranean, *Caulerpa taxifolia* var. *distichophylla* (hereafter *Ctvd*) is an invasive green alga that was first reported in 2007 from the Gulf of Iskenderun, SE Turkey [1]. By 2018 it had spread to several other areas in the East Basin: Sicily, Cyprus, Malta, Rhodes, and Libya. More recently it expanded its range and crossed to the West Basin where it has now reached Sardinia and Tunisia [2]. This was against expectations, as the 15°C winter isotherm was thought to limit spread of this thermophilic species to the area around Sicily [3]. The species was first reported from Malta in 2013 [4], making *Ctvd* the second non-native species of the family Caulerpacae recorded from Malta; *Caulerpa cylindracea* was recorded from Malta in 1997. Field observations made in Malta suggested that *Ctvd* fronds regress in winter and grow back in spring and summer resulting in a marked seasonal change in frond density during the year [4]. Here we report on a two-year study on frond phenology made to see if fronds indeed regressed, to what extent, and if there is inter-annual variability.

## Materials and Method

Using SCUBA diving, monthly frond density counts were taken at Bahar ic-Caghaq (BC) and Marsaskala Bay (MS) between June 2016 and June 2018 (Fig 1). Mean frond density at each site was estimated from 12 replicate counts made using a 0.25m X 0.25m quadrat placed at random within a 2m X 2m patch of substratum colonized by *Ctvd*.

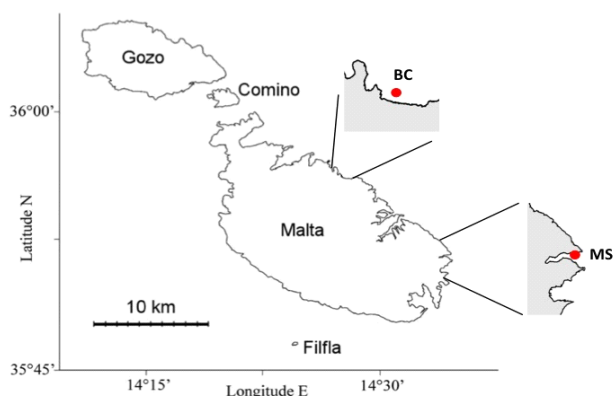


Fig. 1. Map of the Maltese islands showing the location of the two study sites: Bahar ic-Caghaq (BC) and Marsaskala Bay (MS).

## Results

Frond densities of *Ctvd* were highest during the summer months and decreased during the winter months at both sites. The highest density was recorded in July 2016 from Bahar ic-Caghaq ( $972 \text{ N/m}^2 \pm 417.01 \text{ SD}$ ). Between December and March 2018, fronds were still present in low densities at both sites, and had not fully regressed, unlike the complete absence of fronds during the same period in the previous year and in the winter of 2013-2014 [4].

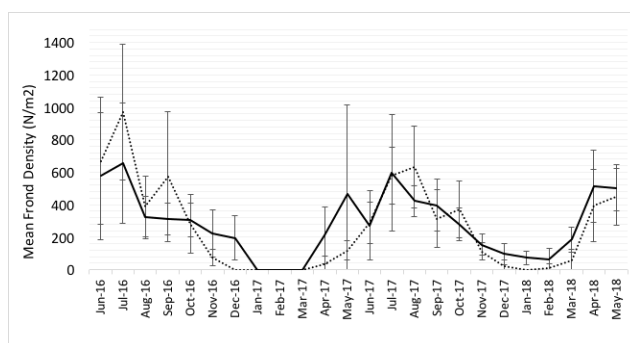


Fig. 2. Mean density of *Ctvd* fronds recorded between June 2016 – May 2018 at Bahar ic-Caghaq (dotted line) and Marsaskala Bay (bold line). Error bars are  $\pm 1$  standard deviation.

## Discussion

The inter-annual variability found in the present study suggests that *Ctvd* may be increasing its invasive capacity, as the low seawater temperature during the winter months is not always causing complete regression of the fronds. It appears that the alga has a higher temperature tolerance than previously thought, which can explain its range expansion and successful establishment in the western basin and its survival at low winter temperatures. The ecological impact of *Ctvd* is likely to be greater should the alga keep its fronds during winter than if the fronds regress and grow back each year.

## Acknowledgments

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# ERYTHRAEAN INVASIVE FISH ON THE UPPER SLOPE: AN EMERGING ISSUE IN CONSERVATION AND MANAGEMENT IN THE MEDITERRANEAN SEA

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## Abstract

Although the ecological importance and impact of non-indigenous species is increasingly recognised and documented in shallow water ecosystems, their presence beyond the shelf has scarcely been documented. A survey of the upper slope biota of the Mediterranean coast of Israel revealed the presence at 200-m depth of individuals of three Erythraean species, the crocodile toothfish *Champsodon nudivittis*, Golani's round herring *Etrumeus golanii*, and the burrowing goby, *Trypauchen vagina*. In the past decade several Erythraean species have been collected on the Levantine lower shelf and upper slope. The spread of predatory and highly fecund invasives poses a distinct threat to the unique, diverse and fragile mesophotic 'animal forests'.

**Keywords:** *Invasive species, Deep sea ecology, Levantine Basin*

In the coastal ecosystems of the Mediterranean Sea, bioinvasions present threats to the local biodiversity comparable to those exerted by climate change, pollution and fisheries. The number of non-indigenous species (NIS) more than doubled in the past 30 years, and is substantially greater in the Levant than in other basins in the Mediterranean due to the propagule pressure exerted by the Suez Canal, which serves as the major pathway of introduction. Since the Suez Canal is shallow, it has been assumed that the populations of the NIS introduced through the canal into the Mediterranean will be restricted to the upper shelf. Indeed, until the 1970s Erythraean biota was typically confined to habitats shallower than 50 m [1]. However, a survey of soft bottom shelf edge biota off the southern Mediterranean coast of Israel, carried out in 2010-2012 recorded 16 Erythraean fish species. A survey of soft bottom biota along the 200 m isobath off central Israel, conducted between October and December 2017, collected specimens of the Erythraean fish species, *Champsodon nudivittis* (Ogilby, 1895), *Etrumeus golanii* Di Battista, Randall & Bowen, 2012, and *Trypauchen vagina* (Bloch & Schneider, 1801).

lower temperatures. It seems that the climatic niche of some Erythraean species is wider than accounted for, or has altered during the invasion, and is likely to facilitate bathymetric range expansion, as well as higher invasion risk into a wider geographic range. **Why does it matter?** Antipatharians, ceriantharians, zoantharians, gorgonians, pennatulaceans and cold water corals have been documented on the shelf and upper slope of the Aegean and Levant seas. These large arborescent anthozoans form patchy 'meadows' which attract highly diverse mesophotic assemblages [3]. These mesophotic assemblages are vulnerable to injury from bottom contact fisheries, together with pollution, offshore extraction and infrastructure, and climate change. Yet, so far no mention has been made on the direct impact of bioinvasions, which has been considered a priority issue in the coastal Mediterranean environment. The occurrence of carnivorous and highly fecund NIS at these depths poses risks to the indigenous biodiversity and sustainability of the unique mesophotic assemblages. The first step in addressing NIS in deeper habitats is targeted monitoring in the most vulnerable areas to study their presence, distribution, ecology, pathway, and to assess the threats they present.

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Fig. 1. *Etrumeus golanii* Di Battista, Randall & Bowen, 2012, *Champsodon nudivittis* (Ogilby, 1895), and *Trypauchen vagina* (Bloch & Schneider, 1801).

The potential distribution of NIS is commonly predicted using the environmental niche model, which considers a known distribution of a species and then defines a potential and realized niche of a species correlating the available information with the environmental variables of a wider area [2]. The invasion of Erythraean species of the Levantine basin, and particularly their recently observed intrusion into the lower continental shelf and upper slope revealed that thermal niche estimations assuming niche conservatism and based on the species' native environment may underestimate their capacity to tolerate

# TARGETED REMOVALS OF INVASIVE SPECIES IN MARINE PROTECTED AREAS

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## Abstract

Invasive species are proliferating in the Mediterranean basin and affect Marine Protected Areas (MPAs). Targeted removals offer potential to control invasive fish populations. Society needs information on their cost-effectiveness to assess whether costs are proportionate to the expected impacts on the environment. This study provides insights into the cost-effectiveness and potential of using targeted removals to manage lionfish invasion in priority habitats of the Mediterranean Sea.

**Keywords:** *Mediterranean Sea, Invasive species, MPAs, Coastal management*

Well policed, highly protected areas can prevent further degradation of marine resources and provide a refuge against the impacts of climate change and biological invasions. However, many MPAs host high invasive species richness [1]. South and Eastern Mediterranean MPAs host higher biomass of non-indigenous and native-range expanding fish than adjacent unprotected areas, leading to calls for targeted removals to control invasive fish [2].

Inclusion of a species on the Invasive Alien Species list of the EU (EC/2016/1141) requires that management measures are cost-effective and proportionate to the impact on the environment. This study elucidates the efficiency of coordinated removals of lionfish *Pterois miles* (Bennett, 1828) in priority areas within MPAs of the eastern Mediterranean.

We coordinated removals in highly infected areas to assess their efficiency in mitigating impacts, and to understand lionfish recolonization. Lionfish were caught using slingshots and removed using specialized containers (Figure 1). Nine ca 0.01 km<sup>2</sup> monitoring stations were selected within two MPAs; six at 20 m ( $\pm$  2 m) depth and three at 7 m ( $\pm$  2 m), and removals of different intensities were carried out at four intervals during the summers of 2018 and 2019. Underwater visual census was used to monitor lionfish and surrounding fish communities on replicate strip transects.

This work was carried out by Periklis Kleitou, Jason Hall-Spencer and Sian Rees from University of Plymouth (UK), Demetris Kletou, Ioannis Savva and Charalampos Antoniou from Marine and Environmental Research (MER) Lab Ltd. (Cyprus), and Carlos Jimenez, Louis Hadjioannou and Vasilis Andreou from Enalia Physis Environmental Centre (Cyprus). It was supported by the LIFE financial instrument of the European Union – RELIONMED project [Grant Agreement LIFE16 NAT/CY/000832].

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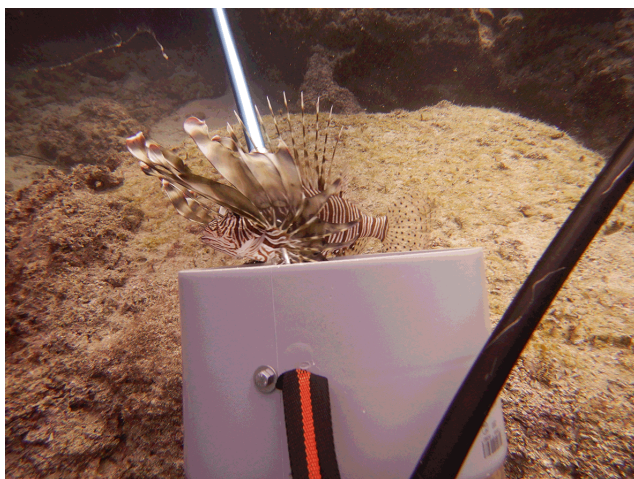


Fig. 1. Lionfish captured using a slingshot being put into a container at 7 m depth of the Cape Greco MPA during summer 2018. These invasive fish have rapidly increased in abundance since the recent widening and deepening of the Suez Canal in Egypt [3].

We found that strip transects underestimated lionfish biomass and that targeted surveys provided a better estimate of the lionfish present. Full removal of lionfish was not possible since some individuals, especially juveniles, escaped. Alternative methods for capturing juveniles should be explored in future (e.g. handheld nets). Seabed habitat features were a major factor influencing lionfish recolonization following removals, those sites that were highly connected required more effort to reduce lionfish densities.



# THE DOMINATION OF INVASIVE SPECIES IN THE PRESENT PHYTOPLANKTON OF THE CASPIAN SEA

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## Abstract

The seasonal maximum of phytoplankton abundance in the central part of the Caspian Sea are formed exclusively due to invasive species. In February-March at a temperature of 9–11 °C, a salinity of 11 epc and convective mixing up to 200 m, the winter-spring bloom of diatom *Cerataulina pelagica* occurs in the deep sea parts. The spring and autumn maximum of phytoplankton abundance are formed due to the diatoms *Chaetoceros peruvianus* and *Pseudo-nitzschia seriata*. Summer bloom of invasive potentially toxic dinoflagellate *Gonyaulax polygramma* was noted in the layer of seasonal thermocline.

**Keywords:** *Phytoplankton, Invasive species, Caspian Sea*

Studies were carried out in 2004-2013 in the central part of the Caspian Sea (Middle Caspian Sea). The methods used are described in [1]. It was shown that at present the entire seasonal maximum of phytoplankton abundance and biomass are formed exclusively due to invasive species (Table 1). In October-December autumn maximum of phytoplankton abundance and biomass in the Middle Caspian are formed due to massive growth of the diatoms *Chaetoceros peruvianus* (up to 1.7 g/m<sup>3</sup>), *Cerataulina pelagica* (up to 1.3 g/m<sup>3</sup>) and the pennate diatom *Pseudo-nitzschia seriata* (up to 0.7 g/m<sup>3</sup>). The winter-spring bloom of diatom *Cerataulina pelagica* (up to 4.2 g/m<sup>3</sup>) was the most powerful in February at a temperature of 10–11 °C, a salinity of 11 psu in the deep sea parts. The bloom took place in upper 100 – meters layer. In May spring biomass maximum of *Chaetoceros peruvianus* (up to 0.4 g/m<sup>3</sup>) was observed in 25-meters layer in the zone of Volga discharge influence. At the same time the remnants of winter-spring bloom of *Cerataulina pelagica* (up to 0.7 g/m<sup>3</sup>) were fixed under the thermocline at 50 m depth. In other years the biomass maximum of *Pseudo-nitzschia seriata* (up to 0.5 g/m<sup>3</sup>) was observed in June under the thermocline (depth of 90 m). The summer bloom of invasive potentially toxic dinoflagellate *Gonyaulax polygramma*, was observed in June in the thermocline (up to 15.2 g/m<sup>3</sup>) over the central part of the Derbent Depression. In August the bloom of this species was associated with the seasonal wind upwelling in the eastern part of the sea (up to 16.7 g/m<sup>3</sup>). This bloom was fixed in the layer of seasonal thermocline at a depth of 17 to 90 m, temperature of 8 – 10 °C and salinity of 11.2 psu. Replacement of the native Caspian Sea dominant species of diatoms and dinoflagellates (*Pseudosolenia calcar-avis*, *Dactylosolen fragilissimus*, *Prorocentrum cordatum*) by invasive Black Sea species indicates the serious change in the ecosystem of the Caspian Sea and it may be associated with changes in physical and chemical parameters of the environment.

Tab. 1. Maximal abundance (numerator, cells/L) and biomass (denominator, g/m<sup>3</sup>) of the invasive species.

| Species                         | May                        | June                        | August                      | October                    | November                   | December                   | February                   |
|---------------------------------|----------------------------|-----------------------------|-----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| <i>Chaetoceros peruvianus</i>   | 1.7·10 <sup>5</sup><br>0.4 |                             |                             | 2.0·10 <sup>5</sup><br>0.5 | 2.3·10 <sup>5</sup><br>0.8 | 3.3·10 <sup>5</sup><br>1.7 |                            |
| <i>Cerataulina pelagica</i>     | 1.3·10 <sup>5</sup><br>0.7 | 2.0·10 <sup>4</sup><br>0.02 |                             | 2.4·10 <sup>5</sup><br>1.3 | 1.0·10 <sup>5</sup><br>0.5 |                            | 7.7·10 <sup>5</sup><br>4.2 |
| <i>Pseudo-nitzschia seriata</i> |                            | 2.0·10 <sup>5</sup><br>0.5  | 2.6·10 <sup>2</sup><br>0.00 | 3.0·10 <sup>5</sup><br>0.7 | 1.4·10 <sup>5</sup><br>0.3 |                            | 1.3·10 <sup>5</sup><br>0.3 |
| <i>Gonyaulax polygramma</i>     |                            | 4.5·10 <sup>5</sup><br>15.2 | 3.5·10 <sup>5</sup><br>16.7 |                            |                            |                            |                            |

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## CHANGES IN PROVISIONING ECOSYSTEM SERVICES CAUSED BY THE INTRODUCTION OF THE MANILA CLAM

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### Abstract

The intentional introduction of the invasive bivalve *Ruditapes philippinarum* (Manila or Asari clam) worldwide as caused positive and negative impacts on ecosystem services. Provisioning services are commonly recognized as a positive change that is provided by introduced species and the value of bivalve aquaculture has most frequently been calculated as the market value of the meat that is produced. The exploitation of bivalve molluscs in the Tagus estuary has always been an activity of great socioeconomic importance, and the recent introduction and increase in abundance of *R. philippinarum* has moved the fishing effort mostly towards this species. The major objective of this study was to quantify provisioning services provided by the Manila clam in the Tagus estuary, based on estimates of the number of harvesters and market value of the meat. The number of harvesters was estimated based on *in situ* counts and surveys conducted among harvesters using different harvesting techniques. The Manila clam market value was calculated on the basis of an annual estimate of the harvesting yield and the selling prices charged by different harvesters. Although the number of harvesting permits in the Tagus estuary is nearly 200, an estimate of more than 1700 harvesters was obtained, mostly using hand picking and raking techniques. The annual catch estimate indicated that 6000-17000 tonnes of *R. philippinarum* were harvested in the Tagus estuary in 2015, with fluctuations associated to seasonal and tidal variations. The estimated annual income provided at the harvesters level was of 10 to 23 million €, showing that this fishing activity, based on an invasive species, represents a very important provisioning service for the regional and national economy.

Keywords: *Ruditapes philippinarum*; invasive species; Tagus estuary (Portugal)

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## **CIESM Congress Session : Fish ecology and biology**

**Moderator : Susana Garrido, IPMA, Lisbon, Portugal**

### *Moderator's Synthesis*

The speakers mainly focused on the spatial structure of fish species and fish trophic ecology, and also covered fisheries-induced stress and larval distribution. The discussion that followed highlighted how important it is to combine different techniques to achieve the most reliable results when studying fish ecology. For example, a combination of techniques such as genetics, otolith shape analysis and body morphometry allows to better ascertain the population structure of marine and freshwater species. Also, combining prey identification in gut content analysis with stable isotopic composition and metabarcoding is essential to have a better description of the trophic structure of marine ecosystems.

Included in the discussion was a comparison of results from the Atlantic and the Mediterranean, particularly from studies regarding the spatial distribution of fish species. Finally, collaborations were established between researchers working on different systems in order to facilitate the access to individuals collected in different areas, of fish species with a large distributional range, to complete their sampling schemes and broaden their results. ?



# LA FORME DU CORPS, DES ECAILLES ET DES OTOLITHES: TROIS OUTILS DE DIFFÉRENCIATION DES ATHERINES *ATHERINA BOYERI* ET *A. PUNCTATA* DU GOLFE D'ANNABA

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## Abstract

La morphogéométrie somatique, la forme des otolithes et des écailles, nous ont permis de différencier deux formes d'athérines marines (ponctuées et non ponctuées) appartenant au complexe d'espèces *Atherina boyeri*.

**Keywords:** *Biometrics, Algerian Sea, Mediterranean Sea, Fishes, Biodiversity*

## Introduction

*Atherina boyeri* est un complexe d'espèces hautement polymorphe. Les travaux de recherche réalisés dans la région méditerranéenne sur ce complexe ont permis de le scinder en trois espèces: deux espèces marines (ponctuées et non ponctuée) et une espèce lagunaire (Trabelsi et al., 2002a ; 2004 ; Boudinar et al., 2015 ; 2016). Nous comparons ici 3 caractères phénotypiques, la forme du corps, celle des écailles et celle des otolithes entre les deux espèces marines *A. boyeri* et *A. punctata*.

## Matériel et méthodes

Un total de 231 athérines provenant du golfe d'Annaba a été traité: 139 individus marins ponctués et 92 individus marins non ponctués. L'étude de la morphogéométrie somatique est réalisée sur un échantillon de 60 individus. Les spécimens ont été numérisés à l'aide d'un scanner à haute définition. Treize points-repères (landmarks) ont été sélectionnés à l'aide du logiciel Tps Dig2 version 2.16. A l'aide du logiciel MorphoJ (V1.06d), nous avons réalisé une analyse canonique de la variance (CVA). En parallèle, les contours de 199 otolithes sagittae (90 individus marins non ponctués et 109 individus marins ponctués), et de 205 écailles (88 individus marins non ponctués et 117 individus marins ponctués) ont été numérisés, à fin de déceler d'éventuelles divergences. Une analyse factorielle discriminante a été appliquée en utilisant les descripteurs de Fourier, ainsi qu'une classification hiérarchique avec le logiciel R (R DevelopmentCore Team, 2014),

## Résultats

L'analyse morphogéométrique somatique nous a permis de distinguer deux groupes différents, un groupe incluant les individus marins ponctués mâles et femelles, et un autre qui est représenté par les individus marins non ponctués mâles et femelles (Fig. 1), l'analyse nous montre également l'absence de différences entre les mâles et les femelles d'un même groupe.

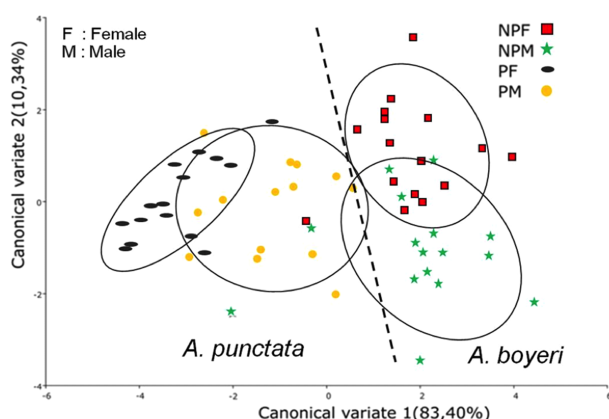


Fig. 1. Projection des coordonnées procrustes et scores des deux premiers axes de l'analyse canonique de la variance. P: ponctués NP: non ponctués, M: mâles, F: femelles.

Pour la forme des écailles, la fonction discriminante de la FDA représente 100% de la variance. Les individus peuvent être différenciés en deux groupes basés sur les deux premières fonctions (lambda de Wilks =0,874;P < 0,001). Les individus

marins ponctués et ceux non ponctués forment deux groupes bien distincts (Fig. 2). Aucune différence n'est observée entre la forme des écailles des mâles et des femelles d'un même groupe. En ce qui concerne la forme des otolithes, les deux premières fonctions discriminantes de la FDA représentent 97,27% de la variance, permettant bien la distinction entre les deux formes d'athérines marines (lambda de Wilks =0,367;P < 0,001) (Fig. 2). De même, aucune différence n'est observée entre la forme des otolithes des mâles et des femelles d'un même groupe.

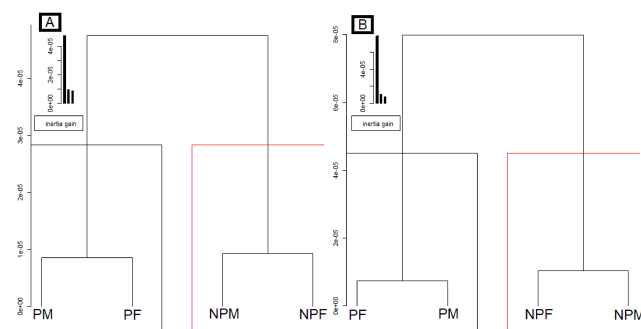


Fig. 2. Classification hiérarchique réalisée en utilisant les descripteurs de Fourier des deux populations d'Atherina boyeri. A: écailles, B: otolithes. P: ponctués; NP: non ponctués; M: mâles, F: femelles.

## Discussion

Les résultats obtenus en utilisant différents outils de discrimination permettent de dire que les deux formes de l'athérine marine, considérées comme des espèces à part entière, sont phénotypiquement différentes. Ce qui constitue un argument supplémentaire en faveur de la reconnaissance de leur statut d'espèces. Ceci est d'autant plus vrai qu'elles proviennent d'une même région (golfe d'Annaba), ce qui exclue l'influence éventuelle de l'environnement sur leur la variation de leur morphologie.

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# MORPHOGÉOMÉTRIE ET OTOLITHOMÉTRIE COMPARÉE DES ATHÉRINES LAGUNAIRES DES RIVES NORD, SUD DE LA MÉD OCCIDENTALE

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## Abstract

La morphogéométrie somatique et la forme des otolithes sagittae de quatre populations lagunaires d'*Atherina boyeri* des rives Nord et Sud de la Méditerranée occidentale est comparée. Trois groupes distincts ont pu être identifiés. Ces résultats montrent une structuration géographique des populations lagunaires.

**Keywords:** *Mediterranean Sea, Lagoons, Biometrics, Biodiversity, Fishes*

## Introduction

*Atherina boyeri* est un poisson téléostéen extrêmement euryhalin. Cette espèce habite les eaux côtières et estuariennes, y compris les lagunes côtières et plus rarement les eaux intérieures. Elle est composée de populations locales semi-isolées, qui peuvent être différentes les unes des autres par rapport à leurs traits biologiques. *Atherina boyeri* est considérée comme étant un complexe taxonomique, divisé par certains auteurs en diverses espèces ou sous-espèces [1-4]. Nous comparons ici des caractères phénotypiques de cette espèce entre lagunes méditerranéennes.

## Matériels et méthodes

L'étude de la morphogéométrie somatique a été réalisée sur un échantillon de 106 individus : Algérie (lagune Mellah: n = 29, Oued Ziama: n = 23), Tunisie (lagune de Bizerte: n = 29), France (étang de Mauguio: n = 25). Les spécimens ont été numérisés à l'aide d'un scanner. Utilisant le logiciel TpsDig2 (V. 2.16). Treize points-repères (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 coordonnées procrustes de chaque groupe d'individus a été réalisée en utilisant le logiciel MorphoJ (V1.06d). En parallèle, les contours de 416 otolithes sagittae (lagune Mellah: n = 90, Oued Ziama: n = 110, lagune de Bizerte: n = 110, étang de Mauguio: n = 106) ont été numérisés et analysés en utilisant le programme TNPC (5.0). Une analyse discriminante a été réalisée utilisant les descripteurs de Fourier. Les discriminations ont été évaluées par validation croisée (Jackknife). Une classification hiérarchique basée sur la méthode de Ward a été réalisée avec le package FactoMineR du logiciel R® (R Development Core Team, 2014).

## Résultats

Dans le cas de la forme somatique, l'analyse canonique des variances (CVA) selon la projection sur l'axe CVA 1 (60,17% de la variance) ou l'axe CVA 2 (27,88% de la variance), montre l'existence de trois groupes (figure 1). Les individus de Oued Ziama et de la lagune de Bizerte forment deux groupes distincts, alors que les spécimens de la lagune Mellah et ceux de l'étang de Mauguio forment le troisième groupe.

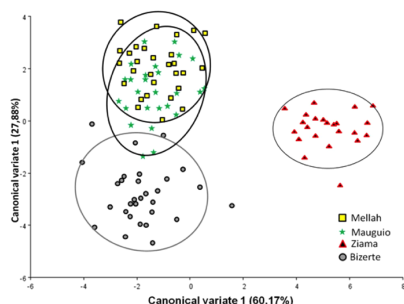


Fig. 1. Représentation des individus projetés sur les deux premiers axes de l'ACV. Les cercles représentent les ellipses de confiance à 95 % de chaque groupe.

Pour la forme des otolithes, les deux premières fonctions de l'analyse discriminante utilisant les descripteurs de Fourier représentent 87,4% de la

variance. Les individus peuvent être différenciés en trois groupes (lambda de Wilks = 0,175,  $P < 0,001$ ), les mêmes que ceux mis en évidence par la morphogéométrie du corps (figure 2). Le pourcentage des individus totaux bien classés est de 73,6%.

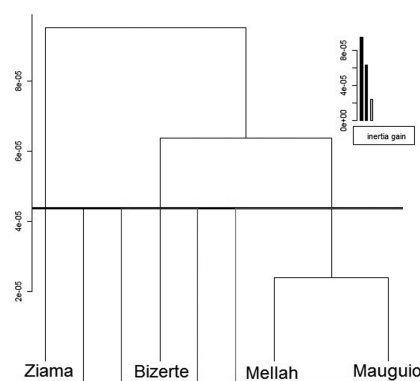


Fig. 2. Classification hiérarchique utilisant les descripteurs de Fourier de la forme des otolithes chez les quatre populations étudiées.

## Discussion

Les résultats obtenus utilisant la morphogéométrie somatique et la forme des otolithes vont dans le même sens et mettent en évidence une variation intra-spécifique dans la forme lagunaire du complexe d'espèces *A. boyeri*. Ces différences peuvent être attribuées à la grande plasticité morphologique reconnue de cette espèce en fonction de son environnement, et correspondent à ce qui a été observé dans d'autres milieux lagunaires en utilisant les outils génétiques moléculaires [4, 5].

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# FORTE STRUCTURATION GÉOGRAPHIQUE DE LA SAUPE *SARPA SALPA* EN MÉDITERRANÉE RÉVÉLÉE PAR LA FORME DES OTOLITHES

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## Abstract

L'analyse de la forme des otolithes sagittae de la saupe *Sarpa salpa*, issue de différentes localités en Méditerranée, nous a permis de distinguer 3 populations correspondant à 3 régions différentes de cet mer: Nord-Ouest (Marseille), Sud-Ouest (Oran), Sud-Est occidentale et Sud-Ouest orientale (Chétaibi, Mahdia, Gabès).

**Keywords:** *Mediterranean Sea, Fishes, Teleostei*

## Introduction

*Sarpa salpa* (Linnaeus, 1758) est une espèce de sparidé grégaire et benthopélagique. Elle est présente dans toute la Méditerranée et sur les côtes européennes et africaines de l'océan Atlantique, du golfe de Gascogne à l'Afrique du Sud et à l'ouest de l'océan Indien. C'est le seul téléostéen macro-herbivore strict de la Méditerranée. Nous recherchons dans ce travail une éventuelle différenciation phénotypique de cette espèce en Méditerranée, en utilisant la forme des otolithes comme outil de discrimination.

## Matériel et méthodes

Cinq échantillons de *S. salpa* issus de cinq régions de la Méditerranée sont considérés. Deux proviennent d'Algérie: Oran ( $n = 9$ ;  $26,2 \leq Lt \leq 37,6$  cm) et Chétaibi ( $n = 35$ ;  $18,5 \leq Lt \leq 27,1$  cm), deux de Tunisie: Mahdia ( $n = 19$ ;  $18,5 \leq Lt \leq 22$  cm) et Gabès ( $n = 30$ ;  $15,3 \leq Lt \leq 19,2$  cm), et un de Marseille ( $n = 21$ ;  $27,5 \leq Lt \leq 32,3$  cm). Les deux otolithes droit et gauche de chaque individu ont été numérisés avec le logiciel TNPC à partir d'un microscope optique muni d'une caméra vidéo reliée à un ordinateur. Les descripteurs de distance (longueur, largeur, périmètre, surface) ont été extraits automatiquement à partir de l'image binarisée en utilisant ce même logiciel. Les différences entre les indices de forme selon le site d'échantillonnage ont été testées par une analyse de variances (ANOVA) complétée par le test de comparaison des moyennes deux à deux (test de Newman-Keuls) en utilisant le logiciel SPSS v. 13.0. Les descripteurs de Fourier sont obtenus en utilisant le logiciel Shape (v1.2) après un seuillage qui permet la détection du contour des otolithes.

## Résultats

La comparaison des indices de forme indique une différence significative entre les échantillons et pour l'ensemble des indices étudiés. Selon le paramètre considéré, les différences sont plus ou moins prononcées. L'analyse factorielle discriminante utilisant les descripteurs de Fourier nous a permis de distinguer trois groupes (Fig. 1) (Wilks's lambda = 0,079;  $P < 0,001$ ). Le premier est représenté par Marseille, le second contient Oran et le troisième regroupe les trois autres localités (Chétaibi, Mahdia, Gabès). Le taux de bon reclassement global est de 59,8 %. Celui propre à chaque population est de 56,14% pour les individus de Chétaibi, de 38,88% pour ceux provenant de Mahdia, de 37,5% pour ceux provenant d'Oran, 75% pour ceux provenant de Marseille et de 52,63 % pour ceux issus de Gabès.

## Discussion

Dans cette étude, nous avons démontré l'existence d'au moins trois groupes différents du sparidé *S. salpa* en Méditerranée, avec des différences Nord-Sud et Est-Ouest de cette mer. Des différences suivant la répartition géographique et l'habitat ont été observée chez d'autres espèces en utilisant des outils morphologiques, comme chez la daurade *Sparus aurata* [1], le loup *Dicentrarchus labrax* [3] et le marbré *Lithognathus mormyrus* [2]. Ces phénotypes pourraient avoir un déterminisme génétique lié à l'état et au niveau de connectivité écologique entre les premiers stades de développement de ces espèces. Compte tenu de ces résultats, des investigations plus approfondies impliquant des outils de biologie moléculaire doivent être menées, afin de vérifier l'hypothèse d'une structuration géographique de *S. salpa* en Méditerranée, et éventuellement entre la Méditerranée et l'Atlantique.

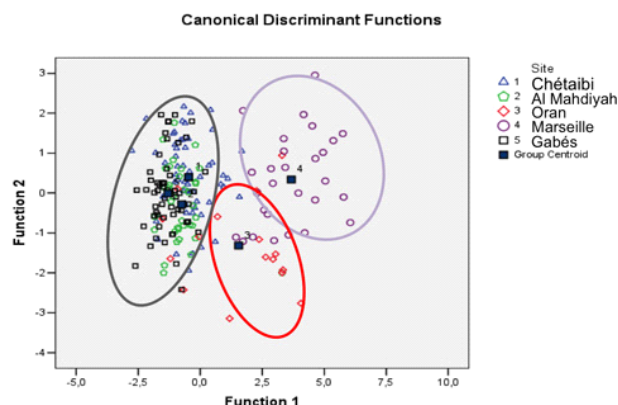


Fig. 1. Représentation graphique de l'analyse factorielle discriminante utilisant les descripteurs de Fourier.

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# SMALL PELAGIC FISH FEEDING FROM THE EASTERN ADRIATIC SEA

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## Abstract

Diet of five small pelagic fish species (sardine, anchovy, round sardinella, chub mackerel and horse mackerel) and their possible food overlap was studied in the eastern Adriatic Sea, from June 2014 to August 2016. Sardine and anchovy fed mainly on copepods, while decapod larvae, together with megalopa stage, appeared to be the most important food source for other pelagic fish, followed by isopods and mysids. Our data provide an important step for further investigations of the potential spatial and temporal food overlap of small pelagic fish under different trophic conditions, which is necessary for better understanding dynamics of pelagic food webs.

**Keywords:** Adriatic Sea, Diet, Fishes, Trophic relations, Zooplankton

Small pelagic fish are crucial in marine ecosystems regarding their significant biomass and connection to the lower and upper trophic levels of the food web [1, 2, 3]. However, most diet studies regarding these species are addressed in a single species approach, without data on diet comparison between small pelagic fish [4]. Therefore, the aim of this paper was to study inter-specific differences in diet of small pelagic fish: sardine *Sardina pilchardus* (Walbaum, 1792), anchovy *Engraulis encrasicolus* (Linnaeus, 1758), round sardinella *Sardinella aurita* (Valenciennes, 1847), chub mackerel *Scomber japonicus* (Houttuyn, 1782) and horse mackerel *Trachurus trachurus* (Linnaeus, 1758) from the eastern Adriatic Sea.

All small pelagic fish samples were collected from commercial purse seine catches from the eastern Adriatic Sea in period June 2014 – August 2016. After total length (TL) and body mass (TW) was measured and sex determined, the entire stomach from each species was removed and fixed with ethanol (95%). Prey items in stomach were counted and the lowest taxon possible was identified under a stereo-microscope. Biometry data of all analysed small pelagic fish are shown in Table 1.

Tab. 1. Biometry of small pelagic fish from eastern Adriatic Sea, June 2014 - August 2016 (number of specimens N, total length TL (mean ± SD), body mass TW (mean ± SD), male-female ratio M/F).

| Species | sardine    | anchovy    | round sardinella | horse mackerel | chub mackerel |
|---------|------------|------------|------------------|----------------|---------------|
| N       | 238        | 178        | 28               | 81             | 49            |
| TL      | 14.32±1.46 | 14.47±1.13 | 22.94±3.09       | 17.55±2.95     | 22.45±4.55    |
| TW      | 21.30±5.21 | 19.55±5.17 | 85.53±36.68      | 44.48±20.91    | 104.03±56.91  |
| M/F     | 0.71       | 0.82       | 2.28             | 0.78           | 0.53          |

Regarding small pelagic fish trophic ecology, the most common prey in stomach of sardine, round sardinella and anchovy were copepods and decapod larvae. In other pelagic fish species, chub mackerel and horse mackerel, larger crustaceans as euphausiids, mysids and decapod larvae become more important food source (Fig.1). Fish larvae accounted 8% in terms of numbers of the diet of horse mackerel. A relatively large diet overlap was also found among small pelagic fish (anchovy, sardine, sprat, Atlantic and Mediterranean horse mackerel, bogue, Atlantic mackerel and Atlantic chub mackerel) inhabiting the Bay of Biscay [4]. Feeding of small pelagic fish (anchovy, sardine, round sardinella and flat sardinella) from Canary upwelling water and frontal zones of Mauritania revealed that anchovy and flat sardinella feed mainly on zooplankton crustaceans, while round sardinella and sardine feed mainly on phytoplankton [5]. Moreover, to accurately quantify the importance of each prey item, the biomass measurements and stable isotope approach is necessary. Also, further research on small pelagic fish and plankton estimations at the same time and place would be of great interest to better understand ecological interaction and also for ecosystem based fisheries management.

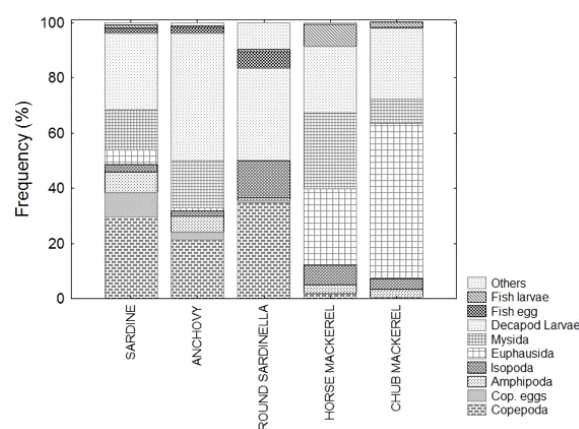


Fig. 1. Percentage of different prey items in the stomachs of small pelagic fish from eastern Adriatic Sea, June 2014 - August 2016.

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# COMPOSITION OF ICHTHYOPLANKTON ASSEMBLAGES DURING SUMMER IN MARINA PORTO MONTENEGRO (SOUTH ADRIATIC SEA)

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## Abstract

Analysis of ichthyoplankton composition in the area of marina Porto Montenegro was carried out in June, July and August 2017 on three research stations. Along with the sampling of ichthyoplankton, an analysis of basic physical parameters of sea water was performed using a CTD probe. The results showed the presence of 11 different species of fishes. The most dominant species was *Lithognathus mormyrus*, followed by *Diplodus puntazzo* and *Callionymus pusillus*. Among the larvae dominant species was *Ctenolabrus rupestris*. It is important to note that spawning of anchovy (*Engraulis encrasicolus*) was extremely scarce, although the area in which research was carried out was defined as one of the main spawning areas of this species in Boka Kotorska Bay area.

**Keywords:** *Ichthyoplankton, Larvae, Adriatic Sea*

The research of early life development stages of fishes was carried out in the marina Porto Montenegro during the summer months of 2017. Analyses were conducted within the framework of environmental monitoring programme and possible impact of exclusive yachts and ships in the area of marina, as well as more intense cruising tourism in the area of Boka Kotorska Bay during last 5 years. Sampling of ichthyoplankton was performed with a WP2 plankton net. Since the research was carried out in a relatively shallow part of the Tivat Bay, the net was towed vertically from a depth of 2 m above the bottom to the sea surface. After sampling, the material was preserved in a 4% solution of buffered formaldehyde. Diversity indices for the period of investigation were analyzed using Shannon Diversity Index ( $H'$ ) and the Simpson Index ( $D$ ) [4]. In the period from June to August 2017, it was found that in the area of marina Porto Montenegro, following fish species found favorable conditions for spawning (Table 1).

Tab. 1.

| No  | Name                             |
|-----|----------------------------------|
| 1   | <i>Engraulis encrasicolus</i>    |
| 2   | <i>Buglossidium luteum</i>       |
| 3   | <i>Parablennius tentacularis</i> |
| 4   | <i>Callionymus pusillus</i>      |
| 5   | <i>Ctenolabrus rupestris</i>     |
| 6   | <i>Lithognathus mormyrus</i>     |
| 7   | <i>Diplodus puntazzo</i>         |
| 8   | <i>Callionymus lyra</i>          |
| 9   | <i>Thalassoma pavo</i>           |
| 10. | <i>Epinephelus</i> sp.           |
| 11. | <i>Gobius</i> sp.                |

## Results and discussion

Analyses of qualitative and quantitative composition of ichthyoplankton showed that throughout the period of investigation spawning of all species was scarce and with low intensity. Although all positions were positive on ichthyoplankton, the abundance was very low and in range between 4-28 eggs/larvae per m<sup>2</sup> of sea surface. The value of Simpson's diversity index was 4.17; 3.05 and 6.82, while Shannon's index was 1.59; 1.32 and 1.99 for June, July and August, respectively. Analysis of abiotic factors (temperature and salinity) did not show significant deviations, and did not constitute a limiting factor for reproduction. A three-year study of the qualitative and quantitative composition of ichthyoplankton in the area of Boka Kotorska Bay showed that the bay is spawning and nursery area of a significant number of commercially important fish species [2]. Earlier data on the abundance of anchovy, *E. encrasicolus*, as one of the most important small pelagic fish species, showed that Tivat Bay (which is the subject of this research) is one of the main spawning areas of anchovy with an abundance of 90-430 eggs/m<sup>2</sup> of sea surface ([3], [1]). The reason for the relatively low diversity of species during summer of 2017 can be multiple.

The most frequent is the anthropogenic impact, ie intensive cruising tourism, devastation of the coastal area by intensive construction, excessive exploitation of fish stocks by commercial fishing and/or illegal fishing, unsolved issue of waste water, waste disposal etc. The fact that in June 2017 no spawning of anchovy was detected, and very low spawning intensity was found during July and August (4-8 eggs/larvae per m<sup>2</sup> of sea surface), points out to the worrying situation. Special attention should be paid to reducing the anthropogenic impact and other factors affecting the degradation of species diversity.

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# STUDY OF STRESS ASSOCIATED WITH TRADITIONAL GERRET OR PICAREL (*SPICARA SMARIS*) CAPTURED IN THE IBIZA ISLAND

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## Abstract

The aim of this study was to determine the antioxidant response of *Spicara smaris* to the recovery process after capture with traditional nets called "Arts de tirada". For this propose, 46 individuals of similar size were captured. In a first experiment, a behavioural study was carried out with 20 individuals and in the second, blood samples were taken from 26 individuals divided into three groups (recent capture, day 3, and day 7). The results show that there is a significant stress at the time of fishing that is progressively normalized during the recovery period. All biomarkers analysed were significantly decreased on the seventh day respect to the initial values with a survival rate of all specimens.

**Keywords:** Stressors, Balearic Islands, Fisheries, Fish behaviour

The fishing of (*Spicara smaris*) is performed by traditional fishing nets along the Balearic Sea for this type of fish called "Artet". In Ibiza is a self-regulated fishing to maintain a balance between the demand and the fishing obtained. For this reason, when fishing is too abundant, the excess of capture is released back to the sea. The main objective of this study is to know the effect of this practice, allowing us to know if the survival of the specimens is possible after being subjected to stressful fishing. Antioxidant defence enzymes play an important role in cellular antioxidant defence systems and protect against oxidative damage. The increase in the activities of catalase (CAT), superoxide dismutase (SOD) and glutathione peroxidase (GPx) is related to the increased production of reactive oxygen species (ROS) (Sureda et al., 2008). SOD activity is usually considered as a good biomarker because it is relatively short-time response to environmental stressors (Sureda, et al., 2008). CAT plays a minor role in the catabolism of H<sub>2</sub>O<sub>2</sub> at low production, but when the rate of H<sub>2</sub>O<sub>2</sub> is enhanced its importance increases. (Sureda, et al., 2018) The GPx is important not only to detoxify H<sub>2</sub>O<sub>2</sub> but also participates in the detoxification of lipid hydroperoxides using glutathione (GSH) (Tejada et al., 2007). The main function of the glutathione reductase (GR) is to catalyze the reduction of glutathione disulphide (GSSG) to GSH, helping to maintain the redox balance in the cells (Box et al., 2007). In the first part of the study 20 individuals were caught and transporting to a fish tank of 1.200 litres conditioned for the study. There, fish were provided with a composite of food flakes and pieces of copepods and rehydrated fish. Water temperature was maintained in the range of the external environment (between 15 ° C and 16 ° C) and a photoperiod of 12 hours of light and 12 hours of darkness. The results of this first week do not provide quantifiable data on the degree of stress, but it can be a useful and non-invasive tool for a preliminary diagnosis of stress (Auro de Ocampo & Ocampo, 1999). After the behavioural study, a survival rate of 100% was observed. The individuals were monitored for a week, and the behavioural observations were made every 6 hours on the first day and every 12 hours the rest of days for a week. The observations showed that the fishes cached have a change in coloration observed at the moment of fishing accompanied by behavioural agitation. At 6 hours the intensity of the change in coloration was decreasing. This alteration has been reversed on the third day, from which a pattern of coloration and stable behaviour has been presented. The second part of the experiment, designed from the results of the first, was divided into three sampling times: a first blood sample was obtained at the time of capture, day 1, a second sample was taken at day 3, and a final sample at day 7. Blood samples were centrifuged to obtain erythrocytes and used to compare the values of some stress biomarkers, such as the antioxidant enzymes CAT, SOD, GPx and GR.

Tab. 1. Significant differences were analysed by an unpaired t-test. P<0,005 was considered statistically significant respect to Day 1(\*)

|                       | Day 1   | Day 3   | Day 7   |
|-----------------------|---------|---------|---------|
| <b>CAT</b>            | 161,92  | 112,15  | 82,54 * |
| <b>(mK/mg prot)</b>   | ± 17,80 | ± 4,16  | ± 1,96  |
| <b>GPx</b>            | 22,56   | 13,69   | 11,02 * |
| <b>(nKat/mg prot)</b> | ± 3,87  | ± 0,57  | ± 1,10  |
| <b>GR</b>             | 2,40    | 1,41    | 1,10 *  |
| <b>(nKat/mg prot)</b> | ± 0,38  | ± 0,06  | ± 0,06  |
| <b>SOD</b>            | 26,65   | 21,85 * | 18,91 * |
| <b>(pKat/mg prot)</b> | ± 1,26  | ± 0,33  | ± 1,32  |

The results of the biochemical tests corroborated the observed behavioural values evidencing a progressive decrease in the values of all biomarkers determined. When faced with a stressor such as fishing, we can observe how the values of antioxidant enzymes and other factors that intervene in the response to stress drastically increase in order to eliminate the ROS generated. SOD activity reported a significant decrease at day 3 respect to the initial value, while the other enzymes decreased in a more gradual way, evidencing significant differences on the seventh day. These values can be related to the responses observed in the visual tracking group, where on the third day they were almost recovered. Therefore, it can be concluded that although the action of fishing generates considerable stress in individuals, this stress is quickly recoverable and should not significantly affect the fish life cycle. The traditional release of the excess of capture is useful for the fisheries strategies which allow adjusting the capture with the market demand.

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**OTOLITH SHAPE ANALYSIS OF THE EUROPEAN SARDINE *SARDINA PILCHARDUS* FROM ATLANTIC AND MEDITERRANEAN WATERS: CONNECTIVITY AND POPULATION DENSITY**

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The European sardine - *Sardina pilchardus* (Walbaum, 1792) - is a small pelagic fish that occurs from the Northeast Atlantic to the south of Cape Verde. In Portugal, sardines are of high cultural importance and constitute the largest national fishing resource in terms of landed biomass per year and overall commercial value. Recent data on landings statistics and recruitment estimates, indicates that the Atlanto-Iberian sardine stock is declining, reflecting the strong reduction in total biomass, estimated to be 75% below the historical average. Like other species of the Clupeidae family, sardines suffer large population fluctuations due to natural causes, the effects of fishing and environmental drivers such as climate change and pollution should be investigated. Currently, for management purposes, a single stock is considered in the Atlanto-Iberian Peninsula. If there is evidence of population structure at the geographical level in this area, is critical to assess the connectivity between stocks (i.e. the rate of exchange of individuals between stocks as measured by genetic flux). The objective of this work is to contribute to the knowledge of population structure of sardines using otolith morphometry. Otoliths from historical IPMA collections were analyzed, during contrasting years of population biomass to study if connectivity is dependent of density. The methods used to evaluate the shape of the otoliths included multivariate statistical analyzes of descriptive otolith information. Each sample digitized image was analyzed and general shape parameters were extracted, as area, perimeter, maximum length, and maximum width, as well as shape indices including circularity, eccentricity, area, perimeter, shape factor, and annual growth increments. This work is part of the project (SARDINOMICS, Mar2020) which intends to evaluate the genetic structure of the populations and their connectivity, allowing the identification of sardine stocks and, using historical samples, estimate the temporal variability of the sardine populations in the national territory, comparing the results derived from molecular and genetic techniques, with the information obtained by traditional techniques using otolith morphometry. This will allow to evaluate the degree of correspondence between methodologies and allowing to evaluate the spatial and temporal consistency of the stocks.

*Keywords: Sardina pilchardus, Otolith Shape, Atlantic Ocean, Mediterranean Sea*

**CIESM Congress Session : Ecology of lagoons and estuaries**  
**Moderator : Ana Brito, MARE, Lisbon, Portugal**

*Moderator's Synthesis*



# SEASONAL VARIABILITY OF THE DRY MASS OF MACROPHYTES IN RELATION TO WATER QUALITY OF THE SOUTHERN LAGOON OF TUNIS

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## Abstract

This work was carried out as part of a multidisciplinary study on water quality in the Southern lagoon of Tunis. Environmental parameters were monitored in 6 different stations and several water quality parameters (total phosphorous, nitrite, nitrate, total nitrogen, dissolved oxygen) were measured. Macrophytes were chosen as bio-indicator and a sampling plan composed of 6 parallel transects across the lagoon from December 2015 to November 2016 was followed up. Results show an improvement in physicochemical water quality and in species richness after the restoration project.

**Keywords:** *Gulf of Tunis, Lagoons, Eutrophication, Bio-indicators*

The Southern Lagoon of Tunis is a coastal Mediterranean lagoon located in the South west of the Gulf of Tunis; Its area is 710 hectares and its depth varied from 2 to 4.5 m. This lagoon used to be one of the most eutrophic lagoons of Tunisia where the phyto-benthic communities were dominated by nitrophilous species of the genus *Ulva* and *Cladophora* [1]. Therefore, it has been the subject of a restoration plan started in 1998 and was completed in 2001. Before the project of development and restoration, the situation of the lagoon was characterized by a strong pollution which was aggravated by the rapid urbanization [2]. To study the Spatio-temporal variations of the dry matter in response to the physico-chemical state of the waters in the southern lagoon of Tunis we did statistical treatments that show the period where the variation is important.

## Principal component analysis PCA with XLSTAT

The analysis in PCA made it possible to construct a factorial space and to define a set of factorial axes whose relative positions illustrate the relations of independence and the degrees of correlation between the variables.

The first two dimensions of PCA express 59.2% of the total dataset inertia.

Eigenvalue: The F1 axis has an eigenvalue equal to 2.205. The axis F2 has an eigenvalue equal to 1.366

## Analysis of covariance (ANCOVA) in R

As show in the figure 1 we note a significant effect of station factor on the dry matter. The ANCOVA test shows a significant effect (p-value = 0.005).

The analysis of variance (dry matter depending on the season) did not show a significant effect (p-value=7.88).

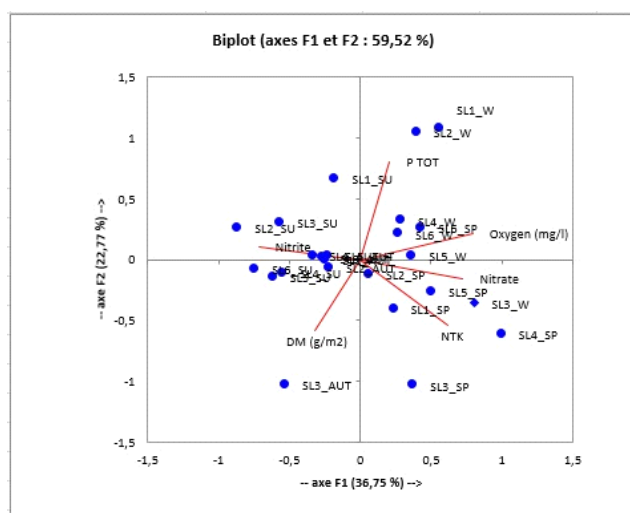


Fig. 1. Principal component analysis PCA (W : winter; SP: spring; SU:summer; AUT: autumn; PTOT: total phosphorus; TKN: Total Kjeldahl Nitrogen).

The multiple comparisons between the different groups show a maximum amount of biomass at station 3 which is significantly different from the first two stations (figure 2).

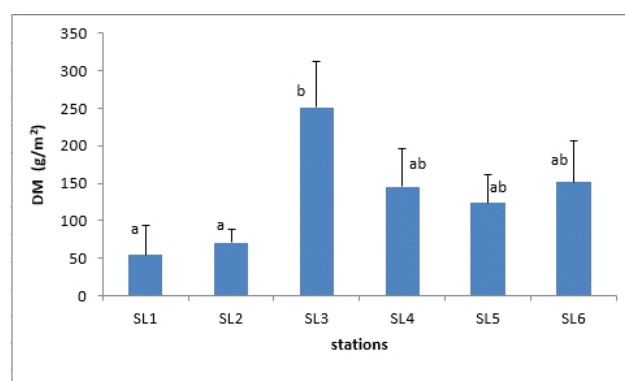


Fig. 2. Dry matter variability between stations

In 2016, the average biomass of macrophytes shows a significant variation. The lowest biomasses are measured on the East of the lagoon. During the winter season, the biomass of macrophytes showed an increasing evolution from East to West with a relative stabilization of growth in the central zone of the lagoon (from SL3 to SL5). The rest of the year exhibit a more pronounced fluctuation in biomass, with a highest value recorded during the autumn period in the central lagoon area (SL3) and a lowest value recorded during the summer season in the East zone (SL1). Referring to the ecological state before the restoration project, a clear improvement of eutrophication indicators was recorded, which reflects the positive changes in water quality. Overall, the observed parameters confirm the improvement of the environmental state of the Southern Lagoon of the Tunisian ecosystem.

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# SALINITY DRIVEN PHYSIOLOGICAL RESPONSE OF BEARDED HORSE MUSSEL, *MODIOLUS BARBATUS* (LINNAEUS, 1758) AND THE NOAH'S ARK SHELL *ARCA NOAE* LINNAEUS, 1758

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## Abstract

Bearded horse mussel *Modiolus barbatus* and Noah's ark shell *Arca noae* are a species of interest for the diversifying shellfish aquaculture on the south-eastern coast of the Adriatic. In this study, oxygen consumption (OC) and total ammonia excretion (TAM) responses to the changes in seawater salinity (37, 30, 25 and 20) were investigated in the laboratory. There is a statistically significant influence of salinity on oxygen consumption and TAM excretion of Noah's ark shell, while the time of exposure to different salinities is significantly correlated to TAM excretion by the bearded horse mussel.

**Keywords:** Adriatic Sea, Bivalves, Physiology, Oxygen, Salinity

## Introduction

Bivalves *Arca noae* Linnaeus, 1758 and *Modiolus barbatus* (Linnaeus, 1758) have become species of interest in recent years and significant research has been carried out on them (Mladineo et al., 2007; Peharda et al., 2013), although literature shows very little data on the physiological response of Noah's Ark shell. Salinity is one of the most important abiotic ecological factors in the estuaries and coastal seas (Berger and Kharazova, 1997). Several studies have been carried out on the effect of changes in salinity on oxygen consumption (OC), total ammonia (TAM) excretion of bivalves (Navarro, Gonzalez, 1998; Tang et al., 2005), but there is no available information on the influence of salinity on the metabolism of *Arca noae* and *Modiolus barbatus*. The aim of this study was to determine OC and TAM excretion of bearded horse mussel and Noah's ark shell related to abrupt changes in water salinity (37, 30, 25 and 20 psu).

## Material and methods

Individuals of *Arca noae* and *Modiolus barbatus* 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. Measurements of OC and TAM excretion were carried out on the organisms under different salinities: 37, 30, 25 and 20 psu using closed volume respirometry. Physiological response for each salinity was measured after 24 and 120 hours (1 and 5 days), in triplicate, to determine the acclimation to changed salinity. intervals with the Oxyscan graphic probe (UMS GmbH, Germany). After the experiment, the soft tissue was dried in a drying chamber at 60 °C for 24 h to a constant mass and dry weight (DW) of shellfish was taken as the basis for calculating the specific physiological rate. After OC measurement, 50 ml of seawater sample from chamber was taken, preserved with 2 ml of 1 M phenol and refrigerated for ammonia measurement (indophenol blue method). Statistical analysis was carried out using parametric ANOVA and Tukey post-Hoc analysis ( $p < 0.05$ ). To compare the metabolic rates between species, t-test was used.

## Results and discussion

Significant difference in OC was observed for Noah's ark shell (ANOVA,  $F = 9.964$ ;  $p = 0.000$ ) exposed to different salinities, with significant groups at 25 and 30 psu (Tukey,  $p = 0.001$ ). Bearded horse mussel did not show statistically significant difference in OC at different salinities and at different exposure times. OC was significantly different between the species at all tested salinities (t-test,  $p < 0.05$ ). *M. barbatus* exhibited lower OC than *A. noae* at all salinities (Fig. 1a). There was a statistically significant difference in Noah's ark shell TAM excretion (ANOVA,  $F = 2.896$ ;  $p = 0.039$ ) due to different salinity, with largest difference between bivalves exposed for 24 hrs to salinity of 25 psu and a group exposed for 24 hrs to salinity of 30 psu (Tukey,  $p = 0.044$ ). Statistically significant difference in the influence of the exposure time to TAM excretion of bearded horse mussels was recorded (ANOVA,  $F = 4.304$ ;  $p = 0.006$ ). Post-hoc Tukey test results showed the difference between shellfish exposed one day and five days to salinity of 20 psu (Tukey,  $p = 0.018$ ). There was a statistically significant difference in TAM excretion between the two species (t-test,  $p < 0.05$ ) (Fig. 1b).

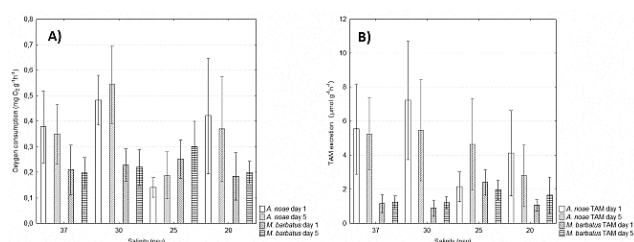


Fig. 1. Oxygen consumption (a) and Ammonia excretion (b) of *Arca noae* and *Modiolus barbatus* in relation to different salinities.

OC values for bearded horse mussel and Noah's ark shell partly overlap. Our results are consistent with the results obtained for the mussel *Mytilus edulis* by Hawkins et al. (1985) and for the dog cockle *Glycymeris glycymeris* by Savina, Pouvreau (2004). Noah's ark shell showed increase in OC with the increase of salinity. In both investigated species in our experiment, an intensive change in physiological response was observed at 25 psu. From the results, it was likely that for the Noah's ark shell, salinity of 25 psu was favourable. Strong reaction of both species to salinity of 25 psu may be the result of natural occurring changes in Mali Ston bay salinity caused by river Neretva and submarine groundwater discharges.

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# ASSESSMENT OF THE CHLOROPHYLL A VARIATION IN A RESTORED SOUTH MEDITERRANEAN LAGOON (NORTH LAGOON OF TUNIS)

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## Abstract

This work concerns the development of a NARX (Nonlinear autoregressive with external input) network model to assess the ecological status of the North lagoon of Tunis after the restoration work through time. Chlorophyll *a* variation was investigated as indicator of water quality, in connection with one nutrient element, the nitrogen at five stations in the North lagoon of Tunis. The model is based by monthly collected data from September 1989 to December 2017. A comparison between simulations and observations showed that the model can reproduce with a satisfactory way the observations. At the beginning of the studied period, we've noticed a decrease in the values of the Chlorophyll *a*, then in 2009 we can see that it's increasing again. seasonal variation is well simulated also.

**Keywords:** Lagoons, Chlorophyll-A, Models, Tunisian Plateau

## Introduction

The North lagoon of Tunis is one of the most important lagoons in Tunisia, that has known a critical ecological state substantially due urban development. Its strategic position in the center of the capital, associated with its ecological importance, has arisen the concern of the Tunisian government and led to the development of a restoration project for the lagoon based on water circulation, held in 1987 and monitored by the SPLT (Société de promotion du Lac de Tunis). The chlorophyll *a* is the most important pigment in aerobic photosynthetic organisms, and its measurement is used as an indicator of the phytoplankton biomass present in the water, and thus the ecosystem degree of eutrophication. The objective of this work is to highlight the ecological evolution of the ecosystem after its restoration, via the treatment of chlorophyll *a* concentration data in relation to the Total Nitrogen.

## Methodology

In order to assess the North lagoon of Tunis ecological evolution, we simulated a Non Linear autoregressive with External Input (NARX) Neural Network. The equation for the NARX model is [1]:

$$y(t) = f(y(t-1), y(t-2), \dots, y(t-ny), u(t-1), u(t-2), \dots, u(t-nu))$$

To evaluate the chlorophyll variation through time in the studied ecosystem, we implemented the model with two time series (Chlorophyll *a* and Total Nitrogen). Note that since we want to evaluate the Chlorophyll variation through time, so it's considered the target input  $x(t)$ , using the total Nitrogen as an external input  $y(t)$ . Five sampling stations were fixed according to an hydrodynamic model, established specifically for the lagoon restoration which was based on water circulation (fig 1).

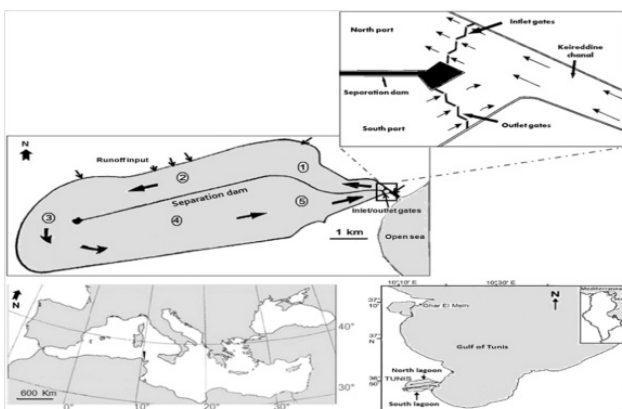


Fig. 1. Location of the study area and water quality monitoring stations (1-5). Arrows inside the map represent the unidirectional inlet/outlet water circulation system [2].

## Results

The model seems to be adequate. It is predicting quite well the observations of the ecosystem ( $R=0.61$ ).

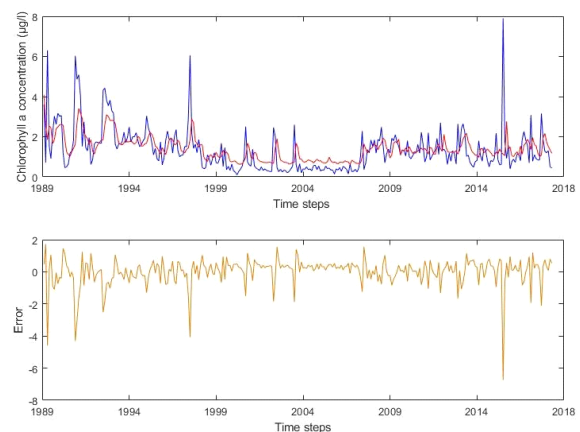


Fig. 2. Variation of the simulated and observed Chlorophyll *a* concentration.

Figure 2 displays a comparison between simulated and observed data of the Chlorophyll *a*, also the error calculated by the model. The general shape of the chlorophyll *a* evolution simulated curve is coherent with the measurements. In the model, we notice at the beginning that there is a downward trend in the chlorophyll *a*, this shows the positive ecological evolution of the lagoon after the restoration works. Since 2009, we notice an increase in the variation of the chlorophyll. The difference between the simulated and observed concentrations can be due to mistakes done during sampling or also mishandling during analyzing. The periodicity noticed, can be explained by the seasonal effect.

## Conclusion

In this work we've studied the evolution of the North Lagoon of Tunis trophic state by analyzing past data of Chlorophyll *a* and total nitrogen. The variation of the chlorophyll *a* has come to confirm the good functioning of the restoration work which is based on a permanent renewal of the lagoon waters allowing the gradual washing of the nutrient reserves in the sediment. As a result, we notice the decrease in the total nitrogen and in the chlorophyll.

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# CHLOROPHYLL A VARIABILITY IN THE INNER PART OF BOKA KORORSKA BAY

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## Abstract

Nutrient and chlorophyll *a* concentrations were analyzed at two stations in inner part of Boka Kotorska Bay. Chlorophyll *a* concentration on 10-years scale decreased and showed significant negative correlation related to monitoring from 2003 – 2013. TRIX index ranged from 2,33 in spring 09/10 to 3,26 in winter 12/13. This study showed state of water quality on 10-years scale, in three annual cycles in Kotor Bay and can be used as a main source in predicting (determining) possible changes in this Bay in future.

**Keywords:** Chlorophyll-A, Adriatic Sea

**Introduction :** Chlorophyll *a* concentration is the main proxy of phytoplankton biomass [1] representing a key oceanic biogeochemical variable. Measurements of chlorophyll *a* concentration and oxygen saturation enable basic but insufficient information to be gathered on the trophic status, so more complex indicators were developed. A complex trophic index (TRIX) based on biological (chlorophyll *a* concentration) and physiochemical parameters (oxygen saturation, mineral and total nitrogen and phosphorus) was introduced by Vollenweider et al. [2]. Boka Kotorska Bay is a semi-enclosed basin of Montenegro, situated in the south-eastern Adriatic Sea (Mediterranean Sea). Kotor Bay is a representative of closed karstic bay of a temperate sea, influenced at the same time by karstic rivers and underground springs [3,4] and by strong anthropogenic pressures [5]. The enrichment of water with nutrients may result in the growth of algal biomass [6]. There are studies of the spatial and temporal distribution of physical, chemical and biological oceanographic properties, phytoplankton, chlorophyll, nutrients and Coloured Dissolved Organic Matter in Boka Kotorska Bay [5,6,7,8]. The aim of this work is to analyze variation in chlorophyll *a* dynamics at the two stations in the inner part of Boka Kotorska Bay and assessing the trophic state using trophic index.

**Materials and methods :** Water sampling was carried out in three series: September 2003-August 2004 monthly; June 2009- May 2010 twice per month and October 2012-September 2013 monthly, at two stations (BK1 and BK2) in inner part of Boka Kotorska Bay. Total number of 362 water samples were collected with 5L Niskin bottles at station BK1 at three depths (surface, 5m and 10m) and BK2 at five depths (surface, 5m, 10m, 20m and 30m). Chlorophyll *a* concentrations were determined according to Jeffrey et al. [9]. Trophic index TRIX was calculated according to Vollenweider et al. [2].

**Results and Discussion :** Chlorophyll *a* concentration showed a pronounced temporal variability. The highest value was measured in winter 09/10 and reached 10.11 mgm<sup>-3</sup> (Fig1).

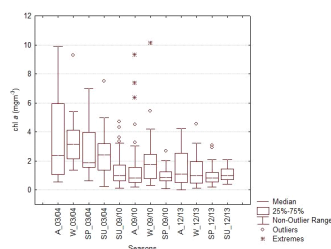


Fig. 1. Box & Whisker representation linear regression of seasonal variation of chlorophyll *a* concentration in Kotor Bay for period 2003-2013.

Medians in annual cycles showed higher values during winter season. Chlorophyll *a* concentration on 10-years scale decreased and showed significant negative correlation related to monitoring from 2003 - 2013 ( $r = -0.392$ ;  $p < 0.05$ ) and according to Håkanson [10] this area can be defined mainly as mesotrophic (median: 1-3mgm<sup>-3</sup>) with individual exceptions

which showed eutrophic and hipereutrophic characteristics.

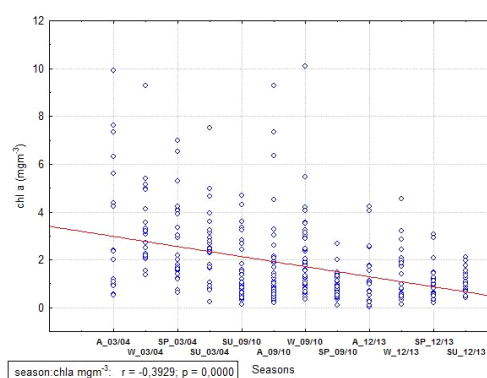


Fig. 2. Linear regression of seasonal variation of chlorophyll *a* concentration in Kotor Bay for period 2003-2013

TRIX index ranged from 2,33 in spring 09/10 to 3,26 in winter 12/13 showing lower values of calculated TRIX mean values as 5.507+0.889 for the Adriatic Sea [2]. This study showed state of water quality on 10-years scale, in three annual cycles in Kotor Bay and can be used as a main source in predicting (determining) possible changes in this Bay in future.

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# SPATIO-TEMPORAL DISTRIBUTION OF BENTHIC MACROFAUNAL COMMUNITIES IN THE LAGOON COMPLEX OF GHAR EL MELH

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## Abstract

The study of benthic macrofaunal structure showed that the values of specific richness and abundance are higher in the winter than in summer. The application of Non-parametric Multidimensional Analysis allowed to isolate the stations S3 and S1 from the other (S2, S5 and S7) characterized by a light perturbation. This result could be attributed mainly to the total organic matter.

**Keywords:** Lagoons, Zoobenthos, Biodiversity, Gulf of Tunis

This study has been realized to evaluate the actual state in Ghar El Melh lagoon. A total, 90 samples has been done during two seasons of the year 2018 (winter and summer) in 8 lagoons areas and 1 marine station. Sampling has been effectuated using a quadrat of 0,25m<sup>2</sup> surface (5 replicates per station). We also sampled the sediment [1]. The analysis of the granulometry showed the dominance of sand and low total organic matter in the majority of the stations indicating normal state except for the stations S6 and S8 which are polluted. The biotic study shows that the marine station S4 and S9 are completely azoic. Values estimated of specific richness and total abundance suggested a notable decrease from winter (41 species ; 1788 sp/m<sup>2</sup>) to summer (34 species ; 860 sp/m<sup>2</sup>). During winter, values of Shannon-Wiener (H') and equitability (E) indices showed that the majority of settlements are with light perturbation to perturbation except in S3. In summer, diversity indices highlights that except for the S3, state stations has degraded with a notable perturbation to serious perturbation and even azoic state (S6). The results of Non-parametric Multidimensional Analysis (MDS) allowed to gather the stations in winter (Fig. 1 A) as well in summer (Fig. 1 B) in two groups.

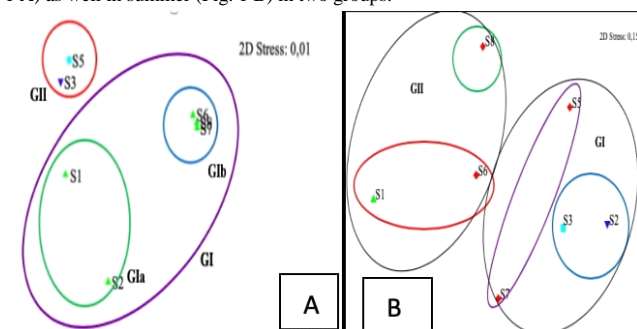


Fig. 1. Non-parametric Multidimensional Analysis (MDS) (A : Winter ; B : Summer 2018)

The impact of different abiotic factors on the benthic macrofaunal structure (ANOSIM) revealed a significant contribution only for the total organic matter concentration.

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## PROMOTING SUSTAINABLE AQUACULTURE IN THE SADO ESTUARY

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### Abstract

Estuarine zones are very productive areas that receive great interest from local communities. While regional socio-economic development is a priority for most managers, estuaries are prone to conflicts that sometimes are hard to handle. Hence, sustainable development, that considers the implementation of sustainable aquaculture practices, has to be based on the preservation of the ecosystem, ensuring the maintenance of habitats, biological components as well as their function and interaction. For this, it is important to understand how environmental and biological conditions vary over time and space and how they interact with the use of the system. The objective of this study is to evaluate the environmental quality of the Sado Estuary, in an integrative perspective, at the ecosystem-scale, promoting the use of the natural element, estuarine microalgae, as a food source in the sustainable production of bivalves, namely the Portuguese oyster (*Crassostrea angulata*) and other species with potential for production. To meet this goal, the estuary was sampled monthly during 2018-2019, regarding physical-chemical (temperature, salinity, oxygen, nutrients) and biological parameters (phytoplankton biomass and species composition, microscopy and HPLC), as well as metals and contaminants. Historical data, from 1986 to 2010, were also gathered. A preliminary analysis revealed the existence of an upstream-downstream gradient for most parameters (temperature, salinity, dissolved oxygen, suspended solids, nutrients and chlorophylls). Nutrient levels were seen to be the highest during winter and the highest values of chlorophyll *a* concentrations were observed in spring/summer, with downstream (near river mouth) peaks in April and upstream peaks in June. Generally, the levels of nutrients and chlorophyll *a* concentrations are within the standard levels for the most Portuguese estuaries. However, in 2018, results revealed a 1-month delay in the phytoplankton bloom occurrence, which may have direct implications for the higher trophic levels.

Keywords: sustainable aquaculture, phytoplankton communities, ecological quality, Sado estuary



## **CIESM Congress Session : Fish population dynamics**

**Moderator : Alexandra Silva, IPMA, Lisbon, Portugal**

### *Moderator's Synthesis*

Fish population dynamics is a vast discipline that investigates the key processes of the variation of abundance: births, immigration, deaths and emigration. The dynamics of fish populations is described with models which assess past, current and future population size. Population and fishery models form the basis to evaluate the performance of harvest strategies in relation to reference points. The goal of such strategies is usually to reach maximum sustainable yield. The presentations of this session spanned a variety of topics: stock/population structure which is fundamental knowledge to apply stock assessment models and also to progress to assessment approaches which account for spatial population structure and connectivity; the spatial dynamics of different life stages, in particular egg and larval stages and how that may affect recruitment success; community structure and variation in the fishery composition, a step towards the application of an ecosystem approach to fisheries assessment and management.

The participants identified potential areas of collaboration between Mediterranean and Atlantic scientists, namely joint research on fish stock identification and stock assessment, merge research carried out on each side of the Strait of Gibraltar (e.g. acoustic surveys for small pelagic fishes) and participation of researchers from Mediterranean countries to ICES working groups and from the Atlantic to GFCM working groups.



# STOCK DISCRIMINATION OF *MULLUS BARBATUS* IN THE WESTERN MEDITERRANEAN USING OTOLITH SHAPE ANALYSIS.

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## Abstract

Otolith shape analysis was examined to determine its utility for stock identification of red Mullet *Mullus barbatus* in Western-Mediterranean Sea. Otolith shape was described using 19 Fourier harmonics and by five indices of shape. Canonical discriminant analysis (CDA) showed that stocks were successfully discriminated with otolith shape data and gives more than 70% of classification rate. The percentage of well classified individuals of *M. barbatus* in predefined groups varied between 63.1 to 80.5% depending on sites. These spatial patterns were most likely linked to differences in environmental conditions between areas and sites. Otolith shape analysis has potential for stock identification of red Mullet on Western-Mediterranean Sea.

**Keywords:** *Western Mediterranean, Fisheries, Analytical methods*

## Introduction

Stock identification and spatial structure information provide a basis for understanding population dynamics and provides reliable resource assessment for fishery management. Red mullet is an important component of the Mediterranean demersal resources. Being of high commercial value, it is one of the main target species of demersal fisheries. The stocks are considered to be heavily exploited. 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 otolith shape analysis.

## Materials and Methods

During the period of January-June 2017, a total of 197 *Mullus barbatus* adult individuals were collected in five heterogeneous locations within two main areas: Marseille coast in the NW Mediterranean (n=18), and Tunis (n=66), Annaba (n=42), Algiers (n=30) and Oran (n=41) coasts in the SW Mediterranean Sea. Individuals were obtained from commercial trawls as well as through local fisherman and by scuba diving. For each fish, total length was measured to the nearest mm and then the sagittae were extracted for analysis. Digital images of otoliths were obtained in standardized conditions to minimize distortion errors. Each pair of otolith (n=394 sagittae) was placed on a dark background with the sulcus side facing down and the rostrum to the left in a horizontal line and digitized with a high-resolution video camera. All statistical analyses were performed with SPSS 21 software package.

The analytical design was set up to determine differences between stocks through canonical discriminant analysis. The objective of CDA is to investigate the integrity of predefined groups, i.e., individuals belonging to a given group such as stocks, through finding linear combinations of descriptors that maximise the Wilks lambda ( $\lambda$ ) [1]. The Fourier coefficients for both right and left otoliths pooled, were used to show the relative positions of the five populations. The CDA performed on these data allowed to separate the stocks of red Mullet *M. barbatus* in tow shores of the Western Mediterranean (Fig. 1).

## Results and discussion

With all samples, the first axis of the discriminant analysis represented 74.4% of the variability ( $\lambda = 0.116$ ,  $p < 0.001$ ). This allowed discrimination of the two populations of Oran and Marseille from the shape of their otoliths. The cohen-Kappa test indicated a high rate of reclassification among the origin groups (80.5 %) (Tab. 1). The otoliths of the Tunis, Annaba and Algiers's group were also differentiated by the second axis ( $\lambda = 0.263$ ,  $p < 0.001$ ). Three main groups can be distinguished. The three samples collected from Algiers, Annaba and Tunis were part of the same group, whereas those of Marseille and Oran were separated into two distinct groups. The primary function appeared to separate the three populations according to the shape of their otoliths.

Tab. 1. Percentages of correctly classified individuals within each sampling site for *Mullus barbatus* in Western Mediterranean Sea

| Site      | % correctly classified |           |         |        |       |       |
|-----------|------------------------|-----------|---------|--------|-------|-------|
|           | Oran                   | Marseille | Algiers | Annaba | Tunis | Total |
| Oran      | 80.5                   | 3.7       | 2.4     | 4.9    | 8.5   | 100.0 |
| Marseille | 2.8                    | 75.0      | 8.3     | 2.8    | 11.1  | 100.0 |
| Algiers   | .0                     | 1.7       | 78.3    | 10.0   | 10.0  | 100.0 |
| Annaba    | 7.1                    | 1.2       | 8.3     | 63.1   | 20.2  | 100.0 |
| Tunis     | 4.5                    | .8        | 6.8     | 12.1   | 75.8  | 100.0 |

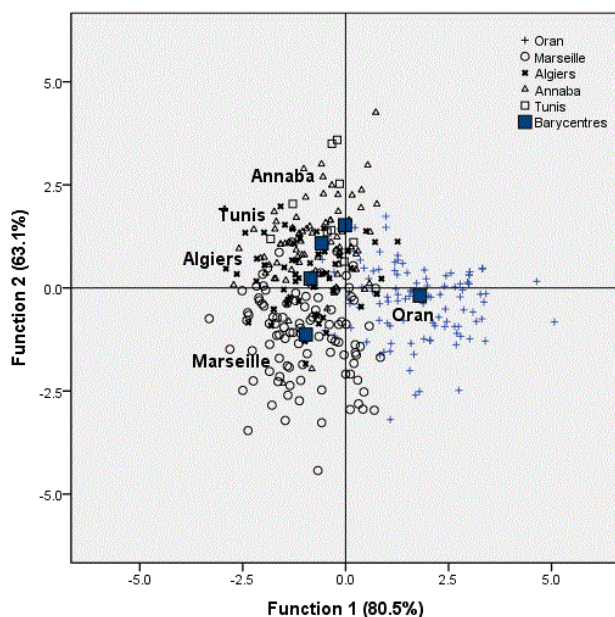


Fig. 1. Canonical discriminant analysis achieved with both otolith of *M. barbatus* collected on Western Mediterranean Sea.

In this study, only adult individuals were examined and this procedure was followed to avoid confounding factors that could be caused by allometric growth. The otolith contour analysis has been used and recognized as an important tool for discriminating fish stocks [2]. Variations in otolith shape of fish from different geographic areas are at least partly expressed during the life history, thereby representing a phenotypic measure of stock identification. In conclusion, in this study, the data indicated a high discrimination rate. This suggests that variability in otolith shape is a good tool for stocks identification in *M. barbatus*.

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# PELAGIC FISH COMMUNITY DERIVED FROM SUMMER ACOUSTIC SURVEYS IN NORTHERN ALBORAN SEA (MEDITERRANEAN SEA)

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## Abstract

Data from the Mediterranean International Acoustic Survey (MEDIAS) carried out in July from 2013 to 2018, covering all the continental shelf, from the coast till 200 m depth, between C. La Nao and Punta Europa (Fig. 1) were processed in order to estimate the abundance (biomass in tons) and distribution of all the pelagic fish species detected during the survey.

**Keywords:** *Alboran Sea, Acoustics, Biomass, Pelagic, Fishes*

## Introduction

In Spain, acoustic research surveys have traditionally been used to evaluate and monitor the population of commercially important pelagic fish species such as sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*), however the pelagic fish community presented in our waters is wider. In the present study we describe the pelagic fish community detected on the Northern Alboran Sea (GSA01, Spanish Mediterranean) continental shelf derived from summer acoustic surveys.

## Material and Methods

The study area prospected by the surveys is located in the Spanish Western Mediterranean continental shelf, limited in the west by the Cabo de Palos and in the east by Punta Europa, in the vicinity of the Strait of Gibraltar (Figure 1). Acoustic surveys were carried out on board a 70 m long research vessel, at 10 knots constant speed, in July, from 2013 to 2018. Acoustic data were continuously recorded from dawn till dusk, with a split-beam scientific echosounder (SIMRAD EK60) equipped with five transducers working at 18, 38, 70, 120 and 200 kHz. The Elementary Sampling Distance Unit (EDSU) was set to 1 nautical mile (nmi). The echosounder was calibrated at the beginning of each survey following the standard techniques [1,2]. Sampling design was systematic and consisted of 58 parallel equidistant transects perpendicular to the bathymetry and covering the continental shelf from 25 to 200 m depth. Inter-transect distance was 4 nautical miles (nmi) (Figure 1). Fish density (sA or Nautical Area Scattering Coefficient (NASC) in m<sup>2</sup> mn<sup>-2</sup>) [3] was integrated at every EDSU using Echoview software (Myriax Ltd) for the 38 kHz frequency. Mid-water pelagic fishing trawls aimed at identifying fish species echotraces detected by the scientific echosounder were performed with a 20 m vertical opening pelagic net and 20 mm codend, equipped with a net-sonder FS 20/25 (SIMRAD).

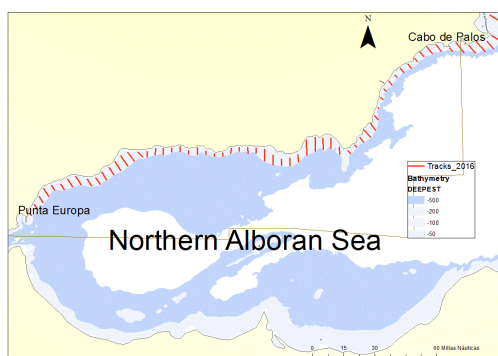


Fig. 1. Study area

## Results and discussion

The results show that the pelagic fish community is composed by eight pelagic fish species with sardine (*Sardina pilchardus*), chub mackerel (*Scomber colias*), Atlantic horse mackerel (*Trachurus trachurus*), Mediterranean horse mackerel (*Trachurus mediterraneus*) and sardinella (*Sardinella aurita*) as predominant species and anchovy (*Engraulis encrasicolus*), bogue (*Boops boops*) and blue

jack mackerel (*Trachurus picturatus*) as species that appear in a more occasionally way (Fig. 2). Perciforms fish species like *S. colias* and *T. trachurus* represent an important amount of the total estimated pelagic fish biomass (tons) (Fig. 2). During the six studied years it was observed a high increase of total biomass of pelagic fish species in this area (from 31200 to 57700 tons) together with a change in the pelagic species composition, due principally to good recruitments of chub mackerel in 2016 and Atlantic horse mackerel in 2017 (Fig. 2). Sardine biomass was abundant in 2018 (Fig. 2).

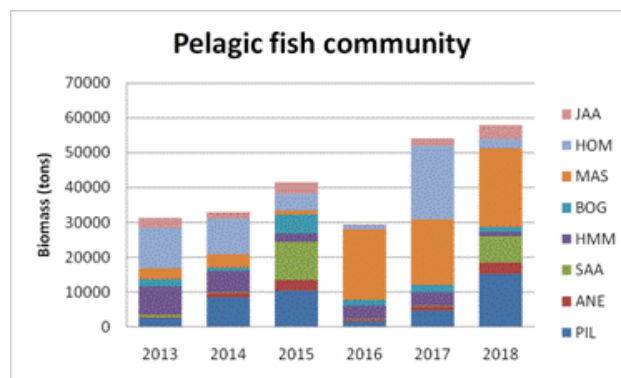


Fig. 2. Fish pelagic species biomass (tons) per year (2013-2018) in the study area. JAA: blue jack mackerel (*Trachurus picturatus*); HOM: Atlántic horse mackerel (*Trachurus trachurus*); MAS: chub mackerel (*Scomber colias*); BOG: bogue (*Boops boops*); HMM: Mediterranean horse mackerel (*Trachurus mediterraneus*); SAA: sardinella (*Sardinella aurita*); ANE: anchovy (*Engraulis encrasicolus*); PIL: sardine (*Sardina pilchardus*).

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# POPULATION STRUCTURE OF THE EUROPEAN CONGER (*CONGER CONGER*) FROM THE AZORES: CAN WE CONSIDER A LOCAL STOCK?

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## Abstract

The objective of this study was to examine the population structure of Conger conger in the Archipelago of the Azores based on all available data (surveys and landings data) to test the hypothesis that the stock of this species in ICES subarea 10a2 represents a management unit fisheries. The results this study suggests that almost every length classes were present (14-260 cm) in the Azores. However, the survey design may be not adapted for this species because juveniles may have been under-represented as well as larger and sexually mature males and females. In conclusion, the results of this study indicate that additional studies focusing on young individuals, mature adults and connectivity are needed to determine whether the *C. conger* can be considered a local population in the Azores.

**Keywords:** Fisheries, Azores, Management

Although there is a wide geographical distribution and relevance in commercial fishing [1,2], the current knowledge about Conger conger is limited and presents conflicts [3,4,5]. In the Azores (ICES Subarea 10a2), the European conger fishery is currently managed through a "precautionary approach", as it has not yet been defined if the component of the Azorean population is a management unit. Therefore, the objective of this study was to examine the population structure of *C. conger* in the Archipelago of the Azores based on all available data (surveys and commercial fishery landings data) to test the hypothesis that the stock of this species in ICES subarea 10a2 represents a management unit fisheries. *C. conger* was caught in all sampling areas of the Azores in a depth distribution ranging from 50 m to 750 m and a mode on the between 350 and 500 m (Fig. 1a). The length distribution ranged from 14 cm to 260 cm with well-defined modal groups and distributed of the between length classes (Fig. 2a) and did not present a vertical stratification by length (Fig. a). Regarding the length composition of commercial landings, the length distribution ranged from 60 to 213 (Fig. 2b). These results suggests that almost every length classes were present (14-260 cm). However, the survey design may be not adapted for this species because juveniles may have been under-represented (gear selectivity) as well as larger and sexually mature males and females (offshore areas). The GLM results of the *C. conger* showed an increase trend on the annual mean length from the fishery ( $\chi^2=215$  388.9, d.f. = 26,  $p < 0.001$ ) and a great interannual variability in the length data from survey ( $\chi^2=216$  58.3, d.f. = 18,  $p < 0.001$ ) (Fig. 1b). In conclusion, the results of this study indicate that practically all lengths of *C. conger* have been captured in the Azores, and additional studies focusing on young individuals, mature adults and connectivity are needed to determine whether the European conger can be considered a local population in the Azores.

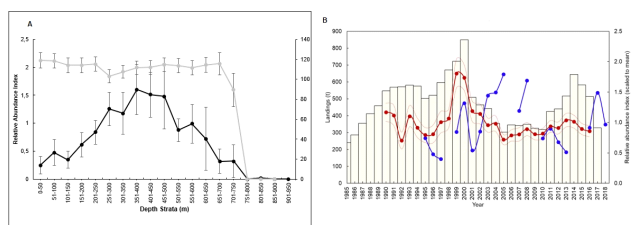


Fig. 1. (A) Mean abundance index (Black lines) and mean length (Grey lines)  $\pm 0.95$  confidence of Conger conger, for the period 1995- 2018, by depth strata from the annual Azorean spring bottom longline survey. Bars represent 95% confidence intervals. (B) Commercial landings (bars) and relative abundance indexes from the surveys (blue color) and derived from commercial catch and effort (standardized CPUE) data (red color) of the Conger conger in the Azores archipelago. Both abundance series have been scaled to their

respective means. Dotted lines represent 95% confidence intervals for the standardized CPUE.

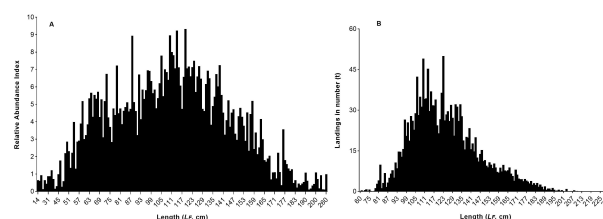


Fig. 2. Length composition of *Conger conger*, for the period 1995-2018, by area from the annual Azorean spring bottom longline survey (A) and length distribution for the period 1990-2016 from the Azorean commercial bottom longline fleet (B).

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# ANCHOVY (*ENGRAULIS ENCRASICOLUS*) AGGREGATION FROM EGGS TO ADULTS. WHERE ARE THEY LOCATED?

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## Abstract

In this study, anchovy spatial distribution, from egg to adult, has been determined in Alboran Sea, under the initial hypothesis of anchovy life cycle can be follow using acoustic methods, given that they provide synoptic information of the entire water column and the fishes scattering properties change as they grow.

**Keywords:** *Alboran Sea, Acoustics, Fish behaviour, Life cycles, Pelagic*

## Introduction

One of the most important events in the anchovy ontogeny development is the aggregation in schools. The first stages of anchovy life, from hatching to larvae, occurs in the water column as part of the icoplancton. During the initial developmental stages (< 6 mm SL anchovy) are found in the upper layers of the water column, (between surface and 20 m) reaching greater depths as they grow [1]. The caudal fin formation (> 8.5 mm SL anchovy) marks a key point since it is related to the beginning of school formation [2], which is related to the decrease in mortality and recruitment success. The beginning of aggregation have been related with the lack of spatial distribution of anchovy in the size range of 20-40 mm SL [3], [4]. Anchovy juveniles and adults follow a typical diel patterns, dispersing at night time and schooling throughout daylight hours, which can be follow remotely by means of acoustic methods [5]. The fish swimbladders resonance depend on the fish length, the bigger the swimbladder the lower the resonance frequency [6]. In this study, the anchovy life cycle has been mapped combining acoustic multifrequency and biological samples.

## Material and Methods

During the MEDiterranean International Acoustic Survey (MEDIAS) carried out in 2014 and 2016 in July, acoustic and biological samples were taken in the continental shelf (30-200 m depth) of Alborán Sea. Acoustic data were collected in a continuous way following a systematic survey design using an EK60 scientific echosounder operating at 18, 38, 70, 120 and 200 kHz. Biological samples were addressed to identify the acoustic records detected, and depending on their particular characteristics different samples devices were employed. A bongo net (90 cm opening) equipped with 500 and 2000 µm net were employed to identify the Epipelagic Scattering Layer (ESL) and the Deep Scattering Layer (DSL), and a pelagic trawl was employed to identify the fish schools echotraces (FISH). Moreover a Continuous Underway Fish Egg Sampler (CUFES) was employed to sample anchovy eggs (EGG). The distribution of each acoustic record, ESL, BSL and FISH were determined by scrutiny the echograms (Echoview software) and they biological identity were define according to the biological samples composition. Finally all the data were integrated in a SIG application (ArcGIS 10.4).

## Results and discussion

The ESL followed the thermocline limits, from 10 to 60 m depth, its resonant frequency was 38 kHz and contained anchovy larvae < 9 mm. The DSL was located on the bottom with a mean vertical thickness of 10 m, its resonant frequency was 18 kHz and contained anchovy larvae from 8 to 30 mm. Anchovy discrete schools were mainly located, from 30 to 150 m depth, their resonant frequency was 18 kHz and they were composed by juveniles and adults from 4 to 12 cm (Fig.1). Our results show the distribution and pattern of aggregation of the anchovy throughout its life cycle in Alborán Sea. Moreover, we have determined that larvae from 8 mm migrate to the bottom and form a continuous layer before forming discrete schools, which may be related to their absence in samples taken using conventional methods of ichthyoplankton sampling.

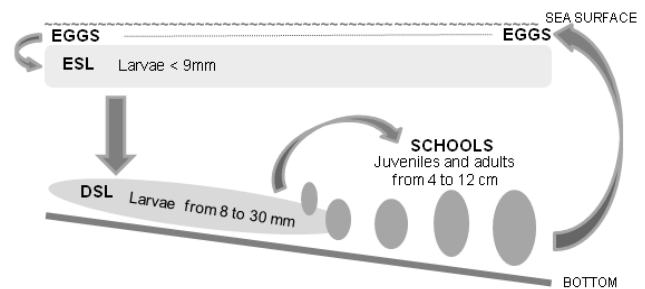


Fig. 1. Anchovy life cycle spatial distribution and aggregation pattern in Alborán Sea. ESL:Epipelagic Scattering Layer, DSL: Deep Scattering Layer

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## SARDINE EARLY LIFE STAGES DISTRIBUTIONS AND LINK TO RECRUITMENT AREAS IN ATLANTIC IBERIAN WATERS

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### Abstract

Recruitment success in small pelagic fishes is dependent on factors related to the populations reproductive potential but it is also highly determined by the survival of the initial life stages from the egg until the recruitment age. Planktonic eggs and larvae are particularly vulnerable to environmental conditions including dispersal which in turn, in the event that advection leads the individuals to less suitable areas, may have influence on the predation pressure, on food availability and ultimately on survival into the recruitment phase.

Previous works have shown that in the Atlantic Iberian waters sardine (*Sardina pilchardus*), when at steady abundance levels, spawns over almost the entire continental platform though with some hot spots [1]. The long time series of high resolution spatial data gathered by IPMA's research surveys (PNAB/DCF) has given ample information on the species spawning and recruitment distribution patterns [2] but the knowledge on the larval spatial occurrence, and the spatial dynamics between the three (egg, larvae, juvenile) stages are poorly investigated.

The present study examines the distributions of sardine eggs and larvae off Iberia during years of different oceanographic scenarios relating the dispersal patterns to the main circulation features. In addition, the existence of recurrent spawning, nursery and recruitment grounds is discussed with regard to the environmental conditions and the early life stages distributions.

Keywords: Sardine, Early life stages; Iberia

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## HOW AN ONBOARD MONITORING PROGRAM CAN REVEAL TRENDS IN PORTUGUESE PURSE SEINE FISHERY?

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### Abstract

The purse seine fishery is one of the most important fisheries in Portugal, accounting for 50% of total landings in weight. Historically, sardine (*Sardina pilchardus*) is the target species of the purse seine fleet. With the decline of the sardine stock and the reduction of annual quotas, this fleet has supplemented its yields by targeting other pelagic species such as chub-mackerel (*Scomber colias*), horse mackerel (*Trachurus trachurus*) and anchovy (*Engraulis encrasicolus*).

Within the framework of PNAB/EU-DCF using the same protocol [1], this work aims to investigate changes in the purse seine fleet activity and catch and landings compositions associated with the decline of sardine, including inter-annual variations of fishing effort, catch, landings and slipping compositions, using on-board observations from 2006 to 2018. More than 400 trips and 450 sets were recorded and carried out in more than half of the national fleet, corresponding to 0.5% of the total fleet effort [2]. Sardine catches and landings declined mostly due to quota restrictions, leading to an increase of catches and landings of chub mackerel, for example. Changes in the target species were also observed although sardine was still the main species captured. In the last two years, an increase in anchovy catches and landings was also observed. The reduction of annual quotas and establishment of daily limit quotas led to the increase of slipping sardine among other species, creating the differences between catches and landings. We observed behaviour changes in the fleet along the country, such as a search for new fishing grounds and species with more market value. Our results are of interest to stakeholders as they provide a perception of changes in the fishery at the national and regional level.

Keywords: Portuguese purse seine, catches, sardine, chub mackerel

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**CIESM Congress Session : Seaweeds / Seagrasses**  
**Moderator : Rui Santos, CCMAR, Univ. of Algarve, Portugal**

*Moderator's Synthesis*

This was the only session focusing on coastal vegetated ecosystems, highlighting this as a minor theme in CIESM. This is also patent in the rather broad title of the session. From the five presentations, four of them were on the Mediterranean seagrass *Posidonia oceanica*, a well-known and widely accepted key species from the Mediterranean Sea. Presentations focused on the ecological role and value of *P. oceanica* beach casts, on the relationships between flowering and elementary and trace element tissue contents, and shoot biometry, on the production of climatically active gases, DMSP and DMSPO, and on how *P. oceanica* habitat complexity determined its use by fishes. The only non-*Posidonia*, non-Mediterranean presentation was on the community structure of macroalgal assemblages in Northern Europe.

The overarching subject of the presentations was then the function and services that coastal vegetation does provide, unfortunately focused only on one Mediterranean species. Perhaps this subject should be more explored in future CIESM congresses, taking into account the highly important ecosystem services coastal vegetation provide, including water purification, biodiversity support, including economic resources, cycling of organic matter, nutrients and toxic compounds and a myriad of cultural services. In face of the present climatic urgency, focus should be put on the major role that vegetated coastal ecosystems have on carbon sequestration and mitigation of ocean acidification. As CIESM intends to look into the Mediterranean-Atlantic connections, it would be interesting to contrast the ecosystem services of *P. oceanica* that are specific to the Mediterranean with the other three European species whose distribution includes both the Mediterranean and the Atlantic.



# MANAGEMENT OF *POSIDONIA OCEANICA* BEACHED ACCUMULATIONS AND THE "ECOLOGICAL BEACH" MODEL

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## Abstract

*Posidonia oceanica* (L.) Delile is a marine phanerogam endemic to the Mediterranean Sea which provides important ecological functions enhancing coastal biodiversity. The beaching of *P. oceanica* remains and other marine phanerogams is a natural phenomenon, observed annually on many coasts. However, the occurrence of *P. oceanica* remains within touristic areas may represent a problem, since most of the beach users still ignore their ecological role and value and consider the plant remains as foul-smelling rejections. ISPRA is therefore promoting the “ecological beach model” as a new management practice for the *P. oceanica* on the beaches, also proposing this model as a new criterion for the assignment of the Blue flag by FEE Italy.

**Keywords:** *Posidonia*, *Mediterranean Sea*, *Beach*, *Coastal management*

*Posidonia oceanica* (L.) Delile is a marine phanerogam endemic to the Mediterranean Sea, which forms dense and extensive green meadows and provides important ecological functions enhancing coastal biodiversity. Seagrass meadows stabilize the sea bed and protect the coastline against the erosive action of the sea. In fact, its growth mode leads to the formation of terraced and compact structures, the so-called “matte”. *P. oceanica* meadows are identified as a priority habitat type for conservation under the Habitats Directive 92/43/EEC [1]. The beaching of *P. oceanica* remains (leaves, rhizomes, fibrous remains) and other marine phanerogams is a natural phenomenon, observed annually on many coasts, especially following the autumn and winter storms. The accumulation of beached biomass, combined with sand, forms very compact and elastic lamellar structures known as *banquettes*. *Posidonia banquettes* have an important role in beach protection from erosion [2], promoting the origin of the coastal dunes; moreover, the leaf litter represent an important temporary sink of biogenic elements, playing a fundamental role in the nutrient budget of *P. oceanica* meadows [3].

The occurrence of *P. oceanica* remains within turistic areas may represent a problem, since most of the beach users, still ignore their ecological role and value, considering the plant remains as foul-smelling rejections, rather than natural components of the coastal ecosystem. These aspects paradoxically imply a decrease in the touristic value of the beaches characterized by *P. oceanica* remains occurrence, consequently local administrations are pushed to remove such deposits to make the beaches more pleasant and usable. Along the Italian coasts, the removal of *Posidonia banquettes* is a widespread management practice before and during the summer season, in order to allow the beach tourism. In this way, large quantities of sand are removed forcing the local administrations to undertake costly coastal protection and beach nourishment interventions. Moreover, this practice causes a considerable increase in the cost of beach cleaning, due to the collection of great volumes of rubbish and its transportation to landfills.

In 2006, the Italian Ministry of the Environment has released an official document concerning the management of *Posidonia* beached accumulations [4]. The ecological role of *banquette* have been recognized; three main management solutions have been indicated: 1) maintenance of *banquettes* on site; 2) reallocation of accumulations within the same beach/ within beaches not accessible/ not used by swimmers / particularly exposed to erosion; 3) removal and landfill in accordance with the current legislation. The maintenance on site of the *banquettes* is the best management solution from the ecological point of view and it can be supported by training and informing citizens, to produce a change of opinion on beached accumulations: from waste to environmental and economic resource [5]. In 2017, ISPRA promoted the “ecological beach model” as a new management practice for the *P. oceanica* on the beach [6] and a new criterion for the assignment of the Blue flag by FEE Italy. The so-called “ecological beach” contributes to enhance both the ecological and functional role of the *banquettes* for the beach ecosystem and the circular economy. The success of the Model requires the best management solutions from an ecological point of view, but also the involvement of the beach users and managers in environmental training and education initiatives. Demonstration prototypes as informative posters [6] (Figure 1) are necessary to inform citizens about the meaning and the ecological-functional value of the model. Environmental

education events are carried out to promote a new perspective on the accumulations of *Posidonia* beached remains: from waste to environmental and economic resource [6]. Specific informations for shoreline managers will aim to produce management support and to maintain the ecological beach model in the future.



Fig. 1. An example of the poster designed and realized by ISPRA to inform citizens and beach users [6].

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# DOES ENVIRONMENTAL CONTEXT INFLUENCE MACROALGAL COMMUNITY COMPOSITION ON ARTIFICIAL STRUCTURES ?

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## Abstract

Artificial structures tend to support less diverse assemblages than natural hard substrata, but it is as yet unclear how this effect varies with environmental context. Here macroalgal assemblages were compared between artificial and natural substrata in different environmental contexts within the Irish Sea. We find no differences in macroalgal community structure between natural and artificial structures in any given environmental context. In contrast, we found coralline species to be significantly more abundant on natural substrata. Community composition differed in two contexts, between estuarine and marine sites, and between sites with different degrees of urban influence. We propose that these differences may be due to the presence and abundances of ‘thick leathery’ species.

**Keywords:** North Atlantic, Algae, Biodiversity, Coastal systems, Rocky shores

Artificial infrastructure has become a significant component of coastal and marine systems, primarily due to accelerated urbanisation [1]. This increase has major implications for coastal biodiversity, as biotic community composition differs between artificial and natural substrata [2]. The eco-engineering approach, which applies ecological principles to the design of artificial infrastructure, is likely to play a significant role in future strategies to incorporate ecologically-sensitive design into marine developments. As primary producers and habitat providers, seaweeds are integral to both the physical and trophic structure of many shallow-water marine systems. Variation in environmental conditions can alter both the species present and their responses to microhabitats [3]. The aim of this study was therefore to investigate how environmental context influences macroalgal community composition on artificial and natural substrata along Irish and Welsh coasts.

We selected 54 sites around the Irish Sea for sampling, 30 along the Irish coast and 24 along the Welsh coast. These consisted of both natural and artificial substrata, and were characterised in terms of their environmental (‘marine’ vs. ‘estuarine’) and anthropogenic contexts (‘urban’ vs. ‘low urban’ vs. ‘rural’). Ten 25 cm x 25 cm quadrats were deployed at all sites and the abundances of all macroalgal species present were recorded as percentage cover. Three-way PERMANOVA and SIMPER procedures were used to characterise patterns in macroalgal communities between sites.

Contrary to expectation, macroalgal abundances on artificial and natural substrata did not differ ( $p = 0.15$ ). There was no evidence of any effect of environmental or anthropogenic context. There was a significant difference in macroalgal abundances between ‘marine’ and ‘estuarine’ sites ( $F = 9.55$ ,  $p < 0.05$ ,  $df = 1$ ), which was due to *Ascophyllum nodosum* predominating at estuarine sites and *Fucus vesiculosus* predominating at marine sites (Table 1). There were also significant differences between sites with different degrees of urban influence ( $F = 3.04$ ,  $p < 0.05$ ,  $df = 2$ ), once again due to *A. nodosum* and *F. vesiculosus*, both of which were present at significantly higher abundances in ‘rural’ locations compared to more urban areas (Table 1).

Coralline species were consistently more abundant on natural rather than artificial substrata ( $F = 10.81$ ,  $p < 0.05$ ,  $df = 1$ ). These tend to display low rates of growth and may be unable to establish stable populations under conditions of frequent disturbance. This has implications for succession on artificial structures, as coralline species have been shown to influence recruitment [4] and may provide a more suitable substrate for settlement of later macroalgal colonists [5].

There was considerable variation among sites in all analyses and we will undertake statistical modelling to investigate associated environmental factors. Although percentage cover is a robust measure widely utilised in this field, it tells us little about the health and persistence of seaweed populations; therefore, we are also undertaking a more detailed investigation focused on the biological function of key habitat providers. The ultimate aim of the work is to inform effective design of eco-engineering solutions to enhance biodiversity on

coastal infrastructure.

Tab. 1. SIMPER results showing taxa cumulatively contributing up to 50% to the dissimilarity between groups tested. Abundances are square root transformed.

| Taxon                     | Avg. Abundance<br>'Marine'    | Avg. Abundance<br>'Estuarine' | Avg.<br>Dissimilarity | Diss/SD | Cumulative<br>contribution % |
|---------------------------|-------------------------------|-------------------------------|-----------------------|---------|------------------------------|
| <i>A. nodosum</i>         | 0.82                          | 6.51                          | 25.55                 | 1.22    | 28.74                        |
| <i>F. vesiculosus</i>     | 2.05                          | 2.00                          | 12.80                 | 0.74    | 43.14                        |
| <i>Ulva</i> spp.          | 1.80                          | 0.98                          | 9.78                  | 0.70    | 54.13                        |
| Taxon                     | Avg. Abundance<br>'Rural'     | Avg. Abundance<br>'Low Urban' | Avg.<br>Dissimilarity | Diss/SD | Cumulative<br>contribution % |
| <i>A. nodosum</i>         | 3.91                          | 0.00                          | 18.73                 | 0.83    | 20.46                        |
| <i>F. vesiculosus</i>     | 3.03                          | 0.77                          | 16.35                 | 0.81    | 38.32                        |
| <i>Ulva</i> spp.          | 1.45                          | 1.91                          | 12.24                 | 0.75    | 51.69                        |
| Taxon                     | Avg. Abundance<br>'Rural'     | Avg. Abundance<br>'Urban'     | Avg.<br>Dissimilarity | Diss/SD | Cumulative<br>contribution % |
| <i>A. nodosum</i>         | 3.91                          | 1.87                          | 18.15                 | 0.88    | 21.45                        |
| <i>F. vesiculosus</i>     | 3.03                          | 2.16                          | 15.98                 | 0.84    | 40.34                        |
| <i>Ulva</i> spp.          | 1.45                          | 1.62                          | 9.66                  | 0.72    | 51.75                        |
| Taxon                     | Avg. Abundance<br>'Low Urban' | Avg. Abundance<br>'Urban'     | Avg.<br>Dissimilarity | Diss/SD | Cumulative<br>contribution % |
| <i>Ulva</i> spp.          | 1.91                          | 1.62                          | 19.43                 | 0.81    | 22.21                        |
| <i>F. vesiculosus</i>     | 0.77                          | 2.16                          | 13.03                 | 0.71    | 37.10                        |
| <i>A. nodosum</i>         | 0.00                          | 1.87                          | 8.15                  | 0.49    | 46.41                        |
| <i>Lithothamnion</i> spp. | 0.62                          | 0.82                          | 7.54                  | 0.60    | 55.03                        |

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# EFFECTS OF *POSIDONIA OCEANICA* (L.) DELILE (1813) FLOWERING ON ELEMENTAL COMPONENTS AND ON TRACES ELEMENTS CONCENTRATIONS

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## Abstract

*Posidonia oceanica* is a magniophyte endemic to the Mediterranean Sea, in which flowering can vary depending on water temperature and nutrient concentration (C,N,P). Along corsican coast, in the Northwestern Mediterranean Sea, the flowering was unusual but in the last 20 years it flowered regularly. The aim of our study was to determine the effect of the frequency of flowering episode on the shoots by measuring the dynamics of elementary (C, N, P) and the trace element contents (TE) in different tissues (leaves, inflorescences and rhizomes) of flowering and non-flowering shoots. This study also focused on the biometry of these shoots.

**Keywords:** *Posidonia*, North-Western Mediterranean, Trace elements, Monitoring, Biometrics

## Introduction

In *P. oceanica*, sexual reproduction is less frequent than asexual reproduction [1], even in comparison with other seagrass species. The flowering is not annual, that conduct to a low genetic diversity [2]. In 2003, an intense flowering event was recorded in the Mediterranean Sea with a high percentage of flowering (PF) and flowering intensity (FI) (PF = 0.86 and IF = 0.23 + -0.03 infl./stem [3,4]. This event coincides with the hottest summer recorded [5]. Since 2003, the flowering phenomena are more frequent in Revelatta Bay. The question that arise from these observations is to know what are finally the different consequences of this phenomenon on the morphology and the content (CNP and TE) of *P. oceanica* shoots.

## Material and Method

Since 1975, in the Revelatta Bay, *P. oceanica* meadow is monitored [6,7]. From Nov. 2006, Oct. 2012 to Jan. 2013, in Oct. 2017, and from Oct. 2018 to Feb. 2019, 5 flowering and 5 non-flowering shoots were randomly taken at 10m depth. The shoots collected were frozen at -18°C. At each sampling, density counts were performed, the shoot density (number of shoots/m<sup>2</sup>), the inflorescence density (number of flowering shoot / m<sup>2</sup>) and the flowering index (%) were calculated. All collected shoots were analysed for biometry. The CN elemental composition was determined using an elemental analyser (vario MICRO cube™, Elementar). For the P and ET (Fe, Co, Se, Mo, Cr, Ni, Cu, Zn, Al, Be, Ag, Sn, Sb, Bi, Cd, Pb), analyses were carried out by Inductively Coupled Plasma Mass Spectrometry using Dynamic Reaction Cell technology (ICP-MS ELAN DRC II, PerkinElmer Inc.).

## Results and Discussion

In Revellata Bay, flowers (<1%) were reported in 1978 [6]. In 1994, the flowering index was at maximum (IF: 36 ± 25%) and also in 2003 (IF: 20 ± 6%). During these 2 years, flowering was also observed throughout the Northwestern Mediterranean Sea. It was hypothesized that an increase in the temperature of seawater could explain this phenomenon of intense flowering [3]. In the Revellata Bay (Fig.1), we observe now regular flowering events; in 2006 this event was correlated with an increase of the sea surface temperature. The flowering index recorded in 2013 is lower than that of 1994 but close to that of 2003. This suggests that there would be a cycle of ten years in the intensity of flowering in Revellata Bay (1994, 2003 and 2012) and that maximum flowering intensities would be reached every 10 years on average [8]. These results finally raise the question of whether the increase in flowering is not a factor of weakening the *P. oceanica* meadow, which would therefore pump nutrients into its reserves to allow inflorescence. In addition, flowering has been shown to cause considerable stress in meadow. In our study, after flowering, many fruits and seeds were observed in May 2013 and the presence of patch of flowers was also noted at the same time. Fruit observations were made in 1994 and 2003, while the 1997, 1998 but in 2006 flowers did not produce fruit [7]. This highlights a possible link between intensity of flowering and fruit production correlated with the ten-year cycle. This paper will present the C, N, P contents, the results obtained since 2006 tend to highlight a drying up of the meadow by flowering looking notably at the decrease of N in flowering samples (in juvenile, adults and rhizomes tissues) (Table1) and a modification of the biometry (lower

width and higher length in adults leaves).

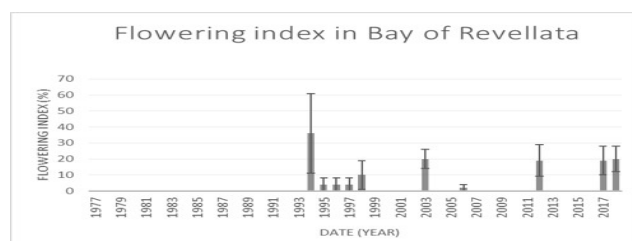


Fig. 1. Evolution of the flowering index in Bay of Revellata from 1978 to 2019.

Tab. 1. Evolution of C,N,P contents of flowering and non-flowering shoots in 2006, 2012 and 2013 in Bay of Revellata.

| year | state | value | Flowering |      |       |      |       |      |       |      |       |       | Not flowering |       |       |       |       |       |       |       |       |      |       |       |       |  |
|------|-------|-------|-----------|------|-------|------|-------|------|-------|------|-------|-------|---------------|-------|-------|-------|-------|-------|-------|-------|-------|------|-------|-------|-------|--|
|      |       |       | Juv.      |      | int.  |      | Adult |      | Shoot |      | Flow. |       | Rhiz.         |       | Juv.  |       | int.  |       | Adult |       | Shoot |      | Flow. |       | Rhiz. |  |
|      |       |       | sd        | sd   | sd    | sd   | sd    | sd   | sd    | sd   | sd    | sd    | sd            | sd    | sd    | sd    | sd    | sd    | sd    | sd    | sd    | sd   | sd    | sd    | sd    |  |
| 2006 | C     | 17.6  | 0.6       | nd   | nd    | nd   | nd    | nd   | nd    | nd   | 30.6  | 1.05  | 18.1          | 0     | 17.1  | 0.36  | nd    | nd    | nd    | nd    | nd    | nd   | nd    | nd    | nd    |  |
|      | N     | 0.74  | 0.15      | nd   | nd    | 1.04 | 0.385 | nd   | nd    | 1.04 | 0.16  | 1.39  | 0.065         | 0.59  | 0.055 | nd    | nd    | 1.27  | 0.27  | nd    | nd    | 0    | 1.5   | 0.31  |       |  |
|      | P     | nd    | nd        | nd   | nd    | nd   | nd    | nd   | nd    | nd   | nd    | nd    | nd            | nd    | nd    | nd    | nd    | nd    | nd    | nd    | nd    | nd   | nd    | nd    |       |  |
| 2012 | C     | 20.9  | 0.67      | 34.1 | 0.87  | 32.4 | 0.92  | 32.5 | 0.94  | 31.3 | 0.87  | 27.1  | 0.69          | 29.5  | 1.428 | 33.3  | 1.209 | 32.4  | 0.88  | 32.8  | 0.695 | 0    | 30.8  | 0.812 |       |  |
|      | N     | 1.26  | 0.140     | 1.55 | 0.092 | 1.09 | 0.091 | 1.23 | 0.099 | 1.37 | 0.099 | 0.46  | 0.19          | 0.478 | 0.16  | 1.09  | 0.154 | 1.09  | 0.154 | 1.28  | 0.194 | 0    | 1.28  | 0.194 |       |  |
|      | P     | 0     | 0         | 0.11 | 0.015 | 0.08 | 0.011 | 0.1  | 0.004 | 0.2  | 0.008 | 0.007 | 0             | 0     | 0.15  | 0.024 | 0.09  | 0.007 | 0.11  | 0.011 | 0     | 0.28 | 0.18  | 0.18  |       |  |
| 2013 | C     | 35.2  | 1.35      | 34.4 | 1.25  | 34   | 0.7   | 33.1 | 0.25  | 28.2 | 0.3   | 35.2  | 0.39          | 35.7  | 0.85  | 34.6  | 0.4   | 33.8  | 0.60  | 33.2  | 0.3   | 0    | 35.1  | 0.85  |       |  |
|      | N     | 2.2   | 0.05      | 5.45 | 0.2   | 1.45 | 0.35  | 1.5  | 0.2   | 1.1  | 0.05  | 1.45  | 0.2           | 1.95  | 0.32  | 1.85  | 0     | 1.35  | 0.05  | 1.5   | 0.05  | 0    | 1.5   | 0.05  |       |  |
|      | P     | 0     | 0         | 0.14 | 0.05  | 0.1  | 0.01  | 0.06 | 0     | 0    | 0.06  | 0     | 0             | 0     | 0.13  | 0     | 0.1   | 0     | 0.12  | 0     | 0     | 0.05 | 0     | 0.05  |       |  |

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# POSIDONIA OCEANICA, A TOP PRODUCER OF DIMETHYLSULFONIOPROPIONATE AND DIMETHYLSULFOXIDE

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## Abstract

We studied the dynamic of dimethylsulfoniopropionate and its derivative dimethylsulfoxide in *Posidonia oceanica*. The annual average concentrations in leaves were  $129 \pm 39 \mu\text{mol.g}_{\text{fw}}^{-1}$  for DMSP and  $5.0 \pm 2.1 \mu\text{mol.g}_{\text{fw}}^{-1}$  for DMSO. DMSP and DMSO concentrations decreased from a maximum in the fall to a minimum in the summer and were mainly correlated to the seagrass leaf size. The similar variation of the two molecule concentrations suggested that DMSO content results from oxidation of DMSP. The DMSP:DMSO ratio, considered as indicator of stress in *Spartina alterniflora*, remained constant around a mean value of 27.7  $\mu\text{mol}:\mu\text{mol}$ . More research is now needed to investigate the functions of DMSP and DMSO in seagrasses, how the DMSP:DMSO ratio will vary under disturbance and whether it is useful as indicator of stress.

**Keywords:** *Posidonia*, *Mediterranean Sea*, *Physiology*

Dimethylsulfoniopropionate (DMSP) and its derivative, dimethylsulfoxide (DMSO) are precursors of dimethyl sulfide (DMS), a climatically active gas that could have a cooling effect on climate and could help to compensate for warming from 'greenhouse effect' [1]. DMSP plays physiological roles in marine autotrophs that has stimulated numerous studies on its production, especially on marine phytoplankton [2]. Among the short list of terrestrial and coastal angiosperms that have a high DMSP content, the marine magnoliophyte *Posidonia oceanica* is the only seagrass reported so far [3]. To extend our limited knowledge on the ecology of DMSP and DMSO in *P. oceanica* leaves, we investigated the temporal and depth variability of the two molecules and the potential role of light, temperature, photosynthetic activity and leaf size on their contents. We further assessed the potential of the DMSP:DMSO ratio as indicator of stress in *P. oceanica*, as previously suggested and observed for the salt marsh plant *Spartina alterniflora* [4,5].

The survey was conducted from April 2015 to July 2016 in a non-disturbed meadow in the Revellata Bay, Corsica (France), as part of the STARECAPMED project. Light and temperature were continuously monitored with autonomous loggers. *P. oceanica* third internal leaves (juvenile leaves excluded,  $n = 3$ ) were sampled around zenith weekly to bimonthly at 10m depth and once early summer 2015 along a 3-36m depth gradient, after *in situ* analysis of leaf photosynthetic activity (ΦPSII). Supplementary leaf bundles were sampled for biometry analysis. Samples were stored frozen until analysis. The DMSP and DMSO concentrations were measured in fresh *P. oceanica* third leaf basal section (0-20 cm in height) after conversion into DMS with the headspace technique with a gas chromatograph [6]. Data were analysed by regression, correlation or variance analyses using RStudio.

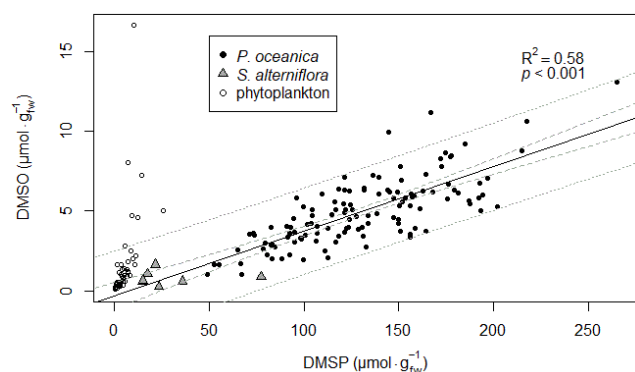


Fig. 1. Scatterplot of DMSP and DMSO concentrations ( $\mu\text{mol.g}_{\text{fw}}^{-1}$ ) in *P. oceanica*, *S. alterniflora* and marine phytoplankton communities. *S. alterniflora* and phytoplankton data are from the literature. The full line models the linear relationship between *P. oceanica* DMSP and DMSO concentrations. 95% confidence and prediction intervals (dashed and dotted lines) are plotted.

Mean DMSP concentrations in *P. oceanica* third leaf ranged between  $62 \pm 17$  and  $205 \pm 58 \mu\text{mol.g}_{\text{fw}}^{-1}$ . The highest leaf value reported in this study was  $265 \mu\text{mol.g}_{\text{fw}}^{-1}$ . These concentrations make the plant the largest reported producer of DMSP among marine and inter-tidal autotrophs since dinoflagellates [2]. Mean DMSO concentrations ranged between  $1.5 \pm 0.7$  and  $8.6 \pm 2.0 \mu\text{mol.g}_{\text{fw}}^{-1}$ . Concentrations of the two organosulfured compounds varied with time: continuous linear decrease from fall to summer, but little with depth. Considering the similar distribution of both molecules (Fig. 1), we hypothesized DMSO content results from the oxidation of DMSP [4]. Of all physiological (ΦPSII), biometrical and environmental (light, temperature) parameters monitored, the lengthening and aging of *P. oceanica* leaf bundle during its annual growth cycle explained best the evolution of leaf DMSP and DMSO concentrations. Concentrations were strongly ( $\rho = -0.75$  for DMSP) and modestly ( $\rho = -0.55$  for DMSO) inversely correlated to the leaf size, i.e., the leaf age ( $p < 0.001$ ). We hypothesized two protective functions of DMSP to explain higher concentrations in young leaf tissues: antioxidant against reactive oxygen species and predator-deterrent. Finally, we observed a constant DMSP:DMSO ratio around a mean value of 27.7  $\mu\text{mol}:\mu\text{mol}$  in *P. oceanica* leaves for the non-disturbed meadow under study. In the salt marsh plant *S. alterniflora* naturally or experimentally stressed, DMSP was converted to its oxidation product, DMSO, which resulted in a change of their ratio compared to healthy plants [4,5]. Similarly as for *S. alterniflora*, we hypothesized the DMSP:DMSO ratio could be useful as early warning indicator of stress in seagrasses independently of the season, the depth or the age of the leaf bundle. The constant ratio we observed in this study for a healthy *P. oceanica* meadow not subject to stressors can be considered as reference value for future work. In conclusion, the present study deepened our knowledge on the ecology of DMSP and DMSO in *P. oceanica* and brought new insights on the concentration dynamics of both molecules in coastal ecosystems overall.

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# INFLUENCE OF SEAGRASS HABITAT STRUCTURE ON COASTAL FISH POPULATIONS

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## Abstract

Variation in seagrass habitat composition has the potential to impact habitat quality for biota relying on this habitat. We assess the effect of differences in seagrass cover, patchiness, and complexity (shoot density, canopy height) in Mallorca, Balearic Islands on fish community composition and the abundance, body condition and growth of *Diplodus annularis*, a resident of *Posidonia oceanica* meadows and an important species in the captures of the recreational fishery around the Balearic Islands. Predatory fish and *D. annularis* biomass decreased with shoot density, however *D. annularis* body condition increased with higher shoot density and lower conspecific density, suggesting that lower competition from conspecifics at higher shoot density benefits *D. annularis*.

**Keywords:** *Posidonia*, Balearic Islands, Biomass, Competition, Fishes

**Introduction & Methods** Seagrass beds play a fundamental role in providing key ecosystem services such as nursery areas for juvenile development and feeding areas for adult fish [1]. Seagrass beds are among one of the most highly impacted coastal habitats in the Mediterranean; boat anchoring, destructive fishing methods and coastal development are all known to reduce the structural complexity of seagrasses [2]. With increasing anthropogenic disturbance, there is concern about overall habitat structure and what effects this may have on local biotas relying on seagrasses. For example, changes in habitat structure can affect access to food resources and/or predators, thus influencing post-settlement growth and mortality, and subsequently adult fish community structure [3]. In this study, fish communities were sampled in July 2018 in twenty sites with different seagrass cover, patchiness, and complexity (shoot density, canopy height) in Mallorca, Balearic Islands, where *Posidonia oceanica* meadows are subjected to high risk of habitat degradation given the island's ever increasing mass tourism and coastal recreational fisheries [4]. Fish were collected using a ganguil trawl modified for fishing over seagrass meadows during three replicate 8-minute tows in each site. Fish were enumerated, measured and weighed. We examine the influence of different seagrass habitat variables on fish community biomass, predatory species biomass (*Serranus scriba*, *Scorpaena porcus*, *Labrus viridis*) and *Diplodus annularis* biomass using GLM models. The effect of shoot density or conspecific density on the  $\log_{10}(\text{weight})$  at  $\log_{10}(\text{length})$  of fish was estimated using linear mixed effect models, using  $\log_{10}(\text{length})$  and shoot density or conspecific density as fixed factors, 'Station' was used as a random grouping variable to account for the non-independence of fish condition measurements within a station.

**Results & Discussion** Predatory fish and *Diplodus annularis* biomass decreased significantly with *Posidonia* shoot density ( $F_{(1,18)} = 7.17$ ,  $p = 0.015$ , Figure 1a;  $F_{(2,17)} = 10.23$ ,  $p = 0.001$ , Figure 1b). Sites with low shoot density were generally characterized by higher nutrient effluent, and thus may benefit fish from higher benthic production and higher food availability even though shoot density was low. Furthermore, visual predators such as *S. scriba* and *S. porcus* that feed primarily on decapods [5] may be able to see prey better at low shoot density. We estimated the condition (weight-at-length) of *D. annularis* using 1467 fish in the size range from 5 to 15 cm. There was a significant interaction effect between fish condition and conspecific density; weight-at-length of *D. annularis* individuals was higher at low conspecific density, the effect being more evident in large individuals than small ones (slope of interaction term fish length : conspecific density = -0.013, SE = 0.005,  $t = -2.82$ ,  $p = 0.005$ , Figure 1c). Weight-at-length for *D. annularis* was also higher at high shoot density where conspecific density was also lower (slope of interaction term fish length : shoot density = 0.0003, SE = 0.0001,  $t = 2.09$ ,  $p = 0.04$ , Figure 1d). Our results suggest that the release of competition from conspecifics for resources such as food affects *D. annularis* body condition. The effect was stronger for large individuals than for small individuals, where competition for resources such as food may be higher in adults that feed on less abundant prey such as decapods and gastropods than in juvenile *D. annularis* that feed predominantly on the more abundant benthonic prey such as harpacticoid copepods [6].

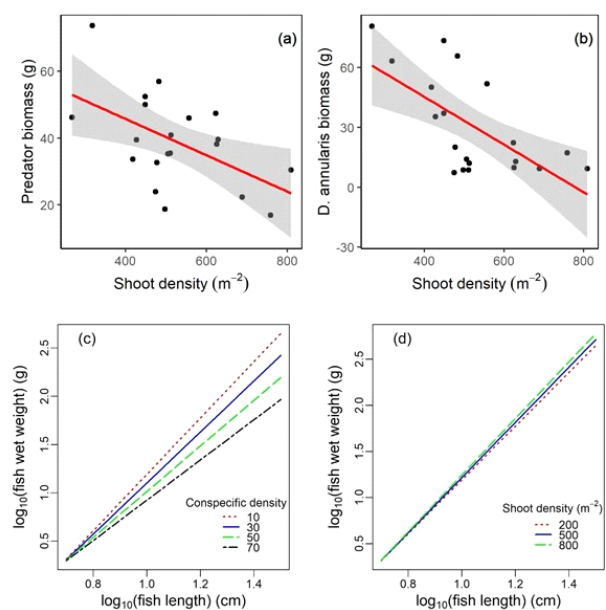


Fig. 1. Predator fish biomass (a) and *Diplodus annularis* biomass (b) decreased with increasing *Posidonia* shoot density. Body condition (measured as weight-at-length) for adult *D. annularis* was higher at lower conspecific density (c), which was characteristic of areas with high shoot density (d). The lines in (c) and (d) are predicted data from a Linear Mixed Effect Model output relating weight to length\*density using site as a random factor.

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**CIESM Congress Session : Gelatinous plankton**  
**Moderator : Sónia Cotrim, MARE - Polytechnic of Leiria, Portugal**

*Moderator's Synthesis*

Overall, 30 people attended the gelatinous plankton session from across the Mediterranean and Atlantic regions who engaged interesting discussions aimed at identifying major knowledge gaps. Several research priorities were identified: The role of gelatinous organisms in ecosystem structure and function: the presentations examined the role of gelatinous plankton in ecosystems structure and function from predator-prey interaction to processes influencing population dynamics, including spatiotemporal distributions, seasonality, and adaptability in diverse ecosystems. For instance, the predatory effect of *Aurelia aurita* and *Mnemiopsis leidyi* in the Black and Adriatic Seas, the invasion of scyphomedusae in the southern Adriatic, the forecasting dispersal of *Mnemiopsis leidyi* around Euroasia. The results demonstrated that we require improved understanding of abundances, diversity, as well as investigating the drivers responsible by the dynamics and biogeography of gelatinous zooplankton blooms, such as climate change and ballast waters discharge. Cryptic and Integrative taxonomy of gelatinous plankton: the research presented highlighted the needs for an integrative understanding about the diversity of gelatinous plankton. For instance high intraspecific diversity, together with morphological evidence points to at least three cryptic species *Oikopleura longicauda* in the Adriatic Sea. An integrative taxonomy approach would enable to establish the distribution and species-specific ecology of important cryptic species. Experimental work on jellyfish to determine basic rate processes: main studies focus on medusae, and too little is known about the benthic polyp stage of the life cycle, which is recognized as crucial in understanding jellyfish proliferations. This knowledge gap is being addressed and continues to be a research priority. Results presented suggest that polyps of *Phyllorhiza punctata* jellyfish are tolerant to ocean acidification (OA). The polyps were able to produce ephyrae independently of pH and no differences on total bud production was observed at the end of trials. Future research should investigate the impacts of environmental factors, such as direct and indirect effects of OA and hypoxia, on growth and asexual reproduction.



# PREDATORY EFFECT OF *AURELIA AURITA* AND *MNEMIOPSIS LEIDYI* ON ZOOPLANKTON COMMUNITY IN THE COASTAL AREA OF THE NORTH-EASTERN BLACK SEA

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## Abstract

Based on a 9-year monitoring of the coastal zooplankton our research provides new estimates of the predatory impact of *Aurelia* and *Mnemiopsis* on zooplankton species.

**Keywords:** *Ctenophora*, *Predation*, *Black Sea*, *Coastal waters*

**Introduction** Gelatinous predators are commonly considered as one of the main consumers of the zooplankton in the coastal areas because they often occur in high densities and biomasses there [6,7,9]. Jellyfish and ctenophores compete with planktivorous fish for the food resource and also feed on its larvae and eggs, so they may have a great influence on the coastal ecosystem [7]. In the Black Sea the main zooplankton consumers were fish and jellyfish *Aurelia aurita*. *Mnemiopsis leidyi* invaded to the Black Sea in late 1980s and its outburst led to the collapse of the pelagic ecosystem [4]. Although the zooplankton community has recovered after that dramatic event two gelatinous predators, *Aurelia* and *Mnemiopsis*, still have a strong effect on the zooplankton [2]. The goal of our research was to estimate the predatory effect of this two species on the zooplankton community.

**Methods** Zooplankton and gelatinous plankton were collected monthly from June 2005 till October 2014 at the 3 stations located over the depths of 25, 50 and 500 meters along the transect off Geledzhik. Gelatinous plankton was identified on board immediately after sampling. Zooplankton were identified to species level and counted under the dissecting microscope. The sampling methods for zooplankton and gelatinous plankton are described in details in [1, 2]. The predatory impact of *Aurelia* and *Mnemiopsis* was estimated as the minimum food requirement (MFR, mgC/day) of these organisms. It was calculated from the energetic loss on respiration taking into account the assimilation efficiency coefficient [5, 8, 9]. The respiration was calculated as the function of weight and temperature following [3, 6].

**Results.** The predatory impact varied significantly at different stations. The mean total MFR value comprised 18% and reached the maximum of 300% of the zooplankton biomass at 25m station. It decreased at 50m station (10% in mean and maximum of 70%) and 500m station (2% in mean and maximum of 9%). The proportion of *Aurelia* MFR in total MFR was more than 70% most of the time. The studying of the MFR seasonal dynamics showed that it was low in winter, started to increase in April and reached its maximum in July. These seasonal changes were observed at all three stations. The analysis of the predatory impact and the zooplankton biomass showed no significant correlations. But during the periods of maximum abundance the influence of gelatinous predators was more pronounced. The most expressed predatory effect was observed at the shelf stations - 25m and 50m depths (fig.1).

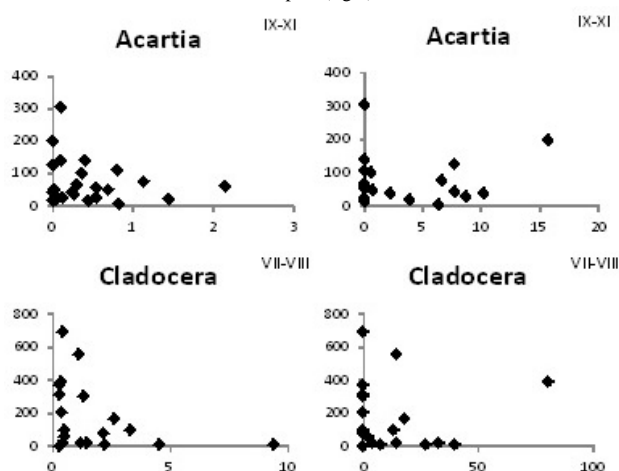
Fig. 1. The predatory impact of *Mnemiopsis* (left panel) and *Aurelia* (right panel) on zooplankton species at the 25m station; x axis is MFR (mgC/day) and y axis is species biomass (mgC/m<sup>2</sup>). In the right corner are shown the months of observations.

The impact of *Mnemiopsis* was greater than *Aurelia* for the most of the species. For migrating species, *Calanus euxinus* and *Pseudocalanus elongatus*, no predatory influence was observed. Heterotrophic dinoflagellate *Noctiluca scintillans* also didn't show any correlation with the predators at all 3 stations. On the whole our data shows that predatory effect of *Aurelia* and *Mnemiopsis* on zooplankton is not severe at the Black sea coastal area, although it can reach high values sometimes. Our results also shows that migrating species are less influenced by *Aurelia* and *Mnemiopsis* than upper-dwelling species.

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# CRYPTIC DIVERSITY OF APPENDICULARIAN *OIKOPLEURA LONGICAUDA*

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## Abstract

*Oikopleura longicauda* is cosmopolit appendicularian species with a preference for warm and temperate waters. In order to determine genetic diversity of *Oikopleura longicauda* we sequenced 307 bp long fragment of subunit I of mitochondrial cytochrome oxidase (COI) of 34 individuals collected in July 2017 at a coastal station in South Adriatic. Our data revealed 4 groups of sequences with more than 16% of uncorrected p-distances indicating that *Oikopleura longicauda* is likely a complex of species with at least 3 different species existing in the Adriatic.

**Keywords:** Biodiversity, Tunicata, Zooplankton, Genetics, Adriatic Sea

## Introduction and methods

Appendicularians are holoplanktonic tunicates known for their exceptional evolutionary rates and short life cycle. Because of their short life cycle they are potentially useful indicator species of different water masses, but because of few taxonomic experts the group as a whole has been underinvestigated. So far there has been only one study of appendicularian population genetics which is remarkably small number for such an important zooplankton group (Sherlock et al., 2017). In order to investigate genetic diversity of *Oikopleura longicauda* we sequenced 307 bp long fragment of subunit I of mitochondrial cytochrome oxidase (COI) of 34 individuals collected in July 2017 at Lokrum coastal station in the South Adriatic (42°37'21"N, 18°06'05"E). DNA was extracted from each individual separately. For amplification of COI fragment we used primer pair longcoif (TGATGGGTGTTCTGATATGG) and longcoir (GAAAGAAGTATTTAAATGACGATC). In addition to our sequences one available sequence from GenBank of *Oikopleura longicauda* COI was also used in analysis (GenBank accession LC222754).

Based on obtained sequences neighbour joining (NJ) tree was constructed with software MEGA7, using uncorrected p-distances and 1000 bootstrap replicates. Average uncorrected p-distances were calculated between major clades of the NJ tree. The 307 bp long nucleotide sequences were translated into 101 aminoacids long sequences to detect aminoacid differences between sequences.

## Results

There are 8 clades in NJ tree with 3.9% or more average uncorrected p-value distance from next adjacent clade (A, B, C, D, E, F, G1 and G2). Clades A+B+C+D, E, F and G differed more than 16% in average uncorrected p-value (Fig. 1.). After translation of nucleotide sequences into aminoacid sequences 5 groups formed. The first one was composed of only clade A, the second was composed of clades B+C+D and clades E, F and F each formed a group, mirroring NJ tree (Tab. 1., Fig. 1.). Even though clades A and B+C+D differ in one amino acid substitution in amino acid sequence they likely represent the same species, with deep mitochondrial lineages. This would put species threshold for COI for appendicularians at more than 8% of uncorrected p-value. We can safely assume that clades which differ more than 17% in uncorrected p-value of nucleotide sequence represent different cryptic species. If that is the case then in the Adriatic alone there would be 3 different cryptic species within *Oikopleura longicauda*: clade A+B+C+D, clade F and clade G. In addition species collected near Japan and represented with GenBank accession LC222754 should also represent forth cryptic species of *Oikopleura longicauda*. Our results show remarkable cryptic diversity of appendicularian *Oikopleura longicauda*. If such diversity is present in other appendicularian species then the appendicularian biodiversity is greatly underestimated. These findings should be corroborated using other markers, such as ITS and 18S sequences.

Tab. 1. Aminoacid differences between different clades. Numbers in table show number of aminoacid differences between 101-amino-acids-long COI fragment sequences.

|       | A  | B+C+D | E  | F  | G |
|-------|----|-------|----|----|---|
| A     | -  |       |    |    |   |
| B+C+D | 1  | -     |    |    |   |
| E     | 2  | 3     | -  |    |   |
| F     | 6  | 5     | 6  | -  |   |
| G     | 15 | 16    | 14 | 16 | - |

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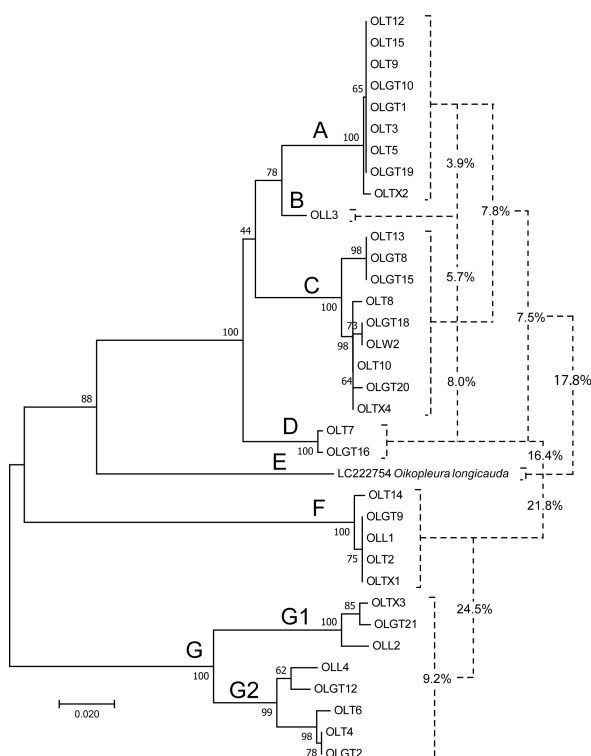


Fig. 1. NJ tree constructed using uncorrected p-value with 1000 bootstrap replicates. The tree is rooted with the most distant clade (G). Major clades are marked with letters and average uncorrected p-value distance between clades is shown.

# DISTRIBUTION, DIET AND ECOLOGICAL EFFECT OF INVASIVE CTENOPHORE *MNEMIOPSIS LEIDYI* IN THE NORTH-EASTERN ADRIATIC SEA

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## Abstract

*Mnemiopsis leidyi* distribution, abundance and diet were investigated in the North-eastern Adriatic from summer 2017 to summer 2018. The abundance of zooplankton and anchovies in the areas where *M. leidyi* was present showed a drastic decrease. The diet of *M. leidyi* consisted of all the zooplankton taxa found in the surrounding waters with a preference towards larger zooplankton and bivalvia larvae.

**Keywords:** Alien species, Adriatic Sea, Zooplankton, Fisheries

The presence of the invasive ctenophore *Mnemiopsis leidyi* in the North-eastern Adriatic since 2016 has risen concerns on its possible effects on fish stocks and tourism. Distribution, abundance and biometric characteristics of *M. leidyi* were monitored during 2017-2018 along the coast of Istria, where large swarms were detected in the summer and autumn. The diet of *M. leidyi*, the structure of zooplankton and the distribution of anchovies have been investigated to verify the possible perturbations induced in the food web of the North-eastern Adriatic. Six field samplings were performed from August 2017 to August 2018 in front of western Istria (Fig. 1). In September 2017 samples were additionally collected by mid-water trawl with small mesh-size cod-end (on trails of 2 NM) during acoustic survey MEDIAS at 24 locations covering the whole North-eastern Adriatic. Ctenophora abundance was determined by visual census from the boat and by a plankton net from the sea surface. For estimating *M. leidyi* diet, 10 individuals were placed in 100 ml filtered (pore size 0.22 µm) seawater. Individuals were stressed by stirring and piercing to favour expulsion of ingested material. Expelled material was fixed with 4% formaldehyde and analysed under a stereomicroscope. Zooplankton was collected by vertical tows using WP2 plankton net.



Fig. 1. Sampling stations and distribution of *M. leidyi* in the NE Adriatic (in grey) in September 2017.

*M. leidyi* was present from the beginning of the summer until the end of November 2017 and reappearing in July 2018. Average abundances (1.9 ind. m<sup>-2</sup>) were similar as in the Baltic and around 30 times lesser than in the western Black sea [1]. Trawler samplings revealed that *M. leidyi* was mainly concentrated in the layer between 0 and 5 m. Biometric analysis showed that the majority of specimens were adults (longer than 3 cm). Zooplankton average abundances in August and September 2017 were lower than in the last two

decades [2], especially with respect to copepods (762±387 ind. m<sup>-3</sup>). The *M. leidyi* diet experiment indicated that their prey was mainly cladocerans, copepods, pteropods, and echinodermata and bivalvia larvae. These were also the dominant zooplankton groups in the plankton samples, noting that only bivalvia larvae were numerous represented as prey. According to acoustic survey (Fig. 2) (September 2015 and 2017), abundance of anchovy was drastically lower in 2017 in the areas with high numbers of *M. leidyi*. These low abundances of anchovies were not recorded at the same stations in the previous years before the occurrence of *M. leidyi*. The results indicate that presence of this invasive species in 2017 significantly disturbed the zooplankton structure and abundance in the eastern Northern Adriatic with a negative effect on anchovy stock, similar as in the Black Sea [3].

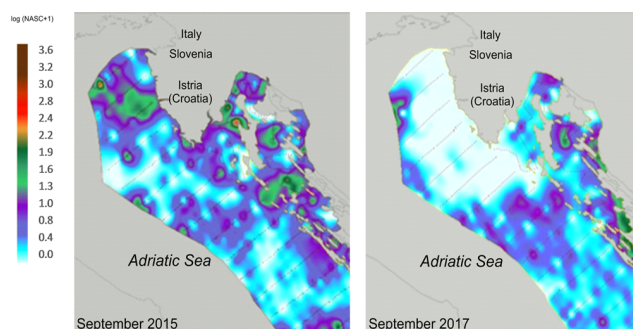


Fig. 2. Comparison between acoustic surveys in September 2015 and 2017 showing on a grey scale the distribution of anchovies in the NE Adriatic. Log (NASC+1) is the logarithm of the nautical mile scattering coefficient which represents the echo sounder output data. Results for 2017 show a significant reduction of anchovies compared to 2015 when *M. leidyi* was not yet present in the Adriatic.

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# SCYPHOMEDUSAE PHENOLOGY AND ABUNDANCE IN BOKA KOTORSKA BAY (SOUTHERN ADRIATIC) FROM 2013 TO 2017

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## Abstract

Six species of Scyphomedusae were recorded in Boka Kotorska Bay from 2013 to 2017: *Chrysaora hysoscella*, *Aurelia* spp., *Discomedusa lobata*, *Cothyloriza tuberculata*, *Rhizostoma pulmo* and *Drymonema dalmatinum*. Among them, *C. hysoscella*, *D. lobata* and *C. tuberculata* formed blooms.

**Keywords:** *Blooms, South Adriatic Sea, Medusae*

## Introduction

In Boka Kotorska Bay, there is still lack of information for gelatinous carnivores despite of the long tradition of zooplankton investigations [1]. After 2013, changes in scyphomedusan composition, phenology and abundance were noticed throughout the Bay. Herein, we present the results of these new observed events.

## Material and Methods

Continuous monitoring of the Scyphomedusae occurrence in Boka Kotorska Bay started in 2013, after the first mass occurrence of some species. Monitoring was conducted by visual observations of scientists from the Institute of Marine Biology (Kotor, Montenegro) from the shore, and during diving. Additional information's were reliable sources on the basis of reports through the actions of "Citizen Science".

## Results and discussion

After the first record of specimen of *Chrysaora hysoscella* in Boka Kotorska Bay in 2006 [2], from 2014 this species were regularly present (Table 1). Especially extended bloom of 14 days was established in 2015. *Discomedusa lobata* is a rare Scyphomedusae and has been common in the Gulf of Trieste until 1980s, only [3]. The reliable record in the Bay date from 2013 when specimens were found sporadically (Table 1). The first bloom, estimated at 100 individuals per 10 m<sup>2</sup>, was noted in April 2014, with another in mid-May. The latest bloom lasted two days, after which no individuals were observed. Higher numbers (10 ind. per 10 m<sup>2</sup>) also were present for over eight days in February 2015, after which individuals were found only sporadically. An extremely dense bloom at the end of March 2015 occurred in a shallow part of the Bay that is influenced by spring water. Water temperature during blooms ranged from 13.5°C to 19.1°C. Salinity generally was low, ranging between 8.5 and 25.5. *Cothyloriza tuberculata* was occasionally observed in the Bay from August to September (Table 1). The bloom was established only in 2017. There was no information for *C. tuberculata* mass appearance in the Bay before. *Aurelia* specimens were less numerous.

Tab. 1. Appearance of bloom forming Scyphomedusae in period 2013-2017 in Boka Kotorska Bay (1- one specimen; 2- several specimens; 3- bloom)

| month     | <i>Chrysaora hysoscella</i> |     |     |     |     | <i>Discomedusa lobata</i> |     |     |     |     | <i>Cothyloriza tuberculata</i> |     |     |     |     |
|-----------|-----------------------------|-----|-----|-----|-----|---------------------------|-----|-----|-----|-----|--------------------------------|-----|-----|-----|-----|
|           | '13                         | '14 | '15 | '16 | '17 | '13                       | '14 | '15 | '16 | '17 | '13                            | '14 | '15 | '16 | '17 |
| January   |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| February  |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| March     |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| April     |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| May       |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| June      |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| July      |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| August    |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| September |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| October   |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| November  |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |
| December  |                             |     |     |     |     |                           |     |     |     |     |                                |     |     |     |     |

According to personal communication of residents, frequency and abundance of this genus were higher in the past. It can be due to direct competition with

*C. hysoscella*, which is fed on other jellyfish. Higher number of *Aurelia* specimens was recorded at the end of May 2015, only (Table 2). *Rhizostoma pulmo* was irregularly observed in the Bay with a higher abundance only in August 2017. Rare species *Drymonema dalmatinum* recently become increasingly common in the whole coast of the eastern Adriatic [4]. It was always recorded with low specimens number. In the Bay, species was found in June and August of 2014, and from April to June 2017, which is the longest known permanent observation of this species in one area.

Tab. 2. Appearance of non bloom forming Scyphomedusae in period 2013-2017 in Boka Kotorska Bay (1- one specimen; 2- several specimens)

| month     | <i>Aurelia</i> spp |     |     |     |     | <i>Rhizostoma pulmo</i> |     |     |     |     | <i>Drymonema dalmatinum</i> |     |     |     |     |
|-----------|--------------------|-----|-----|-----|-----|-------------------------|-----|-----|-----|-----|-----------------------------|-----|-----|-----|-----|
|           | '13                | '14 | '15 | '16 | '17 | '13                     | '14 | '15 | '16 | '17 | '13                         | '14 | '15 | '16 | '17 |
| January   |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| February  |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| March     |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| April     |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| May       |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| June      |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| July      |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| August    |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| September |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| October   |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| November  |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |
| December  |                    |     |     |     |     |                         |     |     |     |     |                             |     |     |     |     |

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# FORECASTING DISPERSAL OF INVASIVE CTENOPHORE *MNEMIOPSIS LEIDYI* A.AGASIZ, 1865 AROUND EURASIA BASED ON CLIMATOLOGY.

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## Abstract

In the last decades climate warming has intensified more in Eurasia compare to the global average. With the warming, some invasive species such as ecosystem engineer ctenophore *Mnemiopsis leidyi* expanded around ecosystems of Eurasian seas. The goal of this work is to determine the spatial pattern of *M.leidyi* expansion in the seas of Eurasia under the climate change impact.

**Keywords:** *Invasive species, European Seas, Warming*

The goal of the paper is to analyze key factors (SST, SSS and Chl) favorable for ctenophore establishment. The study was based on the long-term field and experimental data in different regions of Eurasia [1] and America [2]. Monthly climatological data was used for the analysis of key factors. The results exhibit the current distribution of *M. leidyi*, including known native (coastal waters along northern and southern America), current recipient (Eurasian waters) and new potential areas. Monthly and annual climatology of SST and SSS were obtained from World Ocean Atlas 2013 (WOA13 [3]. Monthly and annual climatology of surface Chl was obtained from SeaWiFS data [4].

We subdivide the *M.leidyi* presence areas as follow:

1. **Occurrence conditions:** areas of general occurrence of self-sustainable *M.leidyi* populations with possibility to reproduce in specific seasons and areas where it can spread and temporally survive without reproductions in unfavorable conditions;
2. **Reproduction conditions:** areas favorable for reproduction and growth of self-sustainable population, which include source and sink areas;
3. **Sterile dispersal:** areas, where alive aggregations, dispersed by local currents may occur without possibility for reproduction.

We determine that the ranges of key factors favorable for *M. leidyi* reproduction in the Eurasian seas are: temperature 11.8°- 27°C for the Southern seas and 10-24°C for the Northern seas, salinity 6-40, Chl above 0.5 mg. m<sup>-3</sup>.

We focused on the western Eurasia, which is a recipient area for established populations of *M.leidyi*. For this region we plotted the maps of occurrence (Fig.1a) and reproduction (Fig.1b) areas based on annual climatology.

Considering the ranges favorable for *M.leidyi* occurrence, which are wider compare to the reproduction range, we observe that *M.leidyi* may occur almost everywhere. Considering the chlorophyll concentration, the most productive areas (Chl>1 mg.m<sup>-3</sup>) of the southern seas locate in the central and southern waters of the Caspian Sea, the coastal waters of the Black Sea, the whole Sea of Azov and Marmara, the northern Adriatic Sea, northern coastal Aegean Sea, Israeli and Egyptian coasts of the Levantine Sea, the Gulf of Lions, the Catalan coast, and the Libyan coast. The most productive areas of the northern seas locate in the North Sea (especially its German, Dutch and Danish coasts), and the southern coast of the Baltic Sea. All these areas are corresponding to areas of *M.leidyi* occurrence observed in natural field observations [1].

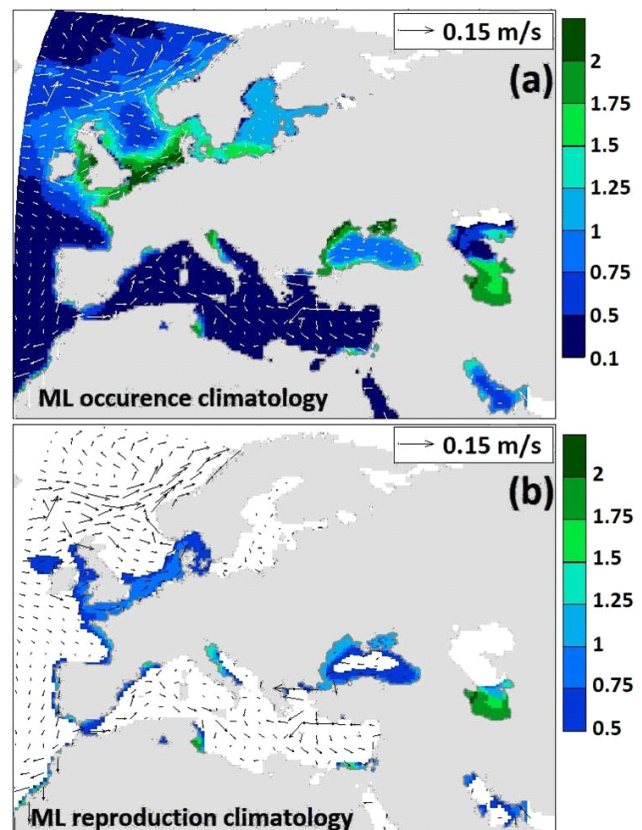


Fig. 1. Annual mean surface Chl climatology in the seas Eurasia for (a) conditions favorable for *M.leidyi* (ML) occurrence, (b) conditions favorable for *M.leidyi* reproduction. Vector arrows in all two subfigures correspond to annual mean surface currents (climatological data for the surface currents from ORAS4 reanalysis database).

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# EFFECT OF OCEAN ACIDIFICATION ON ASEXUAL REPRODUCTION AND STROBILATION PROCESSES OF THE JELLYFISH SCYPHOZOA, *PHYLLORHIZA PUNCTATA*

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## Abstract

Jellyfish blooms have been increasing in last years, causing negative impacts on human social and economic activities. Jellyfish polyp stage plays an important role on jellyfish blooms formations due to its asexual reproduction, rapid reproductive development from trigger to strobilation and ability to produce multiple ephyrae per polyp [1]. Is well known that ocean acidification promotes significant effects on marine organisms – e.g. metabolic, growth and reproduction rates, but information about the impact on jellyfish polyp stage is still scarce. This study aimed to evaluate the effect of ocean acidification on *Phyllorhiza punctata* jellyfish polyp asexual reproduction and strobilation capability. The organisms were exposed to different CO<sub>2</sub> enriched seawater conditions, simulating the future predicted conditions (decrease of 0.3 – 0.4 pH units by year 2100) and extreme acidification scenarios (decrease of 1 – 1.5 units of pH [2]). Concerning to asexual reproduction and strobilation, the obtained results suggest that polyps of *Phyllorhiza punctata* jellyfish are tolerant to ocean acidification. The polyps were able to produce ephyrae independently of pH ( $\chi^2_{(4)}=1.176$ ;  $p=0.436$ ) and no differences on total bud production at the end of trials ( $H_{4.54}=5.021$ ,  $p=0.285$ ) was noted. Future studies should evaluate the combined effect of temperature and pH for a better prediction of *Phyllorhiza punctata* blooms responses on a context of warming and ocean acidification.

Keywords: Ocean acidification, Jellyfish polyps

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## **CIESM Congress Session : Higher Vertebrates**

**Moderator : Teresa Moura, IPMA, Lisbon, Portugal**

### *Moderator's Synthesis*

Concerns over the conservation of higher vertebrates (in particular elasmobranchs, marine turtles, seabirds and marine mammals) have been increasing in recent years due to the recognition of these species as important elements in marine communities and to recent reports of population declines. Given their particular life history traits and dynamics, species within this group are more vulnerable to impacts on their populations and particularly to removals by fishing (unmanaged, unregulated and illegal fishing), habitat degradation or fragmentation and environmental changes. Despite the importance of higher vertebrates in the marine communities and their vast distribution, there is still a general lack of knowledge on various aspects of their biology and dynamics.

The session speakers covered several important research topics, in particular species identification, stock structure, distribution and monitoring. The debate that followed highlighted the need to improve species identification in the case of elasmobranch species. It also noted the need to increase our knowledge of less frequent species or species without commercial interest (in the case of elasmobranchs). The importance of identifying and mapping nurseries and of studying the connectivity among populations or among different areas was also highlighted. Finally, the implementation or maintenance of monitoring programs was considered a critical aspect to address in the short term. These species travel in waters of different jurisdictions, and so coordinated efforts among countries as well as a strong research network are required to successfully address this group of species and properly assess the status of their populations.



# FIRST RESULTS OF THE VIDEO-BASED MONITORING OF THE LOGGERHEAD SEA TURTLE *CARETTA CARETTA* IN THE CROATIAN NATURE 2000 COASTAL SITE

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## Abstract

The first underwater video-based monitoring system in Croatia was established in the Krka Estuary (Ušće Krke), which is part of the Natura 2000, by Ruder Boškovic Institute (RBI) for estuary community survey. Live video from underwater camera is available at the website .(<http://www.sibenik-meteo.com/podvodna-kamera>). During 2018, at eleven occasions, the video system captured a loggerhead sea turtle (*Caretta caretta*), and we could distinguish at least five individual turtles.

**Keywords:** *Turtles, Adriatic Sea, Monitoring*

## Introduction

Environmental monitoring has not been established throughout the marine Natura 2000 areas in Croatia, therefore, the legislation of ecosystem management and protection has not been completely fulfilled. For the first time in Croatia, an underwater motion detection video imaging survey has been carried out by Ruder Boškovic Institute at this Natura 2000 area site named “Ušće Krke” (Site code: HR3000171) from July 2016. After calibration and adaptation period, in January 2018 the video survey monitoring started daily, creating a huge photo data set. In first three month 41 taxa were detected with fish prevalence, 70.73% of all recorded species. The rest being echinoderms 12.25%, cephalopods 7.3%, crustaceans 2.43%, anthozoans 2.43%, reptilians 2.43% and birds 2.43%. (Iveša et al., 2018). The area under video-based monitoring is also part of the Significant landscape category named “Kanal-luka”.

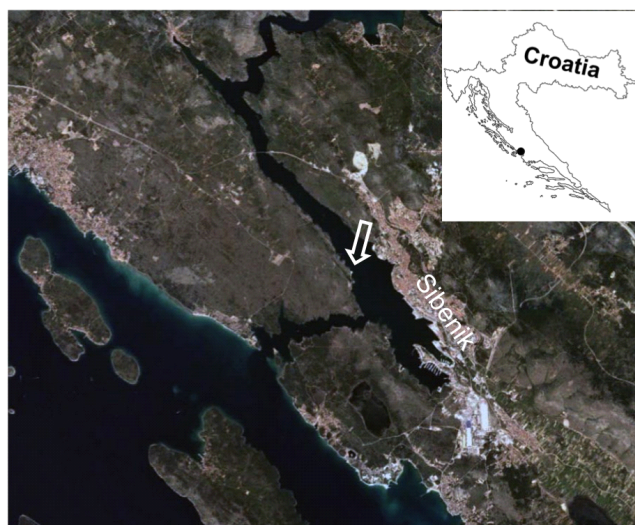


Fig. 1. Satellite image with camera location.

## Materials and methods

Video surveillance camera Hikvision (Model DS-2CD2020F-I) with underwater case is placed at 5 m depth in the Krka River Estuary in front of the RBI marine station (Figure 1). Camera is connected with a marine station network by a 50 m underwater cable. Temperature, tides and salinity data were constantly collected at 2.5 and 5 m depths by two data loggers. Video imaging motion detection software was developed and adapted for animal species counting. All taken photos are visually examined and verified. Live underwater video is available at this website (<http://www.sibenik-meteo.com/podvodna-kamera>).

## Results

During 2018, at eleven occasions, the video monitoring system captured loggerhead sea turtle (*Caretta caretta*), which is strictly protected species in

Croatia. It was recorded once in February, three times in July, four times in September and three times in October. We could distinguish at least five different loggerhead sea turtles. The February turtle had a shell damaged by boat propeller and the September one had ectoparasite (Figure 2).

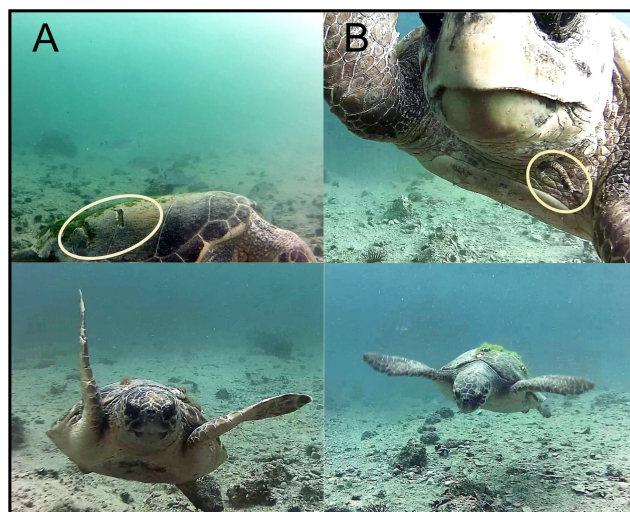


Fig. 2. Loggerhead sea turtles: A) shell damaged by boat propeller, B) ectoparasite.

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# OBSERVATIONS SUR LA BIOLOGIE DE *GALEUS MELASTOMUS* (RAFINESQUE, 1809) DANS LE BASSIN ALGÉRIEN. CNRDPA: ALDEM 2012.

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## Abstract

Le chien espagnol ou appelé couramment « el-gâte » dans la région centre de l'Algérie est le nom scientifique de *Galeus melastomus* (Rafinesque, 1809). Des observations sur la biologie de *Galeus melastomus* ont été réalisées pendant la campagne océanographique ALDEM 2012 effectuée à bord du navire océanographique Algérien Grine Belkacem, depuis la frontière Algéro-tunisienne à la frontière Algéro-marocaine, entre 20 mètres et 800 mètres de profondeur.

**Keywords:** *Elasmobranchii, Fish behaviour, Western Mediterranean*

## Introduction

Le chien espagnol *Galeus melastomus* (Rafinesque, 1809) est un petit requin benthique de la famille des Scyliorhinidae à large répartition verticale (55 m – 1000 m) commun dans la mer Méditerranée [1] capturé aussi dans des profondeurs de 400 et 1400 m dans le bassin occidental de la méditerranée [2]. *Galeus melastomus* est une espèce ovipare qui fraye toute l'année en Méditerranée avec une activité intense au printemps et en été [3]. C'est une espèce qui se présente rarement sur les étals des marchés algériens.

## Matériel et Méthodes

Les données relatives à *Galeus melastomus* ont été enregistrées pendant la campagne océanographique ALDEM 2012 dans le bassin Algérien entre 20 mètres et 800 mètres de profondeur durant la période de mai à juin 2012. L'engin de pêche utilisé est un chalut de fond de type scientifique dont le maillage du sac est de 20 mm. Son ouverture horizontale est de 22 m et l'ouverture verticale est de 1m50. Le paramètre de stratification retenu est la profondeur, avec les limites bathymétriques suivantes: strate A (20-50m), strate B (51-100m), strate C (101-200 m), strate D (201-500m) et strate E (501-800m). Les individus capturés ont été mesurés et pesés. La relation taille-poids est établie par sexe et pour l'ensemble de la population. Deux indices ont permis l'analyse des répartitions horizontale et verticale: la fréquence relative (Fr) et l'abondance relative (Ar).

## Résultat et Discussion

Au total, 662 individus de *Galeus melastomus* ont été collectés pendant la campagne océanographique ALDEM 2012, leurs longueurs totales varient entre 10,3 cm et 58,6 cm, correspondant à des poids de 03 g à 580 g. Une très significative corrélation est observée entre le poids total et la longueur totale ( $r = 0,98$ ) chez la population totale ainsi que chez les mâles ( $r = 0,90$ ) et les femelles ( $r = 0,92$ ). Le coefficient d'allométrie de la relation entre la longueur totale et le poids total ( $b = 2,77$ ) indiquent une allométrie de croissance minorante chez la population totale ainsi que chez les mâles ( $b = 2,73$ ) et les femelles ( $b = 2,69$ ). L'espèce étudiée est présente tout le long de la côte algérienne avec des variations selon la région et la strate considérée. *Galeus melastomus* est absent dans la strate C (101 m – 200 m) mais très fréquent dans la tranche de profondeur qui se situe entre 200 à 800 mètres et très abondant entre 500 à 800 mètres de profondeur (tableau 1).

Tab. 1. Répartition de *Galeus melastomus* dans le bassin Algérien (A: 20 m – 50 m; B: 50 m – 100 m; D: 200 m – 500 m; E: 500 m – 800 m)

| Strate | Secteur | Effectif | Ar   | Fr  |
|--------|---------|----------|------|-----|
| A      | Est     | 2        | 0.06 | 3.1 |
|        | Centre  | 1        | 0.05 | 4.5 |
|        | Ouest   | 0        | 0    | 0   |
| B      | Est     | 5        | 0.16 | 6.3 |
|        | Centre  | 1        | 0.05 | 4.5 |
|        | Ouest   | 0        | 0    | 0   |
| D      | Est     | 33       | 1.03 | 16  |
|        | Centre  | 16       | 0.73 | 9   |
|        | Ouest   | 113      | 2.46 | 11  |
| E      | Est     | 98       | 2.78 | 16  |
|        | Centre  | 93       | 4.23 | 9.1 |
|        | Ouest   | 300      | 6.52 | 6.5 |

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# MOLECULAR APPROACH FOR THE IDENTIFICATION OF SHARKS OF GENUS *CENTROPHORUS* IN MEDITERRANEAN SEA

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## Abstract

A total of 194 specimens of the genus *Centrophorus* from 9 Mediterranean GFCM GSA have been analysed with three different mitochondrial markers (COI, ND2 and 16S) for the proper identification of the species in the area, essential for an efficient and sustainable management of the resource. Both single and concatenated markers point out low sequence variability and the occurrence of most haplotypes shared among Western, Central and Eastern locations. In addition, the comparison with sequences of the genus, obtained from the public repositories, highlights that the Mediterranean samples cluster together, supporting the occurrence of a unique species in the Mediterranean Sea.

**Keywords:** *Elasmobranchii, Mediterranean Sea, Deep waters, Systematics*

The genus *Centrophorus* includes different species of deep-water benthopelagic sharks with a worldwide distribution known as gulper sharks. Its taxonomy has historically been problematic, and the number of species included in the genus has varied considerably over the years and is still under debate [1, 2 and references therein]. The aim of the present study is to use three different mitochondrial sequences (portions of the cytochrome oxidase subunit I COI, NADH dehydrogenase subunit 2 ND2, and 16S ribosomal RNA gene) for the proper identification of the species that occurs in the Mediterranean Sea, essential for an efficient and sustainable management of this resource commonly bycaught in Mediterranean deep-water fisheries. A total of 194 specimens, provisionally attributed to *Centrophorus granulosus*, have been analysed with the mtDNA markers both separately and concatenated. The samples have been collected in 9 Mediterranean GFCM GSA (Geographic Sub Areas) off the coasts of Italy (GSAs 9, 10, 11, 16, and 18), Algeria (GSA4), Spain (GSA5), Greece (GSA20) and Cyprus (GSA25). All sequences have been aligned and analysed with MEGA v7, and the relationship among the concatenated haplotypes has been investigated with unbranched median joining networks, created in PopART v1.7. Both single and concatenated markers point out low sequence variability within the Mediterranean Sea with 9 haplotypes for ND2, 6 haplotypes each for COI and 16S, and a total of 16 haplotypes and 16 variable sites in the concatenated sequences (1662 bp long). The network of concatenated sequences shows the occurrence of two main haplotypes, shared by most GSAs, spread all over the Mediterranean. Additional haplotypes are found to be shared among Western, Central and Eastern locations (fig. 1). Similar results have been obtained with the single genes (data not shown).

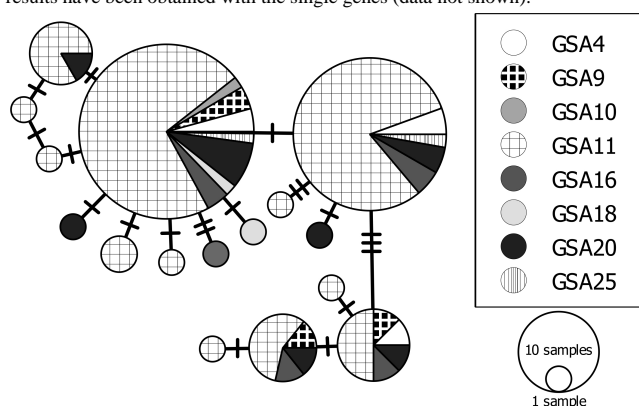


Fig. 1. Haplotype network of the concatenated sequences of Mediterranean gulper sharks. The circles were drawing proportionally with the sequences shared in the haplotype.

The new Mediterranean sequences have been compared for each marker with additional sequences of all the species of *Centrophorus* obtained from public repositories (i.e., GenBank and BOLD), using a Bayesian approach with the software MrBayes v3.2. All the Mediterranean COI sequences cluster together in a highly supported branch (clade G, fig. 2) along with other sequences

originally deposited as *C. granulosus*, *C. uyato*, and *C. zeehaani*, and very close to *C. atromarginatus* (clade F). Recently, the species of clade G have been proposed and tentatively designated as *C. cf. uyato* by several authors (1, 2). Similar results have been obtained with the other two markers (ND2 and 16S, data not shown) and by morphological analyses based on 37 different measurements (data not shown). The Mediterranean sequences are clearly distinguishable from the sequences of *C. mollucensis* (clade A), *C. harrisoni*+*C. isodon* (Clade B), *Centrophorus* sp (Clade C), *C. squamosus* (Clade D), *C. granulosus* + *C. acus* + *C. niaukang* (Clade E, now designated as *C. granulosus*, as *C. acus* and *C. niaukang* junior synonyms).

In summary, our data strongly indicate the occurrence of a single *Centrophorus* species in the Mediterranean and suggest the need for a revision of the systematic of the genus in the area.

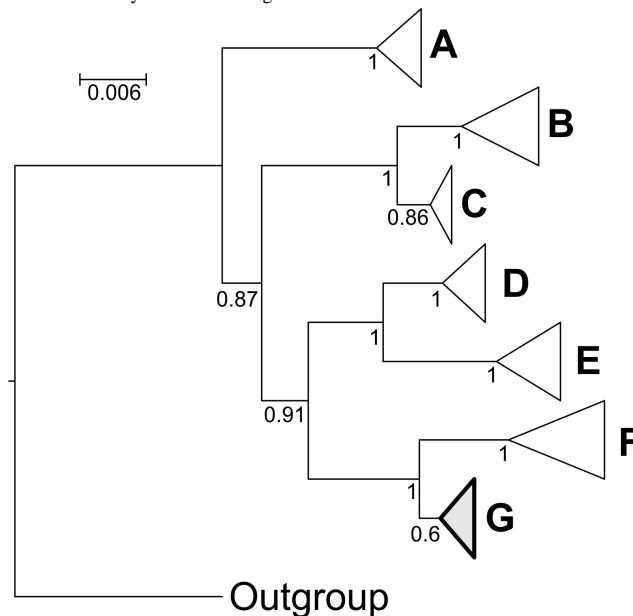


Fig. 2. Bayesian tree of COI sequences. Posterior probability values are shown near the nodes. The outgroup is *Deania calcea*.

**Acknowledgments:** The authors warmly thank the many colleagues and researchers that have helped them in collecting the samples.

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# FIRST CONFIRMATION OCCURENCE OF TWO CARTILAGINOUS FISH SPECIES: LEUCORAJA CIRCULARIS AND L. FULLONICA (RAJIDAE) IN THE LAVENTINE BASIN (EASTERN MEDITERRANEAN)

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## Abstract

This paper reports the first documented record of the *L.circularis* (Cauch,1838) and *L. Fullonica* (L.,1758) ( Family Rajidae ) in Syrian waters and in the Levantine basin. Two specimens of *L. circularis* were caught by bottom trawl at depth about 120 m on 20 February 2017 . On 8 March 2018, one individual of *Leucoraja fullonica* was caught during a trawl survey at a depth of 340 m.

**Keywords:** *Fishes, Levantine Basin, Elasmobranchii, Trawl surveys, Latakia Basin*

On 20 February 2017, two specimen of *Leucoraja circularis* were captured by a bottom trawler about 10 km south-west off the Lattakia coast, 35°34' N 35°37' E, at a depth of 100 m. On 8 March 2018, one individual of *Leucoraja fullonica* (Fig.1) was caught by trawl at a depth of 340 m. This specimen was an immature female measured 365 mm -total length, 210 mm - disc width, and weighted 183.2 g. Identification was made from Fischer et al.,[1]. The morphometric and meristic (teeth in rows upper jaw, teeth in rows lower jaw, nictitating lamellae, median row thorns) were recorded according Consalvo et al.,[2] and Mnasri et al.,[3] The female and male of *Licuraja circularis* (Fig. 2) measuring 580 mm and 628 mm total length (TL) and weighing 880 g and 1240 g total weight (TW), respectively. Morphometric and meristic data of the two specimens are recorded following Stehmann and Burkel [4] and Consalvo et al. [2]. The identification of the specimens as *Lecoraja* genus: Snout short, anterior disc margins somewhat convex, slightly concave; a theoretical line from snout tip to pectoral wing tip cutting front margin of disc; thorns present on disc. This is the first documented record of *L. circularis* in eastern Mediterranean. The occurrence of the two immature specimens of *L. circularis* off the Syrian coast could suggest that a probable *L. circularis* population is established in the area. However, such a hypothesis needs further confirmation. No previous occurrence of *L. fullonica* has been recorded in the Syrian coastal waters [5]; [6]. This record provides evidence that the distributeon of *L. fullonica* extends further east in the Mediterranean Sea to the Levantine Basin.



Fig. 1. Specimen of *Leucoraja fullonica* caught from the Syrian coast. Scale bar= 50 mm.



Fig. 2. Two specimens of *Leucoraja circularis* caught off the Syrian coast , a: female; b: male, scale bar = 100 mm

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# SCANNING ELECTRON MICROSCOPY STUDY OF SOME CIROLANIDAE (CRUSTACEA: ISOPODA) ATTACKING ELASMOBRANCHS FROM THE TUNISIAN COAST

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## Abstract

The genus *Natatolana* is one of the most abundant and widespread isopods. Species of this genus are reported as scavengers for several fish species. In the world, only few studies have reported the association of these scavengers with elasmobranchs. In this study, we report for the first time, the occurrence of these Cirolanidae attacking elasmobranchs from the four existing gulfs across the Tunisian coast.

**Keywords:** *Biogeography, Mediterranean Sea, Predation, Crustacea, Fishes*

Species belonging to the genus *Natatolana* Bruce, 1981 are consistent components of benthic scavenger assemblages' worldwide, attacking both living and dead animals and therefore, playing an ecologically important role in the marine environments and marine food webs [1].

Between September 2013 to September 2016, 1656 fish belonging to four species of elasmobranchs (*Mustelus mustelus*, *M. punctulatus*, *Raja clavata* and *Scyliorhinus canicula*) were examined for scavenger species. Samples were collected along the Tunisian coast (Bay of Bizerte, Gulf of Tunis, Gulf of Hammamet, Gulf of Gabes). All body cavities were carefully examined. Identification of isopods species was based on their morphological features according to [2] and [3]. Some specimens, removed alive from the fish and fixed in ethanol 100%, were dried using CO<sub>2</sub> in an Emitech K850 critical point dryer. After mounting, the specimens were coated with gold/palladium in a Quorum Technologies SC7640 sputter coater and examined with a Hitachi S-3400N scanning electron microscope at an acceleration voltage of 10 kV.

Two species of the genus *Natatolana* were identified for the first time in Tunisia. These species are *Natatolana borealis* (Lilljeborg, 1851) and *Natatolana neglecta* (Hansen, 1890). However, comparing to the drawings given by [2], *N. borealis* have fewer robust setae in the propodus of pereopod 7 (Fig. 1) and the coxae and pleonite 4 of *N. neglecta* are more acute than illustrated by these authors (Fig.2.).



Fig. 1. Pereopod 7 of *Natatolana borealis*

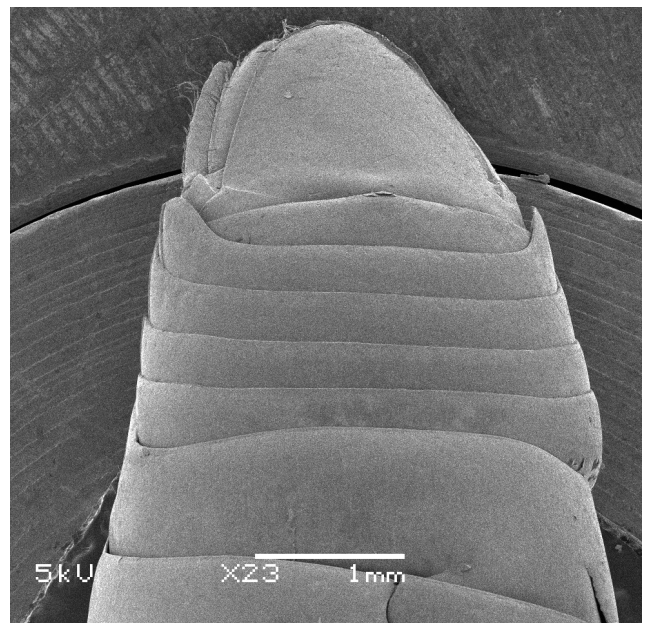


Fig. 2. Pleon of *Natatolana neglecta*

This work allowed us to confirm the presence of *Natatolana* species off Tunisian coasts and on elasmobranchs. Therefore, it would be interesting to study their diversity on a larger scale (in their marine environment and on bony fish) and their morphological (phenotypic) differences from specimens of the North Atlantic.

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## THE ACCOBAMS SURVEY INITIATIVE: THE FIRST SYNOPTIC SURVEY OF THE MEDITERRANEAN AND BLACK SEAS

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### Abstract

The “ACCOBAMS Survey Initiative” (ASI) is a pilot programme aimed at establishing an integrated and coordinated monitoring system for cetaceans throughout the entire ACCOBAMS area. Conducted by the ACCOBAMS Permanent Secretariat in coordination with riparian countries, it supports the implementation of European and regional policies, in particular the Marine Strategy Framework Directive (MSFD-EU) and the Ecosystem Approach process (EcAp -Barcelona Convention UNEP/MAP).

In summer 2018, a synoptic survey was carried out across the Mediterranean Sea and contiguous Atlantic area, combining visual methods (aerial surveys) and visual and passive acoustic monitoring (PAM) from vessels (focused primarily on deep diving species and areas where aerial surveys were not possible). Line-transect sampling methodology was applied and density and abundance estimated through design-based and model-based approaches.

To continue this pivotal research effort, an equivalent aerial survey is planned for summer 2019 in the Black Sea in relation to the MSFD.

As part of the ASI, acoustic and/or visual vessel surveys were planned for those areas where aerial surveys could not be conducted in summer 2018. Equal spaced zigzag transects were designed and 21,829 km of track-lines were surveyed by R/V Song of the Whale in the western basin, Hellenic Trench and Libyan waters. R/V CANA-CNRS covered Lebanese waters, with Egyptian and Syrian coastal blocks to be surveyed during the summer 2019. The ASI vessel surveys provide substantial new datasets that can be compared with previous studies that have identified that the Mediterranean sperm whale subpopulation is alarmingly small.

The 2018-2019 effort will provide an overall picture of the distribution and abundance of cetaceans throughout the ACCOBAMS area, providing robust estimates to be considered as a baseline for further regional systematic monitoring programmes, coordinated and comparable amongst all areas. These data will improve the current knowledge on cetacean abundance and distribution, allow reconsideration of their conservation status, facilitate the development of targeted conservation and mitigation measures and allow for the follow-up to international obligations (EU, UNEP-MAP). Moreover, they will be used to support both place- and threat-based conservation efforts in the Agreement area, with the identification of Important Marine Mammal Areas (IMMAs) and Cetacean Critical Habitats (CCHs), respectively.

*Keywords: large scale surveys, Mediterranean and Black Seas, conservation*

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## GENETIC STOCK STRUCTURE AND CONNECTIVITY IN MEDITERRANEAN AND BLACK SEAS SPINY DOGFISH *SQUALUS ACANTHIAS*

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### Abstract

The spiny dogfish or piked dogfish *Squalus acanthias* is taken in demersal and pelagic fisheries in the Mediterranean and Black seas, where it is currently considered an Endangered and Vulnerable species, respectively, due to declining population trends attributed to overfishing [1]. Initially thought to be widespread in the Mediterranean Sea, the species suffers from common misidentification basin-wide and may in fact be restricted to a few regions [2] such as the Gulf of Lion and the Adriatic Sea. Beyond issues in species identification, little is known about the stock structure and level of connectivity among stocks in the Mediterranean and Black seas, despite the relevance of such information for adequate fisheries management.

This study aims at clarifying the genetic stock structure of *S. acanthias* and estimate current connectivity levels among stocks in the Mediterranean and Black seas. Mitochondrial ND2 and control region sequence data, and 16 nuclear microsatellite loci genotypes were obtained for Adriatic and Black seas collections, as well as from adjacent Atlantic population from around the British Isles. Results show the existence of distinct genetic stocks in the Adriatic and Black Seas with little connectivity between them, as well as with the Atlantic counterparts. Moreover, the Black Sea population exhibits much lower genetic diversity than the Adriatic and Atlantic populations, both at the mitochondrial and nuclear markers. These results have direct application to fisheries management, highlighting the need for urgent adequate management of these unique stocks.

Keywords: nuclear microsatellites; mitochondrial ND2; genetic stocks; Adriatic Sea; Black Sea; sharks

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**CIESM Congress Session : Other zooplankton**  
**Moderator : Ana L. Primo, CFE, Univ. of Coimbra, Portugal**

*Moderator's Synthesis*

Introduction to the session included zooplankton definitions and classification, a quick review of sampling and identification methodologies and the highlight of their importance with the presentation of some studies of the Atlantic.

Presentations covered environmental influence on the ichthyoplankton communities of the North-Eastern Aegean Sea (1) and (2) on microzooplankton at the Mljet Island; (3) the distribution and diversity of zooplankton on a broad North Atlantic transect; (4) the description of the nutrient regime and Chl at the coastal area of Cyprus; the study of the structure and functioning of mesozooplankton in the Mediterranean Sea (5); the distribution of ostracods in the Adriatic Sea (6); and a comparison between classical and molecular approaches for zooplankton biodiversity assessment (7).

Final discussion focused mainly on the new identification methodologies, namely meta-barcoding and zoo-images with the general agreement that these new techniques bring several advantages but should not substitute classical approaches. The importance of analyzing microzooplankton for a better assessment of the marine biodiversity was also recognised.

The importance of long-term time series was stressed out as well as the need of more regional and global scale studies towards a more holistic understanding of the impact of global changes on marine biodiversity.



# NOCTURNAL INVESTIGATION OF PLANKTONIC OSTRACODS IN THE SOUTH ADRIATIC SEA

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## Abstract

Night-time distribution of planktonic ostracods was investigated down to 300 m depth in the open South Adriatic Sea in spring 2009. Among twelve recorded species, *Porroecia spinirostris* dominated in the upper epipelagic layer, *Archiconchoecia striata* in the lower epipelagic and *Proceroecia macroprocera* in the upper mesopelagic zone. The highest ostracod average abundance of  $519.1 \pm 251.84$  ind.  $100\text{ m}^{-3}$  was found in the lower epipelagic layer. With the exception of *P. spinirostris*, recorded species showed higher nocturnal abundances below 100 m depths, with no evidence of near-surface upward migrations during night.

**Keywords:** Adriatic Sea, Crustacea, Zooplankton, Pelagic

Ostracods are a sub-class of small crustaceans which occur in many aquatic habitats. Although they usually inhabit the benthic zone, family Halocyprididae is mostly planktonic. As several planktonic ostracod species are known to perform notable diel vertical migrations [1], we aimed to determine whether there were any particulars in ostracod nocturnal distribution in the upper layers of deep South Adriatic Sea. Sampling was performed down to 300 m in three distinct layers representing the upper epipelagic (A; 0-50 m), lower epipelagic (B; 100-200) and upper mesopelagic zone (C; 200-300 m). Samples were collected with an opening-closing Nansen net (mesh size  $200\text{ }\mu\text{m}$ ) above the 1000 m isobath (S-1000;  $42^{\circ}19'N$ ,  $17^{\circ}26'E$ ), from May 19 to May 25 2009, during five night-time samplings (6:20 pm to 0:05 am). Counting and determination were performed on stereomicroscope (at 4-25 x magnifications), following the descriptions by Angel [2].

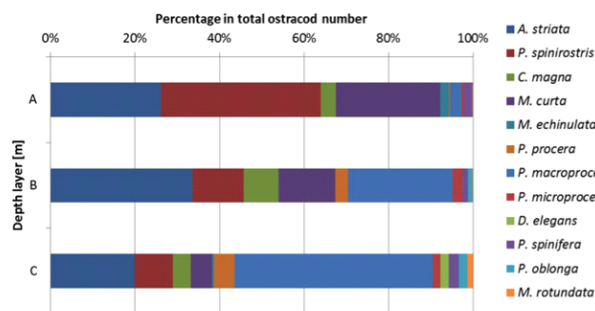


Fig. 1. Average contribution of twelve ostracod species in three sampling layers: A: upper epipelagic, B: lower epipelagic and C: upper mesopelagic.

A total of twelve halocyprid species were identified. *Porroecia spinirostris* was the most abundant in the upper epipelagic zone (A), *Archiconchoecia striata* in the lower epipelagic (B) and *Proceroecia macroprocera* in the upper mesopelagic (C), constituting on average 37.8%, 33.6% and 46.9% of total abundances, respectively (Fig. 1). *Paraconchoecia oblonga* and *Discoconchoecia elegans* were absent in layer A, *Mikroconchoecia echinata* in layer B, while layer C contained all recorded species. Overall, the lowest total average ostracods abundance was found in layer A ( $182.9 \pm 136.49$  ind.  $100\text{ m}^{-3}$ ) while the highest was found in layer B ( $519.1 \pm 251.84$  ind.  $100\text{ m}^{-3}$ ). The differences between layer A and layers B-C were statistically significant (Kruskal-Wallis test;  $K=10.168$ ,  $P=0.006$ ). Principal component analysis extracted four factors, describing 75.98% of total ostracod variability (Fig. 2). The first group (32.31%) contained six species characterized with higher vertical variations in abundances and notably reduced values in layer A (*Conchoecia magna*, *Proceroecia procera*, *P. microprocera*, *P. macroprocera*, *Discoconchoecia elegans* and *Metaconchoecia rotundata*). The second group (21.33%) consisted of four species distributed through A-C layers, with relatively small vertical changes in abundances (*Archiconchoecia striata*, *Porroecia spinirostris*, *Mikroconchoecia curta* and *Paraconchoecia oblonga*). *Paraconchoecia spinifera* (13.48%) and *Mikroconchoecia echinulata* (8.851%) were extracted as separate groups. Both species occurred in very low abundances which varied little in vertical direction. High proportion of juveniles

*M. curta* (up to 92.5%) in the layer B confirmed spring as the period of its intense propagation [3]. During the night hours, the majority of recorded species preferred lower epipelagic and upper mesopelagic layers. However, *P. spinirostris* showed a slight increase in abundance in layer A at night, in accordance with the observed tendency of this species to concentrate in the upper 50 m [4]. Conversely, *C. magna* and *P. macroprocera* concentrated below 100 m depth, indicating the absence of near-surface upward migrations during night-time.

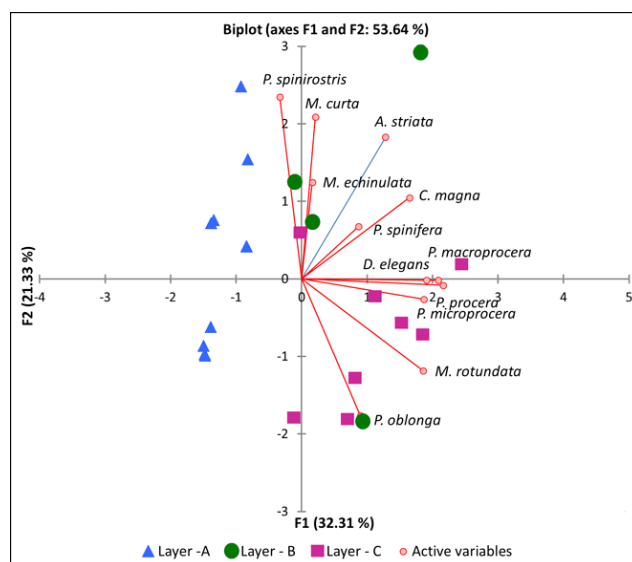


Fig. 2. Ordering of twelve ostracod species obtained by Principal Component Analysis (PCA). Sampling layers are superimposed as qualitative supplementary variables and plotted as triangles (Layer-A, 0-50 m; Layer-B, 100-200 m and Layer-C, 200-300m depth).

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# STRUCTURE AND FUNCTIONING OF EPIPELAGIC MESOZOOPLANKTON IN THE MEDITERRANEAN SEA DURING SPRING PEACETIME CRUISE 2017

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## Abstract

17 zooplankton samples were taken during PEACETIME cruise carried out between May and June 2017. The samples were analyzed using FlowCAM and ZOOSCAN to obtain a complete size spectrum from 100  $\mu\text{m}$  to 1 cm. Dry weight, grazing, respiration and excretion rates were derived using established allometric equations. Results show that during the cruise transect, the average zooplankton grazing rate was 11.9 % of phytoplankton stock and 23.9 % of the primary production, and the ammonium and phosphate regenerated by zooplankton excretion contribute in average to 6.71 and 7.01 % of the total N and P requirements for primary production respectively.

**Keywords:** *Zooplankton, Mediterranean Sea*

The role of zooplankton in marine ecosystems is essential considering its impact on carbon and nutrients cycles and fate. For example transferring energy from primary producers to higher trophic levels giving them a crucial influence on fish stock recruitment [1,2] and modifying the pool of dissolved nutrients available for phytoplankton by grazing and excretion [3]. 17 stations were sampled in May/June 2017 during the PEACETIME cruise over the Western and Eastern Mediterranean Sea (Fig 1) on board the R.V. *Pourquoi pas?* using a bongo frame (60cm mouth diameter) equipped with a 100 $\mu\text{m}$  and 200 $\mu\text{m}$  mesh net and towed from 300m depth to the surface. Oceanographic variables were recorded with CTD (temperature, density, salinity) and chlorophyll-a concentration was estimated from Niskin bottle samples using HPLC. Phytoplankton stock was derived from the integrated value of total chlorophyll. Each zooplankton sample was analyzed later in the laboratory using FlowCAM (<300  $\mu\text{m}$  ESD) and ZOOSCAN (>300  $\mu\text{m}$  ESD). From the zooplankton size spectrum obtained at each station, we derived the dry weight using an area-weight relationship [4], the zooplankton carbon demand (ZCD) assuming phytoplankton as the single food source [5] and the metabolic rates using allometric models [6].

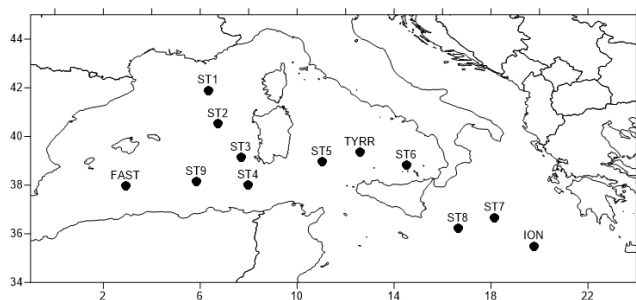


Fig. 1. Map of the PEACETIME study area. Black dots represent the sampling stations.

Total zooplankton abundance (fig. 2a) varies between 551 and 1643 ind  $\text{m}^{-3}$ , with an average of  $1165 \pm 332$  ind  $\text{m}^{-3}$ . <300  $\mu\text{m}$  size fraction has the most significant contribution (72 % on average). Zooplankton biomass (fig. 2b) range from 1.09 to 6.86  $\text{mg m}^{-3}$ , with an average of  $4.92 \pm 1.51$   $\text{mg m}^{-3}$ . Copepods were the most abundant taxonomic group in all stations representing between 36 to 75% of the abundance and 30 to 84% of the total biomass. The ZCD ranged from 0.14 to 0.94  $\text{mg C m}^{-3} \text{d}^{-1}$  which means a daily grazing pressure of 11.9 % (in average for all stations) of phytoplankton stock and a 23.9 % of the primary production. Average ammonium and phosphorus excretion for all stations was  $0.33 \text{ mg NH}_4 \text{ m}^{-3} \text{d}^{-1}$  and  $0.005 \text{ mg PO}_4 \text{ m}^{-3} \text{d}^{-1}$ . This  $\text{NH}_4$  and  $\text{PO}_4$  regenerated by zooplankton contribute in average to 6.71 and 7.01 % respectively of the total N and P requirements for primary production.

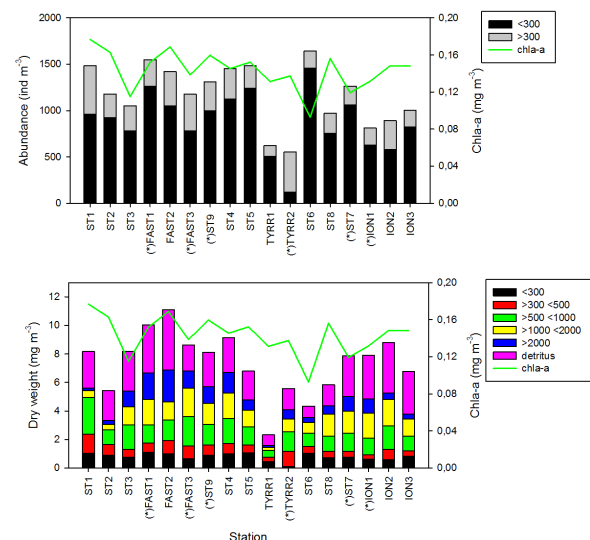


Fig. 2. A) Abundance of small zooplankton (ECD <300 $\mu\text{m}$ ) determined by flowcam and of large zooplankton (ECD >300 $\mu\text{m}$ ) determined by Zooscan. Averaged integrated Chl-a concentrations (straight line). B) Cumulated biomasses of zooplankton size fractions and detritus.

During Peacetime cruise zooplankton biomass and size structure showed no clear pattern with chlorophyll-a. Moderate grazing impact and nutrient regeneration also suggest a poor direct link between phyto- and zooplankton

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# HORIZONTAL ZOOPLANKTON DISTRIBUTION, ITS ABUNDANCE AND DIVERSITY IN A TRANSECT OF THE NORTH ATLANTIC (22°W), DURING JUNE 2018

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## Abstract

Zooplankton abundance and composition was analyzed on the epipelagic layer along a North Atlantic transect (22°W) from Nord Cape Verde to South Iceland in June 2018. The copepods were always dominant among 20 zooplankton groups found and 95 species identified. The abundance was highly variable along the transect with an increase of small copepods and biomass in the frontal region (47°N). Based in the zooplankton structure and the oceanographic environment, the frontal system separated the north from the south region with different copepod contribution and a substantial decrease of species going northward.

**Keywords:** North Atlantic, Zooplankton, Copepoda, Biodiversity, Biomass

The study area, passed throughout a very extense area of the North Atlantic close to the Mid-Atlantic Ridge which is highly diverse with a large number of seamounts and deep valleys which strongly may affect the circulation, production and distribution of zooplankton as well as other marine fauna [1].

In the present work we explore during the “Bathypelagic expedition” in June 2018, the structure of the zooplankton community along a South-North transect in the Northeast Atlantic (22°W), covering more than 4000 km from the warm and saline North Atlantic Central water (20°N) to the northern cold and less saline South Arctic water (55°N). Ten hydrographic and zooplankton stations were sampled and depth stratified to 2000 m depth (Fig. 1).

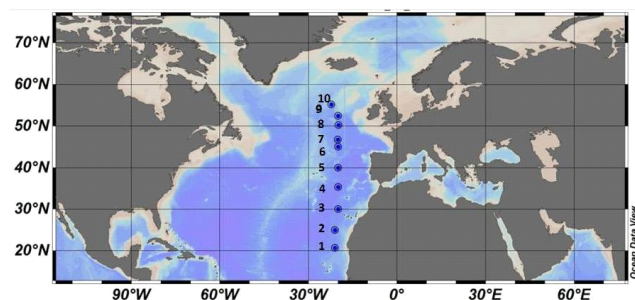


Fig. 1. Map of the sampled area and the zooplankton stations.

Here are presented the data collected in the epipelagic strata (0-200 m depth) for the micro (metazoan), meso and macrozooplankton community, their biomasses, abundance and structure. For the hydrological data was using a Seabird 911 plus Conductivity Temperature-Depth (CTD) instrument with a seabird -43 Dissolved Oxygen sensors and Seapoint Chlorophyll FLuorometer sensor. CTD casts were performed at each sampled station in the upper 200 m depth of the water column. Simultaneously, the zooplankton stations were sampled during day time by means of vertical hauls with a Calvet net of 53 µm mesh to collect the smaller organisms of the zooplankton community and a double WP2 (50 cm wide) of 200 µm mesh for the meso and macrozooplankton community. Just on board all samples were divided in two aliquots, one for the biomass and the data given in mg of Dry Weight m<sup>-3</sup>. The other sample was preserved with formaldehyde (4%) for later taxonomic analysis. Similar methodology was carried out for the larger communities which were obtained after sheaved the samples by a 200 µm mesh. For the microzooplankton samples all metazoan were counted and fractionated in different sizes. All zooplankton groups were identified and standardized to number of individuals per m<sup>3</sup>. The cladocers and copepods were identified whenever was possible to species level, particularly the adults and the juveniles to their genera, following different literature in the area [2, 3 and 4].

Sea Surface temperature (SST) was higher in the southern part of the survey, as it was expected, with >20°C in the first 5 stations, decreasing to the last stations with almost 11°C. The main SST gradient was found around 45°N and 47°N (St 6 and 7) with a SST of 15.6° C and 15° C respectively and 12°C at 200 m depth. The surface salinities (SSS) were higher than 36 PSU in the first 5 stations because the SSS decreased to 35.1 at the last stations. The fluorescence was very low until station 6 and 7, where the highest values were detected. Based on the hydrographic data a frontal region was found around 45°N-47°N and amplified by changes in the biomass, abundance and composition of main copepods. The number of copepod species decreased northward. Accordingly, the biomass of the zooplankton was low but closes in the first 5 stations, increasing their abundances to stations 6 and 7, where a high amount of small copepods and their nauplii were concentrated. *Clausocalanus*, *Paracalanus* and *Oithona* were usually the dominant genera changing their abundances and contribution all along the different regions. In the north region the meso and macrozooplankton abundance increased where the *Calanids* predominated. However, the frontal system appeared to be a barrier to the horizontal distribution of several species, it could favour the accumulation of others.

Thus, in the Eastern area of the North Atlantic, the pattern distribution observed on the zooplankton community and their juvenile stages were closely modulated by the hydrography but also main environmental variables, such as sea temperature and chlorophyll.

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# ENVIRONMENTAL FACTORS, NUTRIENT REGIME AND CHL<sub>a</sub> VARIABILITY IN THREE COASTAL AREAS OF CYPRUS: AN INSIGHT TO ZOOPLANKTON DISTRIBUTION PATTERNS

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## Abstract

Environmental factors influence the distribution patterns and ecological processes of zooplankton. Monthly recording of environmental parameters and sampling of zooplankton and seawater was carried out in three coastal areas (Akrotiri, Kato Pyrgos and Vasiliko) of Cyprus for 12 consecutive months. The preliminary results showed that there is an obvious difference in temperature in the surface layer of Kato Pyrgos in comparison with Akrotiri and Vasiliko during summer. The concentration of Chl<sub>a</sub> exhibited a clear increasing gradient proportional to increasing depth. Lower values of Chl<sub>a</sub> were observed during summer and higher values during winter and autumn.

**Keywords:** *Zooplankton, Levantine Basin*

The homogenization and stratification of waters on a seasonal basis, and their upward movement to the surface (upwelling) alter the physical (temperature, salinity) and chemical (nutrients) characteristics of the water column causing a variety of effects on marine organisms [1]. Life history and composition of zooplankton communities are impacted and formed by the physical, chemical and biological properties of a given ecosystem [2]. This study constitutes the first attempt to record zooplankton species, abundance and phenology in the coastal waters of Cyprus, and to study the role of zooplankton communities in the marine food web. Further, this study aims to study the temporal and spatial distribution patterns of zooplankton in terms of biomass, abundance and species composition, in relation to the environmental factors and the nutrient regime of different coastal areas of Cyprus.

Monthly sampling was carried out in 3 coastal areas of Cyprus (Akrotiri, Kato Pyrgos and Vasiliko) for 12 months in a row (January – December 2016). These areas were selected on the basis of their differences in temperature (Akrotiri and Kato Pyrgos) and anthropogenic impacts (Vasiliko). Four sampling stations were used overall. CTD Sensor was used for recording temperature and salinity. A Niskin bottle was used at 7 depths (0m, 2m, 10m, 20m, 50m, 75m, 100m) for collecting seawater in order to estimate the concentration of nutrients and chlorophyll-a in the water column. The collection of zooplankton was conducted with a WP2 closing net (two vertical tows, 0-50m and 50-100m in Akrotiri & Kato Pyrgos and one in Vasiliko, 0-50m). Zooplankton samples are identified at species level using a stereomicroscope. Zooplankton respiratory rates based on ETS (Electron Transport System) activity [3] will also be investigated by seasonally collected samples.

The fluctuation of temperature, salinity, chl<sub>a</sub> and nutrients in 3 coastal areas of Cyprus (Akrotiri, Kato Pyrgos and Vasiliko) is presented here, aiming to investigate the temporal and seasonal abundance of zooplankton in relation with abiotic parameters. The analysis of in situ data from 2016 showed an evident seasonal pattern of change in temperature; temperatures surpassed 29°C during summer at the surface waters of Kato Pyrgos, and dropped to 17 °C during winter at a depth of 100m in Akrotiri. Higher temperature (~3-4 °C) and salinity (~0.3-0.4 psu) of surface waters (up to 20m depth), occurred in Kato Pyrgos during summer, compared to Akrotiri and Vasiliko (Fig. 1).

In all three areas, the stratification of the water column started in mid-spring and continued all over the year until December. All three areas had similar temperature and salinity profiles in winter, in terms of homogenization. Hence, there were three months of sharp vertical mixing from January to March. The thermoclines and haloclines in spring and summer in Akrotiri and Vasiliko were smoother, in comparison with Kato Pyrgos which showed an abrupt change of temperature in the water column. There was a marked seasonal thermocline between 20 and 70 m depth for four months of the year (June, July, August and September) in Akrotiri and Kato Pyrgos. The thermocline was evident in Vasiliko as well, between 10 and 40m during June, July and August, while in September the thermocline ranged from 25 to 40m (Fig. 1).

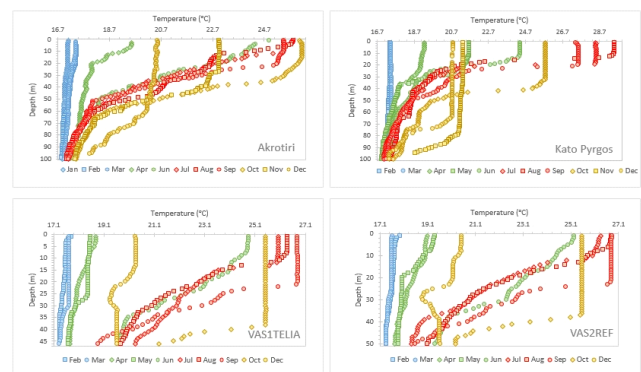


Fig. 1. Monthly temperature variation in Akrotiri (AKR), Kato Pyrgos (PYR), Vasiliko 1 VAS1TELIA and Vasiliko 2 (VAS2REF).

The concentration of Chl<sub>a</sub> exhibited a clear increasing gradient proportional to increasing depth in all the sampling stations. In addition, lower values of Chl<sub>a</sub> were observed during summer and higher values during winter and autumn in all the study areas. Nutrient regime didn't exhibited a clear pattern. Hence, further investigation will be conducted, in order to find correlations with the distribution patterns of zooplankton.

There is an obvious difference of temperature and salinity in the surface layer (up to 20m depth) of Kato Pyrgos in comparison with Akrotiri and Vasiliko, during the summer period. This difference between the south and the north of the island is the highest recorded among marine areas under control of the Republic of Cyprus. This might be due to coastal upwelling (upward movement of waters to the surface) in the south of Cyprus during summer, which caused the decreased temperature. Our hypothesis is that these differences are affecting the structure of zooplanktonic communities. We expect that the future investigation of concentration of nutrients in combination with the analysis of zooplankton samples will enhance our knowledge about the distribution patterns and ecological processes pertaining to these organisms.

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# INFLUENCE OF ENVIRONMENTAL FACTORS ON MICROZOOPLANKTON COMMUNITIES (MLJET ISLAND, SOUTHERN ADRIATIC, CROATIA)

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## Abstract

This study sheds light on the influence of changing environmental conditions on microzooplankton in the semi-enclosed marine system. Temperature separated taxa into distinct thermo- and cryophilic communities. Unusually high precipitation during the spring and summer of 2014 caused extended hypoxia in the fall that affected the abundance and vertical distribution of all taxa. Small copepods *Oithona similis*, *Mesoiokeras hurei*, *Monothula subtilis*, *Oncaea zernovi*, and polychaeta trochophore comprised a community adapted to the hypoxic bottom layer (10% - 14% dissolved oxygen).

**Keywords:** Zooplankton, Hydrography, Anoxia, Mediterranean Sea

Owing to its unique physical, chemical, and biological setting, the semi-closed marine lake of Veliko Jezero (VJ) on the island of Mljet has attracted attention as an interesting case for investigating the structure and function of plankton communities [1].

Due to the unusually large amounts of rainfall during the spring and summer of 2014 in the southern Adriatic (an average  $81.58 \pm 49.38$  mm), we hypothesized that a change in the hydrographic conditions of VJ would substantially influence microzooplankton populations. Samples were collected during daylight in the deepest part of the lake (45 m, Fig. 1), from the beginning of September 2014 to December 2015. Microzooplankton was collected with 5 L Niskin bottles at several depths in each of three vertical zones: Surface Layer above summer thermocline at 0 and 10 m; Mid Layer below the thermocline and over the hypoxic zone at 20, 25 and 30 m; Bottom Layer at 33, 35, 38, and 42 (or 43) m.

Veliko Jezero's microzooplankton may be classified according to their temperature preference: all protozoa, copepod nauplii, *Oithona* copepodites, *O. nana*, and appendicularians are thermophilic while *Mesoiokeras hurei*, *O. similis*, oncaeids, and polychaeta larvae are cryophilic (Fig 2). Higher abundance of heterotrophic bacteria after heavy rain and the subsequent pronounced stratification presumably reflects the increase in allochthonous DOM from local runoff. Thus, fall 2014 was characterized by higher bacteria levels and lower DO below 30 m depth. The present research found DO to be particularly influential in determining zooplankton distribution in VJ: In fact, all taxa correlated with DO (Fig 2). The negative correlations of the copepods *Oithona similis* with DO may be explained by the preference of these species for lower temperatures during periods of thermal stratification. The small benthic-pelagic copepod *Mesoiokeras hurei*, known only from VJ, permanently inhabits the near bottom water [1]. These two species obviously are able to withstand hypoxic conditions. The highest abundance of oncaeid copepodites and adults were in the layer where DO was 10 - 14%. Its abundance in this study — over 100 ind L<sup>-1</sup> (38 m) — is among the higher values reported for oncaeids. Their abundance in the bottom layer under hypoxic conditions may be related to the high amounts of detritus, a possible food source. Two small species were identified: *Monothula subtilis* and *Oncaea zernovi*. In earlier investigations of VJ, however, oncaeids always were less numerous and principally above 20 m [1]. Polychaeta trochophore larvae were especially numerous in the hypoxic layer and their maxima values of 58 ind L<sup>-1</sup> were the highest reported in the Mediterranean.

This study confirms that environmental changes can have quick and dramatic effects on the planktonic community of an enclosed marine system and that near-bottom hypoxia can considerably influence the plankton within the water column. Detailed studies of species-specific adaptations are essential to developing predictions of how zooplankton communities and marine food-webs will respond to future environmental changes. This study was funded by Croatian Science Foundation, the project IP-2014-09-2945.

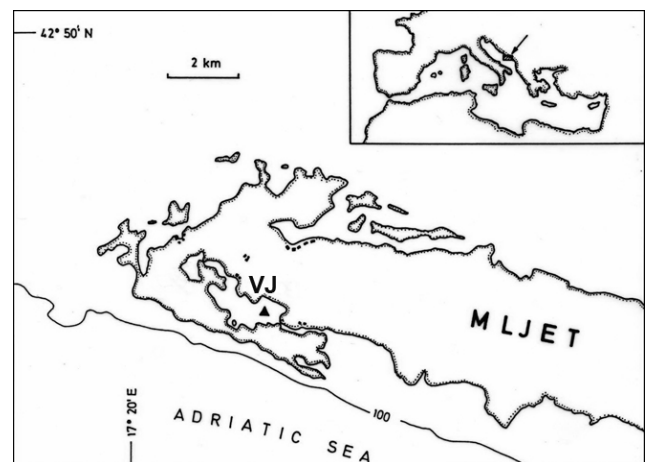


Fig. 1. Study area showing sampling station (black triangle).

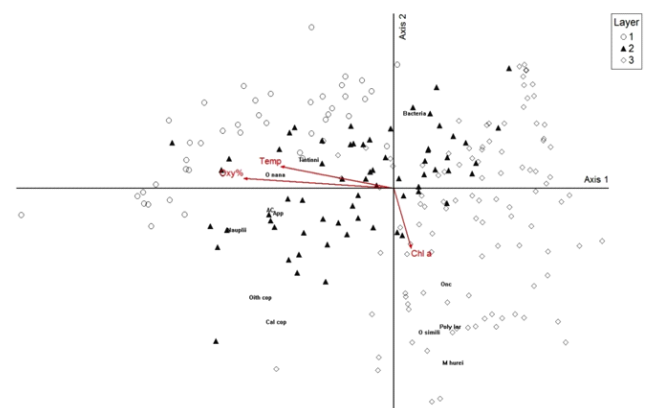


Fig. 2. Principal component analysis (PCA) of the first two axes on the zooplankton abundance data set. Oxy%: dissolved oxygen, Temp: water temperature, Chl a: chlorophyll a, HB: heterotrophic bacteria, AC: aloricate ciliates, Tin: Tintinnids, Cal cop: Calanoid copepodites, Oith cop: Oithona copepodites, Onc: Oncaeida, Poly lar: Polychaeta larvae, App: Appendicularia. Symbols represent samples of the identified group of the layers.

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# **ICHTHYOPLANKTON ASSEMBLAGES AND CORRELATION WITH ENVIRONMENTAL FACTORS IN THE NORTH-EASTERN AEGEAN SEA IN SUMMER 2010**

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## **Abstract**

This study presents the ichthyoplankton assemblages of North Aegean Sea, and specifically the Thracian Sea during July 2010. Classification of stations into groups established two distinct groups of regions, which differed in ambient environmental parameters (depth, temperature, salinity and chlorophyll-a) as well as species composition.

**Keywords:** *Larvae, Eastern Mediterranean*

## **Introduction**

The contribution of Ichthyoplankton research is great in the fields of biology, ecology and systematic classification of fish and in the field of fishery biology [1]. Interpreting the spatial distribution of ichthyoplankton and associating it with various abiotic and biotic factors, can be extracted important information about the biology of the first stages of life of various species as well as the environmental conditions in which the adult populations live and reproduce.

## **Materials and Methods**

A grid of 18 stations (Fig. 1) was sampled from 5 to 14 July 2010, with a double bongo-net (0.250 and 0.335 mm meshed nets) towed obliquely from just above the sea bottom to the surface (maximum to 200 m). Hydrographic profiles were collected using a CTD device on a denser grid of 82 stations. The eggs and larvae of both nets were sorted and identified into taxa (family, genus and species if possible) and their abundance expressed as individuals per 10 m filtered water. nMDS plots of a Bray-Curtis similarity matrix were produced taking into account the most abundant taxa (taxa with only one occurrence at all 18 stations were excluded). Data were transformed [ $\log(x+1)$ ] to enhance the contribution considering only the most abundant taxa.

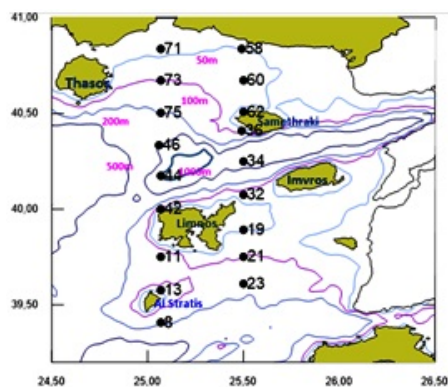


Fig. 1. Map of the study area showing the location of sampling stations

## **Results and discussion**

A total of 59 taxa belonging to 37 families were identified. Eggs were dominated by small pelagic *Engraulis encrasicolus* (84%), *Sardinella aurita* (2.5%) and *Scomber colias* (2.13%). The most abundant larvae were the small pelagic *E. encrasicolus* (72.8%) followed by *Hygophum benoiti* (3.52%), *Chromis chromis* (3.37%), Gobiidae (3.13%), *Ceratoscopelus maderensis* (2.73%), *S. colias* (2.62%), *Serranus hepatus* (1.73%) and *S. aurita* (1.57%). Using nMDS analysis, two different groups of stations were classified. The first group (A) contains coastal species like *S. hepatus* and Gobiidae and the eggs and larvae of small and middle pelagics like *E. encrasicolus*, *S. aurita* and *S. colias*. The second group (B) contains mostly mesopelagic species belonging mainly in the Myctophidae family (Fig 2a). Of the environmental factors investigated, depth, salinity, temperature and

chlorophyll-a were the most useful predictors of larval distribution in the area of north-eastern Aegean. Environmental factors and major contributor species are plotted as correlated vectors. Group A is characterized by lower values of temperature and chlorophyll-a, higher values of salinity and higher depths, whereas group B is mostly combined with higher values of chlorophyll-a and temperature, and lower values of salinity (Fig 2b). Similar studies about the correlation of fish larvae assemblages with the environmental factors were also observed in the same region by other authors [2].

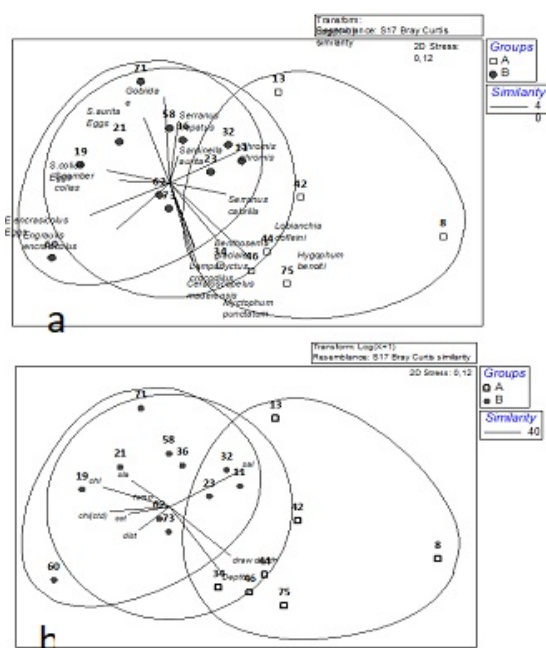


Fig. 2. Non Metric Multi-dimensional Scaling, nMDS with: **a)** most abundant taxa as vectors, and **b)** environmental factors as vectors: [sal (salinity, ctd), st (sea surface temperature, satellite), temp (temperature, ctd) sla (sea level anomaly, satellite), chl-ctd (chlorophyll-a, ctd), chl (chlorophyll-a, satellite), dist (distance from the coast), draw depth (depth of howl), Depth (depth of station)].

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# SUITABILITY OF METABARCODING FOR ZOOPLANKTON BIODIVERSITY ASSESSMENT- A COMPARISON BETWEEN CLASSICAL AND MOLECULAR APPROACHES

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## Abstract

Zooplankton biodiversity assessment is a crucial element in monitoring the marine ecosystem processes and the community responses to environmental alterations. The present study aims to evaluate the suitability of metabarcoding for zooplankton biodiversity assessment. In comparison to the classical morphological method, metabarcoding resulted in higher taxa richness, but it leaks in identifying the copepod diversity. The ecological analysis resulted in very similar patterns in both methods. Metabarcoding seems to be a promising tool, especially in large-scale monitoring programs and in biodiversity assessment of ecosystems with high spatial and temporal variability, where high sampling effort is required.

**Keywords:** *Biodiversity, Metagenomics, Zooplankton, Gulf of Venice*

The rising necessity for taxonomic information across trophic levels to support ecological research, conservation and ecosystem-based management efforts asks for fast and cost-effective methods for biodiversity assessment [1]. As morphological assessments are labour intensive, often the characterization of the spatiotemporal variability of zooplankton assemblages would require an unsustainable effort. Challenges with taxonomic identification due to the complexity of the zooplankton assemblage and the lack of diagnostic characters of immature (larval) stages are key impediments to understand global-to-local patterns of zooplankton biodiversity and biogeography [2]. DNA-metabarcoding is a novel taxonomic method for identifying a specimen, based on the sequencing of a short standardized DNA fragment (barcode), that is unique for each species [3]. Compared with the traditional morphological identification metabarcoding results to be not only faster and more cost-effective, but it achieves also a broad taxonomic coverage [4]. The aim of this study is to evaluate the suitability of metabarcoding in assessing zooplankton diversity patterns comparing it to morphological analysis. Both methods (morphological and molecular) were used to measure taxonomic diversity and community composition. Seasonal zooplankton sampling (24 samples) was carried out between April '16 and February '17 in the Venice Lagoon and the nearby coastal area. Each zooplankton samples was analysed with morphological analysis and with molecular analysis. In this study of a short fragment (~313 bp) of the COI gene was used for molecular taxonomic analysis. The level of taxonomic assignment in the morphological data (MORPH) resulted higher compared to metabarcoding (MBC). The morphological identification could identify some groups only to phylum level (phoronids, ctenophores and nematodes) or to class level (eg. polychaetes, gastropods and bivalves). Some phyla were not documented at all with morphology (Nemertea, Bryozoa, Rotifera, Gastrotricha and Plathelminthes); on the other hand, the class Appendicularia could not be assigned with MBC. The taxa richness found with molecular data is much higher compared to the MORPH. The total biodiversity with metabarcoding resulted in 16 phyla, 31 classes, 180 families, 218 OTUS at species level, while with the morphological identification resulted in 11 phyla, 14 classes, 23 families, 40 taxa at species level. In terms of relative abundance with both methods indicates that arthropods are the most abundant group ( $67.5\% \pm 26.6$  (MBC) and  $83.5\% \pm 16.6$  (MORPH)). The beta diversity analysed by non-metric multidimensional scaling (nMDS) shows that the sample communities of MBC clearly differ by season (permanova:  $F = 1.7528$ ,  $p = 0.001$ ), but not between stations or locations (Fig. 1). However, a separation of the three categories, sea, inlet and lagoon, can be observed. Furthermore, these patterns are consistent with the MORPH results. Significantly differences were found between seasons (permanova:  $F = 2.2049$ ,  $p = 0.001$ ) and also between location (permanova:  $F = 1.8509$ ,  $p = 0.013$ ). The two distance matrixes derived by the two methods are significantly positively correlated (Mantel test (Spearman's rank correlation)  $\rho = 0.611$ ,  $p = 0.001$ ), confirming that morphological and MBC data provide similar assessment of spatial and temporal patterns. The comparison between the methods highlighted that both methods have their hits and misses. MBC was able to identify the taxa mostly to species level, while it misses in other important ecological aspects like the identification of different life stages. Moreover, the amount of shared copepod species is only 40% (23 species), which strongly indicates the necessity of a

local reference database. The method of choice depends on the objectives. MBC is fast and allows therefore large-scale monitoring in short times, especially in ecosystems with high spatial and temporal variability and where a high frequency of monitoring is preferable even if accepting a loss of information in terms of absolute abundance and population structure.

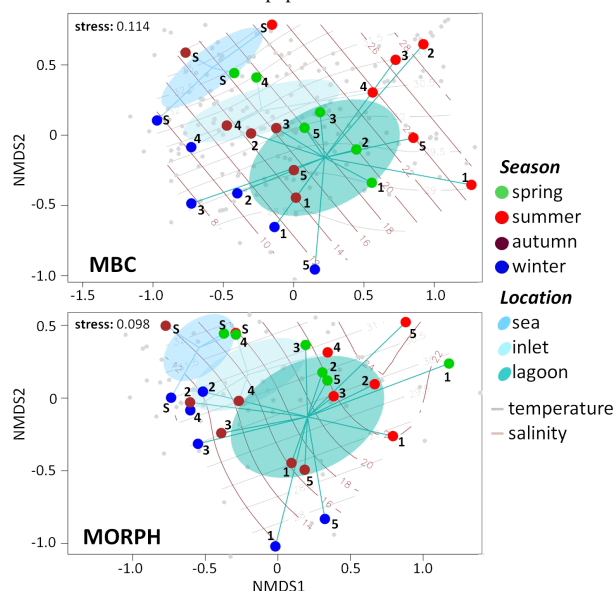


Fig. 1. NMDS plots based on Bray-Curtis similarity. Ellipses represent 3 habitat categories (sea, inlet and lagoon).

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COMITÉ 6  
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Ecosystèmes côtiers

Président : Ernesto Azzurro

CIESM Congress Session : Blue economy
Moderator : Adriana Ressurreição, Univ. of Algarve, Portugal

Moderator's Synthesis

Blue Economy is an emerging concept calling for a better stewardship of the ocean and its resources. It incorporates core principles such as sustainable management, equity, public involvement and stakeholder co-creation in marine management and decision making. The CIESM Blue economy session started with a brief presentation stressing the importance of marine ecosystems to human wellbeing and provided some staggering figures on the world wide ocean economy. It further proceeded to explore one of the ecosystem service frameworks and its prominence in recent European policy making (ex. EU Biodiversity Strategy, EU Blue Growth Strategy, etc.). It concluded by emphasising the importance of Marine Protected Areas (MPAs) to put forward these strategies and to balance different society needs while safeguarding ocean conservation and their services for future generations.

CIESM Blue Economy session tackled several topics ranging from invasive species, tourism opportunities associated with marine resources, tools for integrated coastal management and sustainable food choices. The presentations were followed by a lively discussion where the speakers and the audience had the opportunity to clarify questions and to share experiences. The topic “invasive species” gathered significant interest from the audience. Many questions were posed to better understand the socioeconomic impact of invasive species to the case studies but also how it could be converted into businesses opportunities. The case studies presented at the blue economy session of the 42nd CIESM congress offered useful insights to marine management both to the Mediterranean Sea and the Atlantic Ocean.



ASSEMBLING KEY INFORMATION FOR ANALYSING THE RISK OF RABBITFISH INVASION: A SUPPORT TO COASTAL MANAGEMENT AND MARINE SPATIAL PLANNING

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Abstract

Rabbitfishes have historically established successful populations in the easternmost sectors of the Mediterranean, posing serious challenges for coastal conservation and management of Marine Protected Areas (MPAs) of the Levant. Yet, in the last decade, these species have significantly expanded to the west and north, conquering new areas in their invaded domain. Here we assembled the data available from the scientific literature to reconstruct the chronology of the invasion and to inform conservation interested bodies, such as MPA managers about the expected pressures.

Keywords: *Alien species, Mediterranean Sea*

Rabbitfishes, namely the marbled spinefoot *Siganus rivulatus* Forsskål, 1775 and the dusky spinefoot *Siganus luridus* (Rüppell, 1828), are among the most successful invaders in the Mediterranean Sea. They arrived through the Suez Canal as part of the so called “Lessepsian migration”. The two species became very common in the eastern Mediterranean Sea, strongly interacting with the native herbivores, particularly with *Sarpa salpa* (Linnaeus, 1858) and causing important ecological changes [1]. As recently demonstrated by physiological studies, this invasion is going to be exacerbated by climate change, which is expected to provide rabbitfishes with higher physiological performances compared to those of their native counterparts [2]. Here we carried out a comprehensive review of invasion history, temporal trends, as well as ecological and economic impacts of the two rabbitfishes to summarize the current situation. The marbled spinefoot is widely distributed in all the Eastern Mediterranean Sea and it has recently reached southern Italy in the Pelagie Island MPA. A similar trend, but with a different temporal dynamic, is illustrated for the dusky spinefoot, which after its first record spread through the eastern Mediterranean and established a permanent population in the Sicily Channel, with vagrant individuals detected also in the North Adriatic Sea and Gulf of Lion. The chronology of this invasion is summarized in Fig 1.

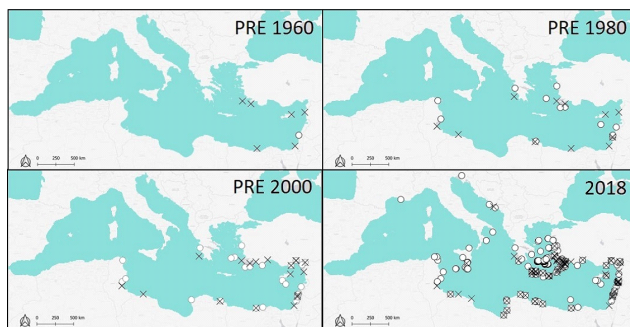


Fig. 1. Cumulative observation of the rabbitfish invasion as reconstructed by the literature analysis. Circles = *S. luridus*; crosses = *S. rivulatus*

Given the extreme urgency of anticipating current and future potential impacts of invasive species on protected ecosystems [3,4], this information provides insight for risk assessment in Marine Protected Areas, which should be ideally complemented by standardized periodical monitoring [5]. Documenting these changes is indeed a significant task to support policy-makers on coastal management and marine spatial planning. If we cannot prevent the arrival and further establishment of tropical invaders, the elaboration and integration of vulnerability assessments and adaptation planning into the coastal management frameworks will help protected areas, local communities and coastal management bodies to react in a more effective manner to the ongoing invasion of a climate-affected region.

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A TRAVEL COST MODEL TO ESTIMATE POSITIVE AND NEGATIVE IMPACTS OF SHARK WATCHING TOURISM ALONG THE ISRAELI COASTLINE

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Abstract

In the last few winters, sharks have been aggregating near the Israeli Mediterranean coast, at a specific point, near Hadera power station. This unusual phenomenon has fascinated residents, visitors, kayakers, divers and swimmers. We analyse the effects of this intense human interest on the sharks, using contingent behaviour, in Hadera and in Ashkelon, where sharks are present but not the infrastructure for their observation. We also report on changes in shark behaviour due to change in tourism intensity. We find a change of about ILS 4.1 million annually for both sites but a larger individual consumer surplus in Hadera, where sharks are currently observable. Touristic intensity crosses the threshold level by about 12%, and making the socio-equilibrium sustainable for both humans and sharks would have a social cost of ILS 0.157 million.

Keywords: *Economic valuation, Coastal management, Mediterranean Sea*

In the last few winters, sharks (Superorder Selachimorpha) have been aggregating near the Israeli Mediterranean coast. We analyse the effects of this intense human interest on the sharks, using Contingent Behaviour [1] in Hadera and in Ashkelon coasts in Israel. We observed contingency trips with and without shark's presence where the baseline is different between the two locations. We also report on monitoring sharks change in behaviour due to the change in diving intensity[2]. Our findings reveal a change of about 4.1 million ILS annually for both sites but a larger individual consumer surplus in Hadera where sharks are currently observable. This study is important because it is a first approach to carry out an economic analysis of tourism benefits from an endangered species where tourism demand is currently rising and may be also associated with some negative results with respect to the species. Travel cost models are important in assessing such touristic benefits. For example, Du Preez et al, (2012), using Travel Cost Method (TCM) in order to value the net benefit (that is, the benefit of visit the site minus the costs associated with it) from tiger shark diving in South Africa, obtained value of 2,080,925 Rand per year [3]. Anna & Saputra, (2017) used TCM the value for whale shark tourism in India of local and foreign tourism, obtained IDR 142.35 billion per year [4]. We demonstrated in the study that prior experience for sharks results in a bigger benefit of a given visit. Based on the Contingent Behavior model we found that diving intensity crosses the threshold level by about 12% and indicate an overall economic value of 0.157 million ILS to converge back into a socio-equilibrium which is sustainable for both humans and sharks. The results of the study suggest that there can be considerable recreational benefits generated by the creation shark's observation option and may provide another perspective of using the economic benefits as a reason for conservation [6]. However, considerable additional research is necessary before these values are used to justify additional investments due to potential risk by over crowdedness and its impact on the sharks. This study demonstrates the potential combination between shark tourism and the shark aggregations phenomenon which, in turn, raises two important questions. The first is concerned with the effect of this anthropogenic interference on sharks. The second question is regarding the impact of regulated shark tourism.

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AN INTEGRATED COASTAL MAP FOR THE MALTESE ISLANDS

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Abstract

The Maltese coastal area, comprising its associated resources and services, is of substantial importance to the Maltese economy. An innovative web interface has been developed to combine information from different sources, including coastal properties, physical features, resources and amenities, into an innovative comprehensive interactive map of the Maltese coastline. It serves as a general informative tool for users in the public domain, bringing different layers of data together, and targeting a delivery over smart media like mobile phones and tablets.

Keywords: *Coastal management, Malta Channel, Mapping, Interfaces*

Being the interface between the land and the ocean, the coastal zone offers an array of socio-economical services [1]. The services offered by the coastal zone can be categorised into three main groups, namely infrastructure, which includes features such as harbours and slipways; food production, which relates to fishing and other associated activities; and recreation, which includes all the features which are aesthetically appealing and attract visitors [2,3]. The coastline of the Maltese Islands, including all of the Islands' beaches, have been the foundation of numerous initiatives aimed at boosting the local economy by attracting tourists and investment. The Maltese Archipelago is composed of three main islands and a number of smaller islets, with a collective coastline of 196 km [4]. A study conducted by MEPA in 2018 determined that 21% (around 41 km) of the Maltese coastline has undergone some sort of development [5].

Maps are important tools whereby a wide variety of information can be displayed and extracted depending on their usage. In the particular case of coastal maps they provide the essential features pertaining to the land and sea boundaries forming part of the coastal zone areas. Malta did not have a single map that displayed all relevant information in relation to the coastal region. This web based map interface strives to fill in this gap by gathering and extracting information from various other existing maps and online sources, on top of additional gathered and updated in-situ information, displayed on layers in a single mapping resource. The Integrated Maltese Coastal Map is freely available online and the data that has been collected so far can be accessed through www.capemalta.net/coastalmap

mapped data suiting their needs, and as an aid to multiple users. Google's Maps Javascript API provides the functionality necessary to achieve this. Various zoom levels are available, with fewer features and items being displayed at lower zoom levels to avoid cluttering. A number of online data sources and maps were consulted and used throughout the data collection and extraction processes, such as with regards to diving sites, marker buoys, Marine Protected Areas (MPAs), and swimmers' zones. Such sources included nautical charts and coastal maps, most of which were published on Local Notices to Mariners. In situ data was collected from along the coast following a systematic procedure, utilizing a GPS to record the location of all features and photo documentation. The collected data was digitised, creating a database composed of eight tables: areacoordinates, areafeatures, areafeature_bay, bays, infrastructure, pointfeatures, linefeatures and linecoordinates. A bathymetric map is added to the map, displaying isobath polylines at fixed depths of 5m depth intervals, up to 100m depth. Swimming Zones and MPAs regions are displayed as polygons. The coastal features are represented using different icons.

The features included in the Integrated Maltese Coastal Map shall aid an array of users, including tourists/visitors, stakeholders and decision-makers, to identify the different amenities available in a particular stretch of coastline. For example, the bathymetric map encompasses a wide range of potential users, including fishermen, coastal navigators and relevant authorities (e.g. Transport Malta, Department of Fisheries and Aquaculture). Similarly, the MPAs displayed in the coastal map allow NGOs (e.g. Birdlife Malta) and decision-making entities (e.g. The Ministry for Sustainable Development, Environment and Climate Change) to easily identify the locate the activities and resources within the different MPAs, and their relationship with other features along the coastline. The map includes a 'beach card' – a beach info section for each bay, indicating whether a particular beach is a Blue Flag beach, its composition (sandy, pebbly or rocky), VHF channel and the availability of numerous amenities, which include: swimmers' zones, public restrooms, Wi-Fi, slipways, parking areas, accessibility, water sports, showers, food and beverage facilities and sunbed rentals. Other ancillary information such as that regarding camping or barbeque allowance areas forms also part of the beach card.

The Integrated Maltese Coastal Map system is set up in a way that allows updating and additions of more data layers, serving as a baseline for its future evolution to serve a wider number of users over newer public media.

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Fig. 1. A snapshot of the online user interface showing the isobaths around the Maltese Islands and information buttons along the coast at the beaches/ports.

The map makes use of the Google maps platform. It is presented on a user-friendly display with simple functionality, allowing users to customise the

SOCIO-ECONOMIC IMPACTS OF THE ALIEN INVASIVE CRAB *PORTUNUS SEGNIS* (FORSKÅL, 1775) IN THE GULF OF GABÈS, TUNISIA

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Abstract

This work for the first time investigates some socio-economic impacts of *Portunus segnis* invasion and its consequences on artisanal fishing activities along the southern Tunisian coasts. Our survey revealed a decline in fishermen's income of 72% due to crab invasion. Overall, 98% of respondents declared that *P. segnis* negatively interacts with the fishing activities by damaging commercial preys in the nets. According to the respondents, the damage ranges from 10% to more than 60% of incomes. On average, in the region of Gabès, we estimate that the blue crab wounds 25% of the captured fish.

Keywords: LEK, Economic valuation, Global change, Invasive species, Mediterranean Sea

Introduction

Invasive Alien Species (IAS) have negative ecological and socio-economic impacts and represent a major threat to marine biodiversity by displacing native species, changing community structure and food webs [1]. They can also affect human health by the introduction of toxic species and parasites and have severe economic implications in fisheries, aquaculture and tourism [2]. This study focuses on the loss and damage caused by the blooms of the Alien Invasive crab *Portunus segnis* in the Gulf of Gabès to the coastal fisheries.

Materials and methods

126 Interviews with local fishermen and sample collection were carried out from seven sites covering 200 km coastline of the Gulf of Gabès located in southern Tunisia (between 35°-33°N and 10°-13.5°E°). The Gulf extends from Ras Kapudia at 35°12'59"N and 11°9'47"E to the Tunisian- Libyan border covering a total area of approximately 35,900 km² (Figure 1). The present study was carried out between March to June 2016. In addition, a participatory monitoring method called Local Ecological Knowledge (LEK) is also used for tracking changes in fish diversity and abundance across the Gulf of Gabès [3] and [4]. The interview concerned socio-demographics of fishermen, characteristics of fishing activity, losses and damages caused the alien invasive crab. It is taken into account for the total monetary loss caused by bioinvasion: losses of fishing gears, fishing time, catch yields and damages; using SPSS Statistic Software version 20.



Fig. 1. Study area and sampling sites in the Gulf of Gabès.

Results and Discussion

The socio demographic characteristics of the interviewed fishermen are described in Table 1. It highlights that the population is relatively young with a level of education not exceeding primary school. 62% of them left school very early to become fishermen. In addition, 80% of the fishermen come from fishing families and in 35% of cases have at least 10 years of fishing experience. The mean daily gross income is 360 € (with 1740 € and 10 € as extreme values). The annual average working days were 205.

Tab. 1. Socio-demographic characteristics of fishermen.

Category	Variable	%
Age (years)	20-39	25
	40-59	65
	>60	10
Level of education	Primary school	62
	Secondary school	35
	University	3
Position	Boss /Operator	80
	Fisherman	20

More than 60% of fishermen systematically capture *Portunus segnis* crab in their gill nets. In 40% of cases, the crab is abundant (more than 25 kg / 50m of nets), in particular with trammel nets. The clogging of the nets depends on the immersion time and can in some extreme cases reach more than 150 kg of crabs / 24 h. The haulage frequency of the nets increased by 20% and 30% of the fishermen do not make any more mending and prefer changing nets. The impacts are very negative and alarming on the production and value of the fishery, especially a drop of 86% for cuttlefish, requiring a relatively long trammel time immersion nets. In the same way 98% of fishermen questioned in Gabès claim that *Portunus segnis* damages their catch and losses were estimated at least at 10% and in some cases exceed 60%. In fact, the average annual income per fisherman averaged € 73,000, but it declined considerably up to € 20,500 after the *Portunus segnis* invasion. The number of annual working days fell from 205 to 153, which generated an additional in lost labor costs representing 25% of the total losses. In addition, clogging reduced fish catches, resulting in a loss of 37%. The frequency of net replacement has increased considerably since the crab invasion in 2014 (from 3 years to 6 months and in extreme cases to a monthly change). Furthermore, in case of huge damages of the nets, the renewal of nets is mandatory and more beneficial than mending. Using LEK approach, fishermen with more than 50 years experience point out changes in fishery landings along the coasts of Gulf of Gabès. Preliminary results highlight a decrease in abundance of native fish species such as groupers. By contrast, schools of non-indigenous fish species such as the barracuda *Sphyrna chrysotaenia* Klunzinger, 1884 are more and more abundant. Experienced professional fishermen attest that the impacts caused by the blue swimming crab are unprecedented compared to the effects of other AIS present in Tunisian marine waters since the last century.

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BLUE ECONOMY AND TOURISM: WHICH SEAFOOD CHOICES ARE SUSTAINABLE?

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Abstract

Portugal is one of the world's largest seafood consumers per capita. Thus, as a producer it has been facing a downward trend in fisheries catch and is in a steady state in aquaculture production. In order to fulfil the domestic voracious consumption, Portugal needs to import about 2/3 of seafood. Ultimately, alongside with locals, tourists are encouraged to consume seafood while in holidays. Here, based on scientific data and on a personal experience in the field, the question about which species are sustainable and what should be consumed instead of being discarded overboard, is raised and discussed. It is suggested that seafood consumers could be engaged to limit the waste of marine resources. Adequate public policies and raising awareness and consumers' education are therefore imperative for sustainable seafood production-consumption.

Keywords: *Artisanal fishery, North Atlantic, Coastal management, Monitoring*

Portugal has been facing decreasing fishing landings (Figure 1) and the aquaculture sector continues in a *status quo* since the 1990's [1]. In the last two decades, the total amount of seafood produced domestically ranged from 200 to 220ktons. However, internal consumption plus tourism reach about 600ktons, positioning Portugal as one of the world's largest seafood consumers *per capita* [2] (Figure 2). So, Portugal needs to import 400ktonnes of seafood. Thus, there is still a large amount of edible seafood that is discarded, just because it has no market value. That is not sustainable in the long term. In Portugal there is a reasonable knowledge about fish species (particularly in the coastal areas), but such fact does not imply that sustainable choices are made [3]. Therefore, to safeguard seafood sustainability, competent authorities should devise marketing strategies in order to promote more suitable consumption and to refrain unwanted catches.

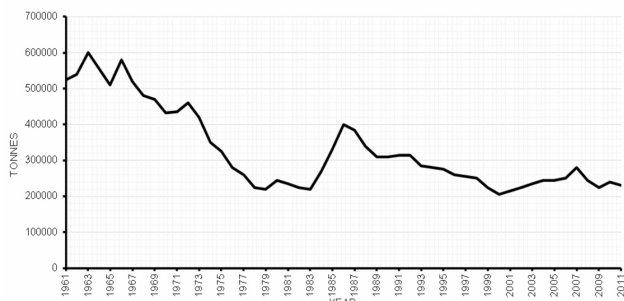


Fig. 1. Annual Portuguese fish landings for the period 1961 to 2010 [1].

When people travel as tourists, they make choices in the decision process of what to eat. Nevertheless, some people in a tourist destination consider local food not just as to appeasing hunger, but as a unique and original attraction during a holiday [4]. In those occasions, individual's choice in terms of food may differ, but still need to choose their dishes from steak (meat), seafood (fish, invertebrates) or vegetarian (fruits, vegetables, seaweeds, algae). However, individual's food choice decisions are situational and dynamic [5] and could even be driven by belief, background knowledge, or other factors. Gastronomic events also have a role in eating decisions [6]. Seafood consumption choice is generated from toxicological, nutritional, ecological, and economic points of view. Few, if any, seafood consumption patterns optimize all the above domains. There is a growing importance of integrating different assessment approaches including biological, social and economic, and engaging stakeholders to better evaluate and manage coastal fisheries [7].

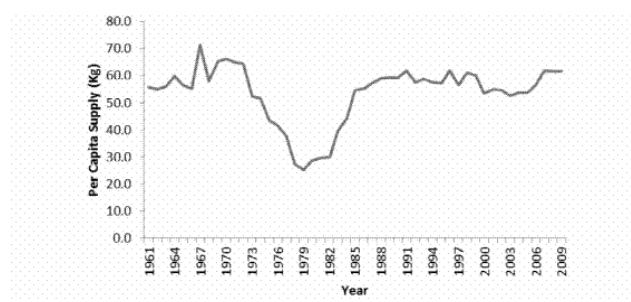


Fig. 2. Annual Portuguese seafood consumption per capita for the period 1961 to 2009 [1].

The rationale in the present research is that when tourists are consuming local seafood, they are also interacting with their hosts and encouraging not only the local economy concerning the food service sector (restaurants), but also the production sector (fisheries or aquaculture). The central question is to find out why consumers (tourists and locals) chose certain species instead of others [8]. The problem occurs when the seafood consumed is not the most appropriate. The solution could be solely to shift from exhausted species to other more abundant. In such situations, is imperative to engage stakeholders into a common ground in order to find out a compromise trying to solve the problem.

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CIESM Congress Session : Human impact on biodiversity

Moderator : Maria Ana Martins, IPMA, Lisbon, Portugal

Moderator's Synthesis



COMPARISON OF THE TOTAL BACTERIAL COUNTS BETWEEN THE BATHING SEASON AND OFF-SEASON IN A NUMBER OF BEACHES IN THE MALTESE ISLANDS

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Abstract

A number of Blue Flag beaches around the Maltese Islands were sampled over a 13-month period in order to study the total bacterial counts during the bathing season (from the third week of May until the third week of October) and in the off-season. A non-Blue Flag beach was also considered for comparison purposes. Relatively low bacterial counts were observed during the bathing season when compared with the winter months. The most prominent variations in terms of total bacterial counts occurred in September, a few weeks before the end of the bathing season. The results also showed variation within the same study areas.

Keywords: *Beach, Coastal waters, Bacteria, Monitoring, Mediterranean Sea*

Introduction

Over the past years environmental awareness in society has run parallel along with development and implementation of environmental management systems in tourist destinations. Schemes such as the Blue Flag are significant as they address the potential hazards of bathing water and emphasise the importance of public awareness of coastal management, thus attracting more safety-conscious, as well as environmentally-conscious beachgoers [1].

According to the Bathing Water Directive (2006/7/EC), all EU member states are required to monitor the water quality in the designated coastal and inland bathing waters throughout the bathing season. This study compares the total bacterial counts between the bathing season (from the third week of May until the third week of October) and the off-season in a number of beaches that have been awarded the Blue Flag (hereafter referred to as BF Beaches) and one beach which is still popular with bathers but does not have the Blue Flag award (hereafter referred to as a NBF Beach). The study also allows for the comparison of natural and non-natural beaches in terms of total bacterial counts.

Material and Methods

Water samples from three natural beaches (Mellieha Bay [BF], Golden Bay [BF] and Ghajn Tuffieha [BF]) and two non-natural beaches (St George's Bay [BF] and Pretty Bay [NBF]) were taken over the course of 13 months between March 2016 and March 2017. Two to three sampling points were considered from each study area with two replicates at each point. pH and temperature were also recorded at each sampling point through *in-situ* analysis.

After sample preparation and incubation [2] the total bacterial counts were taken after 24 hours and 48 hours. Square root transformation was applied to the raw data and statistical analyses were carried out using SPSS v24 (IBM Corp.).

Results and Discussion

In terms of total bacterial counts, the most prominent variations occur around September (Fig. 1). Low bacterial counts were observed during the bathing season when compared with the off-season. September coincides with the beginning of the wet season, which could explain the high levels of bacterial counts recorded during this month. Precipitation could lead to surface run-off ending up directly in the coastal waters. This occurs more frequently when the rain falls on impervious surfaces rather than if it falls on permeable substrata. The high bacterial counts found at St George's Bay could be attributed to the beach being an artificial one composed of granite particles. Sand can be considered a diffusive nonpoint source of pollution and also a habitat for bacteria [3]. Subsequently when intense rainfall occurs there will be a higher infiltration rate resulting in the coastal water becoming saturated with contaminants. There could be other sources of contamination not considered in this study. These could include, but are not limited to the wide array of anthropogenic activities and the different land uses found within and around the study area.

The relatively high standard deviations clearly imply that there is a lot of variation within the same study area. A possible reason for such variation could be the extent of wave action on the beach sand. Implications of wave action vary on the direction, shape and angle of exposure of the shore and, depending on the

actual sampling point, this can contribute to significant variations within the same study area.

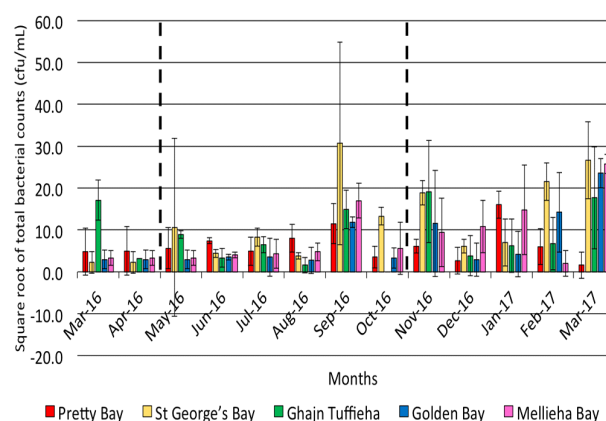


Fig. 1. The square root of the total bacterial counts in cfu/mL after 48 hours incubation. The months shown between the dotted lines represent the bathing season.

Strong variations can be observed when comparing March 2016 with March 2017, with the latter showing an excessive increase in bacterial counts (with the exception of Pretty Bay). This could imply that an increase in the sampling frequency could evaluate the differences in bacterial contamination that might exist among the different beaches and across the different seasons better.

All the beaches considered in this study have their own characteristics which can eventually determine the water quality; some of the beaches are urban while others have rural characteristics. Due to these characteristics, the natural features and the anthropogenic activity would subsequently influence the water quality. Thus, by considering the land-uses in the surrounding vicinity of the beaches, as well as the wide variety of anthropogenic activities found at each beach, a better idea of potential sources of bacterial contamination can be obtained.

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TURRITELLA COMMUNIS: AN ADRIATIC ECOSYSTEM ENGINEER

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Abstract

Common tower shell, *Turritella communis* Risso, 1826 is the most abundant gastropod in the Adriatic Sea. This species is considered an “Ecosystem engineer” as it constitutes a substratum for numerous epibionts and its empty shell provides refuge from predation, lowering the levels of physical or physiological stress for organisms living inside. The aim of this study was to understand the *T. communis* role in the benthos community restoration after gas platform installation, generally causing an initial species richness “breakdown”, and investigate the multi-symbiotic relationships found inside its shells. These shells seem to play a role in the species enrichment process of the benthic community associated to a gas platform.

Keywords: *Adriatic Sea, Biodiversity, Gastropods, Monitoring, Zoobenthos*

The Adriatic Sea is an enclosed basin located in the eastern Mediterranean characterized mainly by sandy-mud bottom. The average depth is 35 m in the northern part of the basin and 140 m in the central one. The north-central Adriatic Sea is also seat of an intense gas extraction production with more than 120 platforms. The installation of these structures inevitably cause some impacts on the benthic communities of the natural seabed, mainly consisting in a faunal depletion just after the platform construction followed by a recover and subsequent enrichment within the first 3 years [1]. In the Adriatic Sea *Turritella communis* is one of the most abundant gastropods characterizing specific zoobenthic assemblages. Two zoocenoses called “Turritella” (alive specimens) and “Turritella profunda” (shells of dead organisms) were identified [2]. The first one live on muddy or muddy-sand sediments, from 20-40 m depth up to a maximum depth of 75 m, with the highest abundance in the area located in front of Po River mouth; the latter occurs in the central Adriatic Sea, between 50 and 100 m depth, on muddy-sand sediments enriched with shell detritus originated from *T. communis* dead conches. Empty shells of this organism can be found at 200 m depth, extending this zoocenosis. *T. communis* is considered an “Ecosystem engineering” (EE) as it is able to create, modify and maintain the habitat, improving heterogeneity and complexity through the provision of refuge for boring organisms and substrate for the epibenthic sessile ones [3].

Macrozoobenthic samples were collected around two gas platforms (GP1, GP2) during the two years after installation. The GPs are installed on muddy-sand bottom in the north-central Adriatic Sea at 47 km and 60 km far from the Italian coast, respectively. Two surveys per year were carried out at each GP. At each survey, four sampling sites were randomly selected at rising distances from GP (<10 m, 30 m, 60 m, 120 m, 250 m, 1000 m away from the GP). Six replicates were collected at each site using a Van Veen grab. The data from the four sites in each distance were pooled together. The biological samples were sieved in situ through a 0.5 mm mesh size. Macrozoobenthos was sorted and identified to species level, weighed and quantified. The nomenclature herein follows the World Register of Marine Species (WoRMS) [5].

Nine macrozoobenthic taxa were exclusively found in association with *T. communis* shells: eight within the shells, the polychaete *Syllis parapari* San Martín & López, 2000, the bivalves *Coracuta obliquata* (Chaster, 1897) and *Montacuta phascolionis* Dautzenberg & H. Fischer, 1925, the sipunculids *Aspidosiphon muelleri* Diesing, 1851 and *Phascolion strombus* (Montagu, 1804), the decapods *Anapagurus* sp. Henderson, 1886, *Anapagurus bicorniger* A. Milne-Edwards & Bouvier, 1892, and Paguridae nd and one attached on them, the anthozoan *Epizoanthus* sp. Gray, 1867. The presence of *T. communis* increased the species richness at GP1 from 3% to 8% and from 4% to 12% in the first and second year respectively (Fig. 1) and from 2% to 11% and from 3% to 8% in the first and second year at GP2 (Fig. 2).

The shells of this gastropod seem to have a role in benthic community restoration after the initial species richness “breakdown” due to the GP installation. In addition, their presence seems to positively influence the biodiversity increase synergistically acting with the GPs “effects”.

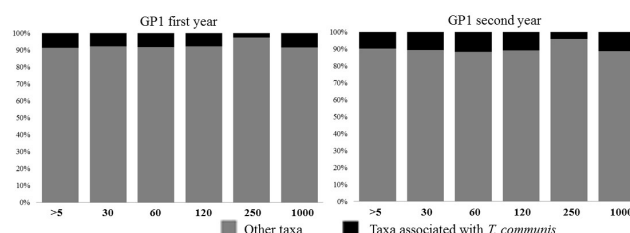


Fig. 1. Percentage of taxa associated with *T. communis* compared to all the other taxa found at different distances from GP1 in the I (left) and II year (right).

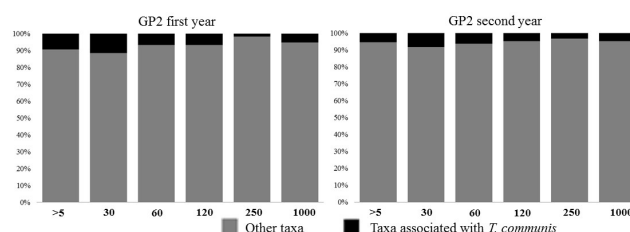


Fig. 2. Percentage of taxa associated with *T. communis* compared to all the other taxa found at different distances from GP2 in the I (left) and II year (right).

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TAXONOMIC SUFFICIENCY EFFECTIVENESS : A CASE STUDY IN THE ADRIATIC SEA

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Abstract

Variations in two biotic indices, Species Richness (S) and Shannon-Wiener (H'), obtained from macrobenthic community around a gas platform placed in the central Adriatic Sea, were analysed to evaluate Taxonomic Sufficiency effectiveness, considering three levels of biodiversity resolution: species, genus and family. No significant differences were found, taking into account both S and H' index, at all considered taxonomic levels.

Keywords: Biodiversity, Zoobenthos, Systematics, Monitoring, Adriatic Sea

Biodiversity is fundamental to study the structure of benthic communities and to identify any eventual impact on them, and taxonomy is the best way to detect any change in communities' biodiversity. Due to the high effort associated to the identification of organisms at species level, Taxonomic Sufficiency (TS) was suggested as an alternative approach to assess macrobenthic communities' biodiversity by using higher taxa levels (e.g. genus and/or family instead of species) in order to reduce the time required for a more detailed analysis [1-2]. The efficiency of TS was tested on the macrobenthic community around a gas platform (GP) placed on soft sea-bottom in the central part of the Adriatic Sea.

Six survey were conducted across three years (2015=Y1; 2016=Y2; 2017=Y3) after GP installation, twice per year and, in each survey, four sampling sites were randomly selected at rising distances from GP: 0, 60 and 120 m. In each survey, six replicates were collected at each site using a Van Veen grab, sieved through a 0.5 mm mesh and preserved in 5% buffered formalin. All the organisms were sorted using a stereomicroscope and then identified, when possible, at species level (SL). The obtained taxa list was then grouped at genus (GL) and family (FL) level, following WoRMS classification [3].

Total Species Richness (S; Figure 1) and Shannon-Wiener index (H'; Figure 2) were calculated for the three taxonomic levels (SL, GL, FL). Two-way ANOVA was performed to detect any significant variation within both indices, using year and distance as fixed factors ($p < 0.05$; $\alpha = 0.05$).

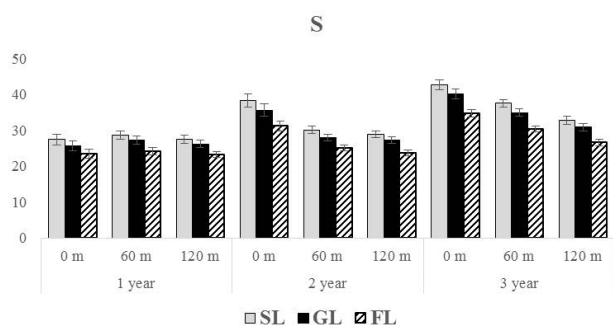


Fig. 1. Total Species Richness (S; \pm e.s.) obtained for the three taxonomic levels at all distances from the GP over three survey years (SL: species level; GL: genus level; FL: family level).

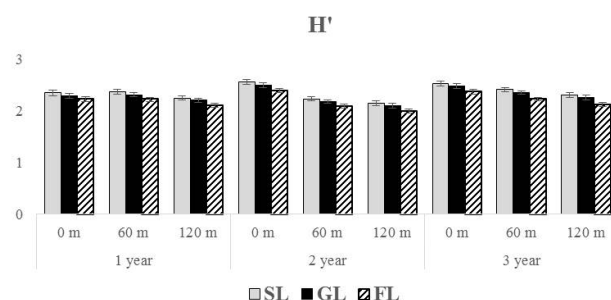


Fig. 2. Shannon-Wiener index (H'; \pm e.s.) obtained for the three taxonomic levels at all distances from the GP over three survey years (SL: species level; GL: genus level; FL: family level).

According with other Authors [e.g. 4-5], all the results obtained for SL, GL and FL underlined a significant increase of S during the sampling period that occurred between Y1 and Y2 at 0 m from GP, and between Y2 and Y3 at higher distances. Same findings were also obtained for H' index for all considered taxonomic levels.

In conclusion, this first approach indicates TS as a powerful tool to assess the impact induced by the construction of an offshore GP on macrobenthic community of the natural habitat. Further studies are however necessary to better understand its actual effectiveness, using more indices (e.g. Bentix, AMBI and m-AMBI) and taking into account different areas.

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CIESM Congress Session : Cooperative research with society
Moderator : Mafalda Rangel, Univ. of Algarve, Portugal

Moderator's Synthesis

The moderator started with a presentation which aimed at outlining the session theme. Special emphasis was given to fishers' participation in research projects, as a way to effectively support education, policy, and conservation, with examples of research projects which have involved fishers' participation and used transdisciplinary participatory approaches to co-creating knowledge. The moderator concluded by highlighting some important challenges, such as how to include European legislation and European research methodologies in southern European countries' research reality.

The five speakers covered a wide variety of interesting topics within the umbrella of cooperative research, from invasive species, small-scale fisheries, recreational fisheries, cetacean interaction, and participatory mapping. Their presentations focused largely on how to integrate users' perceptions, ideas, and knowledge into scientific research, as a way to co-construct knowledge.

A stimulating debate followed, covering ways to map recreational fishing (effort and distribution), using fishers' knowledge about places used for practicing this activity, the perceptions regarding the decrease of the population of bluefish, the consumption of poison fishes such as *Lagocephalus sceleratus*, ways of obtaining reliable data from fishers regarding illegal fishing activities.

The discussion concluded that the amount of time researchers invest to gain fishers' trust and to empower them will yield improved reliability and accuracy of the information received in return.



LOCAL KNOWLEDGE REVEALS THE SUDDEN POPULATION INCREASE OF SEVERAL INVASIVE FISH SPECIES IN THE EASTERN MEDITERRANEAN SEA

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Abstract

New introductions and geographical expansion of non-indigenous species (NIS) are increasingly being monitored by obtaining ecological knowledge from different sea users. In this study, 154 fishermen, anglers, spearfishers and scuba divers participated in an online survey providing information that demonstrated a recently significant increase in the occurrence of five invasive fish species within local landings and underwater sightings. Sea users seem to be aware of the socio-economic consequences of these invaders but not their impact on the environment. Social media provided reliable scientific knowledge on marine NIS in a timely manner, with very limited resources and without the necessity of conventional field surveys.

Keywords: *Invasive species, LEK, Lessepsian migrants, Population Dynamics, Levantine Basin*

Introduction

The introduction and geographic expansion of marine NIS is often difficult to monitor, particularly in the absence of specific procedures for their detection in many marine areas [1]. Recently, participatory approaches are being used in the Eastern Mediterranean to monitor populations of non-indigenous marine organisms, including invasive fishes [2, 3].

Methods

In this study, we collected data from 154 Lebanese sea users who are active on social media in 2018. Data pertaining to the occurrence and population size of non-indigenous fish species occurring in Lebanese waters between 2012 and 2017 was collected using an online questionnaire. Each sea user answered a series of questions regarding recently detected changes in the population size of some fish species. Specific questions such as “when did you see FISH1 for the first time” or “Did the population size increase/decrease or remained stable” within the last 5 years?

Results and Discussion

Of the 11 species reported by participating sea users, *Pterois miles* (Bennett, 1828) was by far the most cited NIS (ca. 65% of participants). *Torquigener flavimaculosus* Hardy & Randall, 1983, *Lagocephalus sceleratus* (Gmelin, 1789), *Parupeneus forsskali* (Fourmanoir & Guézé, 1976) and *Plotosus lineatus* (Thunberg, 1787) were also among the most detected species among which population sizes and abundances have fluctuated (Fig. 1).

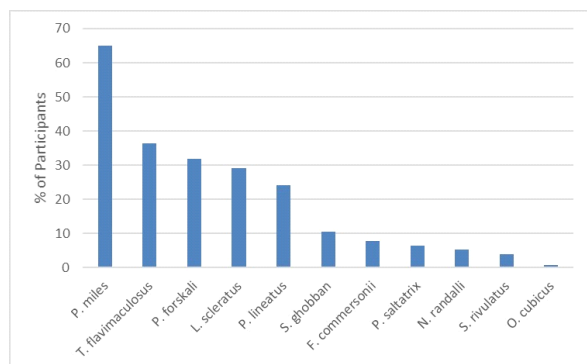


Fig. 1. Percent distribution of invasive fish species reported by surveyed sea users (n = 154)

Other NIS, such as *Siganus rivulatus* Forsskal & Niebuhr, 1775 were rarely reported despite their prevalence. This may be attributed to the fact that they have been introduced a long time ago and may not be perceived by sea users as exotic. Many participants seem to be aware of the socio-economic repercussions of the reported invaders, despite the fact that some were not aware of their impact on the environment.

The study also asserted the power of social media in providing important and accurate observations and perceptions on the status of invasive alien species and their impact on the environment. It also provided a cost-effective and complementary information to traditional surveys, that may be collected in an affordable, reliable and timely manner.

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IDENTIFYING METIERS AND SPATIO-TEMPORAL DYNAMICS OF SMALL-SCALE FISHERIES IN THE FUTURE MPA OF “TAZA” (ALGERIA, SW MEDITERRANEAN)

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Abstract

Creation of a marine protected area (MPA) in “Taza” (Gulf of Béjaia, Algeria - SW Mediterranean) was first proposed by the staff of Taza National Park in 2000. The main objective of this work was to identify the *métiers* practiced by artisanal fishermen in this area through direct observation method of daily landings. It is found that among the five *métiers* characterized by target species, gear type, fishing grounds, and fishing seasons, two *métiers* (“*Mullus surmuletus* trammel net” and “Sparids monofilament gillnet”) are practiced throughout the year, while the remaining three (“*Sarda sarda* driftnet”, “*Merluccius merluccius* set gillnet”, and “*Pagellus set gillnet*”) are specific to a determined period of the year. Moreover, the spatial distribution of fishing effort shows that the fishing grounds are mainly at depths <100 m.

Keywords: South-Western Mediterranean, Fisheries, Marine reserves, Algerian Sea

Introduction

In the Mediterranean Sea, the small-scale fisheries (SSFs) have a high socio-economic relevance for the local communities as they represent an important share of the fish caught and constitute about 80% of the fisheries in terms of fishing vessels [1]. SSFs are characterized by a diversity of target species, gear, and fishing tactics. The diversity and the great variety of their *métiers* create great uncertainty from the perspective of the protection and sustainable management of marine resources. The *métiers* correspond to fishing practices at the scale of the fishing operation, defined as the combination of four variables: one or more target species, a fishing gear, a fishing ground, and a period of the year [2]. In 2009, with the support from the network of MPA managers in the Mediterranean (MedPAN), Taza National Park began a process to include its adjacent marine area covering 9603 ha (Fig. 1) [3].

the multivariate analyses is considered as a *métier*.

Results and Discussion

A total of five *métiers*, using four different gears and targeting 5 main species and/or groups of species, were identified in the area of the future MPA of “Taza”. In terms of fishing gear, gillnets, which account for 59.7% of total fishing operations, are the more common gear used by the Ziamia small-scale fleet. Thirteen of the sixteen fishing grounds used by small-scale fishers are mainly at depths <100 m (Fig. 1) while five of them are located within the perimeter of the future MPA. Observation of the monthly landings (Fig. 2) showed that the fishing of the target species is distinctly seasonal, demanding that fishers tend to rotate between various *métiers* throughout the year and adapt to variations in resource availability.

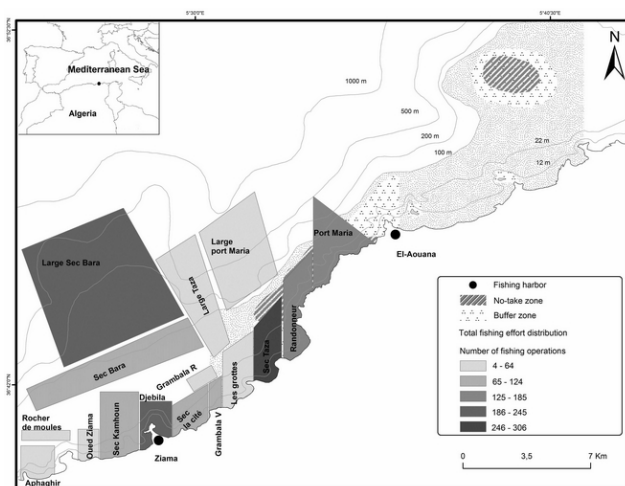


Fig. 1. Map showing location and spatial distribution of the total fishing effort in the future MPA of “Taza”, Algeria. Effort was represented on the basis of the number of fishing operations carried out in the different fishing grounds.

Material and Methods

The study area is located within the future MPA of “Taza” (Algeria, South-Western Mediterranean) (Fig. 1). Catch data were collected via a direct observation method of landings on a daily basis between May 2013 and April 2014. In order to characterize the small-scale fishery activity of the future MPA of “Taza”, at Ziamia harbor, and during an annual cycle, daily observations were made with the help of two observers from the Directorate of Fisheries and Aquaculture of Jijel. A Multiple Correspondence Analysis (MCA) was applied to the data from the active variables: target species, gear type, fishing ground, and fishing period. Then, the main factorial axes were kept for the Hierarchical Cluster Analysis (HCA) based on Ward’s criterion [2]. The latter provided us with a scree plot to which a partition was applied. Each cluster obtained from

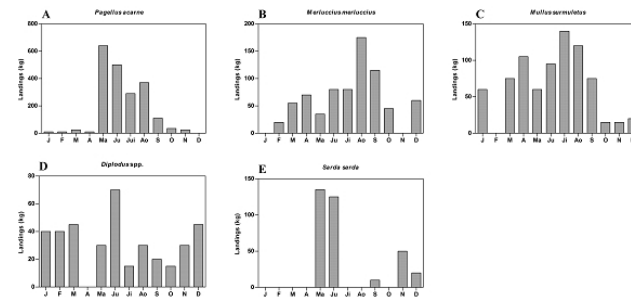


Fig. 2. Monthly landings (in kg) for the five main target species: A, *Pagellus acarne*, B, *Merluccius merluccius*, C, *Mullus surmuletus*, D, *Diplodus* spp. and E, *Sarda sarda* of the small-scale fishery from Ziamia bay (Southwestern Mediterranean) between May 2013 and April 2014. Source [4].

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EVALUATING RECREATIONAL FISHERMEN PROFILES TO SUPPORT MANAGEMENT ACTIONS IN THE GULF OF LION MARINE NATURAL PARK (NW MEDITERRANEAN, FRANCE)

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Abstract

Recreational fishing represents up to 12% of fish harvest and is of growing scientific interest. Sustainably managing this activity requires a characterisation of the impacts and a description of fishermen practices and behaviours that can affect their yield. A study has been conducted since 2010 in the Gulf of Lion Marine Natural Park through three annual campaigns during which 1,660 fishermen were polled by semi-directive on-site interviews. Fishermen profiles were mapped and analysed via a typology, an approach of classification based on sharing characteristics using technical and socio-economic data. For example, four profiles have been differentiated among the population for onshore fishing. These analyses shed new light on the acceptability of management measures by fishermen and on the interpretation of catch and effort results.

Keywords: Fisheries, Marine parks, Behaviour, Coastal management, Mediterranean Sea

Introduction. Recreational fishing is undergoing a growing interest from the scientific community due to its potential impacts on stocks and the marine environment as well as for its economic and social importance [1]. This activity is also considered a major concern for the management of Marine Protected Areas (MPA) but the lack of global data, particularly on fishermen motivations and behaviours, hinders its sustainable management. The purpose of this study was to describe, at the MPA scale, the profiles and locations of recreational fishermen operating onshore and offshore (from a boat), to facilitate awareness and management actions, as well as the evaluation of stocks taken from this fishing activity. The analysis of the 2010-2011 campaign along the rocky coast of the Gulf of Lion Marine Natural Park (PNMGL) complements national studies aimed at assessing the total population of recreational fishers [2] and will serve as a methodological reference for larger scale analyses of the monitoring conducted in 2013-2014 and 2017-2018.

Materials and methods. To describe the recreational fishermen population along the rocky coast of the PNMGL, 280 onshore and 117 offshore fishermen were polled over a full year (from October 2010 to September 2011) by on-site semi-directive interviews using the roving-roving method of sampling. Fishermen profiles were characterised by a typology involving a Factorial Analysis of Multiple Correspondences followed by an Ascending Hierarchical Classification (Ward's method) [3]. For the onshore fishery presented here as example, the analysis was based on 16 variables for socio-economic factors (age, socio-professional category, place of residence, budget allocated to fishing), practices (experience, reason for site selection, fishing frequency and technique used; preferred season, time of the week and the day, and fishing effort) and perception (knowledge of the regulation and solution proposed for preserving fish populations) that emerged as closely linked to each other via Pearson's Chi-squared tests. When the condition of use of Chi-squared test was not verified, a Fisher's test was implemented. Those tests were performed between each couple of variable to describe their linkage and create paired-variables to complement and simplify questionnaires and typology analyses. The high link between variables and the weight of each on the AFCM seems to prove that each question was important in describing the population. Those tests were then implemented to identify the variables that described significantly each fishermen group. The profiles were then mapped and their respective catches compared.

Results and Discussion. The analyses highlighted four profiles mainly characterized by the "Age" and "Socio-professional category" variables: *Pensioners* (72%), *Vacationers* (21%), *Unemployed* (5%) and *Students* (2%). These profiles (Fig. 1) were highly segregated following season and fishing location. The results identify a great lack of knowledge about the protection status of species, except for the *Vacationers* group, and could be used as a reference to evaluate the effectiveness of awareness actions. The profile *Unemployed*, with high experience and technique characteristics, was very localised on the edge of the Natural Marine Reserve of Cerbère-Banyuls included in the PNMGL perimeter, and similar to the *Students*, prioritised yield. Nevertheless, catches by units analyses suggested a greater selectivity of the *Unemployed* (heavy catches) alongside the *Pensioners* and unlike

Vacationers and *Students* profiles. This selectivity, added to a large budget allocated to fishing, makes these less priority profiles in terms of management. These results justify the inclusion of new variables such as "respect of minimum catch size" and "reason for catch release" in future monitoring.

<i>Pensioners</i> (N=201)	<i>Vacationers</i> (N=60)
Age*: >60	Age*: 40-60
Budget*: €	Budget*: €€€ RF
Knowledge*: > >	Knowledge*: > > > >
Experience*: +++	Experience*: +++
Fishing Frequency: medium	Fishing Frequency*: low
Main Period*: autumn	Main Period*: summer
Chosen Site: ubiquitous	Chosen Site: easy access
Motivation: good weather	Motivation*: calm
Cork Fishing	Cork Fishing*
<i>Unemployed</i> (N=14)	<i>Students</i> (N=5)
Age*: 30-40	Age*: 15-20
Budget*: €€€€	Budget*: €€ RF
Knowledge*: > >	Knowledge*: > >
Experience*: +++	Experience*: +++
Fishing Frequency*: very high	Fishing Frequency*: low
Main Period*: spring	Main Period*: spring
Chosen Site: Reserve border	Chosen Site: port
Motivation*: accessibility	Motivation: fish
Hand Fishing*	Cork Fishing*

Fig. 1. Sampling of the variables defining shore recreational fishermen profiles. *: significant result, fish symbol: knowledge on protected species, € allocated budget (€ < 100€/year, €€ 100-500€/year, €€€ > 500€/year), flag: Fishermen origin (France or local from the Pyrénées Orientales département).

In the long term, it would be interesting to monitor the evolution of these profiles and their proportions in order to detect changes in practices and/or behaviours. For the managers, our analysis makes it possible to identify sites and seasons of interest for future monitoring, particularly the site of Port-Vendres, which was very popular for all profiles.

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PARTICIPATORY MAPPING: ELICITING, MEASURING AND VALUING THE JUDGMENT OF LOCAL EXPERTS FOR BIOINVASION RESEARCH

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Abstract

Mapping the distribution and abundances of marine species is a challenging task, at a time of global changes, as ecological sampling cannot often keep up the pace. Although not as accurate as *in situ* field work, Local Ecological Knowledge (LEK) might be a flexible and valuable source of information for this scope. Notably, LEK might be particularly appealing due to possibility of rapid data collection on the large geographical scale, providing advantageous tradeoffs between data availability and data granularity. Here, using the Lagoon of Lesina (southern Italy) as case study, we present some results, concepts and application of this methodology illustrating its wide potential for bio-invasion research and coastal monitoring.

Keywords: Mapping, Adriatic Sea, LEK, Invasive species

Introduction

Obtaining up-to-date information about ecological changes in marine environments involves today an increasing number of researchers and policymakers. Field data collections is time-consuming, expensive, and often unfeasible at large geographical scales. Furthermore, ecological sampling often cannot keep up the pace with rapid and environmental dynamics, resulting in partial or inaccurate data. Not surprisingly, during the last few decades, information retrieval from experts became increasingly popular, especially Local Ecological Knowledge (LEK) [1]. Although often not as accurate as ecological sampling, LEK easily outrun field data collection in terms of costs and time. Such speed can be particularly appealing to study the most rapid forms of ecological changes, like biological invasions, which are progressing at an unprecedented rate in the Mediterranean Sea [2]. In the field of marine sciences, LEK is being increasingly adopted to track the temporal evolution of biological communities [3] but its potential to retrieve information about the geographical distribution of marine species is certainly underexplored. This paper aims to show how LEK can be elicited, measured and evaluated to map the spatial distribution of the Atlantic blue crab (*Callinectes sapidus*) in a Mediterranean coastal lagoon in Southern Italy.

Materials and Methods

From February to April 2018 we interviewed 25 professional fishermen from the Lesina Lagoon (Southern Italy), asking them about the spatial distribution and the abundance of *C.sapidus*. LEK was retrieved in a structured way, as respondents were asked to draw the distribution of each species on a pre-printed map of the lagoon, which was subsequently converted onto a vectorial grid. Abundances were rated on a 6-points ordered scale ranging from "Absent" to "Dominant". We also tested for agreement between respondents with Cohen's kappa and we averaged abundances in each square of the grid, to map the spatial distribution of crab abundances.

Results and discussion

Respondents found maps easy to draw and were good at eliciting their judgments about the spatial variation of crab abundances. Moreover, they moderately agreed ($K = 0.11$) on the spatial distribution of crab abundances and they perfectly agreed ($K=1$) on the fact that crabs were present throughout the entire lagoon (Fig.1). These findings show how promising LEK-based methods can be for participatory mapping at the local scale, even to obtain relatively fine-grained details about the spatial distribution of biological invaders. Moreover they show how LEK can be elicited in a consistent way, and evaluated, in their coherence.

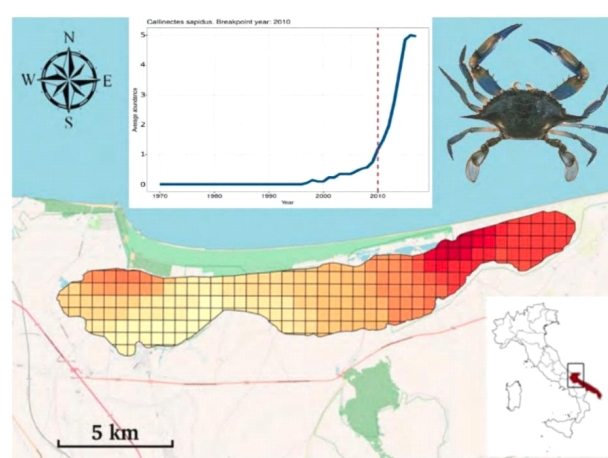


Fig. 1. The average abundance of the Atlantic blue crab (*Callinectes sapidus*) in the Lesina lagoon, Southern Italy. Abundances on the scale ranged from "Absent"(0) to "Dominant"(6). Estimated average abundances on the map ranged from "Occasional" (3 on the scale, yellow) to "Dominant" (6 on the scale, red). The Figure also shows the temporal evolution of the species, elicited with a structured protocol developed by Azzurro et al. [3].

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CETACEAN-FISHERY INTERACTIONS IN SOUTHERN PORTUGAL: RESULTS OF A INTERVIEW SURVEY TO FISHERS, COOPERATIVE RESEARCH AND IMPLICATIONS FOR MITIGATION

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Abstract

We used face to face interviews (n=200) along the Algarve coast covering the most important fishing ports (n=11) to identify areas of most concern for negative interactions between cetaceans and coastal fisheries. Cetacean bycatch indexes and evaluation of fishermen's economic loss were obtained, while creating awareness of the sector to participate in conservation and management issues. Results indicated that the main fisheries affected are the purse seine fishery and the set net fishery using gill or trammel nets. The cetacean species interacting the most in each fishery respectively are the common dolphin, *Delphinus delphis* and the bottlenose dolphin, *Tursiops truncatus*. Ongoing work using a participatory multi-actor approach involving various stakeholders is being used to find the best mitigation approaches to solve the problems.

Keywords: Fisheries, Worldwide, Cetacea, Competition, Conservation

Increasing interactions between fisheries and marine protected species (e.g. cetaceans) are a reality and occur worldwide in many forms [1]. The negative aspects of these interactions for both fishermen (e.g. loss of catch through depredation or gear damage) and for the animals (e.g. incidental capture leading in most cases to death) are of most concern. In the Portuguese southern coast (Algarve), little is known and documented about these interactions. The only works available, indicate that several cetacean species interact with many coastal fisheries in the area, with the purse seine fishery best documented [2,3]. Furthermore, work is still needed to evaluate the level of the events and work toward mitigation strategies. To better understand the level of interactions of the coastal fleet operating in the area, represented mainly by the purse seine fishery and the polyvalent fishery, we performed interviews in the most important ports in the Algarve coast (n=11).

All the interviews were conducted between March and December of 2018 following the method described in [3], and the main questions reflected the fishermen's perception of cetaceans and their interactions with their fishery. The study unit was the vessel and only the skipper was interviewed. To make sure we had an adequate sample size, we tried to interview at least 20% of the artisanal vessels in all the visited harbours. The survey included closed questions on sociodemography, information on the type of fishing gear used, main target species, spatial information about fishing grounds, and interactions between cetaceans and the fisheries.

Results indicate that of the total interviewed fishers using gill and trammel nets, > 80 % have negative interactions with bottlenose dolphins, mostly reflected in the loss of gear and catch through depredation. On the other hand, > 90 % of purse seine fishers indicated that most problems occur when they incidentally encircle common dolphins, being here the negative impact only for the animal when mortality occurs. Further analysis indicates, especially for the gear of most concern, which are the gill and trammel nets, that the area showing the highest level of problems was the eastern side of the Algarve (Figure 1).

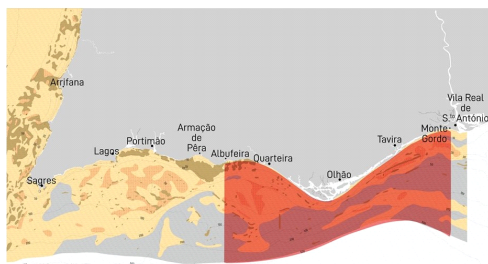


Fig. 1. Map of the Southern Portuguese Coast (Algarve) and fishing harbours sampled. Shaded area was found to be the most problematic for gill and trammel nets interactions with cetaceans

Mitigations strategies are in progress for the detected areas of most concern and fishing harbours have been selected accordingly. This work is made under the scope of the project iNOVPESCA that uses frequent exchange of knowledge and ideas between stakeholders involved (fishermen, scientists and governmental entities), through participatory meetings, workshops and harbour approaches (Figure 2). This approach has revealed to be a promising way to obtain better results in marine management and conservation.



Fig. 2. A) Meeting with fishers to present results of the face to face survey and obtain feedback from mitigation approaches to be used; B) Face to face interviews to fishers in harbours.

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CIESM Congress Session : MPA Research and Tools
Moderator : Barbara Horta e Costa, CCMAR, Univ. of Algarve, Portugal

Moderator's Synthesis

This session was completely full. With eight speakers the session lasted longer than planned (until 17h30), as the main objective was to provide sufficient time for the discussion and debate. My introduction focused on future targets for ocean conservation and on points we all need to tackle to influence the implementation of more and better MPAs. I also presented the Regulation Based Classification System (Horta e Costa et al. 2016), to distinguish partially protected areas from common MPAs globally. The following speakers did a very good job, presenting various issues, including the problem of 'paper parks' and innovative techniques of mapping MPA habitats and assessing MPA effectiveness. This exchange was very interesting. The first presentation by Charles Boudouresque discussed the importance of zoning and implementing de facto MPAs. If really implemented and highly regulated, an MPA can be effective and accomplish its objectives, as happened in Port Cross, France. Anne Chenuil presented a large project assessing biodiversity in Mediterranean MPAs with innovative techniques using standardized protocols in artificial reef monitoring systems, photo-analysis and artificial intelligence. Giovanni Chimienti, presented a remote operated vehicle (ROV) technique that allowed identifying a large patch of a protected coral species within a multi-zoning MPA. Alan Deidun focused on marine spatial planning around Malta, including MPAs and Natura 2000 sites as important tools. Spatial overlap of different activities was analysed, and potential conflicts between users or between users and the environment were identified. Susan Gallon presented the MedPAN network, the level of protection in the Mediterranean, and a summary of the threats. She further discussed the importance of collaborative network to protect and monitor mobile species that are very much under threat. Mohsen Kayal presented a study about the usefulness of using recreational fishing data to assess MPA effectiveness. Cristina Porcu presented trends trends in fecundity of spiny lobster inside versus outside two MPAs. Finally Alen Soldo presented an effective technique to map extensive areas of shallow seagrass meadows within MPAs, using action video cameras and underwater scooters, as commonly done in deep water assessments. The usefulness of these direct (but also recorded) observations was discussed. The following debate was highly interesting, with several questions to all speakers and there was much exchange of ideas about methods, techniques and concepts around MPAs.



MARINE PROTECTED AREAS: MULTI-USE MANAGEMENT (MUM) VS. NO-TAKE ZONES (NTZ) AND THE EFFICIENCY OF LOCALLY MANAGED ARTISANAL FISHERY

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Abstract

Multi-Use Management (MUM), with complex zoning and regulation of uses (including artisanal fishery), is at least as efficient as NTZ management in terms of natural heritage conservation. In addition, it is compatible with sustainable development (including artisanal fisheries).

Keywords: Artisanal fishery, Management, MPAs, Provence

For most environmentalists, managers and stakeholders, the paradigm of a Marine Protected Area (MPA) is the banning of all human activities, mainly artisanal fishery (No-Take Zones, NTZs), but sometimes also diving, anchoring and even sailing and bathing. Most Mediterranean MPAs are based on a NTZ, usually accompanied by a buffer area (where only recreational fishing is prohibited) and a transitional area (no prohibitions, just an obligation to abide by the general regulations - which are not enforced elsewhere) [1].

In fact, how 'natural' NTZs really are can be challenged. In the Mediterranean Sea, some major top predators, such as the monk seal *Monachus monachus* and sharks, are locally or functionally extinct, respectively. Under these conditions, considering that the catch by an extinct population of monk seal was of the same order as the current catch by fishers, the complete ban on artisanal fishing (small-scale fishing) can generate an artificial deficit in top predators [2-3].

The Port-Cros Archipelago (PCA) MPA is located within the Port-Cros National Park (eastern Provence, France, NW Mediterranean Sea). It was established in 1963. The management of the marine area of the PCA MPA can clearly be assigned to the MUM type (Multi-Use Management), characterized by complex zoning of the marine part of the MPA, based on the uses, conservation goals for the habitats and ecosystems and clearly displayed priorities (artisanal fishing rather than recreational fishing) (Fig. 1). MUM management is strongly contrasted with NTZ management, where any form of human activity is prohibited. In addition to the ban on spear fishing, angling and trawling, the PCA MPA has its own artisanal fishing regulations, enshrined in a fishing charter. Regulations regarding maximum vessel length, soak time, mesh size, net length, number of hooks and traps, are more restrictive than those established by French national regulations and by local regulations, established by the *Prud'homme des pêcheurs* (fisher's guild) of Le Lavandou [3]; these regulations are strictly enforced, in contrast with those of most of Mediterranean MPAs, which are actually 'paper parks'. To be allowed to fish inside the PCA MPA, each fisher has to sign the charter each year and abide by its rules. In addition, fishers have to communicate details of their catches to the MPA managers via a fishing logbook; the charter is updated annually, based on scientific monitoring (state of fish populations, CPUE – Capture per Unit Effort) and in consultation with the fishers [4]. The ban on recreational fishing, of which the catch may prove to be greater than those of artisanal fishers, and is of a magnitude [5] that is not fully perceived by the public at large, is a key point in the social acceptance of this set of constraints (fishing charter) by artisanal fishers.

It is worth noting that, as far as the conservation of the natural heritage and the functioning of ecosystems are concerned, MUM management, as practiced in the PCA MPA, is at least as efficient as NTZ management [6]. In addition, it is compatible with sustainable fisheries in particular, sustainable development in general, and fits well with the concept of the socio-ecosystem; beyond the dogmatic ideas of some environmentalists and managers, it is better to have MPAs allowing a responsible artisanal fishing, which really work, than hundreds of NTZs that are only 'paper parks'. Finally, the MUM and NTZ management should not be considered as in opposition to each other and may prove to be complementary: in fact, many effective Mediterranean MPAs, i.e. the very few MPAs which are not paper parks, can be regarded as intermediate between MUM and NTZ management.

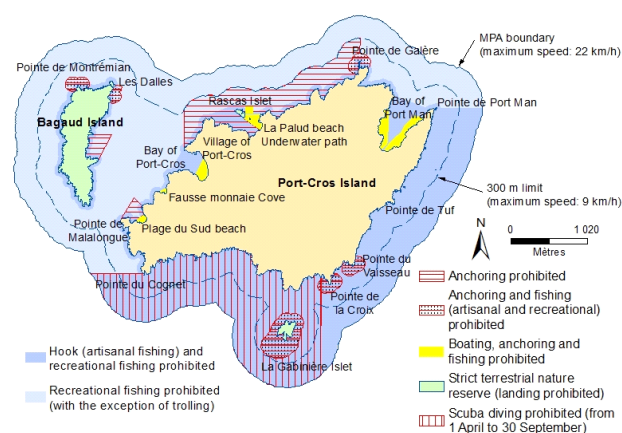


Fig. 1. Artisanal and recreational fishing regulations within different areas of the Port-Cros Archipelago MPA. Areas where anchoring, artisanal and recreational fishing are prohibited are reserved for diving.

Acknowledgements. The authors are indebted to Michael Paul, a native English speaker, for proofreading the text, and to the managers of the Port-Cros National Park.

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SEAMoBB: INNOVATIVE SOLUTIONS FOR SEMIAUTOMATIC MONITORING OF BIODIVERSITY: PHOTO-ANALYSIS OF HIERARCHICAL SAMPLING OF BENTHIC COMMUNITIES FROM SPAIN TO CROATIA

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Abstract

The SEAMoBB project gathers 3 academic partners and 2 enterprises from France, Italy and Spain with the objective of delivering a monitoring protocol for benthic marine biodiversity of rocky habitats. We will unlock the 3 barriers that prevented the development of marine monitoring networks by: (1) establishing rationale rules based on connectivity to determine the network of sites to monitor, (2) standardizing hard bottoms sampling, and (3) automating and standardizing species composition assessment. We did a detailed photo analysis using computer vision algorithms of 28 sites in 4 countries. We found strong effects of plate-faces within the ARMS (artificial reef monitoring systems) and strong spatial effects (site, region, basin...). We explain why ARMS outperform simple colonization plates for monitoring marine communities.

Keywords: Monitoring, Gulf of Lyon

Results and Discussion

Partners of the SEAMoBB consortium combine physical oceanography, population genetics and community ecology to monitor 28 sites and compare methods for connectivity estimation, standardized sampling structures and species composition. Based on this, cost-effective protocols for long-term monitoring will be developed. We already set-up precisely the conditions for metabarcoding [1-2] and photo-analyses (two ways of assessing the composition of benthic species assemblages), we chose model species for population genetics, and ad hoc models of physical connectivity are build for our regions and study sites. We will present our detailed results of comparisons of marine communities based on photo analyses assisted by computer-vision algorithms on the CORALNET portal (UCSD), <<https://coralnet.ucsd.edu/>>. We have not recovered all ARMS units from the sea and so results are not already analysed but we already established that plate-faces are very differentiated and the top faces of the ARMS structures (analogous to usual simple colonization plates made up of a single layer exposed to currents, light and grazing) display a much lower diversity (on photos) with many more green algae, and taxa that are more difficult to identify. The sandwich-like structure of the ARMS containing internal layers (top and bottom faces) and compartmentalized or not (i.e. with or without full passage of currents), therefore makes them particularly adapted for rapid colonization by a diverse flora and fauna [3].

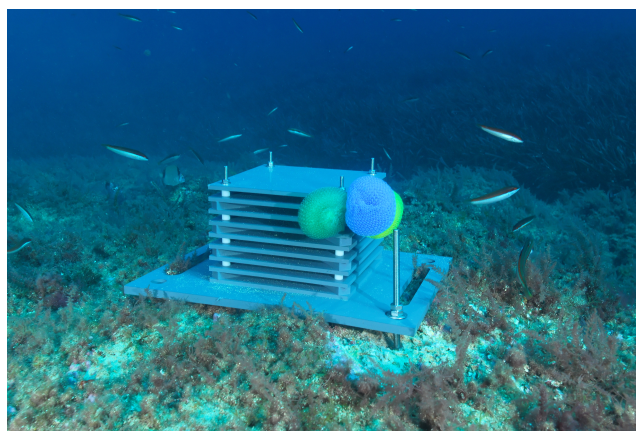


Fig. 1. An ARMS unit just after installation (not colonized yet).



Fig. 2. Example of a photograph from an ARMS (here plate 7, bottom face) after one year in the sea (16-20 m depth).

SEAMoBB Network: Marco Abbiati, Erwan Bouchereau, Virgile Calvert, Sandrine Chenesseau, Federica Costantini, Alexis Crampon, Dorian Guillemain, Jose-Miguel Gutiérrez, Michèle Leduc, TERENCE Legrand, Anne Haguénauer, Christian Marschal, Pascal Mirleau, Laetitia Plaisance, Vincent Rossi, Sandrine Ruitton, Marjorie Selva, Thierry Thibaut, Laurent Vanbostal, Frédéric Zuberer.

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SEARCHING FOR BLACK CORALS: THE EXPLORATION OF TREMITI ISLANDS MPA

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Abstract

A large forest of the black coral *Antipathella subpinnata* was found at Tremiti Islands Marine Protected Area (MPA; Adriatic Sea). Colonies density was locally very high, with a suite of associated species of both conservation and commercial interest. Despite the international protocols assessing the need for protection strategies targeting *A. subpinnata*, many lost fishing gears were observed within the coral forest, particularly in the highly protected zone of the MPA. Thus, a revision of the MPA zonation, a reinforcement of controls against illegal fishing practices as well as the closure of the coral forest area to fishery are needed to protect the newly discovered coral forest.

Keywords: Cnidaria, Coastal management, Conservation, Marine parks, Adriatic Sea

Cold-water corals (CWCs) inhabit the mesophotic and the aphotic zones of the Mediterranean Sea, forming peculiar communities [1] and representing Vulnerable Marine Ecosystems (VMEs) [2]. Antipatharians, commonly known as black corals, are among the main habitat formers of CWC communities on hard bottoms [3]. Thanks to the arborescent structure of the colonies, aggregations of black corals constitute a marine environment whose three-dimensionality is comparable to that one of forests on land, thus belonging to the so-called animal forests [4]. Black coral forests host a rich associated fauna, representing biodiversity hotspots as well as spawning, nursery and feeding areas for numerous species of both commercial and conservation interest [5].

Antipathella subpinnata Ellis and Solander, 1786 (Family Myriopathidae) is the most common black coral species of the Mediterranean continental shelf, representing a key habitat-former of the lower fringe of the twilight zone, where hard substrata are present. Its relevant ecological importance has been recognized worldwide, and *A. subpinnata* is currently a protected species listed in several directives and protocols (e.g., CITES, SPA/BD Protocol, ASPIM, Berna Convention etc.). In this study, we mapped the mesophotic seabed around Tremiti Islands Marine Protected Area (MPA; Adriatic Sea), from 50 to 150 m depth, in order to find hard substrata feasible for black corals settlement and growth. Then, visual explorative surveys were carried out in different areas of the MPA using a Remotely Operated Vehicle (ROV). A total of 753 colonies of *A. subpinnata* were observed from 51 to 80 m depth, mainly along the north and northeast coasts of the archipelago (Fig. 1). Large aggregations of colonies occurred in three sites, two in the Zone B of the MPA (highly protected zone) and one in the Zone C (partially protected zone), with a mean density between 2.2 ± 0.4 and 5.7 ± 0.7 colonies m^{-2} . Few isolated colonies were also observed in two more sites, one in the Zone B and one in the Zone C.

Black coral colonies were locally mixed with other anthozoans such as the gorgonians *Paramuricea clavata* (Risso, 1826) and *Eumicella cavolini* (Koch, 1887), as well as the epibiontic zoanthid *Savalia savaglia* (Bertoloni, 1819). A rich and structured benthic community was observed within the forest, including other habitat formers such as bryozoans, sponges, serpulids and oysters. Associated vagile fauna included species of commercial and/or conservation interest, such as *Palinurus elephas* (Fabricius, 1787), *Octopus vulgaris* Cuvier, 1797 and *Scorpaena scrofa* Linnaeus, 1758. Large predators such as *Epinephelus marginatus* (Lowe, 1834), *Dentex dentex* (Linnaeus, 1758) and *Thunnus thynnus* (Linnaeus, 1758), as well as schools of *Sphyraena viridensis* Cuvier, 1829 and *Seriola dumerili* (Risso, 1810), were often observed swimming within and around the *A. subpinnata* forest. Moreover, some colonies of *A. subpinnata* hosted several aggregates of squid egg masses.

Anthropogenic impacts on the coral forest included a few amount of plastic litter, some gillnets, and numerous longlines entangled both on the coralligenous outcrops and on the *A. subpinnata* colonies. In fact, the rough topography of the area, with several shoals and cliffs very close one to the other, easily cause the entanglement of fishing gears and the physical damage of corals. Most of the lost gears were observed within the Zone B of the MPA, attesting a certain destructive fishing activity affecting the highly protected zone.

Considering the relevant ecological importance of *A. subpinnata* and its sensitiveness to human pressures, a revision of the MPA zonation is urgently needed, together with the reinforcement of controls against illegal fishing activities around Tremiti Islands. The newly discovered sites featured by the presence of few sparse colonies of *A. subpinnata* should be included in the Zone B of the MPA, while a no-fishing area should be established where the coral

forests were found, in order to protect these VMEs and to guarantee a spill-over effect of associated species in the nearby areas. The fishery closure of a relatively small area would represent a valuable example of correct management and proper conservation initiative towards the protection of VMEs.

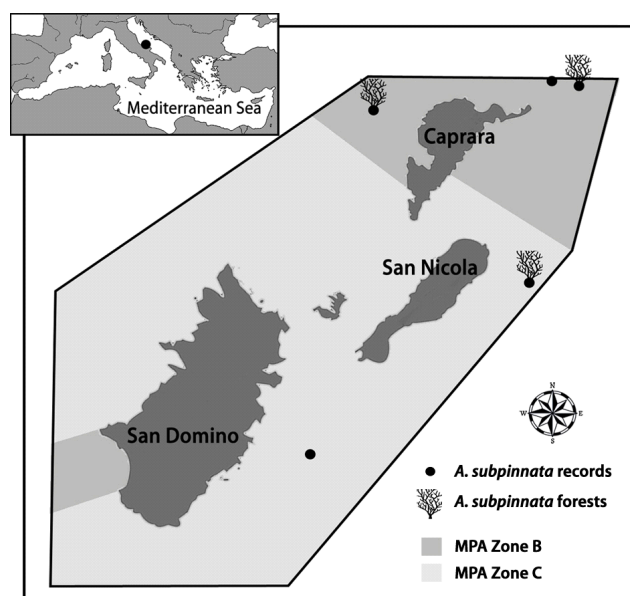


Fig. 1. Map of Tremiti Islands Marine Protected Area with indication of the presence of both isolated colonies and forests of *Antipathella subpinnata*.

Acknowledgements: This study benefited from funding by Ente Parco Nazionale del Gargano and National Geographic (Grant EC-176R-18).

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A SPATIAL PRIORITISATION EXERCISE FOR MARINE SPATIAL PLANNING IMPLEMENTATION WITHIN THE NORTH-EAST MPA OF THE MALTESE ISLANDS

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Abstract

The cumulative pressure/risk posed to both *Posidonia oceanica* seagrass meadows and maerl beds by ongoing maritime activities as well as the cumulative user-user conflict within the NE MPA were quantified and mapped to serve as a decision-support tool for MPA managers implementing MSP provisions in the area.

Keywords: *Marine policy, Marine reserves, Management, Mapping, Malta Channel*

Introduction

In line with inherent obligations for designated Natura 2000 sites, Malta needs to deliver management plans for its designated Marine Protected Areas, including the North-East MPA. In parallel, Malta needs to comply with obligations emerging from the Marine Spatial Planning Directive, which seeks to implement a spatially-coherent methodology in the management of marine resources. [1] argue that the Maltese islands have significant potential to become a prime case study towards the implementation of MSP provisions within MPAs.

Within this context, our research group is participating within the AMARE project (<https://amare.interreg-med.eu/>), funded within the Interreg MED framework, which aims to deliver adaptive management tools for MPA managers, most notably a web-based geoportal. The geoportal combines Geographic Information Science (GIS) principles and tools to harmonize a relatively large and multi-dimensional datasets, including several themes: administration, biodiversity, elevation, geology, habitats and biotopes, hydrography, monitoring, oceanography, socioeconomic, threats. The tool combines intelligent web maps with graphs, charts, tables, and text to unlock, make accessible and re-usable the data relevant for the management of the MPAs in a coordinated manner. The aims of this study are the semi-quantification and visualisation of the environmental pressures or risk exerted by maritime activities ongoing within the NE MPA on two benthic habitats of conservation importance (*Posidonia oceanica* seagrass meadows and maerl beds) as well as of user-user conflicts within the same domain so as to generate a cumulative impact map.

Methodology

In order to achieve both study aims, a 1kmx1km grid resolution was selected on the basis of the MPA spatial dimensions as well as a compromise between the need for fine resolution and the feasibility of data volume management. The intensity of a diverse array of maritime activities (e.g. shipping, recreational boating, fishing, aquaculture, SCUBA diving) conducted within the marine area of interest was quantified through a variety of sources (e.g. VMS data for fishing activity, AIS data for shipping and recreational boating activity, geo-referenced locations of existing fish farms for aquaculture gleaned from the AMARE geoportal and diving site popularity surveys with SCUBA centres for diving).

The spatial extent of the two benthic habitats of interest was mapped. The pressure/risk posed to these two habitats by the maritime activities under consideration was weighted on the basis of outputs provided by the iMSE decision-support tool which in turns applies the ODEMM (Options for Delivering Ecosystem-Based Marine Management) pressures of abrasion, nutrient enrichment and smothering, as well as on expert judgement. ODEMM operates by implementing the DPSIR conceptual framework, whose application in environmental management is becoming ubiquitous (Patricio et al., 2016). For instance, a pressure/risk weighting of 2, 3, 4 and 5 was considered for recreational boating, fishing, shipping and aquaculture, respectively, on *P. oceanica* meadows.

Once quantified, the weighted values were translated into separate cumulative pressure/risk maps for *P. oceanica* meadows and for maerl beds after combining habitat distribution maps with weighted pressure/risk value maps. The cumulative impact map was generated by multiplying the intensity of each maritime activity (calculated arbitrarily along a 1-5 score index) ongoing within each grid cell.

Results

Figure 1 gives the cumulative user-user conflict map for the NE MPA, indicating that the highest conflicts were experienced within the central swathes of the MPA, mainly through the interaction of bunkering, fishing and recreational boating activities within this area.

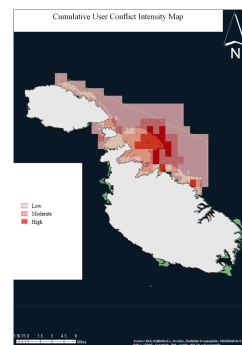


Fig. 1. Cumulative user-user conflict intensity for the NE MPA of the Maltese Islands.

Discussion and Conclusions

A considerable percentage of the NE MPA warrants the implementation of MSP on the grounds of intense user-user spatial conflicts and user-environment impact risks. Maerl assemblages and *P. oceanica* beds were found to be subject to consistently high cumulative impact values for the majority of their spatial extent within the NE MPA. *P. oceanica*, in particular, exhibited maximum cumulative risk intensity values within bunkering zones and also in close proximity to aquaculture zones. As a result of the theoretically high spatial conflicts observed in some areas of the NE MPA, early stakeholder consultation encompassing the full spectrum of NE MPA users is highly recommended. Zonation will likely be one of the area-based management tools (ABMT) applied to the NE MPA, as evidenced by the ongoing MPA zoning exercise conducted by ERA, to which the results of this study could feasibly contribute. The outputs of the current study could be further refined by incorporating additional benthic habitats as well as hydrodynamic modelling in order to assess water column impacts of the assessed activities through dispersal and advection of pollutants, for example. By generating pressure/risk and cumulative impact maps, this study has made a contribution towards prioritising those areas within the MPA which warrant the implementation of MSP provisions, such as zonation, to address the same pressures and impacts.

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TOWARDS TRANSBOUNDARY MONITORING AND CONSERVATION OF MOBILE SPECIES WITHIN THE MEDPAN NETWORK

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Abstract

During their migrations, mobile species experience varying levels of protection and face many threats as they travel through multiple countries' jurisdictions and across ocean basins. Some populations are declining rapidly and an efficient network of MPAs could contribute to their long term conservation by facilitating the implementation of management and conservation measures in key habitats of their life cycle.

Keywords: *MPAs, Management, Turtles, Mediterranean Sea*

The Mediterranean Sea is recognised as one of the world's 25 top biodiversity hotspots. Although it represents only 0.7 % of the global ocean surface, it comprises 4 to 18 % of the world known marine species, depending on the taxonomic group considered [1]. The Mediterranean Sea marine life, however, undergoes multiple soaring pressures, mostly due to human activities, such as professional and recreational fishing, maritime traffic, water pollution, coastal development, introduction of non-indigenous species, and offshore oil and gas prospection and exploitation. In this context, Marine Protected Areas (MPAs) are key tools to mitigate human impacts in coastal environment and promoting sustainable activities to conserve Biodiversity [2]. Mobile and migratory species depend on critical habitats throughout their seasonal movements, including breeding and foraging sites as well as the pathways between them. Loggerhead sea turtles, for example, can be found nesting on a beach in Greece, but forage along the coast of Tunisia, France or Sardinia [3]. These migratory movements, as well as those of a variety of other sea turtles, marine mammals, seabirds and fish, geographically link locations and stressors in distant ecosystems.

Network of MPA managers can thus play a key role for the conservation of mobile species by facilitating the implementation of harmonised protocols and conservation measures at the geographical scale relevant to the ecology of these species. Since 2017 the network of Marine Protected Areas managers in the Mediterranean (MedPAN) is developing and supporting activities, bringing together MPA managers and involving NGOs and researchers working on mobile species (marine turtles in particular), to implement an integrated management strategy for these species. This network, that counts to date 8 founding members, 60 members and 48 partners from 19 Mediterranean countries, is responsible for the management of more than 110 marine protected areas (national parks, marine parks and reserves, Natura 2000 marine sites, regional parks, and many more designations) across the Mediterranean, representing more than 63% of the total of Mediterranean MPAs effectively managed [4, see Figure 1].

Within MedPAN, a Cooperation Framework for monitoring marine turtles, which includes a Data Sharing Charter and a monitoring guide dedicated to answer MPA management needs is currently being developed. This work is coordinated by the Mediterranean MPAs Marine Turtle Working Group (MPATWG), within the MedPAN network. Indeed, Marine Protected Areas (MPAs) managers can adopt measures that help decrease pressures on nesting beaches and sometimes in waters around and by collaborating, they can be increasingly effective at curbing pressures and impacts in mating, migrating, foraging and wintering areas. In addition, MedPAN is organising several workshops in order to identify a path forward incorporating marine mammals in existing and future MPAs' management plan that will contribute to their long-term conservation.

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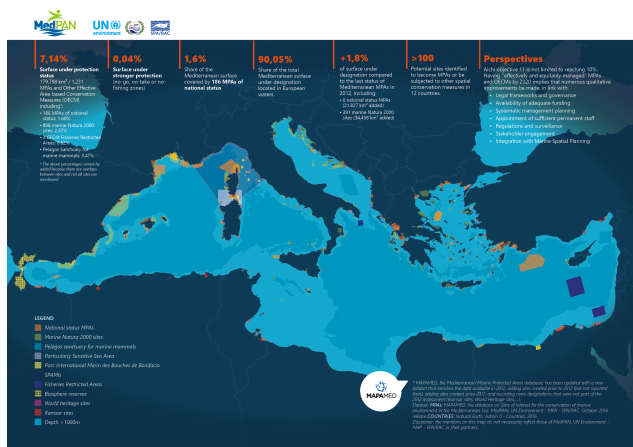


Fig. 1. Key figures of the 2016 Mediterranean MPA status

10-YEAR CHANGES IN RECREATIONAL FISHING YIELDS AT A MEDITERRANEAN MARINE PROTECTED AREA

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Abstract

Marine protected areas (MPAs) are increasingly implemented to counter the decline of marine resources. Yet, the effectiveness of these management strategies remains to be evaluated. To evaluate the effectiveness of the Cerbère-Banyuls marine reserve, one of the oldest MPAs of the Mediterranean, we conducted a decadal scale survey of recreational fishing efforts and yields, and tested whether catch per unit effort (CPUE) and weight by unit effort (WPUE) differed between fishermen performing inside and outside of the MPA. We found that the reserve does not protect against declining CPUE as observed in this area, but promotes higher WPUE. Our results indicate that, more than 40 years after its establishment, fishing efficiency at the Cerbère-Banyuls marine reserve is still changing. We discuss implications in terms of management.

Keywords: *Marine reserves, Monitoring, Fisheries, Management, Mediterranean Sea*

Marine reserves constitute effective tools for preserving fish stocks and associated human benefits [1], but all reserves do not perform at the same level and how marine species respond to management actions in the long run is hard to predict [2]. We conducted a decadal scale survey (2005-2014) of recreational fishing yields around France's Cerbère-Banyuls marine reserve, one of the oldest MPAs of the Mediterranean Sea (Figure 1). Our survey consisted in ~1,500 on-site interviews with fishermen performing in and around the reserve, and recorded ~6,000 catches representing a total weight of ~1 ton for a fishing effort of ~5000 line-hour. Using generalized linear models, we tested whether fishing efficiencies in catch abundance and weight differed between reserve and surrounding non-reserve areas.

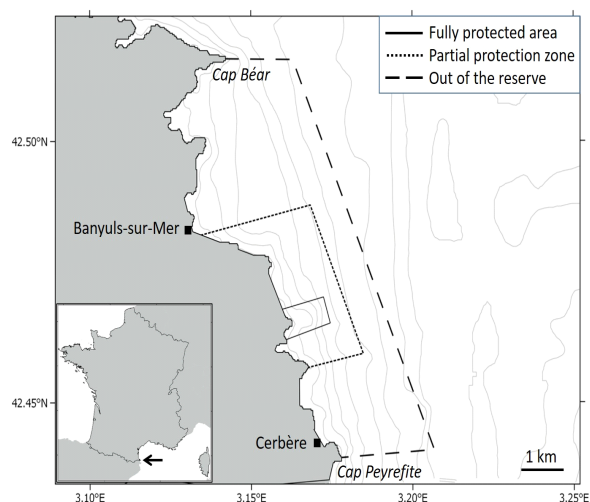


Fig. 1. Map of the surveyed area including the Cerbère-Banyuls marine reserve's fully protected area (no fishing) and partial protection zone (fishing allowed with restrictions) as well as the study area considered outside of the reserve (no specific limitations). Isobaths indicate depth contours every 10 m. Insert indicates the position of the reserve at the border between France and Spain in the Mediterranean Sea.

Overall, fishing yields were 40-50% higher within the MPA than in surrounding areas, indicating significant benefits of the reserve for preserving fisheries resources. However the MPA did not protect against the decreasing pattern in catch per unit effort (CPUE) as observed in surrounding areas between 2005 and 2014 (Figure 2a), weight per unit effort (WPUE) increased in the reserve while decreasing outside (Figure 2b). The differences between CPUE and WPUE trajectories indicate changing fishing yields in the MPA with, through time, catches becoming rarer but bigger, which may indicate changing fish assemblages.

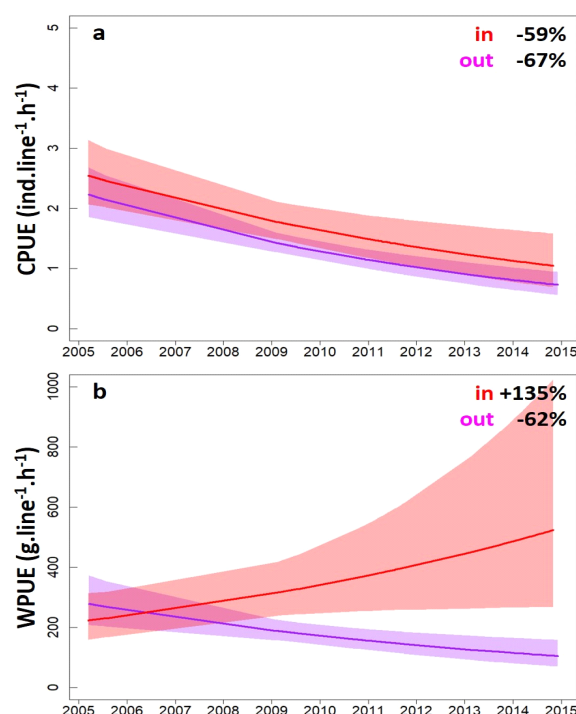


Fig. 2. Trends in catch per unit effort (CPUE, a) and weight per unit effort (WPUE, b) of recreational fishermen performing inside (in) and outside (out) the Cerbère-Banyuls marine reserve. Curves represent mean trajectories and shadings indicate 95% confidence intervals. The percent changes in mean CPUE and WPUE between the beginning and the end of the study period are provided as text on the plots.

Our study illustrates how recreational fishing yields can be used to evaluate the effectiveness of MPA regulations. Our results indicate that, more than 40 years after its establishment, fishing efficiencies at the Cerbère-Banyuls marine reserve are still changing. Further management actions appear necessary to reverse decreasing fishing efficiencies in this region.

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TREND IN SPINY LOBSTER FECUNDITY FROM TWO FULLY PROTECTED AREAS IN THE MEDITERRANEAN SEA AS EVIDENCE OF THEIR SUCCESS

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Abstract

In this study, we assessed the fecundity of spiny lobster *Palinurus elephas* in two Sardinian Fully Protected Areas (FPAs) (CW Mediterranean) and adjacent fishing grounds over time and its reproductive output within the FPAs. A benefit of protection has been observed with higher mean fecundity registered over time inside both FPAs than outside. The maximum Relative Reproductive Potential attributed to size-classes below the Minimum Length Size (MLS) suggests that a review of MLS may be required.

Keywords: Marine reserves, Mediterranean Sea, Crustacea, Reproduction

Fully Protected Areas (FPAs), equivalent to No-Take marine Reserves, are expected to protect many quantitative and compositional components of biodiversity and, at the same time, to potentially help overexploited stocks to recover [1]. Increased recruitment from eggs and larvae exported from FPAs is anticipated to produce much greater benefits for exploited populations than spillover of adults and quantifying the contribution of the FPA to regional reproductive output is the first step towards evaluating such potential [2]. Differences in reproductive output of populations within and outside FPAs have been assessed in fish, molluscs and mainly in lobsters [2]. In this study, we assessed the fecundity of spiny lobster *Palinurus elephas* in two Sardinian FPAs (CW Mediterranean) and adjacent fishing areas over time and its reproductive output within the FPAs. The two FPAs were “Su Pallosu” (CW Sardinia) established in 1998 and “Buggerru” (SW Sardinia) established in 2010. Data on catch and female size (Carapace length, CL, mm) were obtained from experimental and commercial fishing operations. Average mean fecundity (FF, no female⁻¹) was estimated from the female size composition in the catch using the size fecundity relationship obtained for *P. elephas* and assuming as a knife-edge maturity the size at functional maturity estimated within FPAs. Linear regression models were fitted to average FF as a function over time (1997-2013 for Su Pallosu and 2010-2015 for Buggerru). The Relative Reproductive Potential (RRP) was used to establish the size-classes of breeding females contributing most to the egg production of FPAs population. Inside the Su Pallosu FPA, the mean FF oscillated episodically from 1997 (one year before the closing area) to 2002. From 2005 and 2010, the mean FF remained stable, then increased in the last years. In the fished area, mean FF was lowest than that within the FPA until 2008 reflecting a greater proportion of large females inside the FPA (Fig. 1). The increased mean FF in the last time (from 2010), outside, was due to important catches of larger specimens. Inside Buggerru FPA, the mean FF was in increase and higher overtime than that in the neighboring areas where the mean FF was stable and the trend not significant ($F=0.6$; $P>0.05$) (Fig. 1).

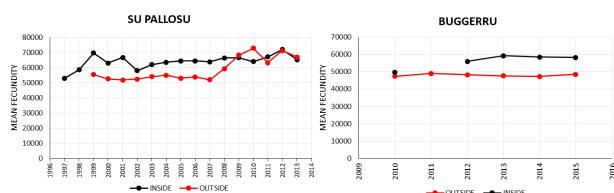


Fig. 1. Trend of *Palinurus elephas* female fecundity inside and outside the Su Pallosu and Buggerru FPAs.

Within both FPAs, size-classes that contributed to maximum RRP were well below the Minimum Length Size established for the species (MLS, 90 mm CL). Within the Su Pallosu area, the maximum RRP was attributed to the 75 mm CL size-class (20%) and 73% of egg production was provided by size-classes below the MLS. Inside Buggerru FPA, the maximum RRP came from the 85 mm CL size-class (23.5%) and 88.5 % of egg production was registered by size classes below 90 mm CL (Fig. 2).

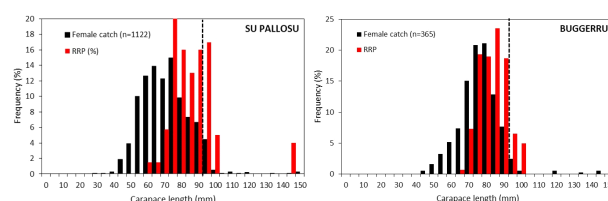


Fig. 2. Relative Reproductive Potential (RRP) in relationship to Carapace length plotted with the length-frequency distribution of the *Palinurus elephas* female catches in Su Pallosu and Buggerru FPAs. The black dashed line indicates the MLS of 90 mm CL.

A benefit of protecting overexploited populations, reported also by [3] is reflected by the higher values in spiny lobster mean fecundity overtime inside both Sardinian FPAs than those registered outside. In addition, the unexpected increase in mean FF during the last years outside Su Pallosu FPA, due to a greater amount of large females, could be the result of a spillover effect. In conclusion, from our results, it is evident that the positive effects of FPAs were powerful. For this reason, taking into consideration the maximum RRP attributed to size-classes below the MLS, the FPAs should be taken active overtime in order to guarantee, together with other management measures in force, the rebuilding of the resource in the surrounding commercial areas.

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AN UNDERWATER VISUAL CENSUS METHOD FOR FAST MAPPING OF LARGE AREAS

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Abstract

Traditionally used methods are not useful for precise mapping of growing number of anchor and mooring sites. Thus, this paper describes an easy to use and low cost method for precise fast mapping of large underwater shallow coastal habitats using direct observation and video documentation obtained by using diver propulsion vehicle and georeferencing.

Keywords: Mapping, Adriatic Sea, Instruments and techniques, Habitat

Human impact and ecological stresses are causing the loss of many coastal habitats with subsequent impact upon fisheries and the environment. In many areas it is already evident that coastal marine biodiversity is decreased as a consequence of the biotic and abiotic changes resulting from anthropogenic activities. Touristy countries are having a particular problem as tourism is growing industry which is resulting with the marine environment accessible to the tourist use constantly spreading. Within tourism industry nautical activities are very dependent on environmental quality, and any deterioration in the marine ecosystem will have a negative impact on it, as well as tourism in general. On the other hand, recreational boating and other related activities are negatively impacting coastal habitats due to the physical damage to the environment caused by anchorage or wave generation, antifouling paints and hydrocarbons releases and other oil residues, black water or sewage, garbage and other waste generated onboard, grey water from all onboard aqueous washings and operations, noise disturbances and introduction of non-indigenous species. Such impact is particularly expressed in islands areas due to the insufficient regulation and difficult control. In order to assess these effects it is essential to know an initial state of the habitat and to monitor underwater environment regularly. However, most of anchor and mooring sites are large in surface and distant from the coast and necessary facilities which makes the use of traditional SCUBA divers methods difficult, time consuming and cost intensive. Hence, aerial and satellite monitoring has limited discriminatory ability in mapping fine-scale substrate mixes, while acoustic methods and use of AUV and/or ROV could provide higher resolution data, but their use in obtaining species specific data is very limited [1]. Thus, there is ongoing need to develop an easy to use and low cost method for precise fast mapping of large underwater shallow coastal habitats. As for the purpose of mapping 29 Natura2000 sites selected as future anchor and mooring sites in Central Eastern Adriatic one of the requests was obtaining data on the presence of protected species it was obvious that the method should use divers for precise species identification [2]. However, as the autonomous diver is restricted by the amount of breathing gas that can be carried, and consequently the surface that can be mapped, authors decided to use Diver Propulsion Vehicle (DPV), commonly known as underwater scooter. DPVs are useful for extending the time and distance range of a diver as well as being capable to carry different accessories useful for the research.

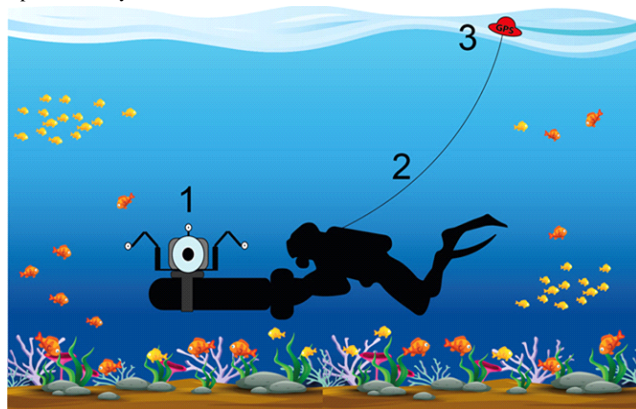


Fig. 1. 1-DPV, 2-buoy line, 3-buoy with GPS.

Therefore, during the survey, two video cameras (one with wide angle lens and one with ability to zoom), one photo camera, diving computer and diving watch

(which data were recorded by video cameras) were mounted on DPV. Georeferencing was obtained by using GPS device mounted on a surface buoy and connected to the DPV with line (Fig. 1). Time on diving watch was adjusted to the GPS time for further precise combining of a video and GPS positioning data. In order to minimize the effect of the buoy line curvature on a precision of GPS data the maximum length of a line always corresponded to previously determined maximum depth. Hence, the diver was constantly winding a buoy line on a reel in order to maintain vertical angle of a line to surface as much as possible. Analysis of obtained data and their comparison with accessible orthophoto images showed that the line curvature didn't significantly impacted georeferencing, probably due to the protocol used and shallow water that rarely exceeded 20 m of depth. All the data were analysed and processed within 24 hours after the dive which resulted with maps of areas indicating marine habitats according to EUNIS habitat classification, EU Habitats Directive and Croatian National Classification of Habitat – NCH (Fig. 2).

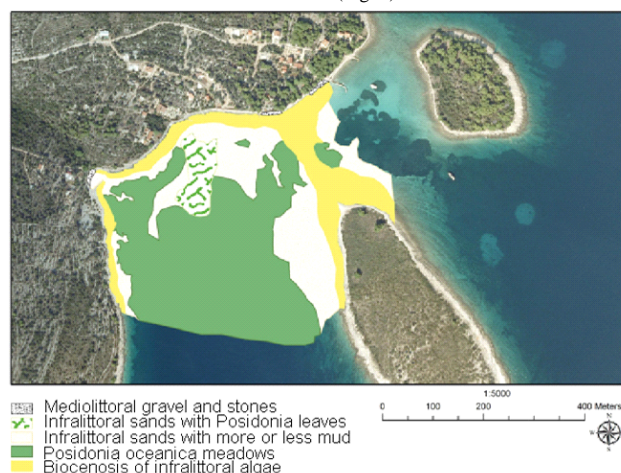


Fig. 2. An example of a map produced by survey method.

Obtained data on distribution and abundance of marine plants and animals, including a presence of protected species, showed that this method, based on direct observations and video documentation, is capable to map marine habitats with sufficient data for initial assessment as well as for a further effective management. The method itself is fast, low cost and it can be performed by a wide population of divers which is of the utmost importance for assessing and monitoring of a many anchor and mooring sites which number is constantly rising.

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CIESM Congress Session : Small scale fisheries
Moderator : Cristina Pita, Univ. of Aveiro, Portugal

Moderator's Synthesis



LITTER FROM DOLPHINFISH FISH AGGREGATION DEVICES (FADS): MANAGEMENT PERSPECTIVES BASED ON A MALTESE CASE STUDY

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Abstract

Large numbers of FADs are deployed by Spanish, Italian, Tunisian and Maltese fishers on an annual basis to catch dolphinfish (*Coryphaena hippurus*). Regulatory systems which employ effective policy measures can prevent the creation of marine litter by instead targeting preferred end-of-life (EoL) strategies for this gear. The necessity of implementing a holistic, regional litter management strategy for this fishery is elucidated based on a case study carried out in the Maltese Islands.

Keywords: *Mediterranean Sea, Fisheries, Marine litter, Marine policy*

Introduction

FAD fisheries for dolphinfish have a long tradition in several Mediterranean countries. In Malta FADs are deployed along a total of 130 transects radiating out from the Maltese Islands every August to December. The FADs consist of cheap materials, including empty plastic bottles or expanded polystyrene as flotation devices, palm leaves or plastic sheets to attract fish, a limestone anchor, and a nylon rope which moors these components together [1]. There is evidence that litter from discarded FADs is a common occurrence in Maltese waters [2]. An average of 15,600 FADs are deployed annually by the Maltese fishery [3], at depths regularly reaching 800 meters where high catches compensate for increased anchoring costs [4]. Rates of FAD loss in Malta are unknown, however a study carried out in Mallorca reported that up to 76% of FADs have to be replaced during the fishing season due to bad weather and maritime activities [5]. The potential marine plastic pollution from FAD nylon ropes is thus of concern. The present study evaluates the current regulatory framework for its inclusion of a litter management strategy and whether it supports the basic steps required to achieve preferred EoL strategies, including the implementation of measures to facilitate the collection, reuse, recycling and/or adequate disposal of nylon ropes.

Materials and Methods

The regulatory framework of the Maltese FAD dolphinfish fishery was assessed through a desk study and in-person interviews. A policy analysis was carried out at national (Maltese), regional (Mediterranean), and supranational (EU and International) levels. Measures can target marine litter prevention, mitigation, removal, or behaviour-changing strategies; the analysed policies were studied for the implementation or support of such measures [6]. In addition, open-ended interviews were conducted with Maltese stakeholders including fishers and several relevant government entities. A SWOT (strengths, weaknesses, opportunities, threats) analysis was used to synthesise results.

Results and Discussion

The policy analysis revealed that although there are numerous international conventions, regional initiatives and EU directives in place to manage marine plastic pollution, litter from FADs has not been targeted by direct management action at national or regional levels (Table 1).

Tab. 1. SWOT analysis of Maltese FAD dolphinfish fishery litter management strategy in a regional context

Strengths	Weaknesses
<ul style="list-style-type: none"> Existing legal framework requiring marine litter management Ongoing regional efforts to implement ecosystem-based fishery management Maltese authorities aware of need to address problem; recent pilot testing of biodegradable ropes 	<ul style="list-style-type: none"> Limited data on extent of problem, difficulties obtaining relevant data Lack of technical FAD gear requirements Absence of incentives for fishers to retrieve and reuse/recycle FADs Different government entities managing fisheries and marine litter
Opportunities	Threats
<ul style="list-style-type: none"> Topical problem: media and public attention on marine plastic pollution Possibility of financial support, e.g. EU Maritime and Fisheries Fund Regional cooperation projects/programmes Existing obligations to retrieve FADs in Balearic Islands and in some Sicilian ports Maltese litter monitoring strategy implemented through Marine Strategy Framework Directive 	<ul style="list-style-type: none"> Lack of holistic fisheries litter management strategy at regional and supranational level Perceived lack of adequate control and enforcement of fisheries management measures at national and regional level Potential impacts on livelihoods of artisanal fishers Challenging economic/political situations in several Mediterranean countries

The fisheries management plan for the Maltese FAD dolphinfish fishery (Malta Legal Notice 354 of 2013) only refers to positive impacts of limestone anchors serving as artificial reefs and increasing biodiversity; there is no obligation to remove FADs at the end of the season. Similarly, Italian fishers deploying FADs at depths beyond 100 m and Tunisian fishers are not obliged to remove FADs after the fishing season [3]. It is not known how many FADs, if any, are retrieved on a voluntary basis. There currently appears to be little to no regulatory support for achieving preferred EoL strategies for FAD mooring ropes. Despite the increased focus on marine plastic pollution and ongoing efforts to address ecosystem impacts of fishing by the General Fisheries Commission for the Mediterranean Sea (GFCM), no holistic approach currently exists to manage litter from dolphinfish FAD fisheries.

Management measures which should be evaluated to reduce marine plastic pollution from FADs include: (i) gear design requirements to increase longevity and facilitate retrieval, (ii) a gear registration scheme to increase accountability for the fate of gear, (iii) adequate port reception and storage facilities for FAD gear, and (iv) introduction of incentives for fishers to reuse ropes or recycle damaged ropes. The Maltese case study highlights that even in this small, artisanal fishery large numbers of FADs are deployed annually, and thus measures to reduce environmental impacts are urgently required at both a national and a regional level.

Acknowledgments

We are grateful to the Maltese fishers and representatives of government entities who agreed to be interviewed.

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BLUEFISH *POMATOMUS SALTATRIX* AGAIN IN THE FISHING CATCHES IN THE NORTHERN ADRIATIC

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Abstract

A large catch of the bluefish *Pomatomus saltatrix* in the northern Adriatic region was recorded again after 16 years of the first large catch of this species in this area. The establishment of its population in the northern Adriatic region is related to changes in climate and life-history traits of the species.

Keywords: *Fishes, North Adriatic Sea*

Bluefish, *Pomatomus saltatrix* (Linnaeus, 1766), is a pelagic and migratory species, which inhabits coastal temperate and sub-tropical waters of all ocean basins except the eastern Pacific. It is found throughout the Mediterranean and Black seas [1], being more abundant in the south and eastern Mediterranean.

This species was fairly rare in the Adriatic, occurring mostly in the southern part [2]. In 1998 a juvenile bluefish was first recorded in the middle Adriatic, North of its usual area of distribution in the Adriatic [3]. In 2003, an unusual and surprising catch of 1,5 tonnes of *P. saltatrix* was recorded in the northern Adriatic (Tar cove, Mirna estuary) [4]. This record was verified as the northernmost record of this species in the Mediterranean area (excluding Black Sea) [4]. In January 2019 the same type of fishing as in 2003 was performed in Tarska cove for experimental purposes. Specially constructed beach seines called 'ciparice' or 'mullet nets' were used. These nets are used only in the area of the Mirna estuary and are targeting mullet species. The total length of the net was 1450 m. They are set so as to enclose the whole bay from one side to the other (north-south). Net is 15 to 30 m deep. Mesh diameter is 22 mm. The temperature at 2 m depth was 11.4°C. A subsample of *P. saltatrix* was obtained for the analysis (N=344). Length frequency distribution (Fig. 1) and length-weight relationship (Fig. 2) of the subsample were obtained. Individuals ranged from 26 to 84 cm (mean length 46.3 cm±9.68), while weight ranged from 158 to 5200 g. The length-weight equation was: $y=0.0092x^{2.9768}$ ($R^2=0.9728$), indicating isometric growth.

Presence of the bluefish in the catches 16 years after the previous one indicates its establishment and persistence in the area. This was also confirmed by the fishermen who consider this species now as a common and abundant in the area. The establishment of the population in the northern Adriatic region seems related to changes in climate and life-history traits as already observed in this species for the area of northwestern Mediterranean (5). The status of the bluefish in the Adriatic Sea needs to be evaluated on a continuous basis because it is becoming increasingly apparent that it can be an indicator of environmental change.

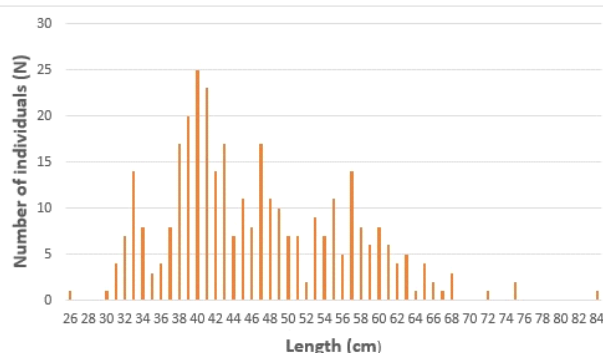


Fig. 1. Length frequency distribution of bluefish *P. saltatrix* captured in Tarska vala in 2019.

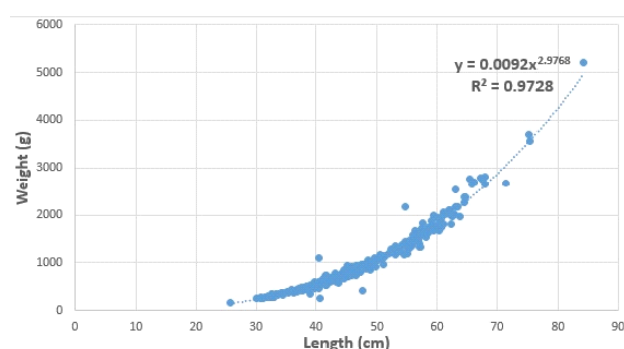


Fig. 2. Length-weight relationship of bluefish *P. saltatrix* captured in Tarska vala in 2019.

Acknowledgements

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BOTTOM OTTER TRAWL DISCARDS IN THE CENTRAL MEDITERRANEAN: IS THE EU LANDING OBLIGATION AN EFFECTIVE MANAGEMENT STRATEGY?

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Abstract

From January 2019 a Landing Obligation (LO) which aims to reduce the wasteful practice of discarding will apply to commercial species managed by Minimum Conservation Reference Sizes (MCRS) in the Mediterranean Sea. An analysis of 2009-2015 landings data for Maltese bottom otter trawlers reveals that no MCRS are currently in place for key target species. Moreover, based on preliminary data from trawlers operating between 460-560 m, over 90% of discarded individuals are not commercial species monitored under the EU fisheries Data Collection Multiannual Programme (DC-MAP). Based on these observations, we discuss the current effectiveness of LO in managing fishery discards.

Keywords: Deep waters, Malta Channel, Demersal, Fisheries

Introduction

As part of the implementation of the revised EU Common Fisheries Policy (CFP; Regulation EU 1380/2013), a LO was phased in from 2015-2019 by first applying it to pelagic catches and species defining fisheries. From 2019 the LO applies to all species subject to total allowable catch limits and Minimum Conservation Reference Sizes (MCRS) in the Mediterranean Sea. The General Fisheries Commission for the Mediterranean (GFCM) estimates that 230,000 tonnes of catches are discarded every year, and that bottom trawlers are responsible for the bulk of discards [1]. In the Ionian Sea, bottom otter trawlers targeting deep-water shrimp species are known to discard 20-50% of catches [2]. A case study approach was used to assess the likely effectiveness of the LO in reducing discards in the Central Mediterranean Sea.

Materials and Methods

Data on landings of Maltese bottom otter trawlers operating in the Central Mediterranean Sea were analysed for the years 2009-2015 in order to identify the most important target species defining the fishery during this period. Official data on landing weights and values submitted by the Maltese authorities in response to fleet economic datacalls issued under the EU fisheries Data Collection Multiannual Programme (DC-MAP; Implementing Decision EU 2016/1251) were analysed for this purpose.

Discards of deep-water bottom otter trawlers fishing at the northern edge of GFCM Geographic Sub-Area 15 were monitored during two fishing trips in July and August 2017: (i) commercial and sensitive species monitored under the DC-MAP data collection protocol were recorded as part of routine on-board observations implemented by the Maltese Department of Fisheries and Aquaculture (DFA); (ii) catches of species not recorded under the DC-MAP were identified, counted and weighed in the laboratory. Five hauls from depths of 460-560 m were analysed for each fishing trip; the average haul duration was 4 hours and 45 minutes.

Results and Discussion

The most important target species defining the Maltese deep-water bottom otter trawl fishery in the years 2009-2015 in terms of both weight and value was the giant red shrimp (*Aristaeomorpha foliacea*), followed by the deep-water rose shrimp (*Parapenaeus longirostris*). Whilst a MCRS of 20 mm carapace length is in place for deep-water rose shrimp (Regulation EC 1967/2006), no minimum size exists for giant red shrimp. This species is consequently not subject to the LO from 2019 even though it is the most important target species for Maltese deep-water trawlers.

Besides the main target species, giant red shrimp and deep-water rose shrimp (which together accounted for 74% of landed individuals), 18 other commercial species were landed following the two fishing trips monitored in summer 2017, including in order of decreasing importance: Norway lobster (*Nephrops norvegicus*), greater forkbeard (*Phycis blennoides*), four-spot megrim (*Lepidorhombus boschii*), hake (*Merluccius merluccius*), and blackbelly rosefish (*Helicolenus dactylopterus*). Fifty-two species with no commercial value were discarded: 83% of discarded individuals were Actinopterygii (27 species), 6% were Elasmobranchii (9 species), 6% were Cephalopoda (6 species), 5% were Decapoda (9 species), and 0.03% were Anthozoa (1 species) (Figure 1).

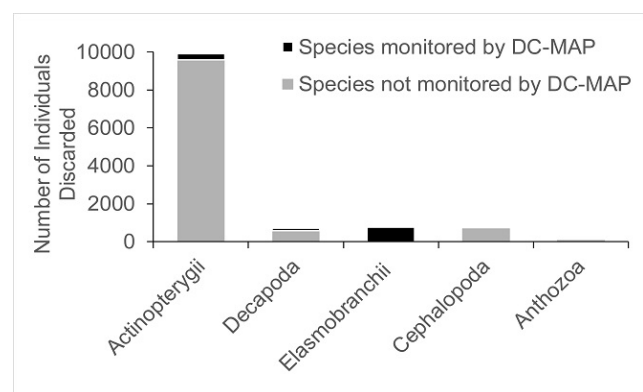


Fig. 1. Number of discarded individuals during the July and August 2017 bottom otter trawl fishing trips monitored / not monitored by DC-MAP data collection protocols.

Only 9.7% of the discarded individuals were recorded during the routine on-board observations. The most commonly discarded species were small non-commercial fish, including shortnose greeneye (*Chlorophthalmus agassizi*; 31% of discarded individuals), roughtip grenadier (*Nezumia sclerorhynchus*; 17%) and hollow-snout grenadiers (*Coelorhynchus caelorhynchus*; 14%), which are not monitored under the DC-MAP data collection protocol. Only 0.1% of the species discarded (hake and deep-water rose shrimp), were subject to a MCRS and thus the LO from 2019.

Discards of bottom otter trawlers targeting deep-water shrimps in the Central Mediterranean are thus mainly composed of small ray-finned fish, which are not fit for human consumption and not routinely monitored under the DC-MAP since they are not commercial or sensitive species. Such species are not considered by the LO. The LO is however also unlikely to be effective for commercial target species since MCRS are not in place for key target species such as giant red shrimp. In fact, hardly any discards of commercially valuable species were recorded during the present study. Therefore, the LO in its current format does not appear to be a viable management strategy to reduce discarding in Central Mediterranean trawl fisheries.

Acknowledgements

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SPATIO-TEMPORAL CATCH VARIATION OF THE SPINY LOBSTER (*PALINURUS ELEPHAS*): IMPLICATIONS FOR THE MANAGEMENT IN CALVI/CAP CORSE

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Abstract

The spiny lobster (*Palinurus elephas*, Fabricius, 1787) is an emblematic species of the Mediterranean Sea. The main objective of this study will be to improve the state of knowledge on the exploitation of this species in Calvi/Cap Corse. The artisanal fishing of spiny lobster in the study area has remained relatively stable (CPUE) in recent years (2004-15).

Keywords: Fisheries, Corsica Trough

The spiny lobster (*Palinurus elephas*, Fabricius, 1787) is an emblematic species of the Mediterranean Sea. According to the International Union for Conservation of Nature (IUCN), overexploitation by professional fishing is a major threat to this species worldwide. It has been assessed as a "Vulnerable" species in the Red List of Threatened Species. In the Mediterranean, for more than 30 years, landings of spiny lobster have declined significantly by between 30 and 50%. In Corsica, the same trend is observed, going from an average production of 300 tons per year in the 1970s to nearly 80 tons estimated during the 2000s (Le Manach et al. 2011).

The main objective of this study will be to improve the state of knowledge on the exploitation of this species in Calvi/Cap Corse, in order to contribute to sustainable fisheries management. Data were collected by scientific observers on-board fishing vessels (see Marengo et al. 2016). In this study, 12 years of monitoring between 2004 and 2015 were analyzed during the peak fishing season (between April and September). A total of 466 fishing trips were performed in the perimeter of the *Parcu Naturale Marinu di u CapiCorsu è di l'Agriate* (PNMCCA, Marine Nature Park), which represents nearly 1300 km of nets sampled over the 12 years (Fig.1). The PNMCCA was created by decree on July 15, 2016. It is the eighth largest French Marine Nature Park of 6,830 km², is the largest marine natural park in metropolitan France.

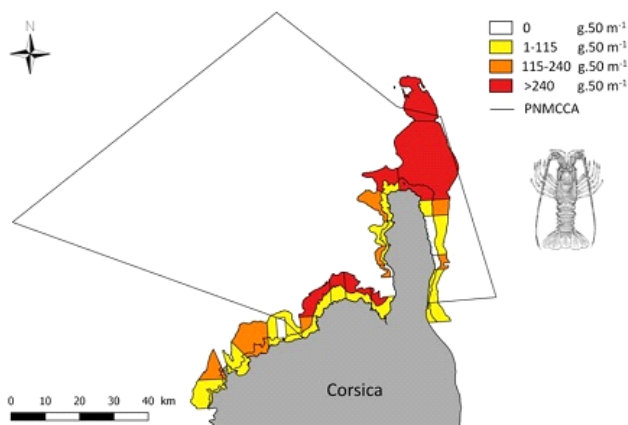


Fig. 1. Spatial distribution of fishing zones based on CPUE (expressed in g.50m⁻¹) between 2004 and 2015 for spiny lobster exploited by artisanal fisheries.

Analysis of the evolution of CPUE in spiny lobster nets revealed no temporal trend, with stable yield over time. CPUE ranged from a low of 208 g.50 m⁻¹ in 2009 to a high of 277 g.50 m⁻¹ in 2014. The spatial distribution of fishing areas shows that spiny lobster is distributed heterogeneously in the study site. It is generally observed that the lowest CPUE values are between 0 and 50 m deep (eg Canari, Pino, Santa Severa) while the maximum values are mainly between 50 and 200 m depth. The highest CPUEs are mainly located in the north of Cap Corse and in the west towards Agriates (Fig. 2). This "hot spots" of exploitation have been identified, these zones correspond to CPUE values

greater than or equal to 240 g.50 m⁻¹ (Agriates, Giraglia, Malfacu, Saint-Florent, Saleccia, Semaphore, Veuves).

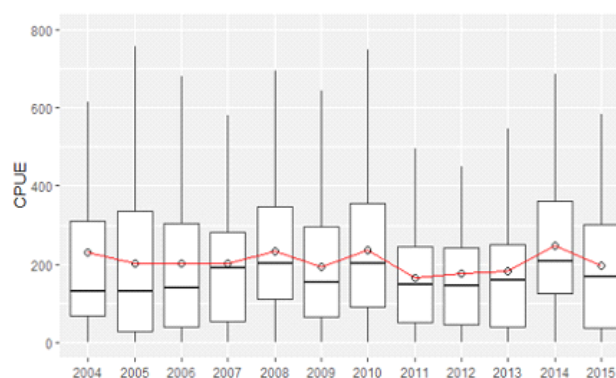


Fig. 2. Evolution of CPUE (expressed in g.50m⁻¹) of spiny lobster between 2004 and 2015.

In conclusion, artisanal fishing of spiny lobster in the Calvi / Cap Corse area has remained relatively stable (CPUE) in recent years (2004-15). In this context, the scientific recommendations for the sustainable exploitation of the resource are essentially the strict respect of the regulations already in force.

To date, the regulations in Corsica include:

- (i) a fishing season open between March 1st and September 30th;
- (ii) a minimum landing size of 240 mm total length (90 mm cephalothoracic length: CL);
- (iii) a ban on the retention and marketing of females, irrespective of age and size;
- (iv) a total length of the nets per vessel not exceeding 5000 m. Finally, despite the existence of fisheries data on the artisanal fishery for *P. elephas*, there is a lack of knowledge about its biology and key elements of its life cycle (population structure, displacement, age, growth, maturity sexual, recruitment, larval stage...).

In this approach, it would be interesting to continue the fishery monitoring with the help of professional fishermen, by increasing the sampling effort on this area.

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AMOUNT AND COMPOSITION OF DISCARDED FISH AND CRUSTACEANS IN FISHERIES OF SOUTH OF MONTENEGRO (SOUTH ADRIATIC SEA)

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Abstract

Analysis of discard, amount of fish and crustacean species as a percentage of total catch and composition, in the southern part of Montenegro (South Adriatic Sea) was carried out during 2018. Main fishing tools used in this area were covered during sampling procedure: bottom trawl nets, gillnets and trammel nets. The results showed that higher amount of discard is present in bottom trawl nets (25.8%) compared to gillnets and trammel nets (14.5% and 2.9% respectively). Main species present in discard were *Scyliorhinus canicula*, *Spicara flexuosa* and *Octopus vulgaris* in bottom trawl fishery, *Muraena helena*, *Merluccius merluccius* and *Uranoscopus scaber* in gillnets and *Muraena helena*, *Symphodus tinca* and *Squilla mantis* in trammel nets fishery.

Keywords: *Adriatic Sea, Fisheries, Fishes, Crustacea*

Investigation of discard amount and composition has been carried out in the southern part of Montenegro, in the area of ports Bar and Ulcinj. This area has been chosen as a BLUE LAND area due to its natural and cultural significance, and fisheries in this area has a long tradition and high importance to the local communities. Discards in fishery present very important problem and are a global issue. Discard is the part of the catch that is not retained on board and is discarded at sea. It may include target species or any other species (both commercial and non-commercial) discarded at sea. According to the latest estimates from the Food and Agriculture Organization of the United Nations (FAO), discarded fish are estimated at 7.3 million tonnes per year [1]. Usually, discards result in a reduction of harvesting opportunities and might have negative consequences on the stocks, ecosystems and environment [2]. Reasons for discarding fish and crustaceans are different: species has no commercial value on market, unfit for human consumption, species is undersized, damaged, etc. Sampling was performed seasonally by observers on board fishing vessels, and most commonly used fishing tools in this area were sampled: bottom trawl nets, gillnets and trammel nets. Highest percentage of discarded fish and crustacean species was observed in bottom trawl fishery (25.8%) compared to gillnet (14.5%) and trammel net (2.9%) fishery (Figure 1). This was expected as bottom trawl is an active type of gear which collects everything in its path and whose selectivity changes during fishing operation, while gillnets and trammel nets are passive, fixed gears, mostly with larger mesh size and whose selectivity remains the same during entire fishing operation.

total of 52 fish and crustacean species were recorded in bottom trawl samples, from which 34 species were landed, 25 species were present both in landed and discarded part of catch, while 18 species were discarded. In gillnets, of 30 species caught in total, 6 were present both in landed and discarded part of catch, while 10 species were discarded. In trammel nets sampled, 28 species were caught in total, 3 species were landed and discarded, and 7 species were discarded. Further monitoring on discard will be conducted in order to obtain a clearer picture of the state of discard in marine fisheries in Montenegro and to build a base for future management decisions on discard reduction.

Acknowledgement

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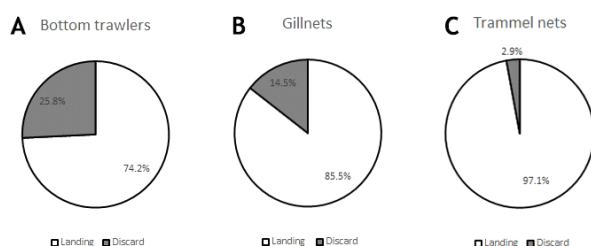


Fig. 1. Percentage of discarded fish and crustacean species in total catch of bottom trawl, gillnet and trammel net fishery (white - landed weight, gray - discarded weight)

Main species present in discard were *Scyliorhinus canicula*, *Spicara flexuosa* and *Octopus vulgaris* in bottom trawl fishery, *Muraena helena*, *Merluccius merluccius* and *Uranoscopus scaber* in gillnets and *Muraena helena*, *Symphodus tinca* and *Squilla mantis* in trammel nets fishery. Reason of high percentage of discard in gillnets is due to a fact that high amount of *Muraena helena* was caught during sampling, and this species has no commercial value in Montenegro, so it gets mostly discarded. Also, *Scyliorhinus canicula*, that is the most discarded species in bottom trawl fishery has no commercial value in Montenegro, and its almost never used for human consumption. Discarded *Merluccius merluccius* individuals from gillnets, highly important commercial species, were damaged and unsuitable for market and human consumption. A

TEMPERATURE DURING SPAWNING AFFECTS SANDEEL LANDINGS IN THE CATALAN COAST (WESTERN MEDITERRANEAN)

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Abstract

The sandeel fishery (*Gymnammodytes cicerelus* and *G. semisquamatus*), regulated by an specific management plan and monitored by a Co-Management Committee, presents annual fluctuations of abundance. The purpose of this study is to clarify whether the cause of these fluctuations is the temperature in the spawning season.

Keywords: *Temperature, Western Mediterranean, Fishes*

The family Ammodytidae belongs to the order Perciformes. Ammodytidae species are distributed in cold and temperate seas, being common in the North Atlantic. Most of these species are winter spawners. Two species of the genus *Gymnammodytes* are found in the Mediterranean: *G. cicerelus* and *G. semisquamatus*.

In Catalonia the sandeel's fishery is regulated by monthly quotes and limitation of the fishing effort (number of vessels and fishing days by vessel) (1). The Co-management committee (CMC) includes the fishing sector, the administration, ONGs and scientists. The monitoring of the fishery, that began with the preparation of the management plan and its implementation, started in 2012. The fishery implements a closure during the spawning period, from 15 December to 1 March.

In 2015 the fishery was closed from August to December by decision of the CCM, because of the very low landings. The low catches of the experimental hauls performed in March 2016 led the fishermen to propose the postponement the opening of the fishing season to April. Sandeel abundance remained low in 2016 and 2017. In 2018 the abundance was higher but low quotas were applied taking into account the precautionary approach (Table1)

Tab. 1. Sandeel Quotes (kg by vessel as decided by the CMC) and CPUE (landed kg by vessel).

	Quote	Quote	Quote	Quote	Quote	Quote	Quote
	2012	2013	2014	2015	2016	2017	2018
MAR		650	320	100		40	70
APR		650	320	100	77	58	70
MAY		584	400	120	50	68	80
JUN	650	520	400	120	61	61	90
JUL	650	520	550	70	74	70	130
AUG	650	520	450		84	50	130
SEP	650	520	200		90	5	130
OCT	650	423.5	200		57	70	130
NOV	650	230	200		72	65	130
DEC	650	260	200		67	65	130

	CPUE	CPUE	CPUE	CPUE	CPUE	CPUE	CPUE
	2012	2013	2014	2015	2016	2017	2018
MAR		522.2	331.5	62.0		33.2	34.4
APR		558.1	353.4	60.3	83.2	59.8	71.4
MAY		534.1	396.3	101.1	53.0	63.8	79.3
JUN	496.1	477.2	380.2	87.2	65.8	67.2	91.1
JUL	528.6	482.6	489.8	45.5	74.2	62.5	120.1
AUG	489.8	477.2	253.7		93.5	4.9	120.3
SEP	476	465.6	119.2		75.2	9.6	121.4
OCT	469.8	392.4	151.6		48.2	60.2	138.2
NOV	452.4	217.5	168.4		48.7	45.4	131.8
DEC	438	217.3	94.7		45.6	51.1	116.8

The reduction of catches is not clear, suggesting a possible combination of anthropogenic effects, such as fishing, and of the environment, mainly temperature. In order to study the possible influence of temperature during spawning in the fluctuations of sand eel, sea surface temperature (SST) from Barcelona was used (<http://marbcn.blogspot.com.es/>). Unfortunately, data from 2007 was not available.

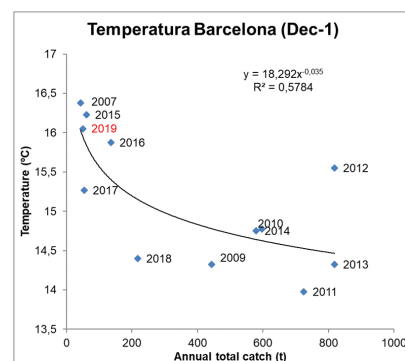


Fig. 1. Relationship between the December temperature and sandeel catches the next year.

Figure 1 shows the relationship between the December temperature (t-1) and catches in year (t), from 2007 to the present. It can be observed a good correlation between the two variables. Nevertheless, this result is not conclusive in that temperature during spawning may not be the only reason for the decline of the population. The high temperatures did not affect the onset and duration of the spawning season because every year the reproduction period occurs the same months (2).

Did SST affect the recruitment? Are the preys of sand eel affected by warmer temperatures? A lot of questions still remain open, so effort to progress in the knowledge of the biology and ecology of this species is highly recommended.

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INFLUENCE OF SIZE ON OXYGEN CONSUMPTION OF THE BEARDED HORSE MUSSEL MODIOLUS BARBATUS (LINNAEUS, 1758) AND THE NOAH'S ARK SHELL ARCA NOAE LINNAEUS, 1758

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Abstract

Oxygen consumption and ammonia excretion were investigated on Bearded horse mussel and Noah's ark shell under laboratory conditions in relation to the shell size (< 25 mm; 25 to 50 mm and > 50 mm). Body size of both species significantly influenced oxygen consumption and ammonia excretion of the Noah's ark shell. In both species, respiration decreased with body size while excretion rate increased with body size.

Keywords: Bivalves, Aquaculture, Oxygen, Adriatic Sea

Introduction

Sustainable management of bivalve molluscs requires an interdisciplinary approach involving knowledge of the physiology of farmed as well as candidate species. In this paper, oxygen consumption (OC), ammonia excretion (AE) related to the size of the Noah's ark shell and the bearded horse mussel was investigated. Comparison of physiological responses of these two species due to the size of the individuals was also made. When assessing the suitability of certain species for culture, it is important to know how physiological responses are influenced by the size of an animal.

Materials and methods

Measurements of oxygen consumption and ammonia excretion were performed on the shellfish samples of both species collected from Mali Ston Bay (Southeast Adriatic). Oxygen consumption (OC) and ammonia excretion (AE) were measured with respect to the different size categories of shellfish (< 25 mm; 25 to 50 mm and > 50 mm). The measurements were performed in the closed respiratory chamber using OxyScan graphic probe (UMS GmbH, Germany). After the measurement period, 50 ml of the sea water sample was taken from the closed chamber, fixated with 2ml of phenol and refrigerated for AE measurement. The concentration of ammonium was determined by the indolfenol blue method [1] modified by [2]. Statistical analysis was carried out using parametric ANOVA and Tukey post-Hoc analysis ($p < 0.01$). To compare the metabolic rates between species, t-test was used.

Results and discussion

Mean oxygen consumption of both *A. Noae* (ANOVA, $p = 0.000195$, $F = 10.543$) and *M. Barbatus* (ANOVA 0.000006 , $F = 16.63$) depended significantly on body size (Figure 1a). In both investigated species, there was a trend of higher respiration rate in smaller animals. T-test showed statistically significant difference for respiration rate between these two species for groups smaller than 25 mm ($t = -2.610$; $P < 0.001$). Excretion rate (AE) of *A. noae* depended strongly (ANOVA, $P < 0.000676$, $F = 8.899$) on body size (Figure 1b) and significant difference was observed for largest animals compared to the other size groups (Tukey, $P < 0.01$). Ammonia excretion of *M. barbatus* was not influenced by body size. T-test showed a statistically significant difference for AE rate between *A. noae* and *M. barbatus* for organisms smaller than 25 mm ($t = 2.173$; $P < 0.05$).

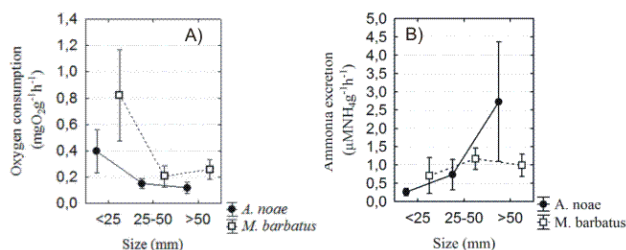


Fig. 1. Oxygen consumption (a) and Ammonia excretion (b) of *Arca noae* and *Modiolus barbatus* related to shell size.

[3] have developed the theory of varying metabolic rates with regard to body size and temperature. The body size is one of the main endogenous factors influencing the energy costs of organisms [4]. In this study, in both *A. noae* and

M. barbatus the respiration rate decreased with body size. For both studied species increase in AE rate is observed with an increase in the body size, consistent with finding that small animals have a relatively low rate of ammonia excretion during spring [5]. In bivalve molluscs, due to a disproportionate reliance on protein metabolism for energy production by smaller individuals the relationship between ammonia excretion rates and body size can be very variable [6].

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CIESM Congress Session : Bioinvasions' impact on fisheries

Moderator : Alexandra Teodósio, Univ. of Algarve, Portugal

Moderator's Synthesis

The impact of bioinvasions on fisheries evidences common problems between Mediterranean and West Atlantic coastal areas as reflected by several case studies discussed during this session. Similar integrative approaches were evidenced especially with the blue crab where traditional surveys are complemented by low cost tools using science-society interactions with mutual benefits, such as early detection and raising awareness.

The debate concluded that legislation to manage marine invasions needs to be developed rapidly, using evidence from other sites impacted by the same species at a regional level, although considering local specific characteristics. Moreover stress was added to the urgent need that governance considers not only monitoring actions but also effective management measures to marine non-indigenous species. There are regional and global solutions necessary to balance economic and conservations goals to tackle NIS proliferation and easing the pressure upon native fisheries resources species most of them already in overexploitation.



SIZE FREQUENCY DISTRIBUTION OF BLUE SWIMMING CRAB *PORTUNUS SEGNIS* (FORSKÅL, 1775) FROM THE GULF OF GABÈS (TUNISIA)

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Abstract

This study carried out during 2 years (2015-2016) aims to explore size frequency distribution of blue swimming crab *Portunus segnis* (Forskål, 1775) in the Gulf of Gabès. The results showed that the carapace width (CW) for males and females ranged from 32 to 155 mm and 27 to 145 mm respectively. The size classes frequency distribution presented a polymodality pattern for both sexes. The biometric traits are essential to manage bioinvasion.

Keywords: *Mediterranean Sea, Global change, Invasive species, Lessepsian migrants*

Introduction: *Portunus segnis* (Forskål, 1775) is one of the earliest alien species observed in the Mediterranean Sea after the opening of the Suez Canal [1]. This crab occurs in Tunisia for the first time in 2014 [2] and has increased rapidly causing disaster for the ecosystem and artisanal fishing activities. This invasive crab has totally invaded the Gulf of Gabès, displaced some natives species of commercial value. It is at the origin of decline of the fishermen's income due to the clogging of the nets and the degradation of the catches [3]. This work focuses on the distribution of the size frequency of the blue crab, an essential ecobiological parameter for decision makers.

Materials and methods: The present study was conducted in the Gulf of Gabès (fig.1) between October 2015 and July 2016 in two sites (Fig.1). A total of 1067 specimens (551males, 516females) were collected by gill and trammel nets in shallow waters between 0.5 to 12m. The carapace width (CW) of each crab was measured with electronic calipers to the nearest 1 mm. Using data on carapace width, size frequency distribution for crabs was depicted in each season.

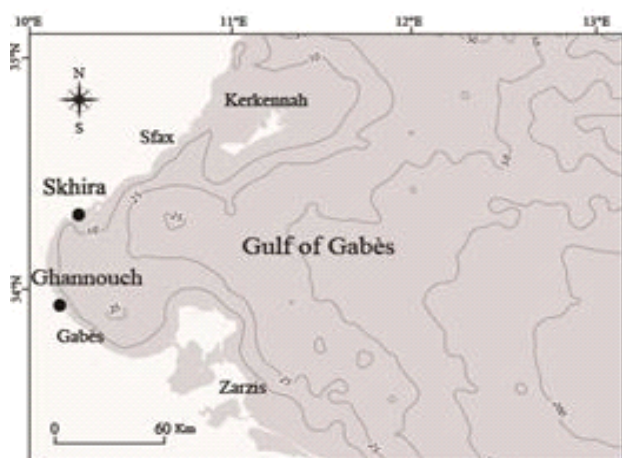


Fig. 1. Study area with sampling sites in the Gulf of Gabès

Results : The examined carapace width (CW) for males and females ranged from 32 to 155 mm and 27 to 145 mm respectively. The mean size of male individuals was 8.33 ± 30.97 mm (minimum = 32 mm, maximum = 155 mm) and the mean size of females was 82.04 ± 25.80 mm (minimum = 27 mm, maximum = 145 mm). The size frequency distributions for males and females presented a polymodal pattern for both sexes (Fig.2). The size frequency distribution showed that juvenile crabs occur in spring. During this season, they are more abundant (size class of 35-75 mm CW).

Discussion: In the present work, the carapace width for *Portunus segnis* ranged from 27 to 155. While, in the Persian Gulf, this parameter oscillate between 35 to 138 mm [4]. The difference is probably due to the ecoregion disparity. The polymodal distribution of size frequency usually signals many age groups within a population, as a result of differential behavior among the demographic group. The present distribution of frequencies of crabs by classes of carapace

width indicates that the smaller size crabs were observed during the spring for both sexes. In Gulf of Gabès breeding and spawning of *P. segnis* extends from March to October, April is the peak period. This result is in accordance with the findings for its congeneric species *Portunus pelagicus* (Linnaeus, 1758) caught in Indonesian Waters [5].

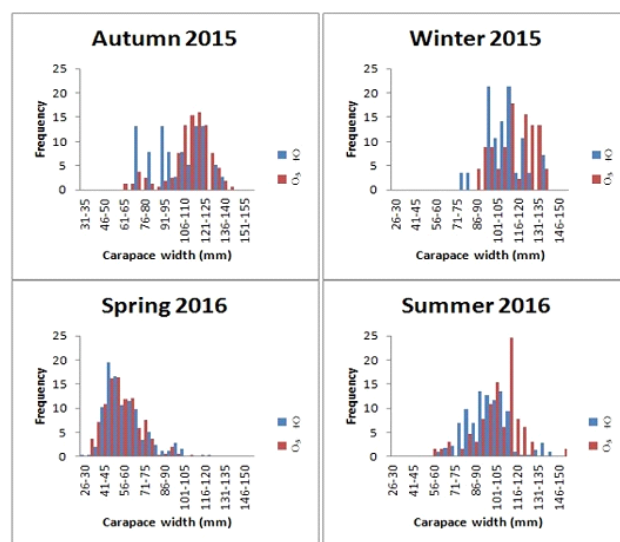


Fig. 2. Seasonal carapace width frequency distribution for both sexes of *Portunus segnis* (Forskål, 1775) in the Gulf of Gabès during 2015-2016

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RELATIVE GROWTH OF THE INVASIVE CRAB *LIBINIA DUBIA* H. MILNE EDWARDS, 1834 (BRACHYURA, EPIALTIIDAE) FROM THE GULF OF GABÈS (TUNISIA)

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Abstract

Morphometric features of the Mediterranean population of *Libinia dubia* were studied by measurements of various parts of body and chelipeds. For 4276 specimens, carapace width (CW), ranged from 22.14 to 89.1 mm, with the most abundant size group of 50-52 mm, was used as a reference parameter. Allometric relationships suggested that most morphometric relations were positive ($b > 1$ or $b > 3$) and highly significant ($t_{cal} > t_{th}$, $\alpha = 5\%$). Study of such bioecological traits is essential to manage bioinvasion.

Keywords: Mediterranean Sea, NIS, Crustacea, Global change

Introduction

Libinia dubia H. Milne Edwards, 1834, native to the western Atlantic, has been observed only in Tunisia since its occurrence in the 1990s in the Mediterranean Sea [1]. This invasive crab has proliferated and invaded the Gulf of Gabès causing damages on ecosystem and threatening coastal fisheries [2]. The aim of this research is to describe the relative growth of the species by analysis of morphometric characteristics.

Materials and methods

4276 crabs divided into 2122 females and 2154 males were monthly collected and examined at different sites from the Gulf of Gabès between January 2015 and December 2016 (Figure 1). Measurements and total weights of body and chelipeds were taken using a digital vernier caliper and digital balance respectively to the nearest 0.01 mm and 0.01 g. Relative growth equation ($y=ax^b$), based on the relationship between studied character and CW, was applied for the interpretation of results and statistical analysis were done using appropriate software.

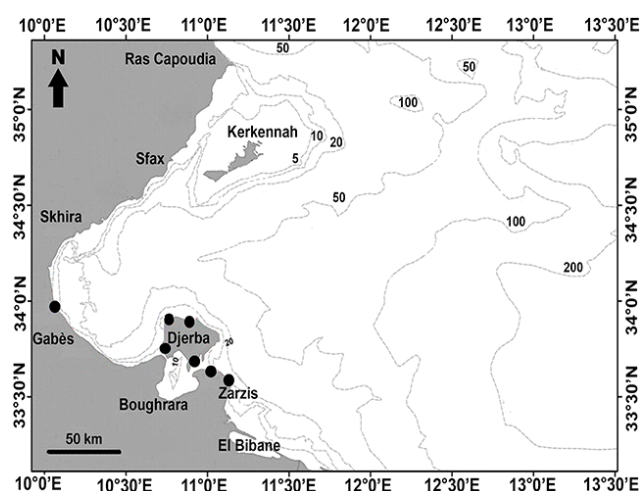


Fig. 1. Location of the study area and sampling sites in the Gulf of Gabès

Results and discussion

Most body parts of *L. dubia* showed negative allometric relations except body height (BH), abdominal length (AL) and width (AW) whereas cheliped characters were positively allometric except cheliped weight (CHWe) for combined sexes. For males, cheliped relationships were highly correlated ($0.59 < R^2 < 0.7$) compared to females ($0.44 < R^2 < 0.55$) which reveals the dimorphism of chelipeds. Values of $t_{cal} > t_{th} = 1.96$ ($\alpha = 5\%$) indicated that differences were significant for most of studied characters (Table 1).

Tab. 1. Morphometric characters of *L. dubia* from the Gulf of Gabès. Total length (TL), carapace length (CL), anterolateral border length (ABL), posterolateral border length (PBL), total weight (TW), cheliped length (CHL), cheliped width (CHW), cheliped height (CHH), M: males, F: females.

Character	Sex	$Y = ax^b$	R^2	t_{cal}	Allometry
TL	M+F	$TL = 2.852 CW^{0.8}$	0.9	58.6	-
CL	M+F	$CL = 1.898 CW^{0.858}$	0.89	33.7	-
ABL	M+F	$ABL = 1.102 CW^{0.898}$	0.69	10.3	-
PBL	M+F	$PBL = 1.172 CW^{0.89}$	0.78	15.1	-
BH	M+F	$BH = 0.535 CW^{1.040}$	0.64	2.57	+
AL	M+F	$AL = 0.063 CW^{1.574}$	0.53	11.8	+
AW	M	$AW = 0.21 CW^{1.023}$	0.68	1.22	+
	F	$AW = 0.443 CW^{1.103}$	0.8	6.18	+
	M+F	$AW = 0.039 CW^{1.586}$	0.19	3.25	+
TW	M+F	$TW = 0.002 CW^{2.582}$	0.77	6.61	-
CHL	M	$CHL = 0.054 CW^{1.684}$	0.66	12.6	+
	F	$CHL = 0.285 CW^{1.169}$	0.45	3.44	+
	M+F	$CHL = 0.185 CW^{1.322}$	0.39	5.97	+
CHW	M	$CHW = 0.002 CW^{1.986}$	0.7	14.8	+
	F	$CHW = 0.033 CW^{1.221}$	0.46	4.31	+
	M+F	$CHW = 0.011 CW^{1.534}$	0.44	8.63	+
CHH	M	$CHH = 0.005 CW^{1.891}$	0.69	14.3	+
	F	$CHH = 0.06 CW^{1.19}$	0.44	3.62	+
	M+F	$CHH = 0.027 CW^{1.44}$	0.39	6.87	+
CHWe	M	$CHWe = 6^{-05} CW^{3.105}$	0.59	0.47	+
	F	$CHWe = 1^{-05} CW^{3.228}$	0.55	0.83	+
	M+F	$CHWe = 0.001 CW^{2.602}$	0.28	1.26	-

As growth progresses, some dimensions of the animal's body may grow much more than others, resulting in the phenomenon of relative growth [3]. Our results corroborate with those obtained for *Libinia ferreirae* native to Brazil [4]. Analysis of morphometric characteristics is required for assessment of the fishery and can serve to detect changes that may occur during growth. Biometric study of *L. dubia* is essential for stocks management. Furthermore, it may be used as a primary data to evaluate the meat and shell yields for several uses (food, feed and bioactive molecules extraction) hence to convert negative impacts of the species into profits [2].

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MONITORING OF *RAPANA VENOSA* ON THE ANAPA BAY-BAR (BLACK SEA)

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Abstract

The article reports on results of the monitoring of a gastropod *Rapana venosa* population structure on several sites of the Anapa bay-bar in the period from 2010 to 2018. The size, weight and condition index of females are lower than those of males. Variations in size, weight and index are most likely related to the population dynamics of its main prey, bivalves *Chamelea gallina*.

Keywords: Population Dynamics, Black Sea, Biomass, Gastropods

Introduced Asian whelk *Rapana venosa* (Valenciennes, 1846) plays a huge role in the functioning of isolated marine ecosystems, such as the Black Sea, and their monitoring is very important for fundamental and practical purposes.

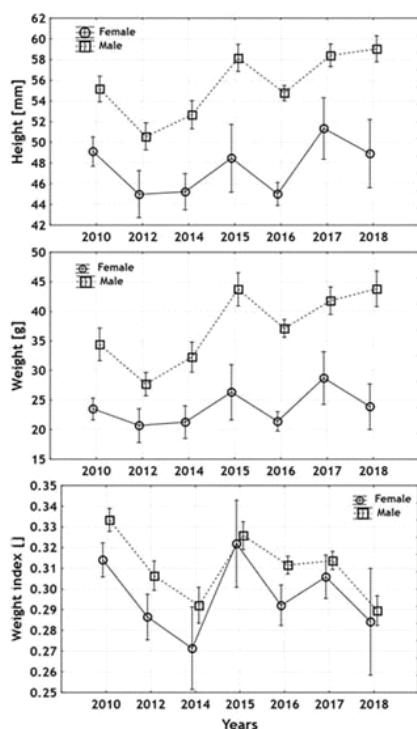


Fig. 1. Dynamics of shell height (H , upper graph), total weight (W_{total} , middle graph), and Condition Index (CI , lower graph) of *Rapana venosa*

Material and methods

Samples of rapa whelks were taken in the area of the Anapa bay-bar, located in the northeastern part of the Black Sea and representing an open section of the coast with a total length of about 40 km. The sampling was carried out by SCUBA diving in 2010, 2012, 2014, 2015, 2016, 2017, and 2018 by 5 sections 7, 18, 24, 29, 40. In total, 1541 specimens were sampled. In 2010, 2012, 2014 and 2015, the whelks were collected without precise reference to depth (2-10 m), in 2016-2018 - from depths of 6 and 10 m. For each mollusc, the following characteristics were determined: total wet weight (W_{total}), soft body wet weight (W_{flesh}), Condition Index, $CI = W_{total} / W_{flesh}$, shell height (H), age and sex. For further analysis, three age categories of mollusks were determined: 1 – young (up to 4 years inclusive); 2 – measure (age 5-6 years, the largest group); 3 – old (≥ 7 years). To analyze the general patterns, all samples were used regardless of the site of collection. The study of spatial and temporal characteristics of *R.venosa* distribution was conducted using samples collected in 2016-2018. We analyzed W_{total} , CI and H (Fractional ANOVA in Statistica 12).

Results

General patterns. Females always had lower W_{total} , CI and H , than males (Fig. 1), and the differences were kept the same in all age groups. Condition index does not change with age, but differs in different years and sections. Size and weight of males increase with age, while in females the variations are insignificant. Over time, H , W_{total} and CI of *R.venosa* change in waves, the years with high values alternate with the low ones. During the investigated period of time, we observed three maxima - in 2010, 2015 and 2017, and two minima - in 2012 and 2016. In females, the fluctuations of the CI curve correspond to those of H and W_{total} , whereas in males – not (Fig. 1). Most likely, this is due to the fact that females, because of high energy losses for reproduction, more sensitively react to changes in the food supply than males.

Spatial and temporal characteristics. When analyzing the samples of 2016-2018, the dependence of H , W_{total} and CI on location and depth of sampling was revealed. Specimens of *R.venosa* were larger at 6, than at 10 m. The H and W_{total} decreased from the periphery of the bay-bar (sections 7 and 40) to its middle (section 24). The main reason for fluctuations in size and biomass of rapana is the population dynamics of its food object, *C. gallina* [1] (Fig. 2).

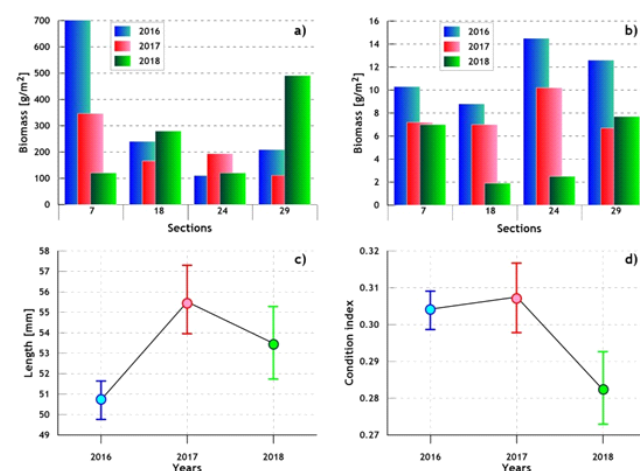


Fig. 2. Biomass (g/m^2) dynamics of *C. gallina* (a) and *R. venosa* (b) at different sections of the Anapa bay-bar; dynamics of H (c) and CI (d) of *R. venosa* sampled at the same sections

Acknowledgments

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MEAT YIELD OF THE INVASIVE CRAB *LIBINIA DUBIA* H. MILNE EDWARDS, 1834 FROM THE GULF OF GABÈS, TUNISIA

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Abstract

The meat yield of three body parts (chelipeds, locomotion appendages and cephalothorax) of 92 specimens (from both sexes) of *L. dubia* was analyzed. The mean carapace width and weight were respectively for females (64.32 mm, 107.9 ±27 g) and (70.13 mm, 148.9 ±54.7 g). The total yield from males (16.62 ±2.4%) was significantly higher than that from females (8.1 ±1.2%). In addition, the comparison of flesh content from the different morphological structures revealed that the greatest percentage was in the carapace (52 and 68.3% respectively for males and females).

Keywords: *NIS, Crustacea, Decapoda, Mediterranean Sea, Gulf of Gabes*

Introduction The spider crab *L. dubia*, a western Atlantic native crab, was first recorded in Tunisia and Mediterranean Sea in 1997 [1]. Actually, this alien decapod is considered as one of the worst invasive species which represent a threat to the sustainability of artisanal fishing in Tunisia [2]. In addition, the abundance and frequency of this alien resource should be commercially exploited to reduce its impacts on ecosystem and fishing activity. However, no data dealing with meat yield and nutritive value are available. Therefore, this preliminary study was carried out to fill this gap.

Materials and methods A total of 92 spider crabs (38 males, 54 females) were randomly collected alive from the Gulf of Gabès and some morphometric characters such as carapace width (CW) and weight (TW) were taken. For each crab, the meat was manually removed and weighed separately from chelae, locomotion appendages and thorax. Then, using a simple linear regression, the total meat content (TM) was related to the TW and their fitting was evaluated with the coefficient of determination (R^2). The mean meat yields by sex and morphological structure were studied using one-way ANOVA (significance level of 5 %).

Results and Discussion The mean carapace width of collected crabs ranged between 53.5 and 85 mm (70.13 mm) for males and from 54 to 87.1 mm (64.32 mm) for females. The total weight varied between 58.1 and 275.5 g (148.9 ±54.7 g) and between 57.1 and 177.8 g (107.9 ±27 g) respectively for males and females. The TM yield extracted from males (16.62 ±2.4% of TW) was significantly higher than that from females (8.1 ±1.2% of TW) and the same occurring when their corporal structures were compared ($p < 0.05$). The comparison of meat content between sexes and body parts is presented in Table1.

Tab. 1. Meat yield/ (sex, morphological structure) (%TM)

	Meat yield (%)			SEM	Morphological structure effect (Pr>F)
	Chelae	Locomotion appendages	Thorax		
Male	25.2	22.8	52	0.69	<0.0001
Female	4	27.7	68.3	1.68	<0.0001
SEM	0.9	1.41	1.8		
Sex effect (Pr>F)	<0.0001	0.09	<0.0001		

SEM: Standard Error of the Mean; Pr>F: p value of the ANOVA test

The meat yield from thorax was the highest one (more than 50%) followed by claws and other pereiopods for males. However, female's meat yield from chelae was the lowest one (4%) even at the same size of male. Indeed, decapods meat yield is influenced by sex and size due to the sexual dimorphism but also by development phase, season, meat extraction process and species: usually Portunids had better flesh content than other brachyurans ([3], [4]). Thus, in the case of this crab, uses should be oriented towards the extraction of bioactive substances rather than human consumption. In addition, crab meat is always associated to each body part

characteristics, namely the morphology and size of cephalothorax thoracomers and the strength of crab chelipeds [4].

Besides, for both sexes, the relationship between TM and TW (Fig. 1) showed the best fit when using a positive linear regression verified by the coefficient determination ($R^2 > 0.9$). In addition, male's muscle meat increases faster than females (Fig.1).

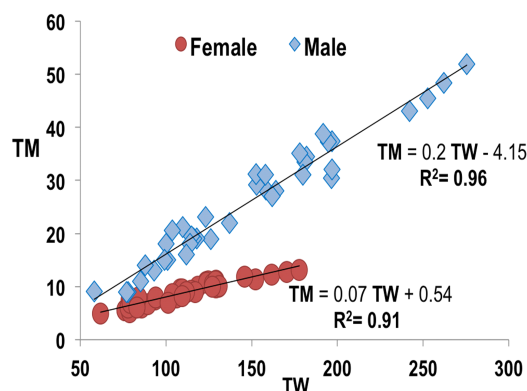


Fig. 1. Meat weight (TM,g) by total weight of *L. dubia* (TW, g) for each sex

Therefore, crab biometric evaluation has enabled the estimation of meat yield based on the TW which can be used as a selection criterion to develop this invasive crab meat production and extractive process ([4], [5]).

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COMPETITIVE DISPLACEMENT OF THE NATIVE *Squilla mantis* BY THE ALIEN INVASIVE STOMATOPOD *Erugosquilla massavensis* IN THE GULF OF GABÈS (TUNISIA)

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Abstract

A bloom of Massawan mantis shrimp *Erugosquilla massavensis* (Kossmann, 1880) is observed in the Gulf of Gabès five years after its first occurrence in 2013 in the same area. The species is already established and regularly caught by commercial benthic trawl among fishery resources. This study focuses the spread dynamics and settlement pattern of this Erythraean species. Where both species coexist, the hourly yields of the native mantis shrimp have dramatically decreased, compared with previous studies (7.2 kg/h in 2006 *versus* 2.4 kg/h in 2018).

Keywords: *Invasive species, Competition, Crustacea, Global change, Mediterranean Sea*

Introduction

Despite its high economic value in the European countries, especially in the Adriatic Sea (5,000 tons/yr) [1], mantis shrimp *Squilla mantis* (Linnaeus, 1758), is considered as a by-catch in Tunisia and commercial catches are usually discarded at the sea. Surveys conducted throughout the Gulf of Gabès allowed to record, for the first time in Tunisia, in 2013, the Erythraean stomatopod *Erugosquilla massavensis* (Kossmann, 1880) [2]. The biogeographical and chronological distribution of the Massawan mantis shrimp which is considered as one of the "worst invasive" in the Mediterranean sea is detailed in previous studies [2] and [3]. The species is already established in the Gulf of Gabès and compete with the native Mediterranean spot tail mantis shrimp. In the eastern basin, *E. massavensis* has an economic impact and threatens the native *Squilla mantis* throughout competition and even endangers commercially important Penaeid stocks since they often prey benthic crustaceans [4].

Materials and methods

The present study was conducted seasonally during 2 periods, 2005-2006 and 2018 before and after the appearance of the Erythraean shrimp by commercial benthic trawl. Fishing operations took place by day and by night at depths ranging from 10 to 180 m on sandy-muddy bottoms.

Results and Discussion

Yields (in kg per hour) of *S. mantis* and *E. massavensis* in the Gulf of Gabès during winter-spring trawling campaigns (2006 and 2018) are summarized in table 1.

Table1. Comparison between hourly yields of the alien and native Stomatopods caught in the Gabès Gulf.

Species	Yields (kg/h)			
	Winter 2006	Spring 2006	Winter 2018	Spring 2018
<i>S. mantis</i>	4,00 to 7,20	2,30 to 4,20	2,40 to 4,60	1,8 to 2,2
<i>E. massavensis</i>	Absent	Absent	5,40 to 5,80	6,60 to 7,80

This result confirms the status *E. massavensis* in the Gulf of Gabès as one of the most successful migrant species in the central Mediterranean sea, due to its high fecundity and predaceous diet [5]. In Tunisia, Stomatopods are not sold on fish markets and are rarely collected by fishermen at the request of Italian restaurants (Fig.1). With the proliferation of the invasive mantis shrimp, we could expect changes in culinary traditions as it is the case with the blue swimming crab *Portunus segnis* (Forskål, 1775). Therefore, important possibilities of bioconversion and valorization may be considered for human consumption, fish meal or other protein based food.



Fig. 1. *Erugosquilla massavensis* (Kossmann, 1880) caught on April 2018 by trammel net at 10 meters depth at Ghannouch (Gabès Gulf)

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JELLYFISH, A THREAT OR AN OPPORTUNITY? THE INVASIVE *BLACKFORDIA VIRGINICA* AS A POTENTIAL FOOD SOURCE FOR AQUATIC ORGANISMS AND HUMANS

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Abstract

Anthropogenic activities and climate changes have promoted the proliferation and establishment of non-indigenous species (NIS) in estuaries worldwide and the Guadiana estuary is no exception. The extensive development in Guadiana estuary (S Iberian Peninsula), namely river-flow regularization, favoured the colonization by several NIS such as *Blackfordia virginica* (jellyfish), *Callinectes sapidus* (blue crab), *Cynoscion regalis* (weakfish). The seasonal occurrence of *B. virginica* blooms have become a reason of concern due to reports of considerable ecological and economic impacts such as the decrease of major zooplanktonic organisms densities, including anchovy eggs and larvae.

Nevertheless, despite their local negative impacts, some studies using stable isotopic analysis suggest that jellyfish often represent an important component in the diet of several species [1]. Furthermore, jellyfish as a fishery resource has been increasing worldwide due to their high abundance, healthy composition and valuable source of bioactive compounds [2]. Therefore, we hypothesize that *B. virginica* is a prey for several opportunistic consumers, including other NIS such as *C. sapidus* especially during blooming events. In addition, considering the density that *B. virginica* in South Portugal estuaries it may be an alternative healthy human food source if it follows the same nutritional composition of known edible jellyfish, with high protein content and low-fat and low-calories properties.

Keywords: *Blackfordia virginica*; *Guadiana estuary (Portugal)*; *non- indigenous species*

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CITIZEN SCIENCE AND SOCIAL MEDIA CONTRIBUTE TO THE INTEGRATION OF MARINE INVASIVE SPECIES INTO THE BLUE ECONOMY

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Abstract

The appearance of species outside their native range poses new challenges to fishery managers. In the case of invasive marine species, they may disrupt established ecosystem dynamics and cause significant economic losses, which requires regional and global solutions to tackle their proliferation. Most invasive species are detected when they already established invasive populations. So, we are trying to change the invasive species management paradigm by introducing some into the local blue economy, and thus attaining economic benefits from species that may threaten local ecosystems, while easing the pressure upon native species [1]. We are also searching for biotechnological, pharmaceutical, or cosmetic applications derived from invasive species or their by-products, thus boosting global blue economy opportunities. The research team already detected several non-indigenous and invasive species in southern Portugal (SW-Iberian Peninsula), as the Atlantic blue crab *Callinectes sapidus* Rathbun, 1896 [1] and weakfish *Cynoscion regalis* (Bloch & Schneider, 1801) [2]. These species are valuable fishing resources in their native range in the Northwest Atlantic, and already received the interest of consumers and national media in Portugal. So, our research efforts focus on assessing the distribution and ecology of invasive species in southern Portugal with the support of citizen science initiatives, including social media. The Atlantic blue crab and weakfish are being tested as gourmet delicacies in collaboration with local chefs, as a way to promote these new resources among the public while increasing their market value and revenue to local fishers. Merging citizen science initiatives and social media are helpful to integrate marine invasive species into the local blue economy.

Keywords: invasive species; citizen science; southern Portugal

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