Impact of climate variability on pelagic food webs in European shelf systems, with a focus on trophic relations between zooplankton and small pelagic fish

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Marine ecosystems around Europe are exposed to the forcing of several climatic phenomena, such as the North Atlantic Oscillation (NAO), the Atlantic Multidecadal Oscillation (AMO) and global warming. The interdependence between these different climate indicators and their individual as well as their combined impacts on marine ecosystems are poorly understood. At present, a fascinating natural climate experiment involving zooplankton and small pelagic schooling fish such as sardines, sardinellas, anchovies and sprats is going on in waters surrounding Europe, which has been largely ignored, in spite of its acute and future commercial importance for the European fishing industry. Numerous observations over the last 20 years demonstrate clearly that small pelagic fish populations in all shelf seas surrounding Europe from the North African upwelling and the Black Sea in the south up to the Baltic Sea and southern Norwegian coasts in the North are shifting their distributional borders northward with concomitant dramatic changes in abundance and recruitment. Spectacular examples are the invasion of the North Sea by anchovies and sardines since the 1990s which have established spawning populations in this northern shelf sea and the unprecedented increase in abundance of sardinellas in the western as well as in the eastern Mediterranean. At the same time, large-scale northward movements of copepod assemblages, the main food source of small pelagics, have been observed in the Northeast Atlantic. All these dramatic changes in distribution and abundance of small pelagics and copepods seem to be primarily associated with recurrent climatic events or periods, oscillations, such as NAO and AMO, and, maybe secondly, with global warming. Presumably climatically induced concomitant changes in distribution and abundance of zooplankton and small pelagic fish in northern and southern European marine ecosystems will be compared with each other in this presentation and mechanisms for causal relationships will be suggested.

Oithona brevicornis (Copepoda, Cyclopoida) - the new component of the Black Sea zooplankton

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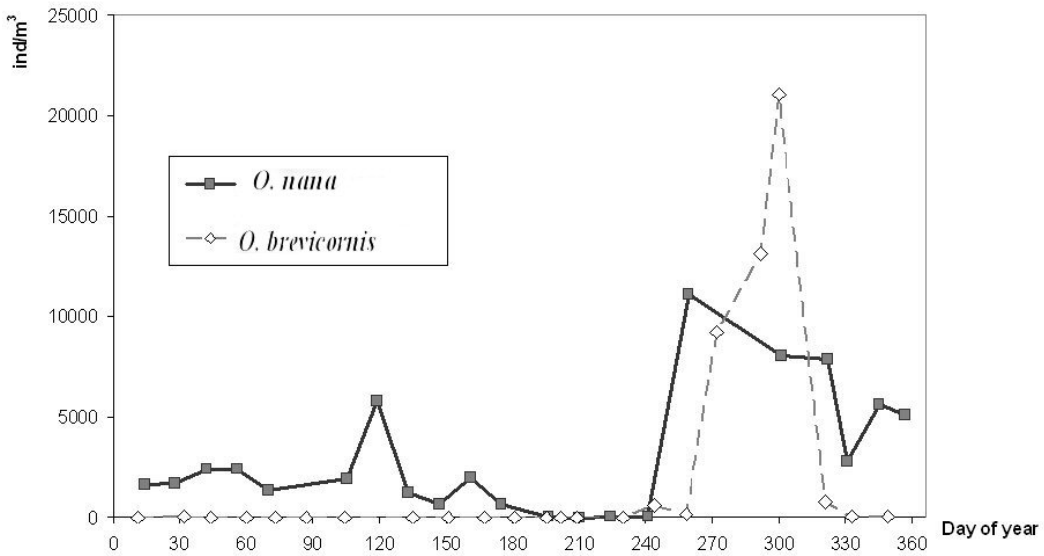
Seasonal dynamics of copepod *O. brevicornis* – the new component of the Black Sea zooplankton in 2005 – 2007 was investigated on the basis of bi-weekly plankton casts at three stations located within and adjacent to Sevastopol Bay, Crimea, northern Black Sea.

After the invasion in October, 2005, *O. brevicornis* was more abundant at the central part of the bay than at its mouth during the whole period of investigations. Only single individuals of the species were registered at the station beside the bay. Seasonal trends of the species were similar on both stations in the bay in the terms of abundance. Since April 2006, *O. brevicornis* disappeared completely from net catches and was absent till July, 2006 when this species appeared again. Especially intensive development of *O. brevicornis* population started in late August and lasted till the end of October 2006, when its abundance had reached its maximum (more than 42000 ind./m^3) in the central part of the bay.

In 2007 the species was present in plankton all year round. Minimal abundance values were observed in June – July. Peak of abundance was recorded at the middle of October at the central part of the bay and exceeded 50000 ind./m^3 – maximal value of abundance of the copepod species in the Sevastopol Bay at least for the last 40 years. Features of biology of invader species, possible route of its invasion in the Black Sea, and conditions abetting successful introduction of the species are discussed.

Figure. Seasonal variation in *O. nana* (19760 and *O. brevicornis* (2006) abundance in the mouth of Sevastopol Bay



Spring and autumn (2006) mesozooplankton communities off south and western Iberia

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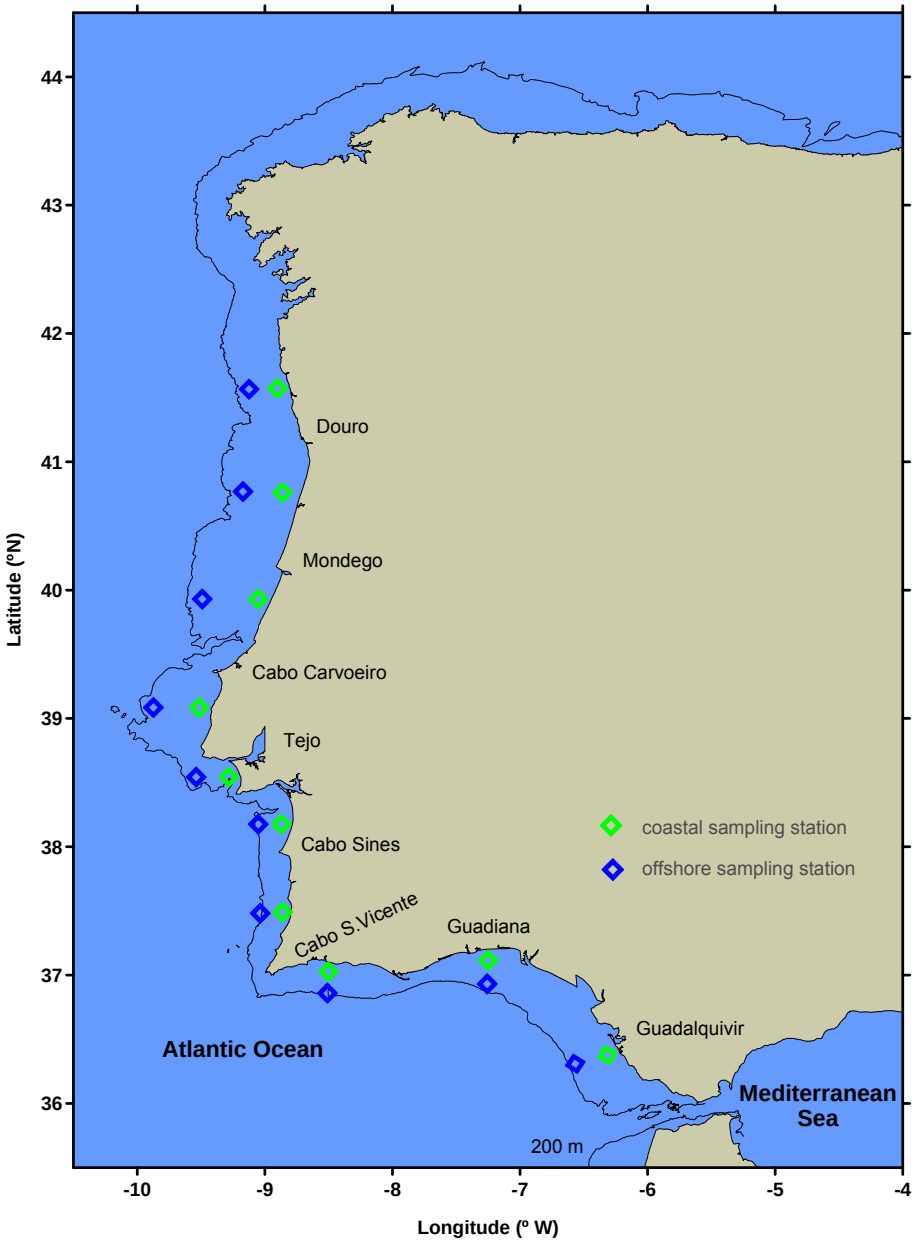
Zooplankton community analysis was conducted for spring (April-06) and autumn (November-06) surveying off the southern Atlantic and western coasts of the Iberian Peninsula. The samples were obtained with a 200 µm Bongo net by oblique towing over the entire water column. A total of 20 samples per survey were analysed from 10 *a priori* defined zones; within each zone a coastal and an outer shelf sample were considered. CTDF profiles were realized together with plankton hauls and surface maps of temperature, salinity and fluorescence were drawn from continuous CTF readings carried out during surveying, along transects perpendicular to the coast, for echo-sounding research.

Zooplankton biomass was higher during the spring period with peak values off the NW coast and the inner Gulf of Cadiz. For the autumn survey this pattern was not so marked. In number of individuals, all regions showed closer results, both for April (higher) and November (lower), but the NW had still the higher values; coastal samples presented, in general, higher abundances. Taxonomic identification of specimens produced a list of 60 *taxa* of which half were copepods. Its proportion varied from about 20% (April, coastal) to over 90% (November, offshore). During spring, in particular in the inshore region, a considerable percentage of meroplanktonic forms were found. A variety of *taxa* were there observed with emphasis on cirripedes and molluscs. Diversity was nevertheless usually higher in the offshore area.

Multivariate data ordination showed clear separation between the samples collected in spring and autumn and also contrast amongst coastal and offshore samples, the latter was more evident in November. Permanova analysis and subsequent pair wise tests, revealed significant differences between April and November samples and between the shore and offshore areas. Within surveys, the coastal and the outer shelf communities were also different and the shore and offshore species assemblage differ with season. The coastal community was dominated by the copepods *Acartia* sp., *Paracalanus* sp. and *Oithona* sp., especially during spring. *Clausocalanus* sp. and *Oncaea* sp. were abundant in outer shelf stations, during both seasons for the former and particularly in November for the latter. *Calanus carinatus*, common in the upwelling season, appeared in April. Other species, such as *Calanus helgolandicus* and *Pleuromamma* sp. were collected offshore. Despite the evidence of diverse hydrodynamic forcing within the study area and the presence of water masses of distinct characteristics, an association of physical patterns and the zooplankton communities was not apparent.

Study area showing sampling location



Mapping and modelling of winter ichthyoplankton distribution and associated zooplankton assemblages in the eastern English Channel and Southern North Sea

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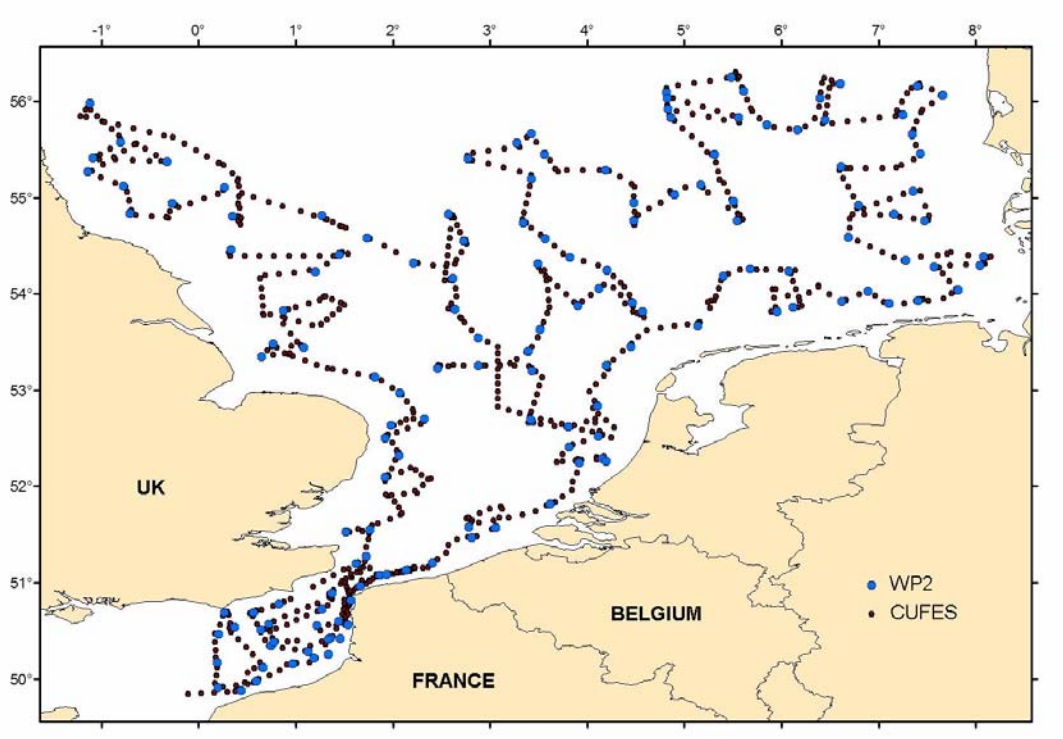
Since the late 90's, changes in abundance of important commercial fish species have been reported in the Channel and the North Sea due to climate changes and/or overexploitation of resources. The spatial distribution of pelagic fish eggs and larvae (ichthyoplankton) is often poorly described although these developmental stages are critical to fish population life cycle and sensitive to hydrological and trophic conditions. The actual fragility of some exploited fish stock leads to consider marine spawning grounds as "sensitive habitats" and studying their spatial extent and location has become essential for understanding and forecasting fisheries recruitment evolution and supporting ecosystem-based management.

This study aims to identify the location and characterize the winter spawning habitats in the Eastern English Channel and southern North Sea and to specify the importance of the environmental and trophic conditions (zooplankton assemblages) on the use of these habitats. The study of ichthyoplankton and associated zooplankton assemblages requires rigorous techniques ranging from sampling protocols, precise species identification methods, spatial analyses to habitat modelling statistics. Ichthyoplankton and zooplankton sampling was carried out at different stations of the study area using two WP2 nets coupled (200 and 500 µm mesh size) and a Methot Isaac Kidd trawl net (MIK, 1.6 mm). As a small scale sampling is more relevant to increase model accuracy the lack of sampling capability using traditional plankton nets has been resolved using a continuous underway fish egg sampler (CUFES). The CUFES operated continuously during the one month survey, providing real-time estimate of fish eggs abundance and their associated zooplankton assemblages at the pump depth (5 meters), every 30 minutes. Distribution mapping (using geostatistical analyses) and habitat modelling of various fish spawning areas were carried out using observed ichthyoplancton and zooplankton abundances and associated physical conditions such as temperature, salinity, seabed shear stress, chlorophyll *a* concentration and bottom sediment type. This enabled to quantify the importance of the environment on the use of these habitats and lead to a thorough knowledge of these winter spawning grounds based on rigorous scientific methods. Furthermore the use a new laboratory imaging system, the ZooScan, to automate identification of fish eggs and larvae will also be discussed in the context of reducing the time involved in sample identification.

Figure 1. Spatial location of CUFES and WP2 sampling points taken by the RV Thalassa from 25 January to 22 February 2008



Zooplankton distribution in Algarve coastal zone (North East Atlantic Ocean)

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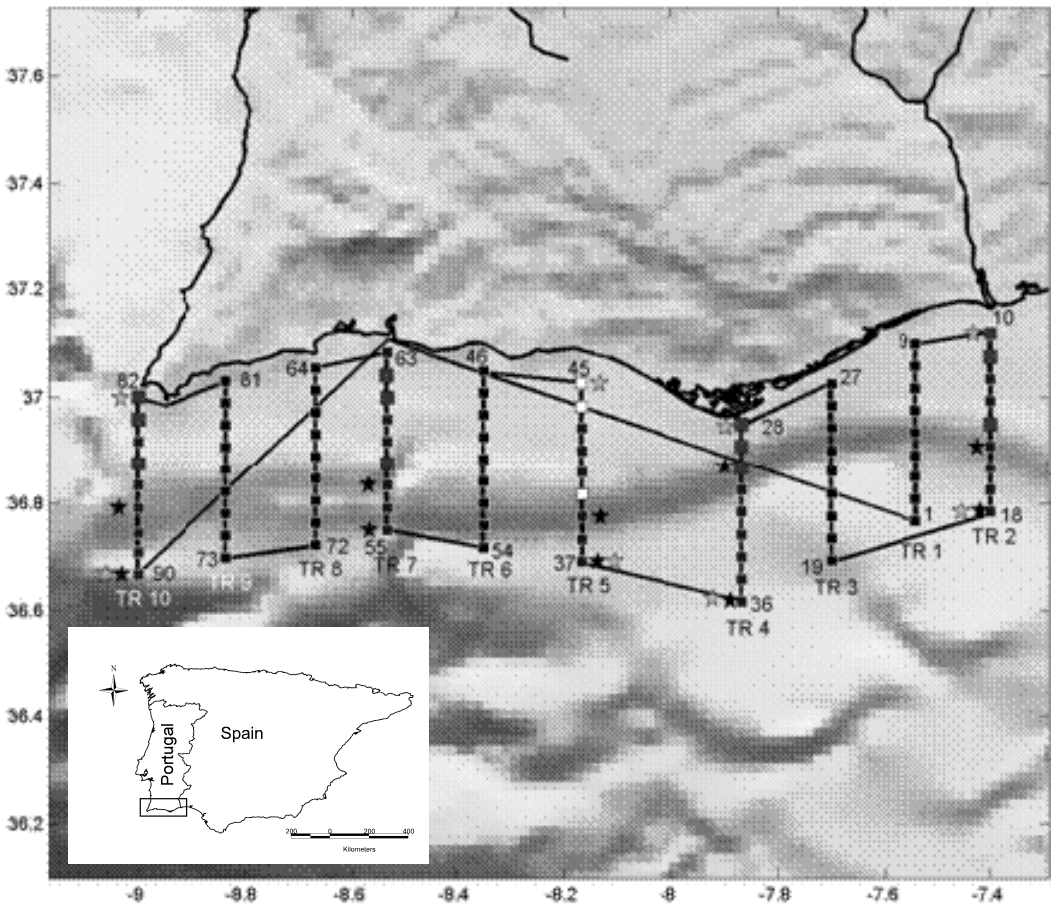
This work is a first attempt to characterize the zooplankton community in terms of abundance and diversity, in the Algarve coastal zone (North East Atlantic Ocean) as a first part of extensive research efforts to understand the dynamics of the west Gulf of Cadiz zooplanktonic assemblages in relation to environmental key factors, such as upwelling and river discharge. Samples were taken from stations off Algarve in the in the autumn time (1-6 October 2006). Transects from the shore were conducted to sample the zooplankton community off Algarve. Several transect were started at the mouths of major ecosystems influencing the Algarve coastal zone (eg. the Ria Formosa, a large coastal lagoon and the Guadiana River, second major river in the Gulf of Cadiz). For each sampled station, vertical trawls from 30 m depth to surface were made using a conical net (1.60 $\times$ 0.37 m, 150 μm mesh-size) type WP2. Samples were preserved in 4% buffered formaldehyde solution for taxonomic counts using a binocular microscope. During this sampling the community was dominated by copepods (54%) mainly *Calanus helgolandicus* and *Acartia clausi*, and by cladocerans (32%) mainly *Penilia* and *Podon*. Total zooplankton abundance show a common trend to decrease from nearshore stations to deep areas (>200 m) and from east to west coast, but diversity indices analysed showed inverse results. The importance registered of small sized species is probably due to the inherent particularity and variability associated with open coastal environments where several upwelling events are observed contributing to the frequent regeneration of food availability and then the renewing of the different populations of zooplankton. Interactions between winds, currents and rivers discharge of Guadiana may explain the high abundances values in central and east areas of Algarve coast. The influence of upwelling in Northwest Coast of Portugal, in the west coast of Algarve and the counter-current of Algarve may sustain the higher diversity of western area. This work enhance the knowledge of the zooplankton density and diversity on the Algarve coastal zone and on the Gulf of Cadiz which are of high importance to follow up the zooplankton through the Strait of Gibraltar, explaining a large part of the zooplankton dynamics in the western part of the Mediterranean Sea.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Zooplankton and phytoplankton monitoring in the North Sea, Nordic Seas, and Barents Sea – Sampling program and aims

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The Institute of Marine Research (IMR) is monitoring and studying zooplankton and phytoplankton in the North Sea, Nordic Seas and Barents Sea. The IMR monitoring program includes standard sections that are sampled several times each year, and basin-scale sampling at pre-selected periods of the year. By using a variety of sampling methods, an extensive horizontal and vertical coverage of the water masses is obtained. The combination of standard sections and basin-scale sampling allow us to study the seasonal cycle, abundance and distribution of plankton species. Aims of the sampling program are additionally to monitor biodiversity, introduction of species, harmful algal blooms and nitrification, and to study effects of climate change. The plankton monitoring gives important knowledge of fish food abundance and serve as input to the ecosystem approach to fisheries management. New developments in sampling techniques and sample analyses are constantly developed and implemented.

Appearance and (quasi) disappearance of copepod species in the Gulf of Trieste at the end of the 1980s, and comparisons with the North European Seas

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The Gulf of Trieste, in the North Adriatic Sea, hosts one of the longest (since 1970) mesozooplankton time-series in the Mediterranean Sea. This work addresses the interannual variability of copepod abundance over 36 years (1970-2005). Two periods have been identified, 1970-1987 and 1988-2005, which are characterized by ecosystem-wide changes. These changes include: the arrival of new species (*Diaixis pygmoea*), the establishment of previously rare species (*Oithona similis* and *Oithona nana*), and the rise (*Oncaea* spp., *Euterpina acutifrons, Paracalanus parvus*) or decline (*Pseudocalanus elongatus, Clausocalanus* spp.) of several species, all together resulting in a different composition of the copepod community between the two periods. Two concurrent phenomena can be hypothesized as underlying causes: a) the general warming (SST) of the area (about +0.5 °C overall, but +1°C in Summer and Fall), which can explain both the northerly extension of species previously found in the southern Adriatic (*Diaixis pygmoea*), and the reduction in cold water species abundance (*Pseudocalanus elongatus*, *Clausocalanus* spp); b) and a step change around 1987, that seems to have affected the entire Mediterranean surface circulation. The changes in copepod abundance seen above are accompanied by changes in the phenology in the majority (65%) of species, with predominantly forward shifts in the timing of the seasonal peak. In particular, the major summer/fall peak not only moves forward by 84 days in the cold water species *Pseudocalanus elongatus* over the 36 years studied, but basically vanishes, possibly explaining the 50% reduction of this species between the two periods. The abrupt decline of *Pseudocalanus elongatus,* however, is not limited to this area, but appears to be part of a larger (North Sea, Baltic Sea) pattern, of likely climatic origin.

Appearance or disappearance of species vs. global warming. Are the outbreaks timing of Pelagia noctiluca (Forskäl, 1771) getting more frequent in the Mediterranean basin?

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The holoplanktonic scyphomedusa *Pelagia noctiluca* (Forskäl, 1771) is known to reach cyclic outbreaks in the western Mediterranean Sea. Major outbreaks have been noticed during the years 1957–1959, 1969–1970, 1982–1984 and 1993–1995. The analysis of recent decades however suggest that the intensity, timing and distribution of *Pelagia noctiluca* populations outbreaks is changing under environment and/or climate factors.

In this work, we investigated decadal records of population density changes of *Pelagia noctiluca* size in different Mediterranean areas (Balearic Sea, Gulf of Tunis, North and South Adriatic Sea and Aegean Sea).

Three different patterns are observed: in the Aegean Sea, outbreaks occur repeatedly every 10 years and persisting 2 or 3 years; in the Balearic Sea this current pattern is observed but the cyclicity and the durability of the outbreaks is changing since 1997 with important outbreaks observed from 1998 to 2000; in Tunis Gulf and until 2007, the outbreaks periodicity is 11 – 12 years similar to that described by Goy et al (1989) for the West Mediterranean Sea. In addition, non – regular events are observed: in Tunis Gulf, the outbreaks appear generally in November and last till January. During the warmest years in 1999 and 2003, outbreaks events were detected over a whole Western Mediterranean Sea. The recent timing and installation of *Pelagia noctiluca,* observed from 2003 until 2008, is exceptional for the South Western Mediterranean basin with densities reaching 27,4 individual.m^{-3} in January 2005 in the Gulf of Tunis and 38,2 ind.m^{-3} in the same area in January 2008. The dynamic of outbreaks in the North and South Adriatic Sea is more difficult to understand. It seems that the periodicity of outbreaks is about 20 years, but in those areas when *Pelagia noctiluca* outbreaks, local hydrological and trophic conditions seems to be favourable to maintain high abundance of *Pelagia noctiluca* for period lasting for more than 10 years.

Such recent ecological changes observed in the timing and strenght of *Pelagia noctiluca* outbreaks appeared related to large – scale atmospheric fluctuations ultimately mediated by the ocean – atmosphere system playing out in the Atlantic Ocean.

Temporal variations in the zooplankton community at 4 European coastal stations: a 10 years time-series comparison

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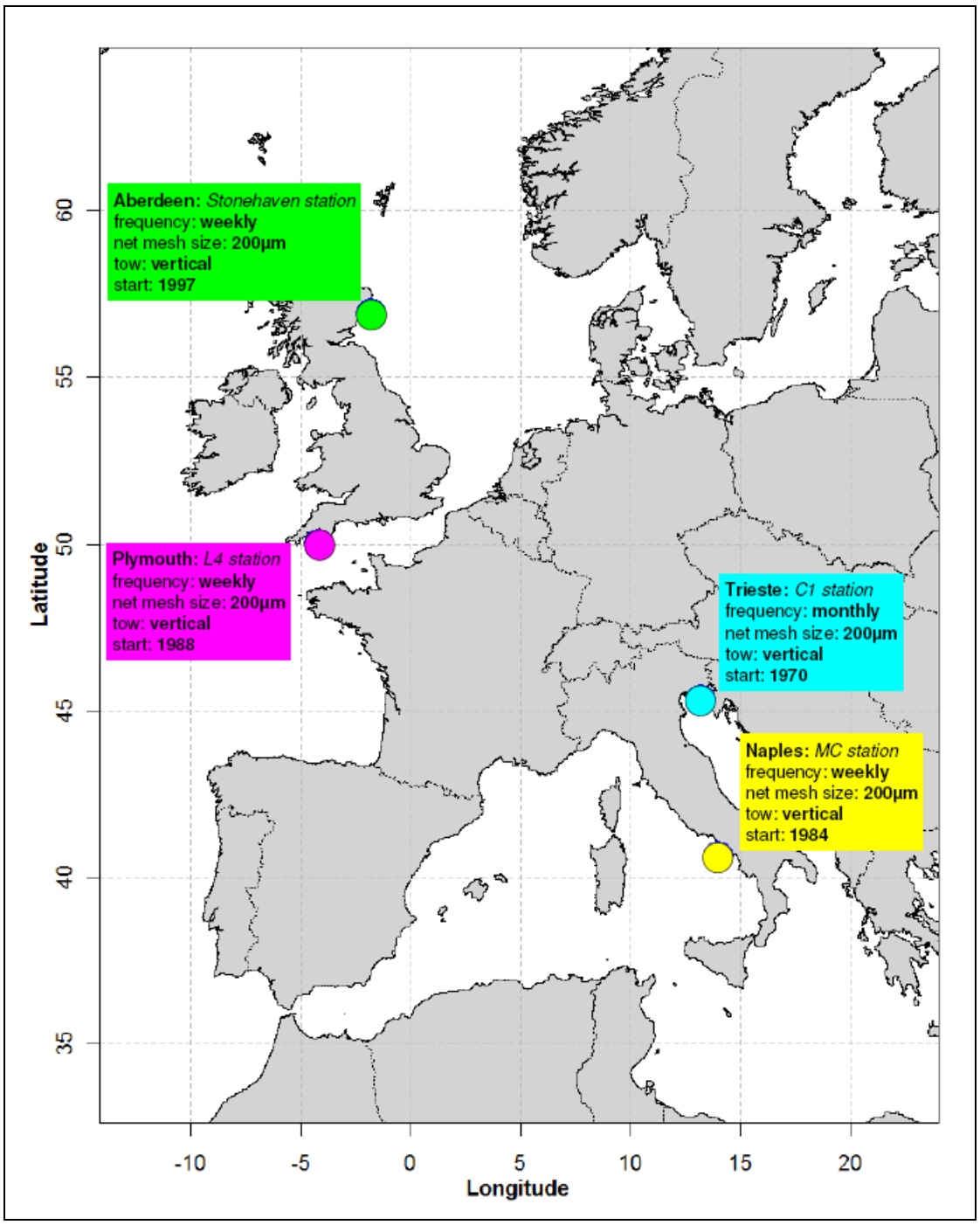
Temporal patterns and structures of zooplankton communities have been studied at four European coastal stations: Stonehaven (north-western North Sea near Aberdeen), Station L4 (Western Channel off Plymouth), Station MC (Tyrrhenian Sea off Naples), and Station C1 (Adriatic Sea off Trieste). These stations are all sampled with a vertical tow using a net of 200µm mesh size, which allows qualitative and quantitative comparisons of 10 years of monthly zooplankton abundances averages since 1997.

An original approach is used, which identifies for each station and year the most abundant species and groups. Together these contribute approximately to 80% of the total zooplankton abundance. Temporal analysis and statistical techniques are used to investigate seasonality, long-term trends, and relationships within the community and with environmental parameters and climate indices. Also, from calculations of diversity indices using a common taxonomic list, the four stations' community compositions and variations were compared.

This successful collaborative approach and common analysis provide a simultaneous overview of 10 years of zooplankton data at four different European marine coastal time-series sites alongside a comparative analysis and synthesis of zooplankton abundances.

Location of the four European coastal stations compared in this study



Decadal zooplankton changes in two different neritic areas of the Western Mediterranean: 1995-2004

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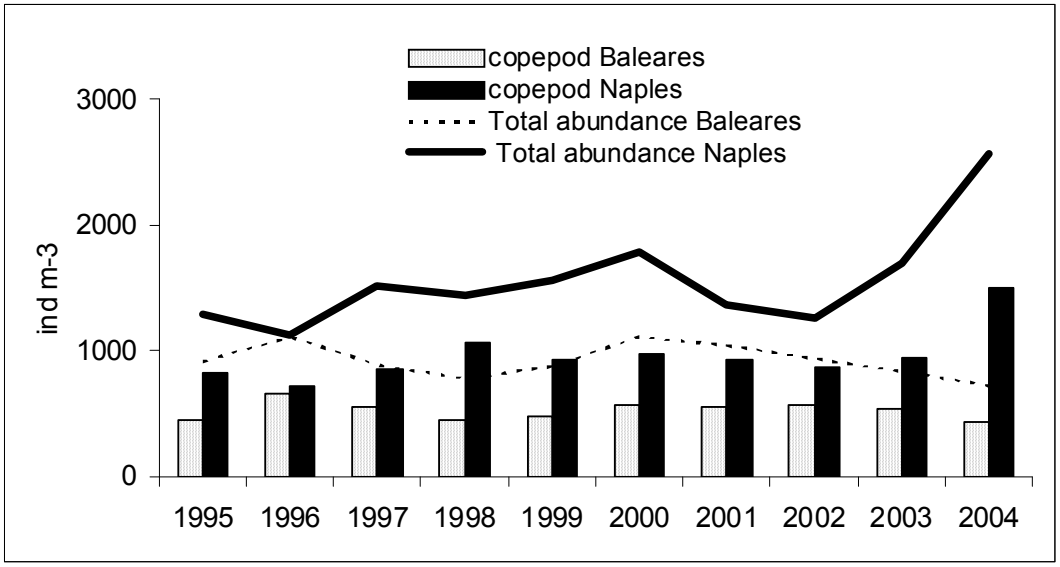
In order to find out overall signals of basin scale and possible relationships between climate changes and zooplankton, two different time-series of the Western Mediterranean were investigated and compared during a 10 year period spanning from January 1995 to December 2004. The two sampling sites, stn PA in the Balearic Sea and stn MC in the Gulf of Naples, are both located in neritic areas (75 m depth) but with different hydrographic features, the former more influenced by open waters and the latter by coastal ones. These features were reflected in the zooplankton biomass, abundance and structure, and related to the neighboring water masses.

During the considered decade, the temperature increased in Naples (mean =19.58ºC) but no trend was observed in the Balearic area (mean =17.74ºC) where, on the contrary, a significant increase in salinity was observed. High biodiversity was recorded at both sites, where zooplankton was dominated by small copepods, with a slightly different rank order among functional groups that reflect the different characteristics of the sites. *Clausocalanus, Oithona, Paracalanus parvus, Acartia clausi, Centropages typicus and Temora stylifera* were the most abundant species with local differences in their relative abundances. Among the other groups, cladocerans were more important in Naples (21%) than in Baleares (9%), while the reverse was true for appendicularians (9% and 18%, respectively). The interannual variability during the study indicated an opposite trend of total zooplankton (Figure 1), mainly due to the main species of copepods and cladocerans and in relation to the oligotrophic/eutrophic features of the sites. Although the period considered is short to investigate climate effects on a larger scale, the synchronies and/or differences in the patterns at the two sites seem to indicate that taxa respond differently to local and/or basin-scale signals. Therefore, the variability observed of these groups can be used as hydrological water masses indicators if we relate to other northern and southern sites in the WM. They may be linked to mechanisms acting over large spatial scales in the whole Mediterranean that can be used for further studies of global climatic change.

Figure 1. Total zooplankton and copepod abundance in Naples and Baleares site



Faecal pellet characteristics and production from mesozooplankton obtained in the Southern North Sea, Eastern and Western Mediterranean

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This work compares mesozooplankton faecal pellet characteristics (shape, volume, sinking rate, estimated density) and production rate from the North Sea (Southern Bight), the Western Mediterranean (Bay of Calvi) and the Eastern Mediterranean (North and South Aegean Sea). The period of study covers contrasting periods (during and outside spring bloom) in each area during 2-3 years (1996, 1997 in Southern Bight of the North Sea; 1997, 1999, 2000 in the Bay of Calvi and 1997, 2006 in the Aegean Sea). Values concern mesozooplankton mixed population (and also single copepod species in the case of the Aegean Sea). We discuss the spatial and temporal differences of faecal pellets characteristics and production in relationship with environmental parameters and their importance as a carbon and nitrogen flux.

Effect of three different nets on the estimates of size spectra, abundance and biovolume of mesozooplankton community in the Ligurian Sea

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Mesozooplankton comprises organisms with body size between 200 µm and 2 mm. This group has a wide diversity which implies a large variability in shape, population dynamics and individual behaviour. Accurate quantification of abundance and biomass of zooplankton is always prone to sampling errors, net dimensions being critical for further interpretation of plankton dynamics. It is of common knowledge that a 200 µm mesh-size net has an underestimation of abundance and biovolume of an important mesozooplankton fraction, those organisms slightly larger or corresponding to the WP2 mesh size (200 µm). In fact, a mesh size of about 50 µm is necessary to collect all mesozooplankton because a large part of living organisms < 400 µm would pass through the mesh size of 200 µm. In contrast, the efficient collection of large organisms requires the use of nets with larger opening diameter and mesh size (>500 µm). In order to quantify the impact of different nets (with different opening diameters and mesh sizes) on the total abundance, total biovolume, and size spectra, we compare the samples obtained using 3 different nets (mesh size of 200, 330 and 680 µm) quasi-simultaneously, during one year. All the samples have been analysed using the ZooScan imaging system in order to ensure standardised and homogeneous treatment.

Microzooplankton (ciliate and dinoflagellate) mediated food web in the oligotrophic Aegean Sea (Eastern Mediterranean)

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Ciliate and dinoflagellate community composition, abundance biomass and trophic mode were analysed at a North-South transect in the oligotrophic Aegean Sea (Eastern Mediterranean). Microzooplankton biomass, dominated by small forms <30μm, as well as mesozooplankton revealed a gradual decrease from North to South. The highest values were negatively correlated with salinity and recorded at the surface waters of the Black Sea Water influenced stations (North Eastern Aegean).

Microzooplankton carbon was at the lower range of values recorded from other ocean systems, indicating a possible strong top-down regulation by mesozooplankton grazers. Species richness and the presence of discrete functional groups such as mixotrophs and heterotrophs indicate that microzooplankton should be viewed as a metabolically active component in the pelagic ecosystem of the Aegean Sea. The trophic importance was assessed, by estimating the potential carbon flow from microzooplankton prey organisms to mesozooplankton predators, compared to the grazing impact of the latter on autotrophs.

Influence of alien species on the seasonal dynamics of zooplankton of the coastal areas of the Black Sea (Sevastopol Bay)

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The seasonal dynamics of abundance and species composition of copepods was studied at a coastal area of the Black Sea (Sevastopol Bay) from 1976 till 2006. The samples were taken monthly at a permanent station located at the entrance of the bay.

The important index of stability of the zooplankton community is the seasonal dynamics as adaptation to the seasonal unevenness of environment. Changes of parameters of environment caused by long-term climatic fluctuations and anthropogenic impact result in arrhythmic of seasonal dynamics. The accidental introduction of alien for the Black Sea species (predatory ctenophores *Mnemiopsis leidyi* and *Beroe ovata*, copepoda *Oithona brevicornis*) caused sharp changes and arrhythmic of seasonal abundance and structure of copepods community.

At present study seasonal succession of abundance and species composition of copepods were considered at 4 different periods:

1970s: seasonal dynamics was typical for coastal areas of the Black Sea. Principal factor regulating seasonal variations of copepods was temperature.

The early 1990s: intensive development of predatory ctenophora *M. leidyi* in the Black Sea led to considerable strengthening of grazing pressure on copepods community at the summer-autumn period. As a result, some indigenous species, including *Oithona nana* with its peak abundance during autumn, disappeared completely from the community. Principle factor regulating seasonal variations of copepods was *M. leidyi*

In the late 1990s cascade effects in mesozooplankton community caused by occasional introduction of particularized predator ctenophora *B. ovata* were revealed. *B. ovata* consumes *M. leidyi*, thus numbers of *M. leidyi* and period of its mass development and, after that, time of its influence on mesozooplankton community decreased, so, numbers of fodder zooplankton increased and seasonal dynamics of copepods changed.

In 2005 new species of copepod – *O. brevicornis* was registered in the Sevastopol Bay. At the end of the year its abundance was rather high. Intensive development of *O. brevicornis* population started at the end of August, 2006 and lasted until October, 2006 when the peak of the species abundance was registered. Thus, the species with pronounced autumn peak of development appeared in plankton of the Bay for the first time since 1989 -1990. This entailed new changes of seasonal dynamics of the copepods community.

Zooplankton abundance and community structure in the Algerian coasts and affinities with Atlantic fauna

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The Algerian coasts occupy most of the southern part of the western Mediterranean Sea. Due to its geographic characteristics, these coasts were dominated by the interaction between light waters of recent Atlantic origin and the resident denser waters. The major feature of its circulation is the Algerian Current (AC). Between 1° and 2° E, this current develops meanders creating small cyclonic and anticyclonic eddies which increase in size in the eastern direction (García-Olivares et al., 2007). The consequence of this mesoscale activity is the increase of mixing which modifies the Atlantic surface Water into Modified Atlantic Water (MAW). During the Mediprod VI cruise, the Algerian current runs as uniform band and does not show instability along the Algerian coast. Due to interactions with offshore Surface Mediterranean Water (SMW) the AC determines a sharp boundary in both physical and biological properties (Raimbault & al., 1993). In this case, the Atlantic inflow was responsible for a productive area (60 $mg.m^{-2}$ of integrated chlorophyll *a*) between 1°E and 4°E surrounded by two oligotrophic systems (Seridji & Hafferssas, 2000). One originates from the Atlantic flow, the other is typically Mediterranean. Four surveys aimed at locating and characterising the Algerian coasts were carried out along transects during 1990, 1998, 2000 and 2004 which the zooplankton distribution and biomass and of a large number of species were recorded. The results were described and contrasted in detail to other regions from the same biogeographical province published in literatures (Alboran Sea, Catalane Sea, Liguro-Provencal basin, east Atlantic Ocean from 10° N to 50° N including West African and Portuguese coasts). In the term of biodiversity records of marine copepods from the Mediterranean Sea contained 530 species. The majority (75%) were originally from Atlantic Ocean. At the Soutwestern Mediterranean basin, from Algerian coasts to Balearics Islands, the copepod fauna was represented by more than 200 taxa. By comparison, this inventory was lower than number (370) that found in East Atlantic Ocean (Razouls & al., 2005-2008).

On the other hand, the comparison made in this present study should be made with caution since it is difficult to compare the numerical data from different type of gear and the different dimension used, such as: number per haul, number per cube metre or per square metre. Therefore those results only can play a supporting role in establishing the effects of various biological parameters such the zones of primary production and chlorophyll maxima plus physical parameters, such as temperature, salinity on the distribution of the species and zooplankton biomass of ecosystems. At these areas, the zooplankton assemblages were defined by both the composition, relative abundance of taxa and biomass and characterize distinct hydrographical regimes. At the Algerian coasts, three groups of copepod species distributed along well defined environmental gradients characterising the distribution of physical variables and Chl *a* were revealed. The first group (*Paracalanus parvus, Clausocalanus arcuicornis, C. furcatus, Mesocalanus tenuicornis* and *Eucalanus elongatus*) was located in the frontal zone. The secound group occupied the Inshore MAW system, and was characterised by a typical neritic fauna (*Acartia clausi, Euterpina acutifrons, Oithona nana* and *Temora stylifera*). These two groups contain species which were originally advected from Atlantic Ocean

into the Algerian current. The third group, occupying the largest region along the sampling transects, may be able to cross the horizontal haline gradient located from the Inshore MAW to the Offshore SMW systems. On the other hand, there was a significant pattern between salinities values and the abundance of some other planktonic species. Cladocereans such as *Evadne* sp., Appendicularians like *Oikopleura* sp. and *Fritellaria* sp. were more abundant in the inshore MAW area (less saline waters < 36.6). Furthermore, the offshore SMW locations (saltier waters > 36.9) were characterised by the dominance of Siphonophores *(Abylopsis tetragona, Eudoxoides spiralis)* and Jellyfish *(Rhopalonema velatum).* The substantial increase in abundances of the total zooplankton community, in particular of some copepod species *(Paracalanus parvus, Clausocalanus sp.)* was also found at Catalane front (Calbert & al., 1996). In the Almeria-Oran front (east of the Alboran Sea, Southwestern Mediterranean Sea) zooplankton biomass was correlated to chlorophyll abundance (Youssara & Gaudy, 2001). The values are higher in the hydrodynamic structures related to the frontal region (Atlantic jet and anticyclonic gyre) than in surrounding Mediterranean oligotrophic waters. Copepods constitute the main of taxon, and among them Clausocalanus and *Oithona* spp. the most important species. In the Liguro-Provencal basin (Northwestern Mediterranean Sea) a thermohaline coastal front separates the coastal area from a central divergence zone. In the frontal area a higher total mesozooplancton and biomass were recorded (Boucher & al., 1987). The juveniles of *Calanus helgolandicus, Centropages typicus* and *Euchirella rostrata* account for the increasing numerical values. Also, a high density of Salps (*Salpa fusiormis*) was observed in the upper 50 m (Gorsky & al., 1991). Similarly, along transects in the north east Atlantic Ocean (48°N – 52°N) there was a marked latitudinal gradient in the distribution of abundance and biomass of zooplankton (Clark & al., 2001). The notable features in the distributions were peaks in both numerical abundance and standing stock in the region. The peaks were closely associated with frontal system. This latter separated northern and southern regions which were hydrographically distinct. The quantitative values were approximately 5 – 10 times greater in the productive system than the average of those obtained in northern and southern locations. The zooplankton assemblages was dominated respectively by herbivorous / omnivorous *(Calanus, Centropages, Pleuromamma* and Cladocera) and carnivorous (Euchaeta and Chaetognatha) taxa. In the same order of idea, at the upwelling areas of Portuguese and west African coasts (around 40°N and 10°N – 30°N, respectively) these areas had significantly higher concentrations in the top 200 m (Boucher, 1987, Piontkovski & al., 2003). Here a large number of herbivorous / omnivorous species of copepods *(Clausocalanus furcatus, C. minor, C. arcuicornis, Acartia clausi, Centropages typicus, Pleuromamma piseki, P. robusta)* and some groups of macrozooplankton (Siphophores, Tunicates and Euphosiids) were found. The gelatinous plankton contributed up to 65% of the species diversity (Piontkovski & al., 2003).

In conclusion, the general results of this zooplankton comparison between Mediterranean Sea and Atlantic Ocean revealed evidence for a well defined spatial structure which closely responds to the major hydrographical features in these areas.

Keywords: Algerian coasts; East Atlantic Ocean, Macrozooplankton, Copepod abundances, Pelagic environment

Zooplankton time series analyses in the English Channel: potential for regional multimetric food web indices

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Ongoing zooplankton research at the Plymouth Marine Laboratory (UK) has established a time series of zooplankton species since 1988 at L4, a coastal station off Plymouth. A data-set has been assembled in the format of an atlas where each taxonomic category is described by its (i) variations in abundance, (ii) variations in the annual average, (iii) average annual cycle, and (iv) variations in seasonality. Parameters additionally measured on a weekly basis include total and size-fractionated chlorophyll, total and size-fractionated particulate CHN and phytoplankton species composition and biomass since 1992. Copepod egg production data, particularly of Calanus helgolandicus, are also available for several years as well as experimental results on this copepod's diet and reproduction. Together with a time series for a range of physical and chemical, including vertical temperature and salinity profiles, this data set has been recently placed into the context of an integrated Western Channel Observatory (www.westernchannelobservatory.org). The WCO is an ideal location as it has a history of more than 100 years of in situ sampling, represents both oceanic and coastal environments within 30 km of PML, and will feed into ecosystem models (e.g. ERSEM) to assess changes in the marine environment.

Similarly, the French IFREMER has established a monthly time series of zooplankton species since 1975 at Gravelines, a coastal Station on the French coast of the Dover straits. This survey is done in the framework of a research programme designed to monitor the effects of nuclear power plants on the environment and living resources and includes the following parameters measured on a weekly basis: temperature and salinity, ammonium, nitrate, chlorophyl a and phaeopigment concentrations, as well as phytoplankton abundance. While phytoplankton data are already available in the IFREMER database Quadrige (http://www.ifremer.fr/delao/francais/valorisation/quadrige/) zooplankton species abundance will be added to this database soon.

By integrating these quantitative *in situ* measurements at both sides of the Channel, phenologies and their dependence on environ mental factors will elucidate changes in the planktonic food web and higher trophic levels. Through envisioned collaborations along the British and French coasts for a multidisciplinary ecosystem-based approach that will encompass the whole English Channel (CHARM project: Channel integrated Approach for marine Resource Management), such analyses provide a resource to develop a comprehensive plankton inventory of the English Channel. Such a database will provide a basis for the development of multimetric food web indices at the gateway between the North Sea and the open North Atlantic.

Fig. 1: Sampling stations of two plankton time series along the coasts of the western and eastern English Channel

Long-term change in zooplankton community structure and function: a case study from the North Pacific Subtropical Gyre

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We used species-level analyses and compound-specific stable isotope methods (CSIA) to assess multi-year change in the structure and functioning of the zooplankton community at an oligotrophic open-ocean time-series site, Station ALOHA (22.45°N, 158°W). Mesozooplankton biomass and abundance in this region, the North Pacific Subtropical Gyre (NPSG), increased significantly from 1994 to 2005. Our goal was to assess zooplankton community variability at the species level and to determine if these changes were driven by fluctuations in nitrogen (N) source. Our species-level analyses indicate that the increase in zooplankton biomass was driven by NPSG system dominants, i.e., small cyclopoid copepods and calanoid copepods from the Families Clausocalanidae, Paracalanidae and Mecynoceridae. Furthermore, CSIA indicated that the NPSG zooplankton community is supported both by biological fixation of atmospheric N_2 (45%) and entrainment of NO_3^- from the main thermocline (55%). However nitrogen isotopic compositions of several copepod species increased significantly from 1997 through the winter of 2000, indicating that entrainment of NO_3^- was enhanced over this time period. Based on the zooplankton nitrogen isotope time-series and the concurrent changes in plankton community structure, we conclude that enhanced NO_3^- entrainment may have initiated a shift the NPSG ecosystem in 1998.

Interannual variability of the surface zooplankton of the Bay of Calvi (Corsica)

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In the oligotrophic Bay of Calvi, Corsica (Ligurian Sea), the seasonal dynamics of surface zooplankton communities is studied from 1979. Zooplankton time series for the last three decades emphasize that, as a specific characteristic of the Bay of Calvi, a plurimodal plankton bloom occurs generally between January and April with a period of maximum varying from one year to another. Later in the season, the plankton biomass remains very low from May to December, generally without autumn bloom.

A seasonal succession of characteristic plankton assemblages is observed: e.g. 1) late winter and early spring assemblages with large diatoms, radiolarians, tintinnids and euphausiids; 2) spring assemblages with small diatoms and herbivorous copepods; 3) late spring and summer assemblages dominated by phytoflagellates and cyanobacteria, ciliates, omnivorous and carnivorous copepods, salps and appendicularians; 4) late summer assemblages, often characterized by mixotrophic components.

The spring bloom does not occur each year, depending on minimal value of nutrient supply. When it occurs, it concerns only large diatoms and metazooplankton. Smaller phytoplankton and microzooplankton present less interannual variability.

An important interannual variability of zooplankton assemblages and food webs is observed, and seems to be controlled more by hydro-climatic changes than by anthropogenic perturbations.

As a general rule, the organisms size decreases from late winter to autumn and the diversity increases. This succession corresponds to the ecosystem functional response to the decrease of nutrient availability.

The times-series results enlighten that main factors controlling the specificities of the surface plankton ecosystem of the Bay of Calvi are the typical strong oligotrophy, the wind stress variability, the vicinity of Liguro-Provençal Front, the interactions with Posidonia seagrass and the winter climate variability.

Because of its oligotrophic status and sensitivity to climate forcing, the plankton ecosystem of the Bay of Calvi is at the limit between a state characteristic of temperate ecosystem functioning and a state characteristic of tropical ecosystem functioning.

The zooplankton from the golf of Annaba (SW Mediterranean) submitted to an estuary plume

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The coastal zooplankton from the golf of Annaba has been studied seasonally from vertical tows taken in 8 stations differently submitted to the Mafrag estuary plume. Simultaneously, nutrient and physico-chemical parameters were measured. In the opening period of the estuary, the chemical enrichments conditions support a large stock of phytoplankton biomass in particular in spring in contrast to the closed period. Concentrations of dissolved inorganic nitrogen varied between 3 and 68 µM and for phosphate values were about 0,7- 6 µM.

The average phytoplankton biomass reaches 1-2 $mg.m^{-3}$ and those of particulate organic carbon was about 2-4 $mg.l^{-1}$. The zooplankton was found highly varied and dense in the period of exchange with the estuary in which abundances were in average close to 1 700 $ind.m^{-3}$. During this period, Copepods were very dominant (44,8 - 94,5 %) through the development of *Clausocalanusfurcatus*, and *Oithona helgolandica*. The closing period, is mostly characterized by the dominance of *Paracalanus indicus, Oncaea venusta* and *Centropages typicus* with low density values regarding the abundance in the cold period. Moreover, the copepods were highly diversified but among 75 copepod species, only 6 neritic forms constitute the basic community. The rest of taxa have different affinities to oceanic waters (55 species), deep (15 species) and Atlantic (12 species).

Terrestrial run-off and hydrography influence trophic relationships and pelagic food web structure in the central- and southern North Sea

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The North Sea receives nutrients via atmospheric input, Atlantic inflow, and from the catchment areas of surrounding countries. Uncertainty exists, to what extent terrestrial run-off affects coastal and off-shore plankton communities. Stable isotope analysis ($\delta^{13}C$ and $\delta^{15}N$) has been used to identify trophic relationships in aquatic ecosystems, whereas $\delta^{13}C$ measurements of lipid biomarker profiles have only recently been established to characterize energy sources, composition, and fate of organic matter (OM) from primary producers to consumers. Therefore, when combined $\delta^{13}C$ and $\delta^{15}N$ allow description of trophic relationships, while fatty acids allow assessment of food preferences and OM transfer.

To estimate the effects of terrestrial run-off and the susceptibility to climate change, particulate organic matter (POM) and dominant zooplankton (*Calanus* spp., *Centropages typicus*, *Sagitta* spp.) have been collected over an annual cycle at three hydrographically distinct sites in the central- and southern North Sea: the Oyster Ground (OG), north of the Dogger Bank (DB), and at the Sean Gas Fields (SG). Bulk isotope ratios and $\delta^{13}C$ of phospholipid-derived fatty acids (PLFA) were measured via IRMS and GC-c-IRMS, respectively.

In February POM total PLFA content was lowest at the SG and highest at the OG. Compared to the SG, a larger variety of typical bacterial PLFA was found at the OG and DB sites. The total PLFA content increased during succession of the spring bloom to maximum values at the OG in May. At the same time total copepod lipid content decreased. *Sagitta* spp. collected at the OG in May contained the highest amount of PLFA and the widest spectrum of bacterial PFLA. Zooplankton PFLA $\delta^{13}C$ were generally highest at the SB and lowest at the DB. Overall *C. finmarchicus* showed a smaller variety of typical bacterial PLFA and a smaller variation in $\delta^{15}N$ compared to *C. helgolandicus*. Microscope counts of micro- and mesozooplankton provide further evidence of multivorous food webs at the OG and SG, including the microbial food web.

Different stable isotope ratios of POM and zooplankton between the southern and central North Sea sites suggest that pelagic food webs in the southern Bight may be influenced by terrestrial run-off, whereas food webs in the central North Sea are influenced more by Atlantic influences and internal nutrient regeneration. *Sagitta* spp. likely contributes to a large extent to lipid C flux to the benthic domain. Wider food ranges (e.g. *C. helgolandicus*) may provide a competitive advantage when microbial food webs are active/dominant.

The use of Hardy Continuous Plankton Recorder in the Mediterranean: interested sampling method for implementing zooplankton atlas project

Topic: Harmonization of methods, overview of experimental work

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The standardization of Zooplankton in sampling and analysis methods is very important for comparison Zooplankton Ecology in two of different large scale marine regions. In fact the harmonization of the methods is of great importance to conceive good comparative results. The use of different classical plankton nets and sampling gears depend on the objective of the research project and on the prevailing hydrological and biological conditions of each investigated area. However, although the North Atlantic and the Mediterranean are adjacent marine environments, there is big difference in the ecology of the two seas, in spite of certain common resemblances. In order to compare the Ecology of Zooplankton between the North Atlantic and the Mediterranean, it is necessary to use the same sampling methods to facilitate the comparison. The Continuous Plankton Recorder (CPR), new undulating model is very efficient to study the qualitative and quantitative distribution of zooplankton species on a large scale. This high speed sampler which was used in the North Atlantic since the fifties has produced a good result as Zooplankton Atlas of the North Atlantic. We suggest the use of this the CPR in the Mediterranean within the framework of a project to be implemented in coordination with the team of British researchers using this sampler at Plymouth Laboratory.
The project consists of the establishment of permanent sampling routes through the use of the C.P.R by commercial boats or tourist ships sailing between the west and the eastern Mediterranean, or from the south to the north Mediterranean coasts. This project should be organized by specialized teams in the major Mediterranean harbour cities in fixed routes such as Marseille-Alexandria, or Naples-Beirut, Alger-Nice, Pireaus-Barcelone, etc.

Such a project has to be studied and agreed with Mediterranean teams and Plymouth and proposed for support by sponsored and concerned organization such as the CIESM, the ICES or the EU in Brussels.

Keywords: Zooplankton Ecology, Methodology, Sampling, Distribution, Mediterranean.

Plankton alien species of indo-pacific origin in Levantine basin: is it an index of tropicalization of the area or a sequence of global warming?

Topic: Appearance or disappearance of species vs global warming

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The Lebanese Basin of the Eastern Mediterranean, including the Lebanese seawaters is highly oligotrophic water body, the most impoverished world's oceans. Seawater temperature and salinity averages are the highest in the entire Mediterranean reaching a maximum of 30ºC and 39.75‰ during summer. The opening of Suez Canal in 1869, constitute a link and hydrological barrier between the Red Sea and the Mediterranean; it enhances migration of marine organisms northward. This continuous phenomenon has been increased after the construction of Aswan high dam which regulates the flood of the Nile. Multi-decadal oceanographic cruises in coastal and neritic Lebanese seawaters during the last four decades (1965-2005) have produced a list of introduced exotic species of Eritrean and Indo-Pacific origin.

Monthly and seasonally cruises were conducted since 1965 at 46 inshore and offshore stations along the Lebanese coast (33º42'-34º28'N and 35º27'-35º31'E), providing long-time series of hydro-climatic data and plankton samples, including temperature, salinity, dissolved oxygen, PH, nitrate, phosphate, chlorophyll, phytoplankton and zooplankton.

Among a thousand of found zooplankton species, hundred of introduced Indo-Pacific and Eritrean origin invader species were identified, many of them considered as aliens. The majority of them have have established permanent populations and stable ecological niche in the Levantine coastal waters. Few species have succeeded to transgress toward the western Mediterranean regions. Some species of temperate Atlantic succeed to reach our coast on the behalf of the surface current entering by Gibraltar strait to reach Levantine waters; they are considered as hydrological indicators of Atlantic current.

The number of alien species has been increased since the opening of Suez Canal in 1869 and augmented after the construction of Aswan high dam. Every year more introduced species are recorded to be added to the list of aliens in the area in keeping impact on the biodiversity of the plankton community.

These hydro-biological changes occurring in the Levantine Basin have created a certain "Tropicalization"of the seawaters and traduced by the close resemblances of hydrological conditions between the Levantine Basin and those of the Red Sea and by the large amount of common species found in the both marine environments. The increasing migration process is due not only to the man-made activities namely the opening of Suez Canal and the construction of Aswan High Dam, but also to the climate change inducing global warming noticed during our survey in the last four decades.

Muggiaea atlantica: an Atlantic indicator of hydroclimatic changes in the Mediterranean

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The geographical expansion of the calycophoran siphonophores (Cnidaria) *Muggiaea atlantica* recorded by long-term monitoring in the Ligurian Sea and Adriatic Sea suggests that this species is able to track hydroclimatic changes in the Mediterranean basin. The appearance and increasing dominance of the atlantic *M. atlantica* in comparison with the mediterranean co-generic *M. kochi* has been related to low water temperatures recorded in the 1980s in the Ligurian Sea and in the middle 1990s in the Adriatic Sea. Such hydrological changes were associated to large-scale hydroclimatic fluctuations, i.e. the North Atlantic Oscillation (NAO) and Eastern Mediterranean Transient (EMT).

M. atlantica, although being a species typical of cold atlantic waters, is able to survive and reproduce efficiently also at the temperatures characteristic of the north-western Mediterranean and Adriatic, where is now established and one of the main gelatinous carnivorous during spring-summer.

The plankton monitoring in the Bay of Tunis indicates only occasional records of *M. atlantica.* However, recent data in the Bay of Bizerte which is more influenced by the offshore atlantic circulation, show relatively high abundance of *M. atlantica* in the winter period. Overall *M. kochi* dominate in the tunisian region, which seems to have environmental characteristics not suitable for *M. atlantica* to establish.

The results of this comparative study indicate that it is fundamental taking into account the different sub-regions dynamics when investigating the effect of climate change in the Mediterranean basin. For this, it is necessary to expand the plankton monitoring, including inshore and offshore waters in the main sub-systems characteristic of the Mediterranean Sea.

Design and performance of a new macro-plankton trawl in combination with a multiple cod-end system

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Macro-zooplankton species of marine ecosystems are generally under represented in standard zooplankton nets probably due to avoidance in the entrance to the sampling gear. The use of pelagic fish trawls for sampling of these organisms is also uncertain due to the problem of defining the effective mouth opening of trawls with progressively decreasing mesh size towards the cod-end. Our objective was to design a trawl for representative sampling of macro-zooplankton, which could be used in combination with a modified multiple cod-end (MULTISAMPLER) to obtain depth stratified samples.

The new macro-zooplankton trawl has a moth opening of 6x6 m, a total length of about 50 m, and a mesh size of 6 mm (inside stretched length) from the entrance of the trawl to the cod-end. It can be operated from a vessel rigged for standard pelagic trawling and can be used in combination with the same trawl doors that is used for pelagic fish trawls. The remotely operated modified MULTISAMPLER carries five cod-ends with the same mesh size as the trawl, and allows five independent depths to be sampled during one haul. Results on performance and catch characteristics of the trawl during a series of test hauls are presented.

Climate and jellyfish outbreaks in the Mediterranean Sea

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Jellyfish are critical components of marine ecosystems. Whether variations in their population size are driven by human- or climate-mediated processes is a matter for current debate and a challenge in biological oceanography. Here we gathered pluriannual information of Mediterranean jellyfish to synthesize basin scale trends of jellyfish outbreaks, their strength and frequency, over the last decades, and to quantify their potential link with Hemispheric-wide climate forcing. Through a downscaling and meta-analysis approach we quantified leading interactions between Hemispheric-wide climatic modes and regional atmospheric indices across the Mediterranean basin and tested whether the temporal dynamics of jellyfish outbreaks are consistent with the climate-related environmental changes the Mediterranea Sea undergone during the last decades. We provide quantitative evidence that jellyfish populations integrate climate related changes in the Mediterranean basin, with close correlations between climate variations and their outbreaks dynamics. Also, we identified threshold values from which climate effects on jellyfish become noticeable, suggesting that the climate – jellyfish relationship raises according to the strength of climate forcing. Our results support the occurrence of short time windows, during which jellyfish population may be more sensitive to climate variations, and environmental conditions during such periods may substantially increase or impair jellyfish outbreaks. The possibility of using the jellyfish outbreak dynamics for assessing pelagic environmental changes in marine ecosystems is considered.

Black Sea ecosystem has been basically recovered as inferred from distribution of gelatinous organisms in the southern region

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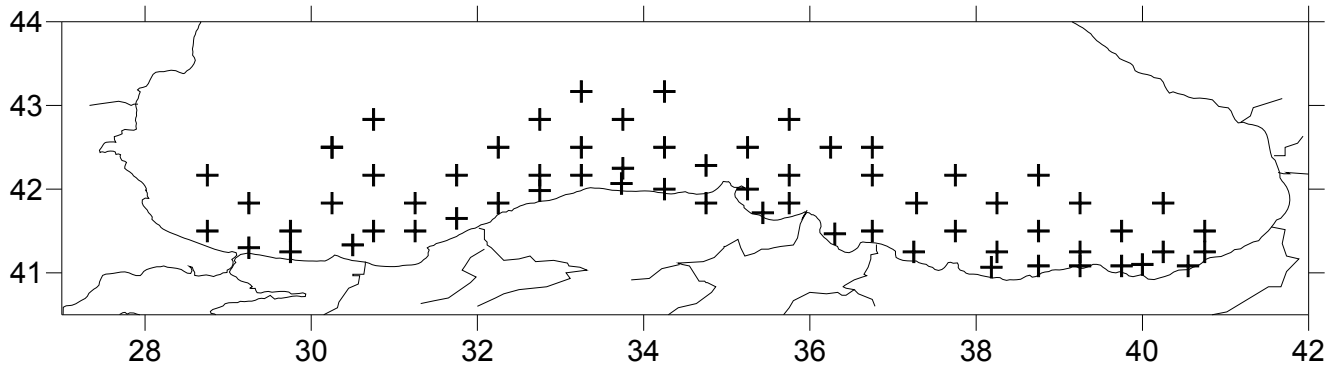
The horizontal distribution, abundance, and biomass of gelatinous zooplankton (*B. ovata*, *M. leidyi*, *P. pileus* and *A. aurita*) were determined in the southern Black Sea studies during three 18-21 day cruises on the "R/V Bilim" of Institute of Marine Sciences (IMS-METU) in June, October 2006 and May 2007 (Figure 1). Ctenophores and jellyfish were collected with a Hensen net (0.7 m net diameter, 300 µm mesh) at 65, 72, and 93 stations in June, October 2006 and May 2007, respectively. *B. ovata* was observed only October 2006 while the rest of the species were recorded all the sampling months. The average number of individuals of *Mnemiopsis* was significantly higher in October than in June and May whereas in June the average biomass (52 g m^{-2}) being double of those in the other months. The mean abundance and biomass of *Pleurobrachia* and *Aurelia* were significantly lower in October when *Beroe* was observed, than in June and May. An average biomass of about 9-35 g m^{-2} was measured for all species in October, about 5-10 folds of that of June (50-400 g m^{-2}) and May (28-300 g m^{-2}). *Mnemiopsis* and *Beroe* were least numerous (1-7 ind m^{-2}, 1.4 ind m^{-2}, respectively), with highest numbers (139-274 ind m^{-2}) belonging to *Pleurobrachia*.

Statistical analyses showed that hand-balance was still relevant device to measure the wet weight of gelatinous organisms as compared with those by e-balance, except of biomasses of *Pleurobrachia* at a critical p value (p=0.06). Aboral length of *Pleurobrachia* must be measured in a precision of $1/10^{th}$ of millimeter. Length-weight equations were not an appropriate converter from lengths to biomass quantification for the gelatinous organism due to growth rates variable depending on the condition of the seas, e.g. water temperature, food availability as occurred in an experience of the Black Sea. Regardless of climatic change and fishing pressure and predation as in an example of the bonito on the anchovy in 2005, the Black Sea ecosystem has been radically undertaken bottom-up and top-down control with decreasing eutrophication and removal of *Mnemiopsis*' deep impact on mesozooplankton by a new invader *Beroe* blooming once a year. Forage mesozooplankton was first affected in fast response to the periodic *Mnemiopsis* outbreaks which occasionally reflecting next anchovy catches as well as *Aurelia* population in the Black Sea whereas *Pleurobrachia* was one seemingly least affected. *Mnemiopsis* and *Pleurobrachia* were targeted food for *Beroe*. Ecosystem of the Black Sea has been experienced with A Fall and Spring life like a fluctuating that of a human being as stated in a paper "Fall and Arise of the Black Sea Ecosystem" by Kideys (2002).

Figure 1: Sampling stations for distributions of the gelatinous organisms in June, October 2006 and May 2007.



Structure of zooplankton communities at 3 contrasting sites in the North Sea

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Abstract

Zooplankton community structure was examined at 3 ecohydrodynamically distinct sites in the North Sea: in the southern Bight (SB), at the Oyster Grounds (OG) and north of the Dogger Bank (ND). Cruises took place in winter, spring and autumn 2007. Samples were collected using vertically hauled ring-nets with different mesh sizes: 50µm, 200µm, 270µm and 500µm. Preserved samples were split: (1) to estimate crustacean biomass using a chitin assay (Harris *et al*. 2000), and (2) for microscope analysis. Larger copepods were counted by species and developmental stage; most other taxa were identified to genus. Species were assigned to broad functional groups: calanoid, cyclopoid and harpacticoid. Calanoid copepods were categorised as large or small calanoids. Large calanoids included the adults and juveniles of species of *Calanus*, *Metridia*, *Euchaeta*, *Labidocera* and *Anomalocera*. Small calanoids included the adults and juveniles of species of *Acartia*, *Candacea*, *Centropages*, *Isias*, *Microcalanus*, *Paracalanus*, *Pseudocalanus* and *Temora*.

Estimates of biomass were highest (2.5 g C m^{-2}) at the ND site in May. Similar results were obtained from the 200µm, 270µm and 500µm nets. At the SB and OG sites, relatively high biomass values were obtained from the 50µm net samples. Average biomass ratios (50:200µm nets) showed that biomass in the smaller size fraction was approximately 4 times higher than in the ≥ 200µm fraction at the SB and 2 times higher at the OG. In terms of abundances, copepods dominated the zooplankton community at all sites. Small calanoids dominated the 200µm net samples at all sites during all cruises (up to 1.2 x 10^5 individuals m^{-2}), except at the ND site in April. At the ND, large calanoid copepods contributed 50 % of total copepod numbers in April (up to 1.5 x 10^5 individuals m^{-2}), approximately 1 month after the spring phytoplankton bloom. Results of this study show that small calanoids are an important component of the zooplankton community at the 3 study sites in the North Sea, including the site north of the Dogger Bank. Also, that the use of large-mesh-sized nets (≥ 270µm) may result in underestimates of crustacean biomass and copepod abundance.

Reference: Harris, R., Wiebe, P., Lenz, J., Skjoldal, H.R., Huntley, M. 2000. ICES Zooplankton Methodology Manual. Academic Press, London. 684pp.

Niche separation of *Clausocalanus* species in the Mediterranean sea and in the Atlantic Ocean

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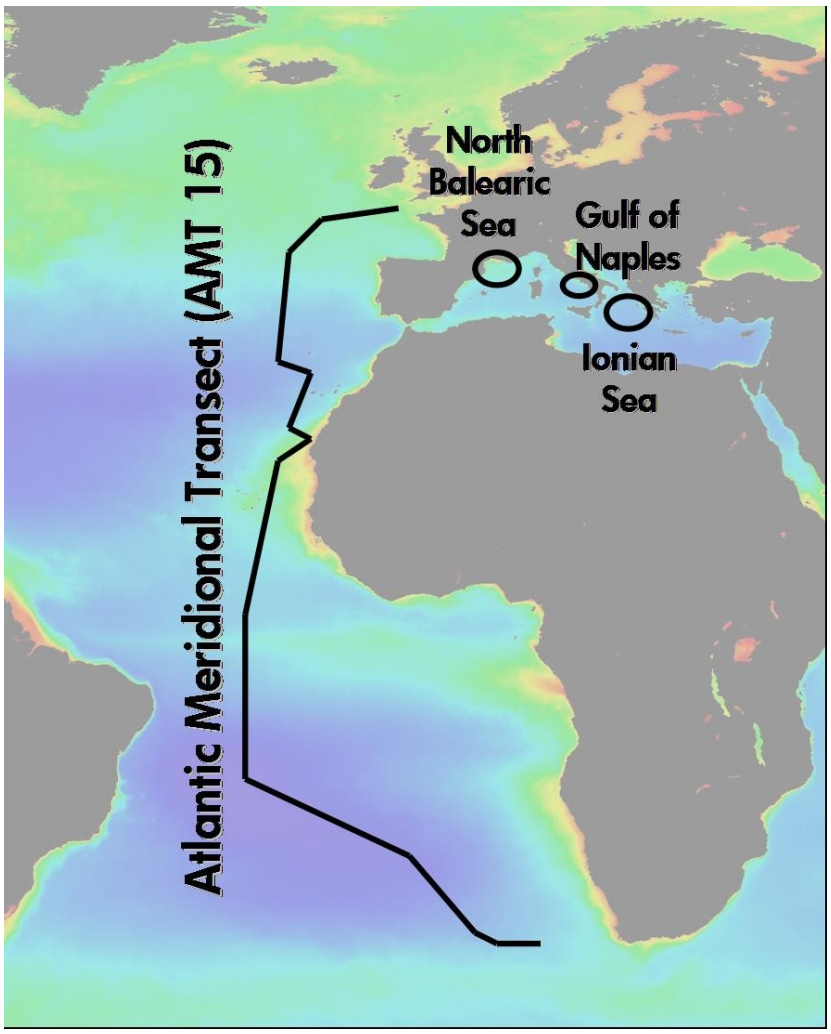
The epipelagic copepod genus *Clausocalanus* is numerically important in the oceans over a wide range of latitudinal and trophic conditions but difficulties in taxonomic identification at the species level have limited the information about the quantitative distribution of its numerous congeners. Samples collected with 200 µm mesh nets during various surveys conducted in the last years in very different marine regions both in the Mediterranean Sea and in the Atlantic Ocean allowed us to investigate the distribution of eight *Clausocalanus* species at different temporal and spatial scales in order to characterize their niches. The seasonal and vertical distributions of *Clausocalanus* species in epipelagic oligotrophic waters were analysed in 2002 at an offshore site (Stn L20) in the open Gulf of Naples (Tyrrhenian Sea, Western Mediterranean) collecting samples at discrete layers. The annual cycle in the upper 50m was compared with the annual cycle observed at the coastal eutrophic Stn MC (site of a long-term zooplankton time-series since 1984). Such comparison allowed the study of the seasonal distribution of *Clausocalanus* species under different trophic conditions. Spring *Clausocalanus* assemblages were investigated in the oligotrophic Ionian Sea (spring 2002) and in the eutrophic North Balearic Sea (spring 2003). This allowed comparison of *Clausocalanus* assemblages in the open sea in the same season but in very different trophic conditions. The distribution of *Clausocalanus*species at a larger spatial scale (latitudinal) was addressed in the Atlantic Ocean during the Atlantic Meridional Transect programme (AMT 15, September-October 2004). The whole data set of *Clausocalanus* occurrence and abundance was analysed in relation to the principal environmental parameters recorded in parallel to zooplankton sampling (temperature and autotrophic biomass) in order to describe species ecological features and determine the extent of the niche separation among congeneric species. Results revealed that despite the eight circumglobal *Clausocalanus* species largely co-occurring over their environmental range (niche breath), their optima (i.e., the environmental conditions under which a species largely occurs) differed considerably. The three smallest *Clausocalanus* species (*C. paululus*, *C. pergens*, and *C. furcatus*) were the most abundant both in the Mediterranean Sea and in the Atlantic Ocean and their niches were clearly defined and separated suggesting that they might be considered good sentinels of changes in copepod communities due to climate change.

Map of the areas sampled for distribution of *Clausocalanus* species



EUR-OCEANS meeting of experts on the consolidation of plankton datasets to validate Plankton Functional Types models

Pesant, S.[1], C. Le Quéré and G. Gorsky (others to be confirmed)

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Pelagic marine ecosystems are subject to several perturbations, some of which are linked to short-term events or long-term trends in the regional and global climate and in human activity. Plankton biodiversity is often an indicator of these perturbations and a key measure of their impacts on marine ecosystems at various spatial and temporal scales.

In addition to describing the biogeography of marine life, biodiversity may play a central role in the functioning of marine ecosystems and their associated biogeochemical fluxes. For that reason, ecosystem and biogeochemical models are progressively incorporating compartments that represent distinct taxonomic groups or key Plankton Functional Types [e.g. 1]. With the aim to constrain and validate such models, several European initiatives [e.g. 2, 3, 4, 5] are currently gathering plankton biodiversity data. The success of these efforts will depend on our ability to assemble datasets generated over the last century and to rigorously transform the data, taking into account the various methods used for sampling and analysis, and the evolution of nomenclature.

To address nomenclature issues, international and European initiatives are developing authoritative taxonomic list of marine species [6, 7] that are augmented by the scientific community and reviewed by experts. Nevertheless, the systematic validation of historical datasets against these lists is not yet established. Besides nomenclature issues, traditional and emerging methodologies must be rigorously cross-validated (e.g. systematic vs. targeted counts, expert-to-expert validation; manual vs. automatic identification; algorithms converting pigments into taxonomy). Furthermore, the conversion of abundances into biomass is of special interest to modellers, but conversion factors used in the different datasets vary considerably.

The European Network of Excellence for OCean Ecosystems ANalysiS (NoE EUR-OCEANS) has recently organised a meeting of European experts in marine plankton biodiversity, database management, and ecosystem modelling. We present here a set of recommendations from that meeting, which objectives were to:

Review the contributions of past, current and planned working groups on the topic (e.g. SCOR, ICES, IOCCG) and set recommendations for a better integration and implementation of these efforts;

Consolidate plankton data into biomass of Plankton Functional Types (PFTs), encompassing data from molecular biology & genomics, size fractionation, pigment fractionation, taxonomy (species or groups), particulate matter constituent fractionation (carbonate, silicate) and ocean colour;

Address the reconstruction of complete PFT biomass from partial PFT information

1. DGOM: Dynamic Green Ocean Models (www.eur-oceans.eu/integration/wp3.2/)
2. EUR-OCEANS: European Network of Excellence for Ocean Ecosystems Analysis (www.eur-oceans.eu)
3. SESAME: Southern European Seas: Assessing and Modelling Ecosystem changes (www.ncmr.gr/sesame/)
4. MarBEF: Marine Biodiversity and Ecosystem Functioning EU Network of Excellence (www.marbef.org)
5. Marine Genomics Europe (www.marine-genomics-europe.org)
6. ITIS: International Taxonomic Information System (www.itis.gov)
7. WoRMS combines several Registers of Marine Species (www.marinespecies.org/)

What is Green Ocean Modelling?

Dynamic Green Ocean Models are mathematical representations of the ocean which include ocean currents, chemical processes and a representation of marine ecosystems that is based on the concept of Plankton Functional Types (PFTs). Plankton both responds to, and influences climate. In order to quantify and understand the interactions between marine ecosystems and climate, phyto- and zoo- plankton communities are simplified in the model into PFTs according to their size and functional role (Figure 1).

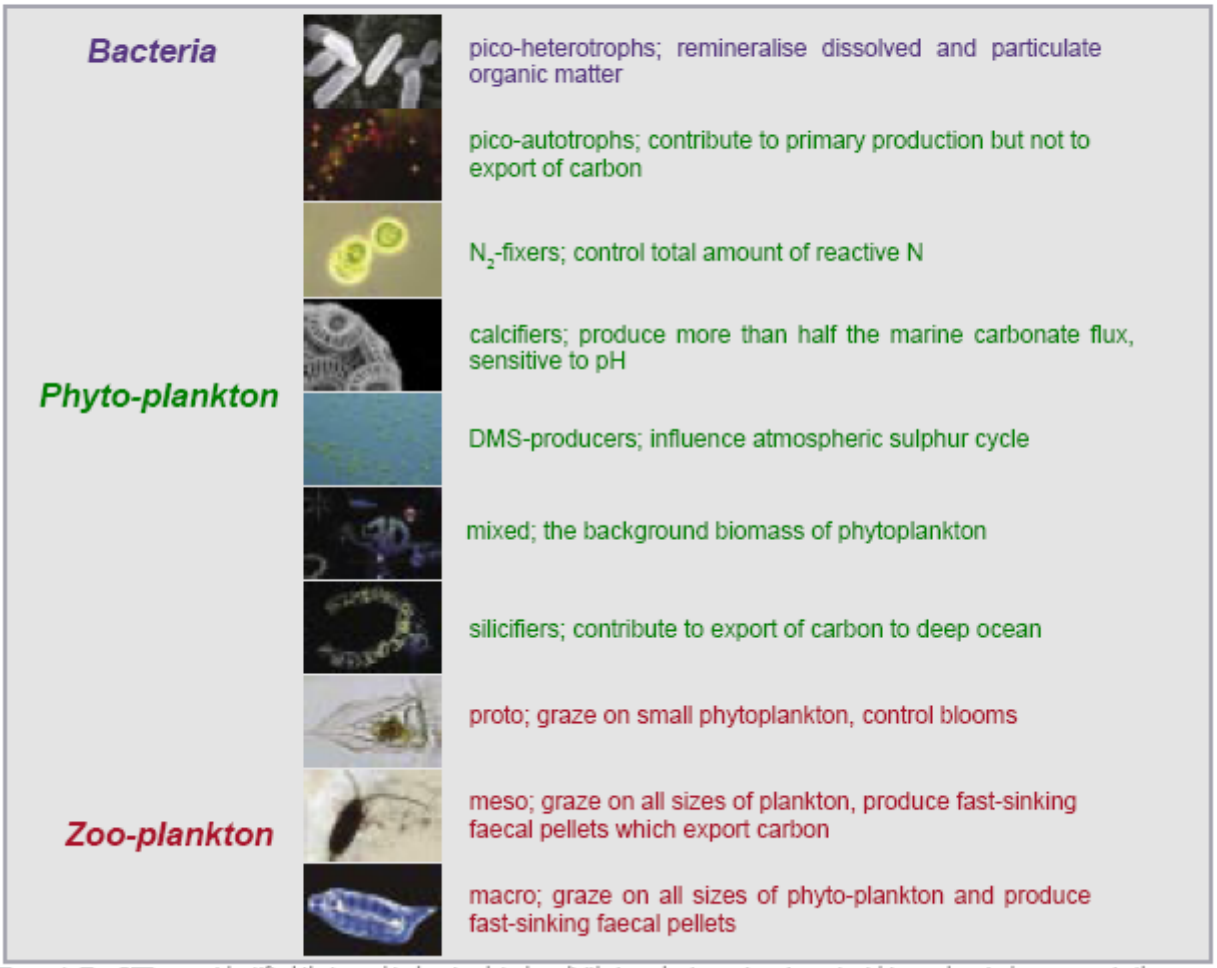

Figure 1. Ten PFTs were identified that need to be simulated explicitly in order to capture important biogeochemical processes in the ocean.

The 2003 heat wave and marine plankton communities

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Heatwaves are extreme atmospheric events with dramatic social and ecosystem consequences. In August 2003, Europe experienced the hottest heatwave ever recorded. The average air temperature exceeded the previous record set 246 years ago. The impact of heatwaves on marine plankton communities is poorly understood. We seek for the footprints of the 2003 heatwave in monthly fluctuations of remotely sensed chlorophyll *a* and onboard sampled zooplankton over the Mediterranean Sea basin. Temperature records have indicated that in the sampled regions the 2003 sea surface temperatures were 1 to 4 degrees Celsius higher in comparison to “standard” years (in 2001, 2002, and 2004). Zooplankton time series from the Villefranche Bay (Ligurian Sea), the Gulf of Naples (Tyrrhenian Sea), Saronikos Gulf (Aegean Sea), the Gulf of Trieste (Adriatic Sea), and the Gulf of Sevastopol (the Black Sea) showed no well developed anomalies in the total abundance of copepods as well as the abundance of some key species (*Acartia clausi*). In some region, "typical" summer populations (*Penilia avirostris*, Cladocera) were less abundant in August through December 2003, compared to the same periods in 2001-2002 and 2004. SeaWIFS chlorophyll *a* time series reconstructed for "buffer zones" surrounding zooplankton sampling points, show absolute minima in summer 2003 for Naples, Sevastopol and Trieste (this last with a longer period signal), while no evident footprints of the heatwave on remotely sensed chlorophyll-a were found for the other two sites.

A new fine-mesh zooplankton time series from the Dove sampling station (North Sea)

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The Dove Marine Laboratory (Cullercoats, North Shields, England) plankton sampling station lies approximately 5.5 nautical miles east of Blyth on the Northumberland coast. Sampling for coastal zooplankton has been undertaken at approximately monthly intervals since 1971 using WP3 (1 mm mesh), WP2 (200 µm mesh) and fine-mesh ring-nets (65 µm mesh). Up until now, only the catches from the coarse nets (WP3 and WP2) have been analysed and previous studies have focussed on the dynamics of the mesozooplankton.

Here we present for the first time the results obtained from the fine-mesh net. Results show decreasing trends for some copepod species, and a clear seasonality in the abundance of copepod nauplii. Comparison of the time-series from the fine-mesh net with the WP2 and WP3 nets shows substantial differences in catch efficiency for most organisms.

There is an urgent need to better understand marine ecosystem functioning, and in particular how climate change may affect primary and secondary production. Such climate-induced changes may impact ecosystem functioning, by cascading up the food web from the lowest to higher trophic levels. This dataset is a complement to the mesozooplankton Dove time series, and the samples from the fine mesh net are of particular interest, since they provide quantitative abundance estimates for an extended range of species and life-stages. In combination with other time series such as the ones issued from the Continuous Plankton Recorder and Helgoland, it should provide a useful tool to help to further our understanding of zooplankton ecology in the North Sea.

Nutrient recycling by zooplankton in Lake Kinneret - Israel

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Lake Kinneret is the only natural freshwater lake in Israel. The lake's nitrogen, phosphorus and carbon budgets are driven by internal and external processes with the importance of each process varying seasonally. One of the biological processes that effect the macro-nutrient budget is the recycling of nutrients by zooplankton. Different zooplankton species have dissimilar ratios of elements (C:N:P) in their bodies requiring different N:P ratios from their food, with excretions of unequal N:P ratios. As a result, the zooplankton species composition can greatly affect nutrient concentrations in the lake and phytoplankton community.

This study, examines the role of zooplankton in recycling nutrients in Lake Kinneret. The focus in this study is mostly on two major zooplankton groups in the lake: Copepoda, and Cladocera. The main goal is to determine the contribution of the zooplankton community to the nitrogen and phosphorus budgets in the lake.

According to the results to date, there is a change in excretion rates over the course of the year. This means that the copepod excretion rate is not constant but changes according to the ambient conditions; chemical and/or biological. Furthermore, excretion rates of the natural zooplankton community is about 60% and 20% higher during spring and summer than during fall and winter for PO_4 and ammonia excretion, respectively. This coincides with the higher water temperatures and higher metabolism rates. These results provide initial support for my hypotheses as the high summer excretion rates occur at a period of low external nutrient inputs though production the rate is high. The relatively high excretion rate during the summer, can thus represent a vital source for nutrients during this period of year.

Overview of mesozooplankton spatial distribution in the Mediterranean Sea

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During the last two decades the number of mesozooplankton studies in the East Mediterranean Sea has increased and some of them were performed simultaneously in the west and east basins. Based on the literature issued from these studies, an overview of the spatial variability of mesozooplankton standing stock and community composition is attempted. Standing stock values rarely exceed 2000 ind m^{-3} and 20 mg DW m^{-3} (for the upper 100 m), reflecting the oligotrophic character of the entire sea; exceptionally high values are observed in areas influenced by the Atlantic and Black sea waters or large rivers and in areas positioned over extended continental shelves. The general picture of increasing oligotrophy has been to be true for mesozooplankton through results of synoptic cruises in the entire Mediterranean Sea. In addition mesozooplankton standing stock does not present a homogenous distribution within each geographic area mainly due to the hydrological and circulation mesoscale features affecting the particular region: fronts, large river plumes, cyclonic and anticyclonic gyres, upwellings. Results issued from samples collected by fine mesh size nets (45-80 μm) have pointed out the significance of the small size zooplankters within the Mediterranean pelagic ecosystem.

Indeed copepod species less than 1 mm dominate in the epipelagic layer all over the Mediterranean, similarly to the neighbouring subtropical Atlantic. *Clausocalanus* spp *(*mostly *C. furcatus, C. pergens, C. paululus, C.arcuicornis*) are the most abundant, accompanied by *Oithona spp (*mainly *O. plumifera, O. similis, O. setigera*), *Oncaea spp.* A spatial differentiation seems to exist for next in rank species since *Centropages typicus, Temora stylifera, Paracalanus parvus, Acartia clausi* are more abundant in the west Mediterranean, Adriatic and N.Aegean Seas, whereas *Corycaeus* spp*., Farranula rostrata, Calocalanus* spp., prefer rather the east Mediterranean sea. The community composition and structure has been found to be affected significantly by the mesoscale hydrological and circulation features. Overall the spatial variability of Mediterranean mesozooplankton reflects the environmental variability of this “miniature ocean”.

Temporal fluctuations of zooplankton communities in Varna Bay (Western Black Sea) and Sevastopol Bay (Northern Black Sea): a comparative study

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Human activities are mainly concentrated in the coastal regions which appeared less capable to assimilate the adverse effects of those threats. The consequences of foremost pressures to European coastal areas, respectively to the Black Sea such as water pollution, eutrophication, loss of biological diversity, introduction of non-indigenous species, over fishing, land use and landscape deterioration, and coastal erosion have been already well documented (Moncheva et al., 2001, Prodanov et al., 2001, Gubanova et al., 2002, Kamburska, 2004, Kideys et al., 2005, Oguz, 2005, Kamburska et al., 2006). Insufficiency of comparable time series data across the coastal areas of the Black Sea is still a key problem for a comprehensive assessment of the marine environment. The present study is focused on the comparison of the zooplankton quality and quantity parameters in two vulnerable coastal areas Sevastopol Bay (Northern Black Sea) and Varna Bay (Western Black Sea). It aims to assess the current state and long-term trends of zooplankton communities of the two regions of the Black Sea and the response to anthropogenic and environmental shifts. The objectives are: 1) to reveal the structure of zooplankton community in both areas; 2) to contrast temporal variability of the plankton fauna structure in the coastal ecosystems of Northern and Western Black Sea. Observations are based on the long-term data for mesozooplankton abundance, key species and taxonomic groups, temperature and salinity collected at monitoring stations in Varna and Sevastopol Bays during the period 1967 - 2005 (Varna Bay) and 1976-2005 (Sevastopol Bay). The results of inter-annual dynamics of mesozooplankton quantity revealed similarities in the timing of maximum abundance during the 1980s in both areas. The structure of the community significantly shifted over the decades and the reorganization was mainly with respect to dominant groups and species. Thus *Oithona nana* maintained high density in the period 1976-1980, while *Acartia clausi* (dominant over the year) and *Pleopis polyphemoides* were constant components of the plankton fauna with similar dynamics mode in the study regions. In spite of the observed similarities, zooplankton communities in Varna and Sevastopol Bays manifested peculiar features. The total abundance in Varna Bay ranged from 1083 ind.m^{-3} to 52 978 ind.m^{-3}, while in Sevastopol Bay it varied from only 276 ind.m^{-3} to 14501 ind.m^{-3}. During the period 1976-1980, the zooplankton amount in Sevastopol Bay was from 2 to 12 fold higher than in Varna Bay. Since the 1980 the total mesozooplankton abundance increased in Varna Bay in contrast to Sevastopol Bay. *Noctiluca scintillans* was regularly presented in Sevastopol Bay, but with lower numerical abundance compared to Varna Bay where it often reached "blooming" concentrations. The alterations in zooplankton assemblages could be further attributed to the impacts of climate and anthropogenic activities in both regions.

Seasonal composition and abundance of Chaetognath species off coast Iskenderun Bay in the eastern Mediterranean

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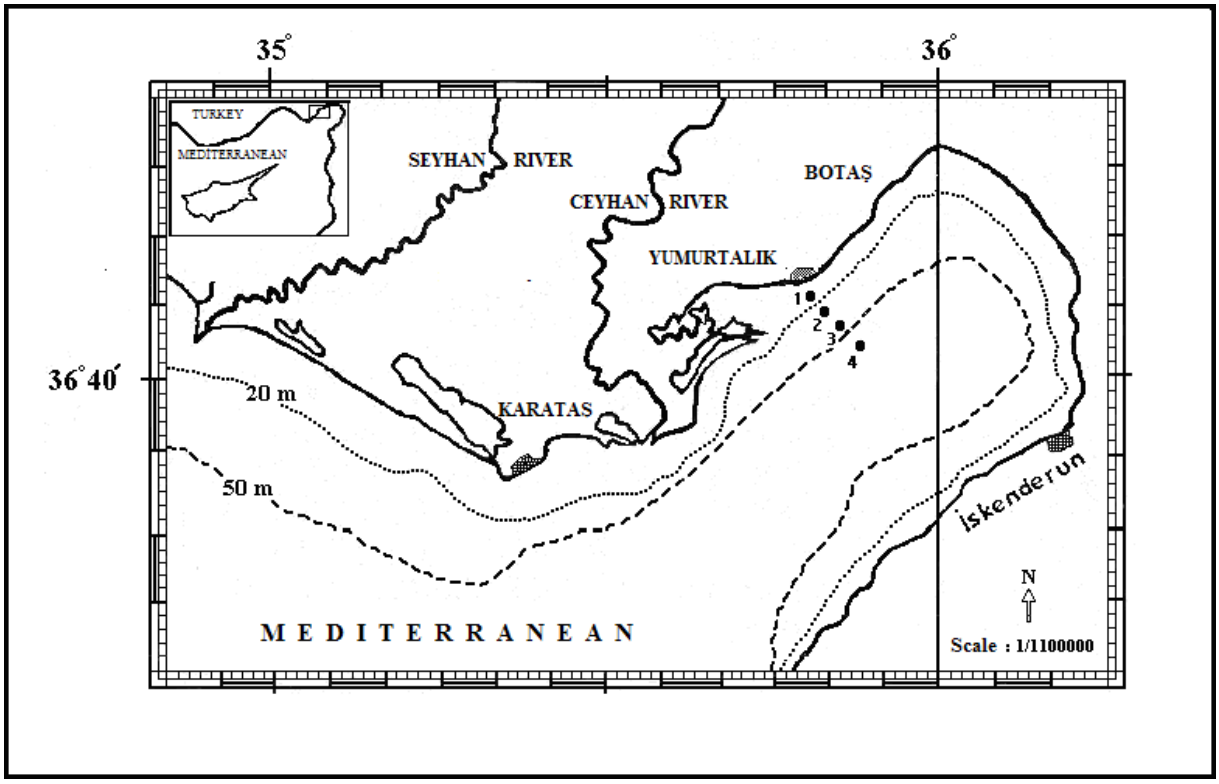
Distribution of chaetognaths species and their abundance were determined off the coast of Iskenderun Bay in the Eastern Mediterranean In the study. A total of six species belonging to five genera were found: *Flaccisagitta enflata, Mesosagitta minima*, *Serratosagitta serratodentata*, *Sagitta bipunctata*, *Parasagitta friderici* and *Parasagitta tenuis. F. enflata* was observed as dominant species in both of horizontal and vertical samplings. Mean abundance of the total chaetognath species showed difference at seasonally, the highest one being found in spring and the lowest being found in summer. Species found were taken at epipelagic depth and do not include mesopelagic and deep water species.

Figure 1. Research station in the Iskenderun Bay



Biodiversity studies of zooplankton community in coastal waters of southern Adriatic - Boka Kotorska Bay

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The species composition, abundance, biomass and production of zooplankton were determined fortnightly from January 2004 to December 2004 in the coastal waters of southern Adriatic. Boka Kotorska Bay represents a relatively closed part of the sea, formed by 4 bays with various specific values of ecological factors, such as the pronounced impact of surrounding mainland and the large influx of fresh water during the colder part of the year, as well as the impact of the open sea, which is most pronounced in the Bay of Herceg Novi. The ecological specificities of the eutrophic area of Boka Kotorska Bay are reflected at the taxonomic composition, quantity and distribution of both the individual species and the overall zooplankton. The dynamic character of Boka Kotorska Bay is also influenced by the Eastern Adriatic Current, which brings warmer, more saline water from the eastern Mediterranean. During the winter months, the current brings water into the Adriatic, while during the summer the dominant direction is the opposite one, down the western coast of the Adriatic basin. Warmer, more saline water enters the Boka Kotorska Bay along the sea bottom, as indicated by more intensive recording of stenovalent species at Bay of Herceg Novi and their decreasing presence toward the inner waters of the Bay. The zooplankton of Boka Kotorska Bay is different from the open water or the northern areas of Adriatic, due to presence of certain dominant eurivalent species and intrusion of allochthonous species of open deep sea into the zone of coastal waters. The comparison of these results with data from other coastal and bay areas of Mediterranean and Adriatic has shown a seasonal pattern in behavior of the plankton community and a repetition of a general trend characteristic for coastal waters in tropical and subtropical zones. There are two recorded seasonal maximums in zooplankton, in spring and autumn. The copepods have the dominant role in defining the seasonal fluctuations in abundance of zooplankton, however during the warmer period of the year the Cladocera may surpass them in numbers. This phenomenon is recorded in our research data as well, as in July and August of 2002 we have recorded the species *Penilia avirostris* Dana, which appeared in extremely high numbers and dominated the zooplankton community of Boka Kotorska Bay. In this paper we are also presenting the data on the zooplankton groups: Medusae, Siphonophorae, Polychaeta, Chaetognatha, Pteropoda, Copepoda, Cladocera and Appendicularia (Larvacea), while only the Copepoda were subject to long-term studies so far. The physical and chemical parameters of environment were measured and analyzed simultaneously with zooplankton studies. This paper also presents in great detail the space-time oscillations of hydrographic factors in the Bay. The research program and research stations were carefully chosen so they enable a detailed overview of the hydrographic characteristics of the sea and the structure of zooplankton fauna.

Keywords: biodiversity, zooplankton, Boka Kotorska Bay, southern Adriatic

Zooplankton time series in the Sea of Marmara

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An interrupted 11-year time series from May 1997 to December 2007, based on monthly or fortnightly samplings, was examined in relation to hydrography and chlorophyll *a* in the NE Sea of Marmara. Strict stratification of the basin amplified the magnitude of eutrophication, originated from NW Black Sea shelf and inner inputs, and primary production is limited to a very narrow upper layer. The steep halocline limiting vertical migration minimized day/night differences and lower layer had very few abundance when compared to upper layer. Zooplankton time series shows variations in both zooplankton abundance and species assemblages. A clear increase trend in zooplankton abundance through the study period can be recognized, while this pattern has been ceased by the dense mucilage formation in autumn of 2007. As a unique characteristic of Marmara zooplankton, dominance of Cladocera in samples, rather than Copepoda, has been maintained through the study period. As an important cladoceran, there is an increase in *Penilia avirostris* abundance, while small variations in the environment rapidly limited *Penilia* dominance in summer, such as in 2000. Another important fluctuation is detected in the dominant copepod species. In majority of samples till the summer of 2005, *Acartia* spp. (mainly *A. clausi*) appeared as the dominant species, however in the following period, a warm water species, *Paracalanus parvus* dominanted the copepod fauna and represented in high numbers through the year. Seasonal samplings performed in 2005-2006 in the whole basin revealed that Marmara zooplankton evolves with significant spatial patterns. In addition to higher abundance, species assemblages also varied in eutrophic or polluted bays. Abundant species such as *Paracalanus parvus* and *Penilia avirostris* were replaced by *Acartia clausi* and *Pleopis polyphemoides* in eutrophic bays that are known to be tolerant to pollution.

Etude de la communauté zooplanctonique de Tanger et M'diq (Détroit de Gibraltar)

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La comparaison de la communauté mésozooplanctonique entre la région de Tanger et M'diq a été réalisée le long de deux années d'études 2006 et 2007. L'échantillonnage a été effectué sur trois périodes de chaque année au niveau de trois stations le long de chaque radiale: atlantique (station 1: 35°53N 5°12E ; station 2: 35°43N 5°12E et station 3: 35°34N 5°05), et méditerranéenne (station1: 35°46N 5°57W ; station 2: 35°45N 6°07W et station 3: 35°46N 6°15W)).

L'ensemble des taxons identifiés dans les deux milieux se répartie en deux formes de vie ; holoplanctonique et méroplanctonique, dont les copépodes dominent qualitativement et quantitativement l'ensemble du peuplement zooplanctonique et ce au niveau des deux secteurs prospectés. 86 espèces recensées à Tanger et 82 à M'diq dont 64 sont communes aux deux secteurs.

L'analyse spatiotemporelle de la richesse spécifique en copépodes a révélé que le nombre d'espèce le plus élevé à Tanger est de 36, alors qu'il est de 30 à M'diq. Dans les deux secteurs prospectés, les valeurs les plus élevées de la richesse spécifique ont été enregistrées en décembre 2006 et en novembre 2007. En revanche, au cours des autres mois des deux années, la richesse spécifique n'a pas dépassé généralement 25 espèces et ce pour les deux secteurs.

La comparaison spatiotemporelle des densités totales des copépodes a montré que les fortes densités ont été enregistrées en 2007 par rapport à 2006, et principalement à Tanger où le maximum de densité est de 1092,8 ind.m^{-3}, alors qu'il est de 796,1 ind.m^{-3} à M'diq.

La composition quantitative du peuplement copépodique a montré que ce dernier est dominé généralement en 2006 par *Paracalanus parvus* et *Oncea venusta* et ce au niveau des deux écosystèmes étudiés. En 2007, le peuplement des copépodes est dominé généralement par *Calanus helgolandicus* à Tanger et par *Centropages typicus* à M'diq, avec un maximum d'abondance en juillet qui est de 15% chacune.

Les valeurs de la diversité spécifique exprimées en indice de Shannon en 2006 n'ont pas dépassé 4 bits et ce au niveau des deux secteurs étudiés. En 2007, la diversité spécifique est plus élevée principalement à Tanger où les valeurs dépassent généralement 4 bits au niveau de toutes les stations et au cours des différents mois. Le peuplement des copépodes donc est plus stable en 2007 par rapport à 2006 et à Tanger qu'à M'diq.
Mots clés: Copépodes, indices biologiques, Tanger, M'diq.

Study of the zooplanctonic community of Tangiers and M'diq (Gibraltar strait)

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The comparaison of the mesozooplanctonic community between the area of Tangiers and M'diq was carried out along two years of studies 2006 and 2007. Sampling was held over three periods of each year at of three stations along two transects: the Atlantic (station1: 35°53N 5°12E; station 2: 35°43N 5°12E and station 3: 35°34N 5°05), and the Mediterranean transect (station 1: 35°46N 5°57W; station 2: 35°45N 6°07W and station 3:35°46N 6°15W).

The whole of taxas identified in the two ecosystems are distributed in two forms holoplanctonic and meroplanctonic, in which Copepoda dominate quality and quantity the whole are zooplanctonic groups and this occurred in both prospected transects. 86 species listed in Tangiers and 82 in M'diq, 64 are common to both sectors.

Spatiotemporelle analysis of Taxonomic richness of copepoda analysis in space and Eveness revealed that the highest number of species were 36, and found in Tangiers. Whereas, this number was only 30 in M'diq. Regarding temporal variation, the highest values of species richness were recorded in December 2006, and in November 2007. However, during the other months of both years, species richness did not go beyond 25 species in both transects.

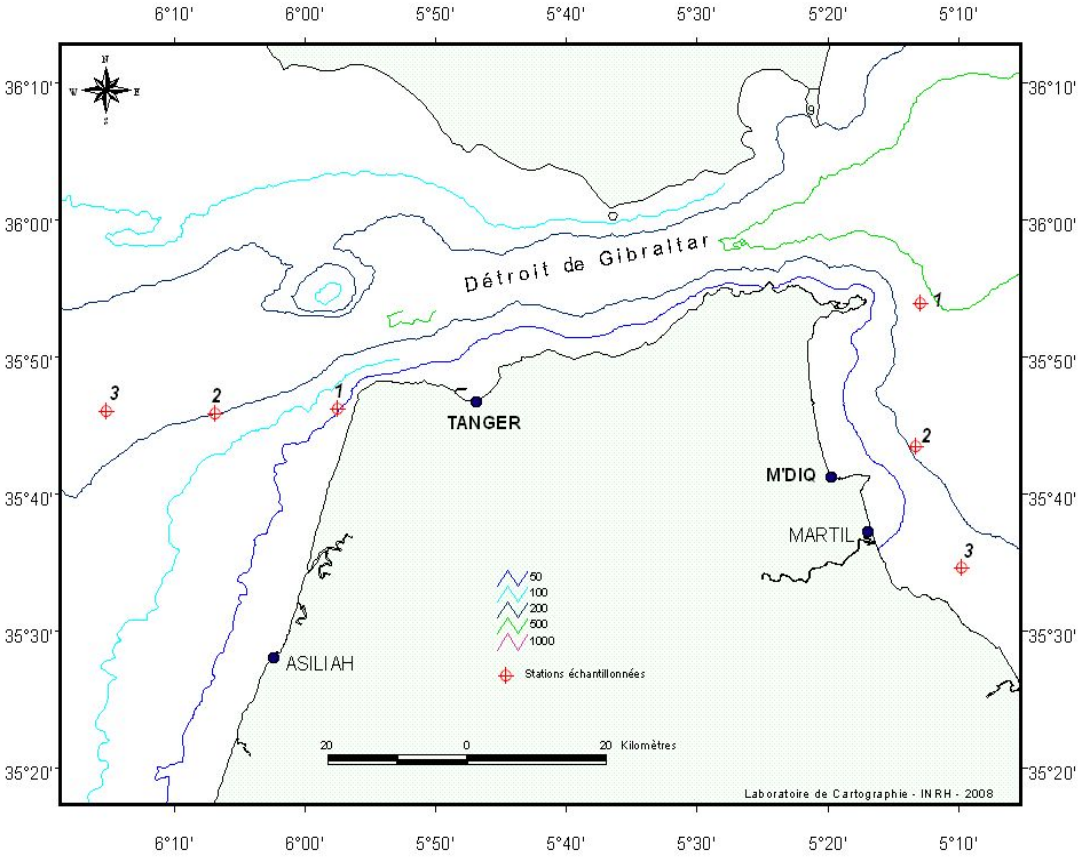
The whole copepods densities comparison in space and time revealed that values were highest in 2007 than 2006, and mainly in Tangiers where the maximum was about 1092.8 ind.m^{-3}, and 796.1 ind.m^{-3} in M'diq.

The comparison in quantity of copepods was dominated by *Paracalanus parvus* and *Oncea venusta* in 2006, this is true for both ecosystems studied. In 2007, copepods are dominated by *Calanus helgolandicus* in Tangiers, and by *Centropages typicus in* M'diq, with a maximum of abondance in july,which's 15% each.

In 2006 species diversity values expressed in Shannon index, were not more than 4 bits in both transects. In 2007, the diversity was higher, mainly in Tangiers where the values were more than 4 bits in all stations, and months. Copepods were thus, more stable in 2007 than in 2006, and in Tangiers more than in M'diq.

Keywords: Copepods, biological index, Tangiers, M'diq.

Stations of samples



Influence of salinity variations on zooplankton community in El-Mex Bay, Alexandria, Egypt

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El-Mex Bay, west of Alexandria, receives a heavy load of waste waters (7×10^9 m^3/year) both directly from industrial outfalls and indirectly from Lake Maryuit via El-Mex Pumping Station. Zooplankton samples were collected bimonthly from seven stations during the period March 2005 to January 2006 to illustrate the influence of salinity variations on the abundance and community structure of zooplankton in El-Mex Bay waters.

Based on the salinity values, four water types are identified: the mixed land drainage (L) of salinity < 10ppt, mixed water (M) of salinity range 10 to 30ppt, diluted sea water (D) of salinity range 30 to 38.5ppt and Mediterranean Sea water (S) of salinity > 38.5.

The highest zooplankton standing crop (106.6×10^3 ind.m^{-3}) was recorded in the mixed land drainage water type (L), while the lowest counts (5.9×10^3 ind.m^{-3}) was found in the Mediterranean Sea water type (S).

Rotifera were the most dominant zooplankton groups in water type (L) constituting about 86% to the total zooplankton and represented by 19 species belonging to 10 genera. *Brachionus urceolaris* and *Filinia longiseta* dominate Rotifera population. Protozoa was the second important group in this water type contributing 9.23% to the total zooplankton crop.

In water type (M), Rotifera, Protozoa and Copepoda were the most dominant groups constituting 57.87%, 21.32% and 13.45% to the total zooplankton counts respectively. In water type (D), Copepoda and their larval stages were the most dominant zooplankton groups constituting about 51% to the total zooplankton. Protozoa was the second important group constituting 37.20%, while Rotifera represented only 4.20%.

In the Mediterranean water type (S), Copepoda and their larvae were the most dominant zooplankton group, forming 49.46% of the total zooplankton. *Oithona nana, Acartia clausi* and *Paracalanus parvus* dominated Copepoda population. Cirriped larvae occupied the second order of abundance at this water type with a percentage frequency of 19.17% to the total zooplankton.crop.

Keywords: Zooplankton, salinity variations, water types, Mediterranean, El-Mex Bay, Egypt.

Temporal and spatial variability of *Farranula rostrata* (Copepoda, Cyclopoida) in the Mediterranean Sea

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Non-calanoid copepods (i.e., Cyclopoida), have been found to be numerically important in oligotrophic seas and to have such ecological impacts that set them apart from most other planktonic crustaceans. Despite the presence of the cyclopoid genus *Farranula* in the Mediterranean Sea and Atlantic Ocean, the available information regarding its spatial and temporal distribution is rather limited. Based on data collected from open sea as well as coastal regions of the Mediterranean Sea, we present here the first comparative overview of the spatial and seasonal variability of *F.rostrata* in different Mediterranean regions.

We have studied data collected at four ongoing zooplankton time-series stations in the Mallorca Island (Balearic Sea), the Gulf of Naples (Tyrrhenian Sea), the northern Adriatic Sea and the Saronikos Gulf (Aegean Sea) as well as monthly data collected during one year in the Bay of Tunis. At all five areas, the absolute abundance of the species as well as the relative abundance among copepods was found to be low; thus the species has not been referred among the abundant or even common species in the above areas, either in other Mediterranean coastal areas according to the literature, being almost absent in confined areas. Regarding the offshore waters, the relative abundance of this species is more important among copepods than in coastal waters and it seems to be a key component of the zooplankton in very oligotrophic areas e.g during June 1999, *F. rostrata* accounted more than 30% of the total copepod community (exceeding that Corycaeus spp. and Oncaea spp.) in the ultra-oligotrophic environment of Levantine Sea, and its contribution decreased gradually towards the West Mediterranean Sea.

F.rostrata population was perennial throughout the year in almost all studied coastal areas. Pronounced seasonal signals in abundance and relative abundance were observed for *F.rostrata* in the Gulf of Naples, the northern Adriatic Sea, the Bay of Tunis and the Saronikos Gulf; abundance minima occurred during early summer and maxima in fall-winter, when the influence of open sea becomes more intense in coastal waters. No clear seasonal pattern was observed in Balearic Sea, an area largely and continuously affected by offshore waters; the above patterns confirm the pelagic character of the species. These first observations suggest that aspects of the reproductive strategy and its feeding behavior should be investigated in order in understand the ecological role of this species within the pelagic food web of oligotrophic areas.