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Report of the Joint ICES/CIESM Workshop to Compare Zooplankton Ecology and Methodologies between the Mediterranean and the North Atlantic (WKZEM)

27-30 October 2008

Heraklion, Crete, Greece

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive summary

The Joint ICES/CIESM Workshop to compare zooplankton Ecology and Methodologies between the Mediterranean and the North Atlantic (WKZEM) met at the Hellenic Centre for Marine Research, Heraklion, Crete, Greece, from 27–30 October 2008.

The objectives of the Workshop were to provide a forum in which scientists present and discuss results of ongoing research projects in the North Atlantic and the Mediterranean, focusing on the regional ecosystems' structure and functioning, and with emphasis on comparative aspects.

The Workshop was attended by 43 people, 28 from the Mediterranean Science Commission (CIESM) and 15 from the International Council for the Exploration of the Sea (ICES). Participants represented institutions from 20 different countries. The workshop was divided into 4 theme sessions with in all 34 presentations and 5 posters being presented, and two informal theme discussion sessions.

The workshop identified latitudinal and longitudinal differences in ecosystem structure and functioning, and addressed the issue of top down control of ecosystems in relation with climate change. It is evident that there are key species and indicator species to both ecosystems, although some species are common to both systems. There is considerable exchange between basins (gene flow, species introduction, invasions, disappearance), and it is evident that the Mediterranean is influencing the N-Atlantic.

Collective actions that need to be implemented in future include 1) reinforcing of time-series; 2) the creation of a virtual network of experts from both communities; 3) establishment of long-term connections between WGZE and CIESM; 4) continuation of cooperation and future meetings of the two groups, 5) maintenance of a common website; 6) training courses and summer schools.

The Workshop was funded by EUROCEANS and CIESM. In addition, the Hellenic Centre for Marine Research provided logistical support. The support of these bodies is greatly appreciated.

1 Background to the Workshop

At the annual meeting of the Working Group of Zooplankton Ecology (WGZE) in Lissabon 2005, Dr Gabriel Gorsky, coordinator of the Zooplankton Indicators programme of the Mediterranean Science Commission (CIESM), put forward the idea that the two research communities, the ICES and the CIESM, should have a joint meeting in order to address and discuss issues of common interest. It was felt that such a meeting was important for comparative purposes, so as to address what is causing the difference between the two ecosystems. It was noted that some species are common to both systems and it would be interesting to compare their ecology between the two regions. It was also felt that possible links between plankton in the North Atlantic and the Mediterranean, and how they may be influencing each other, need to be elucidated. And lastly, the need for coordination of approach to plankton monitoring is apparent.

In 2006 a formal proposal was made to ICES for a joint meeting/workshop of ICES and CIESM scientists involved in pelagic ecology, especially plankton ecology. The proposal was approved by the ICES Council the same year. At the annual meeting of WGZE in Riga in March 2007, where CIESM was also represented, it was decided that the best time to hold the workshop would be the latter half of October, and that the place should be Heraklion, Crete, Greece, at the kind invitation of Dr Ioanna Siokou-Frangou, Institute of Oceanography, Hellenic Centre for Marine Research. An announcement was sent out to both scientific communities (ICES and CIESM) 7 August 2007, and a Workshop Web page published 14 January 2008. The CIESM Zooplankton Indicators program diffused a second announcement on January 16 and following the discussions with the CIESM Director General office a budget was set up to help the travel and accommodation costs of some of the participants. At regular, monthly intervals an update was made through Internet that summarized the progress concerning the participation and abstracts of the Mediterranean scientific community.

The North Atlantic encompasses several highly productive sea areas around its continental shelf margins that provide work and living to local communities. In contrast the Mediterranean Sea is oligotrophic with low fishery production, similar to the subtropical part of the North Atlantic; nevertheless the extraordinarily rich variety of singularities driving ocean life and biogeochemical dynamics of this enclosed sea makes more critical its sustainable use by the surrounding human populations. Although there are important differences between these two ecosystems, they also share several common features and belong to the same ecosystem type or biome as defined by Longhurst (1998, The Ecological geography of the Sea), given that the greatest number of species in the Mediterranean Sea are of Atlantic origin. The seasonal cycle of primary and secondary production is more or less similar for both regions. This is mainly driven by physical processes affecting the stability of the upper layers of the water column and the resuspension of nutrients from the deeper layers up into the photic zone.

The majority of species in the Mediterranean Sea are of Atlantic origin Both the North Atlantic Ocean and the Mediterranean Sea have deep oceanic basins that serve as overwintering sites for ontogenetically migrating zooplankton. Dominant species are common in both areas at same latitude in the epi- and mesopelagic layers, whereas the bathypelagic species of the North Atlantic are excluded in the Mediterranean Sea by the Gibraltar strait sill. There is need to study and explain the extent at which spe-

cies are being advected between the regions with inflowing and outflowing currents through the Gibraltar Strait, especially because changes will occur with the apparent tropicalization of the Mediterranean Sea. Interestingly, marginal seas of the North Atlantic and the Mediterranean Sea, such as the Baltic Sea and the Black Sea, have common characteristics (low salinity, anoxic bottom layer, high production).

Both areas have a strong history of plankton research. In the North Atlantic, The ICES Working Group on Zooplankton Ecology (WGZE), reviews sampling and analysis technologies, and monitors zooplankton sampling activities, including comparative analyses of zooplankton time-series from national monitoring programs in relation to climate variability. In the Mediterranean and the Black Sea, The Mediterranean Science Commission (CIESM) supports a network of marine researchers from 23 member states, applying the latest scientific tools to better understand, monitor and protect their fast changing and highly impacted sea areas. It is hoped that the interactions between CIESM and ICES communities will mutually enrich the marine zooplankton research activities of both groups.

Long-term variations in plankton abundance and composition, some probably induced by human activities, have been documented both in the Mediterranean and in the North Atlantic. Comparisons and syntheses of plankton research between these areas are of increasingly high importance and necessity. These efforts must consider the varied and interactive effects of climate change, eutrophication, pollution, harvesting, species introductions etc. There is a strong need for collaboration and comprehensive ecosystem approaches in marine research and for the provision of data and advice to managements and policy groups. Making comparisons between contrasting and similar ecosystems is a practical and useful approach. This coordinated approach is required and brings benefits from application and transfer of wider knowledge and skills, along with the harmonization of methods and approaches.

2 Objectives

The objectives of the Workshop, as stated in the announcement to the scientific community, were to provide a forum in which scientists present and discuss results of ongoing research projects in the North Atlantic and the Mediterranean, focusing on the regional ecosystems' structure and functioning, and with emphasis on comparative aspects. The workshop will serve as an arena and focus for communication between WGZE and CIESM scientists, providing an opportunity for mutual updates on activities and plans, thus creating stimulus for further analyses and for future collaboration between the scientists involved.

The terms of reference were:

a) review and consider comparison of zooplankton ecology of the Mediterranean and the North Atlantic, with emphasis on common species and size structure using common numerical methods;

b) review and consider overview of ongoing time-series programmes;

c) review and consider harmonization of methods, overview of experimental work;

d) review and consider appearance or disappearance of species vs. global warming;

e) review and consider autecology of key species.

WKZEM will report by 1 December 2008 for the attention of the Oceanography Committee, and ACOM.

3 Structure

The Workshop was attended by 43 people, 28 from the Mediterranean Science Commission (CIESM) and 15 from the International Council for the Exploration of the Sea (ICES). Participants represented institutions from 20 different countries (Annex 1).

Submissions (papers or posters) to the following topics were invited (comparative presentations were especially encouraged):

- Comparative zooplankton ecology of the North Atlantic and the Mediterranean Sea
- Overview of ongoing time-series programmes in both regions
- Harmonization of methods, overview of experimental work
- Appearance or disappearance of species vs. global warming
- Autecology of key species
- The marine foodweb from microzooplankton to small pelagic fish

The four day programme included three days with presentations and discussions (i.e. half day to each topic outlined above), half day with discussions on perspectives and future plans, and a half day field trip (Annex 2). The Workshop language was English.

The Worksop also included two informal theme discussions, one on "Time series and sampling" and the other on "Zooplankton databases and data treatment" (Annex 2). During the former a discussion took place on new time-series and sampling strategy, intercomparability of time-series, and potential benefits of comparing Northern and Southern seas time-series. During the latter, issues like data treatment, data exchange and databases were discussed.

The Workshop was organized by Astthor Gislason (Marine Research Institute, Iceland), Gabriel Gorsky (Observatoire Océanologique, France) and Ioanna Siokou-Frangou (Hellenic Centre for Marine Research-local organizer) and Co-Chaired by Astthor Gislason and Gabriel Gorsky.

A Scientific Advisory Committee was appointed consisting of Nejib Daly-Yahia (University 7 November – Carthage, Tunisia), Roger Harris (Plymouth Marine Laboratory, UK), Steve Hay (Fisheries Research Services, UK), Ioanna Siokou-Frangou (Hellenic Centre for Marine Research, Greece), Kremena Stefanova (Institut of Oceanology, Bulgaria), and Luis Valdés (Centro Oceanográfico de Gijón, Spain).

4 Funding

In October 2007 Roger Harris, Javier Ruiz and Ioanna Siokou-Frangou (leaders of the N.Atlantic system and the Mediterranean system within EUR-OCEANS) wrote a proposal to EUR-OCEANS asking for support for the organization of the Workshop. Due to budget restrictions the proposal was not approved; thus the system leaders proposed to use a part of their system's budget. This was accepted by EUR-OCEANS in January, which made 5600 Euros available, half of the sum from the Mediterranean EUR-OCEANS System and half of it from the N-Atlantic EUR-OCEANS System. The funds covered expenses with coffee breaks, workshop dinner, renting of bus, and book of abstracts. Gabriel Gorsky also ensured that funds were made available to the

workshop by CIESM allowing 5 participants (Gaby) from the Mediterranean side to take part. In addition, the Hellenic Centre for Marine Research (Greece) hosted the workshop and provided secretariat and technical support for the presentations. We thank EUROCEANS, CIESM and the Hellenic Centre for Marine Research for the financial and logistical support.

5 Workshop website

Todd O'Brien set up a Workshop Web page (http://www.wkzem.net/), hosted at the National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Science and Technology (NOAA-NMFS, Science and Technology) (Annex 3). The website contains information on the background, aims, meeting program with speakers, travel, meeting venue and accommodation. The website also contains a list of participants that was updated as people registered. Abstracts were posted on the website as they became available. The website is being maintained after the workshop and information of the publication of the proceedings can be found there.

6 Scientific presentations and discussions

6.1 Session 1: Overview of ongoing time-series programmes and methodology in the Mediterranean and the North Altantic

Chair: Erhan Mutlu; Rapporteur: Maria Grazia Mazzocchi

In this session, interesting contributions presented results from ongoing investigations in different European Seas with comparative approaches focused on zooplankton spatial and temporal patterns or different methodological aspects.

Cecilie Broms started this session illustrating the field investigations conducted by the Institute of Marine Research (IMR) on phyto- and zooplankton 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 in selected periods of the year, with an extensive horizontal and vertical coverage of the water masses. Biodiversity, introduction of species, harmful algal blooms (updated every week in the website) and nitrification are monitored with an ecosystem approach to fishery management also in relation to climate change. The interannual patterns of small copepod species (e.g. *Paracalanus*, *Pseudocalanus*, *Acartia*) and *Calanus finmarchicus* were shown and the first record of *Mnemiopsis leydi* in the Skagerrak in autumn of 2006 was reported.

Damien Eloire presented part of his PhD project on the comparative analysis of temporal patterns and structures of zooplankton communities in four European coastal time-series: Stonehaven (northwestern 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 were sampled with comparable methods and overlapped for the period 1998–2007. The analyses were based on the most abundant species and groups that contribute about 80% of the total zooplankton abundance and were performed by using an R-toolkit prepared by Damien. The communities at the four sites show differences in seasonal and long-term patterns, likely linked to marked differences in the local environmental features. To a question addressed by Denis Altukhov, who remarked the difficulties in comparing datasets with different levels of taxonomic identification, Eloire answered that this problem was considered and addressed at the beginning of this project.

Another comparative analysis of time-series was presented by MaLuz Fernandez de Puelles, who illustrated some seasonal and interannual patterns of mesozooplankton in two sites of the Western Mediterranean, the Balearic Sea (st. 1) and the Gulf of Naples (st. MC) during the decade 1995–2004. The two sampling sites 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 waters. These features reflected in the zooplankton biomass, abundance and structure. High biodiversity was recorded at both sites, where zooplankton were dominated by small copepods (*Clausocalanus, Oithona, Paracalanus parvus, Acartia clausi, Centropages typicus and Temora stylifera*). Among the other groups, cladocerans were more important in Naples than in Baleares while the reverse was true for appendicularians. Astthor Gislason wondered why *Calanus helgolandicus* did not appear among the most abundant taxa as commnly observed in the Atlantic and MaLuz answered that this species is neither common or abundant in the Mediterranean, where small calanoids and cylopoids characterize the epipelagic communities also in open waters. Roger Harris remarked that this kind of studies performed at species level allow recording the possibly appearance and disappearance of species.

Claudia Halsband-Lenk presented a project in collaboration with Elvire Antajan on the comparison of two time-series at sites located on the west (st. L4, Plymouth Marine Laboratory, UK) and the east (Gravelines, IFREMER) sites of the English Channel. The two sites have very different environmental features and the series have dissimilarities in periods and methods. However, they partially overlap in time and include the same environmental and phyto- and zooplankton parameters and their comparative analysis contributes to the Program Interreg IV: CHARM Phase 3 (Channel Integrated Approach for Resourche Management) with the goal of developing a multimetric foodweb index. The preliminary results of this comparison show similar SST anomalies at the two sites in 1988–2007 but some differences in the abundance of dominant phytoplankton groups and the abundant copepod *Temora longicornis*.

Jean-Henri Hecq showed the seasonal dynamics of surface zooplankton communities in the oligotrophic Bay of Calvi (Corsica, Ligurian Sea), where a time-series is conducted since 1979 by collecting samples with horizontal tows. The annual cycle is characterized by a plurimodal zooplankton peak that occurs generally between January and April with interannual variability. After spring, the zooplankton biomass remains very low until December. A strong decrease of chlorophyll concentrations was recorded in the years after the high values in 1979–1988, as well as a decrease in zooplankton biomass (as fresh weight). The important interannual variability observed in zooplankton assemblages seems to be controlled by hydro-climatic changes. In summers of 2005 and 2007, swarms of large *Pelagia* were observed in the Bay of Calvi. Stimulated by questions from the audience, the presentation was followed by an interesting discussion on *P. noctiluca*, its distribution, life cycle, and role in the pelagic foodwebs.

Webjörn Melle focused his presentation on macro-zooplankton species, which are generally under represented in standard zooplankton nets probably due to avoidance in the entrance to the sampling gear. He presented a new trawl (mouth opening 6x6 m, total length of about 50 m, mesh size of 6 mm from the entrance to the codend) properly designed to collect representative samples of macro-zooplankton, which could be used in combination with a modified multiple codend (MULTISAMPLER) to obtain depth stratified samples. The performance and catch characteristics of the trawl were tested during a series of surveys conducted in parallel with the traditional

fish trawl and with MOCNESS. The results showed the selective efficiensy of each gear in sampling different size fractions and macro-zooplankton species (e.g. *Sergestes arcticus*, *Benthosema glacialis*, *Meganictiphanes norvegica* and others). Answering a question of Gaby Gosky, Webjörn specified that the optimal depth range of performance for the new trawl is down to 600–700 m.

Kremena Stefanova presented the comparison of the zooplankton abundance and species composition in two coastal areas of the Black Sea, the Sevastopol Bay (1976–2005) and Varna Bay (1967–2005). This study was aimed at assessing the long-term variability of zooplankton communities and their response to anthropogenic and environmental factors. The comparison of interannual variability of mesozooplankton revealed similarities in the timing of hghest abundance during the '80s in both areas, but with values much higher in Sevastopol than in Varna Bay. The temporal changes in the structure of zooplankton communities and the peculiar features of each site were highlighted and related to anthropogenic, local and climate factors.

Gabriel Gorsky presented the results of a comparative analysis by Carmen Garcia Comas and colleagues conducted at LOV to assess the sampling efficiency of different nets by considering the total abundance, total biovolume, and size spectra of zooplankton communities. The comparison was based on samples obtained quasi-simultaneously during a year using three different nets: WP2 (200 μm), Juday Bogorov (300 μm), Regent (690 μm). This comparison was aimed at establishing if it is possible to merge samples for obtaining a longer time-series for zooplankton collected at a single site, as it is the case of the time-series at Point B in the Bay of Villefranche (Ligurian Sea, Western Mediterranean). All samples were analysed using the ZooScan imaging system in order to ensure standardized and homogeneous treatment. The statistical analysis of ZooScan data for the good recognition of zooplankton groups showed that the Regent net gave the best results, likely due to the net selection for the larger animals. The numerous questions posed after the presentation helped in clarifying various aspects of the best utilization of the ZooScan for zooplankton sample analyses.

Cecelia Hannides applied species-level analyses and compound-specific stable isotope methods (CSIA) to assess multiyear change in the structure and functioning of the zooplankton community at the ALOHA time-series in the North Pacific Subtropical Gyre (NPSG). This is an oligotrophic oceanic site with features similar to most open Mediterranean regions. Since zooplankton increased significantly at ALOHA from 1994 to 2005, the study was aimed at establishing if such variability occurred also at the species level and was driven by fluctuations in nitrogen (N) source. The results indicate that the increase in zooplankton biomass was driven by small cyclopoids and calanoids (e.g. Clausocalanidae, Paracalanidae, Mecynoceridae). CSIA indicate that the NPSG zooplankton were supported both by biological fixation of atmospheric N_2 and entrainment of NO_3^- from the main thermocline. This latter source appeared enhanced over this period since 1998.

During the Summary Discussion, numerous interesting topics emerged from the presentations were recalled and further developed. Among them, the abundance and role of small copepods in the Mediterranean and in the Atlantic (as well as in the NPSG) stimulated various contributions and comments. On the other hand, it was also remarked that information on macrozooplankton is similarly limited notwithstanding their relevance as consumers and food source for fish. Major attention should be focused on these extreme size categories of the planktonic animal

communities , both in relation to the standing stock and structure of zooplankton and their role in the trophic webs in this changing ocean scenario.

6.2 Session 2: Comparative zooplankton ecology of the North Atlantic and Mediterranean and autoecology of key species

Chair: Maria Manuel Angélico, Rapporteur: Kremena Stefanova

Denis Altukhov opened the session with a talk on *Oithona brevicornis* (Copepoda, Cyclopoida) which has been identified as a new copepoda component for the Black Sea zooplankton assemblage. Dr. Altukhov discussed some aspects of its biology, possible route of its invasion and conditions abetting successful introduction of species. *O. brevicornis* manifested clear seasonal trend with peak in autumn (late October-early November). It contributed high per cent to the total copepods abundance in the central part of the bay. Seasonal dynamics and distribution of *O. brevicornis* in 2006 – 2008 has much in common with the seasonal dynamics of *O. nana* (which disappeared in the entire Black Sea after *M.leidyi* invasion) in the 1970ies at the entrance to the Sevastopol Bay. It was noticed that the species is not observed yet in other regions of Black Sea. In the discussion after the talk, it was noted that future investigations should be aimed at finding relations between phytoplankton, bacterioplankton and nutrient conditions and *O. brevicornis* development and distribution. The authors excluded "Mediterranisation" as a reason for *Oithona* penetrating in the Black Sea; most probably the vector is the ballast water.

Maria Manuel Angélico gave a talk about autumn (2006) mesozooplankton communities off south and western Iberia. Dr. Angélico discussed the main characteristics of the mesozooplankton communities along the Atlantic South and Western Iberia based on comparisons between coastal vs. offshore regions, spring vs. autumn, and regions. New results were demonstrated synthesizing research on the seasonal variability and region contrasting (coastal vs. open sea). Multivariate and Permanova analysis and subsequent pair wise test were applied and revealed significant differences between April and November samples and between the shore and offshore areas. Despite the evidence of diverse hydrodynamic forcing within the study area and a clear relationship between the zooplankton community and the environmental variables associated, no contrast in the plankton composition was apparent with regional oceanographic patterns. The discussion after the talk identified as an important component of future investigations to include information for currents in the study area and to compare Portuguese and Spanish regions (along Barcelona coast). It was remarked that taxonomic details were needed in order to assess potential patterns in the zooplankton distribution.

Elvire Antajan talked about the mapping and modelling of winter ichthyoplankton distribution in the Channel and Southern North Sea. The study identified the location and characteristics of winter spawning habitats of some commercially exploited fish species in the Eastern English Channel and Southern North Sea, and specified the importance of the environmental and trophic conditions on the use of these habitats. The study mapped the spatial distribution of ichthyoplankton abundance for the main species; modelling of their preferred and optimal habitat to help decision-making and planning of human activities. Different types of sampling methods and laboratory analysis were used and compared emphasis was placed on the use of an image analyses system for automated identification of organisms. Through spatial modelling an example was given for assessing preferred and suitable habitats and comparison with observed egg distribution. In the following discussion it was noted

that the study was based on preliminary results of a project and it is due to be developed and investigated in detail.

Antonia Giannakourou gave a talk on microzooplankton (ciliate and dinoflagellate) mediated foodweb in the oligotrophic Aegean Sea (Eastern Mediterratean). Dr. Giannakourou presented the potential carbon flow from microheterotroph prey organisms to mesozooplankton predators, compared to the grazing impact of the latter on autotrophs. A gradual decrease of microzooplankton biomass as well as mesozooplankton from North to South was revealed. An important conclusion about the microzooplankton as a metabolically active component in the pelagic ecosystem of the Aegean Sea was made. Low ciliate biomass (compared to other ocean systems) indicated that mesozooplankton grazing can exert significant top down control on ciliate stocks. In the discussion that followed, it was emphasized that microzooplankton play an important role in the ecosystem, and people were asked to keep that in mind during the discussions during the workshop.

Amina Berraho spoke about the zooplanktonic community of Tangiers and M'diq (Gibraltar strait) (A. Zaafa *et al.*: Study of the zooplanktonic community of Tangiers and M'dig (Gibraltar Strait). The study compared the mesozooplankton population structure and copepod communities between the Atlantic and the Mediterranean regions. Different types of biological indices were applied to conclude that a high similarity of specific composition of copepods population exists between regions. Besides copepods density showed a coast-offshore gradient and a seasonality in the Atlantic transect, but in the Mediterranean transect, the spatial and temporal distribution of copepods density was variable. Abundance of different species presented a high spatial and temporal variability excluding *Paracalanus parvus* and *Oncea venusta* which mainly dominated the copepods population in both regions. The discussion that followed was mainly directed to the variability of copepod assemblages and their spatial distributions. The relevance of comparison with zooplankton composition from Atlantic southern Iberia was noted.

Maria Grazia Mazzocchi spoke about niche separation of *Clausocalanus* species in the Mediterranean Sea and in the Atlantic Ocean (A. Peralba *et al.*: Niche separation of *Clausocalanus* species in the Mediterranean Sea and in the Atlantic Ocean). The aim was to compare ecological traits of eight *Clausocalanus* species at different spatial and temporal scales. Three major aspects were presented: annual cycle, vertical distribution and spring distribution in different trophic conditions. Some conclusions: 1) Niches seem to be clearly separated among congeners with similar size and largely overlapping in congeners with different size: 2) Small *Clausocalanus* species could be used as good 'indicators' of environmental conditions and sentinels of climate changes. *Clausocalanus* assemblages more diversified in oligotrophic than in eutrophic regions. In the discussion after the talk it was noted that *Clausocalanus spp*. could possibly serve as an indicator of climatic changes and environmental conditions.

Ioanna Siokou-Frangou presented an overview of mesozooplankton spatial distribution in the Mediterranean Sea. Based on the literature of the last 20 years and new "freshly" collected data in the SESAME project, an overview of the spatial variability of mesozooplankton standing stock and community composition was given. The mesoscale hydrolographic and circulation features have a significant effect on the community structure. The mesozooplankton community was more heterogenous in 2008 compared with previous period. In general the eastern basin is poorer in terms of abundance than the western one. This spatial variability should be reflected in the foodweb structure of this "miniature ocean". Mediterranean waters dominated by

small (egg carrying – low mortality) size copepods and their juvenile stages all year-round. A discussion followed where the importance of the study was emphasized, and it was proposed to extend the investigation to include data on total mesozooplankton structure and abundance.

Erhan Mutlu) presented a study by Tuba Terbiyik and Ercan Sarihan on seasonal composition and abundance of Chaetognath species off the coast of Iskenderum Bay in the Eastern Mediterranean. Seasonal pattern and population density of six Chaetognath species was described applying two sampling strategies (vertically and horizontally). Results suggested that the impact of the mesoscale processes on the distribution and abundance of chaetognaths appears to be complex. In addition, certain species can be used as 'indicators' characterizing different water masses. Thus, chaetognaths appear to be especially suitable for the study of the effects of physical processes on the dynamics and variability of zooplankton populations.

Aziz Haffersass talked about zooplankton abundance and community in the Algerian coasts and affinities with Atlantic fauna. At the Algerian coasts, three copepod assemblages were identified, a coastal and a frontal group and an ubiquitous community. The zooplankton were distributed along well defined environmental gradients characterizing the distribution of physical variables and Chl *a*. Species belonging to groups 1 and 2 were originally advected from the Atlantic Ocean into the Algerian current; distribution and the number of Atlantic copepods were linked to Atlantic inflow. In the discussion that followed addressed issues such as the sampling procedure, identification criteria of frontal zones, and seasonal pattern. It was proposed to evaluate the data with colleagues from Atlantic Ocean to find relationship with physical process and to think for new survey in collaboration.

Vera Vukanic spoke about biodiversity studies of zooplankton communities in coastal waters of southern Adriatic –Boka Kotorska Bay. The aims were to determine basic regularities of oscillations of ecological parameters important for fluctuations in biodiversity of the zooplankton community, to present a detailed overview of the whole zooplankton community, and to define position and role of dominant species. The results, compared with data from other coastal and bay areas of Mediterranean and Adriatic, were used to show a similar seasonal pattern in behaviour of the plankton community and a repetition of a general trend characteristic for coastal waters in tropical and subtropical zones.

Soultana Zervoudaki spoke about temporal and spatial variability of *Farranula rostrata* (Copepoda, Cyclopoida) in the Mediterranean Sea. Based on data collected in coastal and open sea areas of the Mediterranean Sea, a first comparative overview of the spatial and seasonal variability of *F. rostrata* in different Med regions was presented. Some conclusions: 1) At the coastal areas, the absolute abundance of the species was low while in open sea it is more important; 2) Pronounced seasonal signals in abundance were observed in the Gulf of Naples, the northern and southern Adriatic Sea, the Bay of Tunis and the Saronikos Gulf while no clear seasonal pattern – in Balearic Sea, an area largely and continuously affected by offshore waters, 3) Species is a key component in the communities in particular in E Mediterranean. A discussion followed on the ecology of the species and its temporal variability.

Radhouan Ben-Hamadou presented data on zooplankton distribution in the Algarve coastal-zone (North East Atlantic Ocean). The goal of the study was to determine zooplankton communities and species dominances in the Algarve coastal zone and to assess the effect of river outflow and upwelling events on the spatial variability of the zooplankton in the region. Results showed the domination of cladocereans and cope-

pods. No clear patterns in spatial distribution were apparent, possible influence of instant conditions (hydrology and hydrodynamics) were mentioned; Feasible efficient and informative future monitoring by sampling key few locations (river and lagoons mouths and coastal station). After the talk, more information was provided for upwelling process conditions and relation with plankton community development. Some proposals for the timing of sampling procedure were made.

Howaida Zakaria spoke about the influence of salinity variations on zooplankton community in El-Mex Bay, Alexandria, Egypt. Based on the surface salinity, four types of water could be identified: 1) Mixed land drainage (L) with a salinity of < 10.00 ppt; 2) Mixed water (M) with a salinity range from 10.00 to 30.00 ppt; 3) Diluted seawater (D) with a salinity range from 30.00 to 38.50 ppt; and 4) Mediterranean Sea water (S) of salinity > 38.50 ppt. Each of the types above was characterized by a particular zooplankton community. The highest zooplankton abundance was observed in the mixed land drainage type. Mediterranean water type differed greatly from type L, M and D water represented intermediate stages. A discussion followed addressing to the variability of copepod assemblages, and their spatial and seasonal patterns.

During the general discussion after the presentations under Session 2 the issue was raised as to what was known and what the studies have added to our knowledge for the North Atlantic, Mediterranean Sea and Black Sea. A new component of the Black Sea ecosystem, *Oithona brevicornis* (Copepoda, Cyclopoida), has been identified. The species is not observed yet in other regions of the Black Sea. It seems as small *Clausocalanus* species could be used as good 'indicators' of environmental conditions and sentinels of climate changes. Although the definition of "indicator" may vary with objective and area of interest. *Farranula rostrata* was identified as a key component in very oligotrophic areas especially in Eastern Mediterranean. The microzooplankton may be characterized as a metabolically active component in the pelagic ecosystem of the Aegean Sea. Low ciliate biomass (compared to other ocean systems) indicated that mesozooplankton grazing can exert significant top down control on ciliate stocks. New results were presented on the mapping of spatial distribution of ichthyoplankton abundance for the main species and modelling of their preferred and optimal habitat to help decision-making and planning of human activities. The geographic "puzzle" of the Mediterranean Sea is more complete (especially in the east). The eastern basin is indeed poorer than the western, but there are areas of the E-Mediterranean presenting more similarities with the W-Mediterranean (both as standing stock and as community composition). The characterization of the Mediterranean Sea as a "miniature" ocean may be useful for comparative purposes and studies of ecosystem processes. The importance of including oceanographic data in ecological studies was emphasized. Some results showed variability in plankton assemblage in association with regional hydrodynamic patterns.

Some notable gaps in knowledge: The reproductive strategy of *Farranula rostrata* and its role in the trophic foodweb should be investigate in order to permit a better understanding of its ecological role within the pelagic foodweb of oligotrophic areas. The biology, ecology and the role of Coryceidae and Oncaeidae in the Mediterranean pelagos needs to be studied. Signals from climate change and anthropogenic forcing need to be distinguished.

Future studies should include the extension of monitoring programmes along the coasts of the Mediterranean and Atlantic. When possible, hydrographic and other environmental information should be included in such studies. Indicators to measure

the ecosystem response should be developed. The aim should be to detect more relevant species and/or groups and to identify changes in plankton communities and explore and compare with other regions in Atlantic Ocean and Mediterranean-Black Seas. On the map of Atlantic Ocean, Mediterranean and Black Sea there are many missing data especially along the connecting areas (Mediterranean- Black Seas; Mediterranean – Atlantic sea; Mediterranean –Red Sea- Indian Ocean). It is important to explore how to complete this picture (for example could be used as a base of project proposal). In the discussion, the importance of links between the two science communities (N-Atlantic, Mediterranean) was emphasized. Collaborations could be built by the exchange of ideas and knowledge and producing common work: collaborative papers, projects, meetings, workshops, website.

6.3 Session 3: The marine foodweb from microzooplankton to small pelagic fish

Chair: Roger Harris, Rapporteur: Néjib Daly Yahia

Dr Roger Harris opened the session and invited the first speaker Dr Jurgen Alheit to present his contribution.

Jurgen Alheit spoke on the impact of climate variability on pelagic foodwebs in European shelf systems, with a focus on trophic relations between zooplankton and small pelagic fish. 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. 20–25% of total world fishery is represented by Sardine, Anchovy, Sprat and Sardinella. Numerous observation 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. Dr. Alheit discussed how these species responded to climate variability.

Dr. Alheit referred to the work of Sabatel *et al.*, 2006 (Sardinella in the Spanish waters) and Wasmund and Uhlig, 2003 which have shown changes accross 3 trophic levels (phytoplankton, zooplankton and fish).

Important changes that have taken place are 1) Changes in trophic levels. Regime changes in copepod community dominated by *Acartia* and *Temora* have been observed in the Baltic Sea since 1990. These changes seem to induce changes in fish abundance and dominance with an increase of Sprat densities from 1992. 2) Changes in phenology. Changes in phenology induce mismatch situations for Sprat. Sprat gonadal maturation cycle 2002/2003 shows that Sprat peak spawning is May/June in 2002 while during 2003; the spawning activity is as high as in May/June 2003. 3) Changes in distribution. There's a geographic shift of ecosystems and egg and larvae of Anchovy and Sardines in German Bight sampled with a Bongo net are not observed from 10 years!!

Decadal changes in distribution of Northeast Atlantic Calanoids in relation with NAO have also been observed. Anchovy catch rates show that from 1990 to 1995 there's an increase of the stocks in the Bay of Biscay and North Sea and from 2004 a total absence. Dr Alheit linked these changes to global warming.

In conclusion, changes in dynamics of small pelagic fish population can indicate climate changes. The spectacular examples are the invasion of the North Sea by the An-

chovies and Sardines since the 1990 which have established spawning populations in this northern shelf sea and the unprecedented increase in abundance of *Sardinella* in the western and eastern Mediterranean Sea. At the same time as shown in his presentation, there's a large-scale northward movements of copepod assemblages, the main food source of small pelagic fish.

Dr. Alheit ended by reminding the group of an ICES / PICES / GLOBEC – SPACC workshop that will be held in Hamburg – Germany from 3 to 7 November 2008 on the subject "Changes in distribution and abundance of clupeiform small pelagic fish in relation to climate variability and global change [WKSPCLIM].

Dr Maria Grazia Mazocchi asked if there is a relationship with diet of this pelagic fish? Dr M-Luz Fernandes de Puelles asked how important *Acartia* and *Temora* was in the Baltic Sea? Similarly, Dr Mohamed Néjib Daly Yahia asked if stomach contents were studied? Dr Alheit answered that actually the dominant copepod species in the stomachs are *Acartia* and *Temora* the Baltic Sea

Costas Frangoulis spoke about faecal pellet characteristics and production from mesozooplankton obtained in the Southern North Sea, Eastern and Western Mediterranean. Dr Frangoulis compared mesozooplankton faecal pellet characteristics (shape, volume, sinking rate and 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 North Sea; 1997, 1999, 2000 in the Bay of Calvi and 1997, 2006 in the Aegean Sea. The results show that the faecal pellet volume decrease from the North Sea to the Mediterranean Sea and that the faecal pellet volume is correlated with mesozooplankton individual Dry Weight. In the Southern North Sea, there's a decrease of the faecal pellet production rate because there's a change in the phytoplankton composition from Diatoms to *Phaeocystis.*

Dr Maria Grazia Mazocchi asked if coprophagy was measured, and Dr Frangoulis answered that coprophagy has not been measured. Dr Howaida Zakaria asked about a possible confusion between faecal pellets and other organic mater? Dr Frangoulis answered that the shape of faecal pellet is characteristic and well known and there are identification keys. Dr Mohamed Néjib Daly Yahia: how long is the experiment for faecal pellet production rate measurement? Problem of organism stress during experiment! Dr Frangoulis answered that the experiment time is a few minutes, so it's possible that organisms are emphasized.

Benjamin Kürten gave a talk about how terrestrial run-off and hydrography influence trophic relationships and pelagic foodweb structure in the central and southern North Sea. In this work stable isotope analysis $\delta^{13}C$ and $\delta^{15}N$ have been used to identify trophic relationships in aquatic ecosystems. $\delta^{13}C$ measurement of lipid biomarker profiles have only recently been established to characterize energy sources, composition and fate of organic matter from primary producers to consumers. To estimate the effects of terrestrial run-off and the susceptibility to climate change, particulate organic matter 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) the north of the Dogger Bank (DB) and at the Sean Gas Fields (SG). Bulk isotope ratios and $\delta^{13}C$ of phospholipids-derived fatty acids (PLFA) were measured via IRMS and GC-c-IRMS, respectively.

Dr Kürten proposes to use lipid biomarkers as a method to link photosynthesis and fish production in the North Sea. Phospholipids derived from fatty acids (PLFA) are considered as good lipid biomarkers to measure production and characterize heterotropism. The results show that there are elevated number of material PLFA markers at Dogger Bank and Oyster Ground. There is a small variability of trophic level markers $\delta^{15}N$ in *Calanus finmarchicus* and *C. helgolandicus*. This means that heterotrophic food prevailing for *C. finmarchicus* in the North Sea. Under stratified conditions copepods accumulated more lipids, while mesozooplankton appears decoupled from small sized POM variation. Microscope counts of micro- and mesozooplankton may provide further evidence of multivorous foodwebs at the Oyster Ground and Sean Gas Fields including the microbial foodweb.

Stephane Pesant talked about EUR-OCEANS meeting of experts on the consolidation of plankton datasets to validate Plankton Functional Types (PFT) model. A group of European experts in marine plankton biodiversity, database management and ecosystem modelling met recently under the framework of EUR-OCEANS and identified 10 Plankton Functional Types. Dr Pesant described a set of recommendations from the meeting, which objectives were to: (1) review the contribution of past, current and planned working groups on the topic (e.g. SCOR, ICES, and IOCCG) and set recommendations for a better integration and implementation of these efforts; and (2) consolidate plankton data into biomass of Plankton Functional Types (PFTs). Dr. Pesant proposed that (1) IMBER, EUROCEANS, MARBEF and MGE will be approached to support the development and networking of small communities around the different sources of PFT data; (2) standards vocabularies describing parameters and methods will be used; (3) proper bodies (i.e. BODC; PANGAEA, IFREMER) will be approached; (4) PANGAEA be the designated information system to develop PFT data (http//doi.pangaea.de).

Dr. Pésant's presentation stimulated a discussion on data ownership and the extent by which data should be made available to the wider scientific community before actually being analysed and published by the collecting institutes. Opininons differed among the Workshop participants as to how this would be best achieved. The discussion concluded that all participants who will provide a paper with WKZEM presentation for the online journal JORD (see Section 7) will also prepare a meta-database before next summer.

6.4 Session 4: Appearance and disappearance of species vs. global warming

Chair: Maria Luz Fernandez de Puelles, Rapporteur: Claudia Halsband-Lenk

The opening presentation was given by Alessandra Conversi, entitled "Appearance and (quasi) disappearance of copepod species in the Gulf of Trieste at the end of the 1980s, and comparison with the North European Seas". Alessandra introduced a time-series at two stations in the Gulf of Trieste (Adriatic Sea) with data from 1970 to 2005. The region is characterized by relatively high permanent production as compared to other, more oligotrophic regions of the Mediterranean, and fairly low diversity with about 30 neritic species. About 20 copepod species are recorded there with *Acartia clausi* as the dominant form and high abundances of *Penilia avirostris* in July and August. The dataset revealed changes in physical conditions in the late 1980s, dividing the time-series into two distinct periods, from 1970 to 1987 (T1) and from 1988 to 2005 (T2), based on cumulative sums of winter SST. These two periods were associated with changes in the ecology of zooplankton: The number of total copepods doubled in T2, together with changes in phenology of *Pseudocalanus elongatus*. This

summer/fall species shifted its seasonal maximum to about one month later than in T1, coinciding with a general decrease in abundance. In some instances *Pseudocalanus* even disappeared and may be at the brink of extinction in the area. On the other hand, a new species, *Diaxis pygmaea*, arrived in the Gulf and became a regular resident. *Oithona* spp. also increased, indicating a shift towards smaller species. These changes were related to changes in the climatic forcing: in addition to changed patterns of precipitation and wind conditions, the Ionian gyre reversed from anticlockwise to clockwise, probably shifting southern species northward. However, these changes occurred at two time-scales, while the gyre reverse was abrupt, the warming trend is a comparably slow process. A similar phenomenon was recorded for *Pseudocalanus elongatus* in the North and Baltic Sea. PCA analysis for both datasets revealed the influence of various climatic indices (NAO, EA, NHT, etc.) on planktonic species timing.

The talk was followed by questions from Jasmin, who suggested that changes in the food chain could be responsible for phenology changes rather than temperature trends alone, and Ioanna Siokou-Frangou, who was interested in which *Oithona* species had been recorded in the Gulf of Trieste. Alessandra replied that several species were combined in the counts.

The second presentation was given by Nejib Daly Yahia, entitled "Are the outbreaks timing of *Pelagia noctiluca* (Forskäl, 1771) getting more frequent in the Mediterranean basin?" Nejib started off by demonstrating that jellyfish have outbreaks typically in the warm season and outlined the two hypotheses that have been suggested to explain them. Mass occurrences may be related either to climatic indices such as the NAO, or alternatively be caused through foodweb relationships. Nejib then presented a dataset covering the period 1978–2007 with quantitative and semi-quantitative information from different regions of the Mediterranean Sea, including the Gulf of Tunis, the Adriatic Sea, the Aegean Sea and the Balearic Sea. He demonstrated that both regular and irregular peaks of *Pelagia noctiluca* had been recorded in different regions and posed the question in how far large-scale processes are involved in producing such patterns vs. regional climatic processes. A statistical analysis revealed that the periods of climatic shifts differed between regions, separating the Aegean Sea from the more similar Southern Adriatic and the Gulf of Tunis. Moreover, an 11-yearly cycle of *Pelagia* outbreaks was more recently superimposed with more numerous peaks that do not fit the general pattern. In a PCA analysis *Pelagia* abundance clustered with the Northern Hemisphere Temperature (NHT) in January. From these results it was concluded that *Pelagia* outbreaks have changed in the western Mediterranean in relation to climate variability, where the best indicator was the NHT index in winter. Finally the authors suggest including *Pelagia* as an indicator of change in the marine foodweb.

Gaby followed up with the question if eutrophication may also be connected to *Pelagia* outbreaks, but Nejib said there was no evidence of this.

The next talk was given by Alexandra Gubanova with the title "Influence of alien species on the seasonal dynamics of zooplankton of the coastal areas of the Black Sea (Sevastopol Bay)". Long-term climatic fluctuations in combination with anthropogenic effects have changed the marine environment of the Black Sea. Alexandra compared the Black Sea foodweb 1) before the invasion of *Mnemiopsis leidyi* (1976–1980), 2) after introduction of *Mnemiopsis leidyi* (1980–1989), 3) before invasion of *Beroe ovata* (1989–1990), 3) after invasion of *Beroe ovata* (2002), and 4) after invasion of *Oithona brevicornis* (2006). The pre-invasion scenario was characterized by seasonal oscilla-

tions of *Acartia margalefi* and *Oithona nana*. Then, *Mnemiopsis* increased the predation pressure particularly on summer zooplankton community, as shown by a fourfold increased predation coefficient. As a result, copepod abundance was low all year-round in 1989/90. In 2002 a predator of *Mnemiopsis, Beroe ovata*, was introduced followed by a trophic cascade releasing predation pressure on copepods. In the following years copepod abundance peaked again in August, but species composition had changed to different congeners (dominance of *Acartia clausi/tonsa* and *Oithona similis*). Finally, yet another *Oithona* species entered the scene in 2006, *Oithona brevicornis*, contributing up to 80% in autumn months. However, *Acartia margalefi* had also been recorded again in 2007.

Next was a presentation by Sami Lakkis, given by Gaby Gorsky in his absence, entitled "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?" Data on water chemistry were presented for the period 1965–2004. Typical temperatures ranged from 16 to 30°C in an oligotrophic setting with regular seasonal fluctuations of salinity. A shift in temperature-salinity patterns was observed in the late 1980s, accompanied by a decreasing trend in phytoplankton abundance in the early 1990s. This was paralleled by low zooplankton abundance and biomass. Low phytoplankton diversity was contrasted by low biomass but high diversity of zooplankton. A number of alien species were recorded, including 55 copepod species, cirriped larvae and appendicularians, revealing similarities with the Red Sea system. The author noted 45% of endemic species as well. In conclusion, the data show an increased tropicalization of the Levantine Basin.

The question if the number of endemic species suggested in the talk is realistic initiated some discussion in the audience lead by Gaby, Maria Luz and Ioanna. Interest was expressed in a list of alien species in that area. Moreover, the issue of taxonomic competence was raised in order to achieve consistent datasets and improve taxonomic standards among researchers, referring to the SESAME taxonomic workshops as a good example. Emphasis must be given to taxa that are important but difficult to identify, such as the *Clausocalanus* species complex and *Oithona* species among others. Gaby also noted a demand for more frequent taxonomic updates within the community as they arise.

The following two presentations were both given by Priscilla Licandro. The first dealt with the "Impact of Global Changes on the Dynamic of Carnivorous Gelatinous Plankton in Mediterranean Pelagic Ecosystems" with *Muggiaea atlantica* as example. *M. atlantica* is a colonial calycophoran siphonophore that can express high growth rates and therefore reaches very high abundances in favourable conditions. In recent years it started to outnumber the endemic species *M. kochi* and the presentation poses the question if *M. atlantica* has recently increased on a basin scale. In a time-series in the Ligurian Sea (Bay of Villefranche) *M. atlantica* has increased its dominance since the mid 1980s on the expense of *M. kochi*, which in turn decreased. This phenomenon was confirmed by data from the Gulf of Tigullio. An explanation was sought in the fact that a change in the hydroclimatic index NAO in the late 1970s had caused a cooling in the western Mediterranean, followed by a warming trend after the mid-80s. It appeared that *M. atlantica* was well adapted to cold temperatures and thus increased during the cooling phase, however maintained high abundance also thereafter and persisted during the warmer 1990s. In the Bay of Bizerte (Tunisia) in contrast, the occurrence of *M. atlantica* was dependent on Atlantic inflow events and was not a dominant species there. In the southern Adriatic *M. atlantica* has been recorded since 1997, where it was actively reproducing since then. In this case the appearance of the

species was related to the Eastern Mediterranean Transient (EMT) which was characterized by a frontal system that separated the circulation between the Ionian and the Levantine basins, coinciding with an inflow of Atlantic water into the Adriatic Sea. In conclusion, *Muggiaea atlantica* increased in the last decades in certain regions of the Mediterranean following hydrological changes in relation to large-scale climatic fluctuations and associated low temperatures. Although able to reproduce efficiently at lower temperatures than *M. kochi*, *M. atlantica* may still reproduce efficiently also at higher temperatures and thus easily established itself in the northwestern Mediterranean and Adriatic Seas. Differences in the distribution and abundance of *M. atlantica* may indicate that some regions are more sensitive to hydroclimatic changes, or that other environmental factors should be considered to explain the increasing dominance of this Atlantic species in the Mediterranean.

Two questions were raised in the follow up: Alessandra asked if there might be competition for resources between the endemic *M. kochi* and *M. atlantica*. This has to date not been studied. Another question related to the morphology of the hydrozoic form of *M. kochi*.

The second talk was given by Priscilla in lieu of Juan Carlos Molinero, entitled "Climate and jellyfish outbreaks in the Mediterranean Sea". The Mediterranean can be considered a climate change hot spot. Because gelatinous zooplankton channel energy flow away from fish, the question if these organisms increase and why has triggered both public and economic interest. This study has standardized several datasets and combined them with both large-scale and regional scale climatic indices (RCIs) with the aim of quantifying the downscaling of climate conditions from the large-scale Atlantic level to regional levels. The long-term trend in Sea Surface Temperatures (SST) shows mainly positive anomalies since the 1980s, which led to enhanced stratification. SST in the Mediterranean is significantly linked to gelatinous plankton outbreaks as revealed by a meta-analysis. However, this relationship proved to be discontinuous and not significant more recently (since 2000). Mediators of climatic conditions are predominantly surface atmospheric pressure, precipitation and SST. Water column stability and temperature preceding their seasonal peak determines interannual variations of jellyfish outbreaks. In addition, overfishing may contribute to the rise of gelatinous plankton and reinforce the climatic relationship.

Ben Hamadou asked how the RCI is calculated in detail. Priscilla mentioned several parameters that comprise the RCI. Grazia inquired if the life cycles of the species involved are temperature-sensitive, but this has not been studied yet. Jürgen commented that he was confused about the lumping of several climatic indices, which in turn represent only proxies of climate conditions consisting themselves of a conglomerate of parameters; so are proxies of proxies still meaningful?

Erhan Mutlu presented next that the "Black Sea ecosystem has basically recovered as inferred from distribution of gelatinous organisms in the southern region". Dramatic anthropogenic impacts, such as nutrient loads from the Danube river), have caused changes of the Black Sea ecosystem and were documented since the 1960s. In addition, the Black Sea has been invaded by Mnemiopsis leydei about two decades ago. These changes have been accompanied by episodic changes in the chemical and biological properties of the Black Sea system, e.g. in the structure of the mesozooplankton. Small forms, such as Acartia and Oncaea, had been replaced by larger organisms in the 1980s. The carnivorous Beroe is located between the rim current and the coast and between the two main gyres of the Black Sea, while Mnemiopsis, Beroe's main prey, is co-located with eddies and downwelling locations. Pleurobrachia pileus is

present on the northern edges of eddies, *Aurelia* sp. prefers waters between eddies instead. A comparison of the patchiness of *Beroe*, the distribution patterns of *Mnemiopsis* and *Pleurobrachia* and the size structure of *Mnemiopsis* in June and October 2006 and May 2007 revealed the following: *Mnemiopsis*, outbreaks co-occurred with the collapse of small pelagics (anchovies); their biomass and abundance decreased since *Beroe* arrived in the Black Sea; the length-weight relationships of *Mnemiopsis* depend on its size structure, as larger individuals were recorded since the arrival of *Beroe* in 1997. In conclusion, decreased eutrophication (bottom–up) and reduced top–down control of *Mnemiopsis* on zooplankton have contributed to a recovery of the Black Sea ecosystem. However, it should be noted that the catch of anchovy was again reduced after an increased catch of bonito, its predator, indicating enhanced predation pressure of bonito on anchovies.

Last but not least the session was concluded with a talk given by Serena, outlining "The 2003 heat wave and marine plankton communities". In summer 2003 the average temperature exceeded the previous record of 1757 and was one of the most oligotrophic years in the Mediterranean, especially the Adriatic Sea. Highest Sea Surface Temperatures (SST) of 20 years had been recorded at 5 stations, in the Bay of Villefranche, Naples, Trieste, Saronikos and Sevastopol. There were no consistent effects on the total number of copepods at these stations, but *Centropages typicus* was significantly reduced. In the Gulf of Trieste the lack of a chlorophyll peak led to reduced abundance of *Penilia* sp. A substantial drought in the terrestrial environment impacted on the marine system due to a lack of fresh water input and consequently continuously high salinities. The cold water species *Pseudocalanus elongatus* had a record low abundance. The conclusions were as follows: some of the typical summer species were reduced in certain regions. The signal was strongest in the Gulf of Trieste, with the worst drought for 15 years. Some species appeared to be more sensitive to 'hot water' than others. It is thus proposed to use summer species as indicators for warming, e.g. *Centropages typicus, Penilia avirostris* and *Pseudocalanus elongatus*.

Meriem suggested also *Paracalanus* as indicator, as it disappears in August and September from Algerian waters. Maria Luz asked for clarification concerning the different depths of the 5 stations presented to assess possible offshore influences. Gaby pointed out that *Penilia* makes a good indicator, as it is an interesting case and easy to identify. Nejib raised the possibility of *Centropages chierchiae* as Atlantic indicator.

Maria Luz summarized that several interesting groups of organisms had been identified in this session that indicated climatic changes by their appearance or disappearance, in particular certain copepods and jellies. While the Mediterranean is a very complex system, the Black Sea provides an especially good example to study such causal relationships.

Ban Hamadou reported that he had found a new species of jellyfish (Hydrozoa) in the Gulf of Cadiz and inquired if other people had seen it in their samples, which was not the case.

Gaby raised the question what kind of indicators we should look at within the larger Mediterranean/Atlantic community, individual species or rather community structures? Priscilla mentioned the example of Atlantic/Pacific comparisons attempted by the SCOR group and suggested to compare population structures also in the Mediterranean, thus focus on groups rather than single species. Nejib added that it may be advantageous to come up with a list of key species that people could work on. In this context Maria Luz raised the issue of harmonization of methods among us as well as an intercalibration of species names, as it had become apparent, e.g. in the Lakkis

talk, that there might be different vocabulary in use in different places. A common language among researchers was considered crucial to successfully tackle the scientific questions.

Gaby demanded to give more consideration also to predator-prey relationships, since foodweb components and thus foodweb structure will change upon arrival of new species. This requires looking at larger spectra of organisms and their relationships. As an example, he mentioned the jellyfish *Pelagia noctiluca*, which may impact on the species composition of zooplankton. Another example is the case of doliolids and salps, which modifies the planktonic system through predation on copepod eggs. Mass occurrences of such filter-feeders may trigger behavioural changes of copepods, in addition to the removal of eggs etc. In turn, copepods eat appendicularian eggs as well, causing oscillations in the recruitment of both groups.

Maria Luz suggested that we should attempt to do inter-latitude comparisons of Mediterranean, Atlantic and other areas. She pointed out that the contributions from e.g. Tunisia and Lebanon will help to understand the influence of areas other than the Atlantic, such as the Red Sea, in terms of a tropicalization of the Mediterranean. There should therefore be a balanced research effort to uncover both the impacts from the North Atlantic and from adjacent seas in the south.

Ioanna noted that it may not be sensible to define exact key species, as we cannot predict what we are going to find next. There may also be a time constraint as to how fine-scaled our taxonomic analyses can be.

Roger replied to this that a communications network would help to spread the information if something unusual shows up at some station to inquire if others observe it too, or could start to watch out for certain phenomena more specifically.

Benjamin suggested identifying suitable 'key species' according to their thermal optima and determine the likelihood of their appearance or disappearance. Astthor replied that such optima would depend on location and might be different between regions. Moreover, as shown by Priscilla (see above) indicator species can, after initial establishment, adapt to a suboptimal temperature range, possibly making predictions based on thermal optima unreliable. Priscilla added that the changes we are dealing with are also more complex than just warming, as shown for the EMT, which included hydroclimatic changes.

Nejib asked if we could identify one favourite key species for everyone? Ioanna suggested that a species of socio-economic interest should be chosen. Grazia opted for *Penilia* and *Temora stylifera*, two species that expanded in the last years, as good case studies to start with in a review paper. This could be extended to community structure as well, but it would be a good idea to start with dominant species.

6.5 Poster Presentations

Five posters were presented and briefly introduced by one of the co-authors.

Benjamin Kuerten presented results from 3 stations in the North Sea where he had sampled zooplankton with 3 different mesh sizes at high frequency (every 4 h). Both 270µm and 200µm underestimated zooplankton biomass, pointing to the importance of the small size spectrum with nauplii and small species. These were efficiently samples by the 50µm net only. The seasonal succession of species was also studied.

Sophie Pitois introduced the audience to the existence of the Dove (UK) time-series, which was examined with special emphasis on the fine mesh measurements from a

65µm mesh net, in addition to 2 other size fractions of 270 µm and 1000µm. The fine mesh samples had only recently been analyzed and reflected annual changes of total abundance. Interestingly, some species showed different trends in the small size fraction than in the larger ones. Information on nauplii and young copepodite stages may be useful for production models.

Tamar Rachamim studied nutrient recycling of zooplankton in a lake in North Israel. Changes in the recycling of phosphate were recorded during a seasonal cycle. Mesozooplankton consisted mainly of copepods and cladocerans and their seasonal excretion reached a maximum in summer. It was concluded that zooplankton excretion is a major source of phosphate in this system, contributing between 66.8% and 58.7% of total PO_4 in summer and winter, respectively.

Meriem Khelifi-Touhami presented data from the Gulf of Annaba, Algeria. The seasonal cycle of zooplankton was studied on WP-2 (200µm) samples in dry vs. wet seasons, when the Mafraq estuary enriches the Gulf with nutrients. The dominant species were determined in both seasons.

Roger Harris presented a poster in lieu of Delphine Bonnet and Severine Boyer dealing with the distribution of the copepod *Paracartia grani*, an intermediate host of the oyster pathogen *Marteilia refringens*, in southeast France. They reviewed the historical distribution of *P. grani* in Europe, and analyzed the species' impact on the local zooplankton community. It appeared that other *Acartia* species are declining since the arrival of *Paracartia*, raising the question how *Paracartia* impacts on native biodiversity.

6.6 Theme Discussion 1: Time series and sampling

Chair: Astthor Gislason, Rapporteur: Webjörn Melle

Astthor Gislason introduced the workshop participants to the discussion by summing up and expanding on the themes of the Workshop.

Under the heading "Intercomparability of time-series and their harmonization" he pointed to the new version of the ICES Zooplankton status report which for a number of time-series of zooplankton and additional data on temperature and chlorophyll now presents new and identical statistical analyses of all time-series sites covering major parts of the ICES area (including some Mediterranean sites). Since the report focus on unit less anomalies, intercomparison between sites is facilitated.

Damien Eloire presented the design of an R-script toolbox where he has included the possibility of performing all analyses done on the time-series within the ICES Zooplankton Status Report. For details on the analyses available in the R-toolbox, please contact D. Eloire.

Priscilla Licandro informed about new CPR-routes established in the Mediterranean, now with analyses of gelatinous zooplankton. The hope is that these will become permanent routes in future.

Astthor Gislason ended the introduction by pointing at the main objective of the Workshop – what are the benefits of comparing Northern and Southern zooplankton time-series.

The workshop participants agreed that the Status report is very important and more time-series from the Mediterranean and the Black Sea should be included. Perhaps additional parameters besides temperature and chlorophyll, such as microzooplank-

ton and phytoplankton species, should be included in future. New and short time-series should be included at an early stage in order to secure data.

A new Eurocean dataportal has been established and data rescue funded. Within this dataportal data from national and international databases can be extracted. All data rescued by Eurocean funding are stored in databases accessible through the dataportal. That existing time-series are made available to the scientific community through dataportals or common databases, was strongly advocated by many workshop participants.

The importance of improving quality of data by arranging workshops on taxonomy was emphasized.

Sampling of zooplankton is done by different gears, with different mesh sizes, to different depths and with different time resolution. Still data can be compared! Any data from a new site will be of interest and importance. Good records of metadata, however, must be available. Various regions have different levels of capabilities in sampling, data storage and handling. Data should be harmonized, but this is often an economical issue.

6.7 Theme Discussion 2: Zooplankton databases and data treatment

Chair: Stéphane Pesant, Rapporteur: Damien Eloire

The focus of the second workshop was on zooplankton databases rather than data treatment since the latter aspect was addressed during the first workshop session. The majority of participants to this workshop are responsible for high-quality zooplankton time-series datasets that are essential to the comparative analysis of the Mediterranean and the North Atlantic zooplankton ecology.

The workshop started with a presentation given by Stéphane Pesant to address the availability and accessibility of existing datasets, leading to a discussion where participants were asked to indicate if/where they usually archive their data, and to indicate if/where/how they access data from databases in order to complement their own data. This exercise provided an overview of the most well known and used Data Centres, including NMFS-COPEPOD (Coastal & Oceanic Plankton Ecology, Production & Observation Database; http://www.st.nmfs.noaa.gov/plankton/), National Oceanographic Data Centre (NODCs), and the World Data Centre for Marine Environmental Science (WDC-MARE / PANGAEA®; http://www.pangaea.de). However, the majority of participants indicated that they keep their data locally, either as a collection of files or in small databases within their respective laboratories, without archiving them in National or World Data Centres.

Following this exercise, discussions went on to identify the main issues that drive participants away from archiving and sharing data in established data centres. The main reason is that collecting net samples and identifying zooplankton species and development stages is time consuming and very expensive, so that participants wish to be the first to publish their data and get recognition for their work. Unfortunately, the time frame for publishing taxonomic data are often longer than the two-year moratorium period recommended by many research projects, during which period metadata are public but data can be kept out of the public domain. There was a non-unanimous but general anxiety among participants to the effect that some scientists may extract other scientists' data from databases and publish them without informing or acknowledging the authors. Practices such as the use of citable, unique dataset

identifiers (e.g. doi), protecting datasets with passwords, or keeping track of who downloads datasets were discussed. Although these practices may reassure some participants they are not yet fully implemented in data archives. Stéphane Pesant demonstrated how datasets can be extracted from data portals and data warehouses, and how datasets can be cited using unique dataset identifiers. The PANGAEA® information system of WDC-MARE was used as an example.

The second part of the discussion concerned the actual process of submitting datasets to data archives. Examples and comparison of different methods used to submit were given. Stéphane Pesant emphasized that, in order to compare zooplankton time-series from the Mediterranean and the North Atlantic, datasets must be harmonized, which requires the development of standard vocabularies describing parameter names, units, and sampling and analysis methodologies such as CPR data, net sampling, optical sampling, acoustic sampling, mass measurements, preservation, manual counting, automated counting, biovolume measurements, and biomass computations. Additionally, it must be emphasized to plan expert-to-expert comparisons of taxonomic identification under microscopy or using automated imaging systems. These comparisons are essential to compare counts made by experts in different regions/labs and also at different periods of long-term time-series. Standard vocabularies for taxonomy are now well established and maintained by registers of marine species such as ERMS, WoRMS and ITIS. However, most data centres do not yet have the capacity to archive biological data, especially taxonomy.

The recent developments of e-journals (electronic journal) dedicated to the publication of data were discussed during the workshop. Two examples of such journals were given by Stéphane Pesant: "Earth System Science Data – The Data Publishing Journal" (www.earth-system-science-data.net) at Copernicus publishing and "Journal of Oceanography Research and Data" (www.obs-vlfr.fr/Journal/index.php/JORD). The advantages of such journals are that they are peer-reviewed, they count in citation indices, and both the article and the data are available online. These journals are thus a mean to publish datasets rapidly since the paper itself does not involve in-depth analysis of the data.

In order to safeguard and share zooplankton time-series data, leading to comparative analysis of the Mediterranean and the North Atlantic zooplankton ecology, we recommend to setup a small community, comprising field and lab scientists working on zooplankton, modellers and scientists specialised in meta-analysis and information system managers. This community could seek workshop funds from European and international consortia/bodies such as ICES, CIESM, IMBER, EUR-OCEANS and MarBEF+. The goals of this community would be to:

(1) Promote and facilitate the submission of data into designated National Oceanographic Data Centres (NODCs) or, in cases where NODCs cannot handle biological data, these should be submitted to a World Data Centre (WDC), notably WDC-MARE in Europe. Information systems such as EMBL-EBI (genetics), EurOBIS (biogeography), NMFS-COPEPOD (zooplankton), NOMAD (HPLC), PANGAEA (all marine data), and SAHFOS (CPR) typically extract data from archives and repackage them into predefined or customizable collections. The community should request from NODCs and WDCs that data be made available to these information systems.

(2) Develop standard vocabularies describing variables, sampling protocols and analytical methods. This work should be lead by data managers from the relevant information systems and data centres, building up on existing initiatives such as those

undertaken by the IOC-IODE programme, the NERC Data Grid programme, the SeaDataNet programme, and the Marine Metadata Interoperability network.

(3) Recommend best practices to harmonize existing data and plan the collection of new zooplankton data. Harmonisation involves the comparison of sampling and analytical methods and planning involves selecting preferred sampling and analytical protocols for plankton determination, including complementary measurements required to compute carbon biomass or metabolic rates, e.g. wet weight, size, biovolume or carbon content of plankton and sometimes environmental conditions such as temperature or food concentration.

7 Publication of workshop proceedings

The issue how to present the results of the workshop to the wider scientific community was discussed. Besides producing a Workshop Report to ICES and CIESM it was felt that a further reporting of the outcomes of the Workshop was needed. There was consensus that the Workshop should also produce a special issue of ICES Cooperative Research Series with extended abstracts of all presentations. A recommendation has been made to the ICES Publications Committee to that effect. The idea if to publish selected papers of the workshop in a scientific journal, either as a collection of papers or a single review article, was discussed. It was felt that a possible avenue for such a venture would be the online journal JORD (https://www.obs-vlfr.fr/Journal/index.php/JORD).

8 Concluding Remarks

The following time table was set up for the dissemination of the results of the Workshop:

- 15 November 2008: Abstracts of contributions sent to Astthor Gislason that will see to it that they be posted on the WKZEM website.
- 1 March 2009: Extended abstracts for ICES Cooperative Research Series to be sent to Astthor Gislason and Gaby Gorsky. They will send instructions as to how these should be formatted.
- 1 July 2009: MS edited by Astthor and Gaby sent to ICES Cooperative Research Series for publication.
- 1 July 2009: Deadline of manuscript submission to JORD.

The workshop identified latitudinal and longitudinal differences in ecosystem structure and functioning, and addressed the issue of top down control of ecosystems in relation with climate change. It is evident that there are key species and indicator species to both ecosystems, while some species are common to both systems. There is considerable exchange between basins (gene flow, species introduction, invasions, disappearance), and it is evident that the Mediterranean is influencing the N-Atlantic.

Collective actions that need to be implemented in future include:

- Reinforcing of time-series
- A virtual network of experts should be created, with a description of the expertise by the participants, which should be circulated among the partners.
- Long-term connections between WGZE and CIESM should be established.

- There is consensus that the groups should meet again in future, possibly at a location not so far from the N-Atlantic as the present Workshop, thus stimulating better participation from the N-Atlantic side. Timing of this event was not resolved.
- A website should be created. Whether it should be part of the MedZoo website or a continuation of the WKZEM website remains open.
- Other future collaborative actions may include training courses and summer schools.

Annex 1: List of participants

Name	Address	Email
Alheit Juergen	Leibniz Institute for Baltic Sea Research, Seestr. 15, 18119 Warnemuende Germany	juergen.alheit@io-warnemuende.de
Altukhov Denis	Plankton Department, Institute of Biology of the Southern Seas, 2, Nakhimova ave., Sevastopol, 99011 Ukraine	dennalt@gmail.com
Angélico Maria Manuel	INRB/IPIMAR - National Institute for Fisheries and Sea Research, Lisboa, Portugal	angelico@ipimar.pt
Antajan Elvire	IFREMER, Laboratoire Environnement Ressources, BP 699, 62200 Boulogne sur Mer, France	Elvire.Antajan@ifremer.fr
Ben-Hamadou Radhouan	CCMAR - Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal	bhamadou@ualg.pt
Berraho Amina	Institut National de Recherche Halieutique Département d'Océanographie et d'Aquaculture Laboratoire d'Océanographie Biologique 2, Rue de Tiznit, Casablanca Morocco	amina_berraho@yahoo.fr
Broms Cecilie	Institute of Marine Research, Bergen, Norway	cecilie.broms.aarnes@imr.no
Conversi Alessandra	CNR - Consiglio Nazionale delle Ricerche, ISMAR - La Spezia, Forte S. Teresa, Loc. Pozzuolo, 19032 Lerici (SP) Italy	a.conversi@ismar.cnr.it
Daly Yahia Mohamed Néjib	University 7 November - Carthage. Faculty of Sciences of Bizerte Laboratory of Aquatic Systems Biodiversity and Functionning Bizerte Tunisia	nejib_daly@yahoo.fr
Daly Yahia Ons	Agronomic National Institute of Tunisia, 43 Avenue Charles Nicolle, 1082, Tunis, Tunisia	dalyyahya.ons@inat.agrinet.tn
Eloire Damien	Plymouth Marine Laboratory Prospect Place, The Hoe, Plymouth, PL1 3DH, Devon UK	dmelo@pml.ac.uk

Name	Address	Email
Fernandes de Puelles Maria Luz	Baleares Center, Spanish Institute of Oceanography P.O.Box 291 07080 Palma de Mallorca Spain	mariluzfernandezdepuelles@yahoo.es
Fonda Umani Serena	Department of Life Sciences, University of Trieste v. Valerio 28/1 34123 Trieste Italy	s.fonda@units.it
Fragopoulu Nina	Laboratory of Zoology, Department of Biology, University of Patras 265 00, Rion, Patras Greece	nfrago@upatras.gr
Frangoulis Costas	Institute of Oceanography, Hellenic Centre for Marine Research (HCMR) Greece	c.frangoulis@ath.hcmr.gr
Giannakourou Antonia	Institute of Oceanography, Hellenic Center for Marine Research (HCMR) P.O. Box 712, Postal Code 19013, Mavro Lithari, Anavissos, Attiki, Greece	agiannak@ncmr.gr
Gislason Astthor (Chair)	Marine Research Institute, Skulagata 4, Reykjavik, Iceland	astthor@hafro.is
Gorsky Gabriel (Chair)	Observatoire Océanologique, LOV - UMR 7093, BP 28 06234 Villefranche-sur-Mer Cedex, France	gorsky@obs-vlfr.fr
Gubanova Alexandra D	Plankton Department, Institute of Biology of the Southern Seas, 2, Nakhimova ave., Sevastopol, 99011, Ukraine	adgubanova@gmail.com
Hafferssas Aziz	Faculté des Sciences Biologiques, Université des Sciences et de la Technologie Houari Boumedienne, Alger, Algérie	hafferssas@yahoo.fr
Halsband-Lenk Claudia	Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, UK	clau1@pml.ac.uk
Hannides Cecelia C. S.	Energy, Environment and Water Resources Center, The Cyprus Institute, 15 Kypranoros Street, 1645 Nicosia, Cyprus	cecelia.hannides@gmail.com
Harris Roger	Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, UK	RPH@pml.ac.uk

Name	Address	Email
Hecq Jean-Henri	Oceanology, MARE Center, University of Liège, 3 B 4000 LIEGE – Belgium, STARESO BP 33, F 20260 Calvi Corsica, France	jh.hecq@ulg.ac.be
Heard Jessica	Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, UK	jessh@pml.ac.uk
Isari Stamatina	Laboratory of Zoology, Department of Biology, University of Patras, 265 00, Rion, Patras, Greece	misari@upatras.gr
Khelifi-Touhami Meriem	Département des Sciences de la Mer, Faculté des Sciences, Université Badji Mokhtar, Annaba 23 000, Algérie	khelifi_meriem@yahoo.fr
Kuerten Benjamin	School of Marine Science and Technology, University of Newcastle, Ridley Building, Room 260, Newcastle upon Tyne, NE1 7RU, UK	kuertenb@web.de
Licandro Priscilla	Sir Alister Hardy Foundation for Ocean Science (SAHFOS), The Laboratory, Citadel Hill, Plymouth, England PL1 2PB, UK	prli@sahfos.ac.uk
Mazzocchi Maria Grazia	Stazione Zoologica Anton Dorhn, Villa Comunale, 80121 Napoli, Italy	grazia@szn.it
Melle Webjörn	Institute of Marine Research, Bergen, Norway	webjoern.melle@imr.no
Mutlu Erhan	Institute of Marine Sciences and Technology, Dokuz Eylul University, Inciralti, Izmir, Turkey	erhan.mutlu@deu.edu.tr
Pesant Stephane	CNRS, Laboratoire d'Océanographie de Villefranche, 06230 Villefranche-sur-Mer, France , Université Pierre et Marie Curie-Paris, Laboratoire d'Océanographie de Villefranche, 06230 Villefranche-sur-Mer, France	pesant@obs-vlfr.fr

Name	Address	Email
Pitois Sophie	CEFAS, Lowestoft Laboratory, Lowestoft, Suffolk, NR33 0HT, UK	sophie.pitois@cefas.co.uk
Pitta Paraskevi	Institute of Oceanography, Hellenic Centre for Marine Research, 46.7 km Athens-Sounio ave, PO Box 712. 19013 Anavyssos Attikis, Greece	vpitta@her.hcmr.gr
Rachamim Tamar	Kinneret Limnological Laboratory, Israel, Oceanographic & Limnological, Research PO Box 447, Migdal 14950, Israel	tamarbsor@nana.co.il
Renz Jasmin	Research Institute Senckenberg, DZMB-Deutsches Zentrum für marine Biodiversitätsforschung, Martin-Luther-King Platz 3, D-20146 Hamburg, Germany	jrenz@senckenberg.de
Said Mohamed	Professor of Physical Oceanography, National Institute of Oceanography & Fisheries (NIOF), Alexandria, Egypt	mamsaid2@hotmail.com
Siokou-Frangou Ioanna	Institute of Oceanography, Hellenic Centre for Marine Research, 46.7 km Athens-Sounio ave, PO Box 712. 19013 Anavyssos Attikis, Greece	isiokou@ath.hcmr.gr
Stefanova Kremena	Institut of Oceanology, Bulgarian Academy of Sciences, P.O. Box 152, 9000 Varna, Bulgaria	stefanova@www.io-bas.bg
Vukanic Vera	1. Laboratory of Zooplankton, 85330 Kotor, Montenegro, 2. University of Novi Pazar, Department of Biology, Vuka Karadzica bb, 36600 Novi Pazar, Serbia	v_vukanic@yahoo.com
Zakaria Howaida	National Institute of Oceanography and Fisheries (NIOF), Egypt	howaidazakaria@hotmail.com
Zervoudaki Soultana	Hellenic Centre for Marine Research, I. Oceanography, P.O. Box 712, Anavissos, 19013, Greece	tanya@ath.hcmr.gr

Participants of the Joint ICES/CIESM Workshop to compare Zooplankton Ecology and Methodologies between the Mediterranean and the North Atlantic (WKZEM)

Annex 2: Agenda

Monday 27 October 2008

08:45–09:00 REGISTRATION

09:00–10:00 OPENING ADDRESSES (Gabriel, Ioanna, Astthor)

10:00–10:20 INTRODUCTION OF PARTICIPANTS

Session 1: Overview of ongoing time-series programmes and methodology in the Mediterranean and the North Atlantic

Chair: Ehran Mutlu; Rapporteur: Maria Grazia Mazzocchi

10:20–10:40 Cecilia Broms and Webjörn Melle
Zooplankton and phytoplankton monitoring in the North Sea, Nordic Seas, and Barents Sea – Sampling program and aims

10:40–11:00 Damien Eloire, Alessandra De Olazabal, Serena Fonda Umani, Roger Harris, Steve Hay, Maria Grazia Mazzocchi, Behzad Mostajir, Jens Rasmussen, Paul Somerfield, Valentina Tirelli and Delphine Bonnet
Temporal variations in the zooplankton community at 4 European coastal stations: a 10 years time-series comparison

11:00–11:30 COFFEE BREAK

11:30–11:50 Mª Luz Fernandez de Puelles and Maria Grazia Mazzocchi
Decadal zooplankton changes in two different neritic areas of the Western Mediterranean

11:50–12:10 Claudia Halsband-Lenk and Elvire Antajan
Zooplankton time-series analyses in the English Channel: potential for regional multimetric foodweb indices

12:10–12:30 Jean-Henri Hecq and Anne Gofart
Interannual Variability of the Surface Zooplankton of the Bay of Calvi (Corsica)

12:30–14:20 LUNCH BREAK

14:20–14:40 Webjörn Melle
Design and performance of a new macro-plankton trawl in combination with a multiple codend system

14:40–15:00 Kremena Stefanova, Lyudmila Kamburska, Alexandra Gubanova and Denis Altukhov
Temporal fluctuations of zooplankton communities in Varna Bay (Western Black Sea) and Sevastopol Bay (Northern Black Sea): a comparative study

15:00–15:20 Carmen Garcia Comas, Xiaoxia Sun, Lars Stemmann, Pieter Vandromme, Léo Berline, Esmeraldo Dos Santos, Marc Picheral, Stéphane Gasparini and Gabriel Gorsky
Effect of three different nets on the estimates of size spectra, abundance and biovolume of mesozooplankton community in the Ligurian Sea

15:20–15:40 Cecelia C.S. Hannides, Michael R. Landry, Maria Saburova, Alexandra Gubanova, Elena Popova, Tatyana Melnik and Brian Popp
Long-term change in zooplankton community structure and function: a case study from the North Pacific Subtropical Gyre

15:40–16:30 SUMMARY DISCUSSION OF SESSION 1

16:30–17:00 COFFEE BREAK

17:00–18:00 THEME DISCUSSION 1: TIME SERIES AND SAMPLING
Chair: Astthor Gislason/Gabriel Gorsky; Rapporteur: Webjörn Melle
Among others the following subjects will be addressed:
1 – New time-series and sampling strategy
2 – Intercomparability of time-series and their harmonization
3 – Benefits of the intercomparison of Northern and Southern seas time-series

Tuesday 28 October 2008

Session 2: Comparative zooplankton ecology of the North Atlantic and the Mediterranean and autoecology of key species

Chair: Maria Manuel Angélico; Rapporteur: Kremena Stefanova

09:00–09:20	Denis A. Altukhov and Alexandra D. Gubanova *Oithona brevicornis* (Copepoda, Cyclopoida) – the new component of the Black Sea zooplankton
09:20–09:40	Maria Manuel Angélico and Marta Silva Spring and Autumn (2006) mesozooplankton communities off south and western Iberia
09:40–10:00	Elvire Antajan, Stéphanie Lelièvr, Corinne Martin, Caroline Warembourg and Sandrine Vaz Mapping and modelling of winter ichthyoplankton distribution and associated zooplankton assemblages in the Eastern English Channel and Southern North Sea
10:00–10:20	Antonia Giannakourou, Paraskevi Pitta, Soultana Zervoudaki. Epaminondas D. Christou and Ioanna Siokou-Frangou Microzooplankton (ciliate and dinoflagellate) mediated foodweb in the oligotrophic Aegean Sea (Eastern Mediterranean)
10:20–10:40	A. Zaafa, Omar Ettahiri, N. Elkhiati, L. Somoue, Amina Berraho, Sukina Zizah and A. Mekaoui Study of the zooplanctonic community of Tangiers and M'diq (Gibraltar Strait)
10:40–11:10	COFFEE BREAK
11:10–11:30	Àurea Peralba, Maria Grazia Mazzocchi and Roger P. Harris Niche separation of *Clausocalanus* species in the Mediterranean Sea and in the Atlantic Ocean
11:30–11:50	Ioanna Siokou-Frangou and Maria Grazia Mazzocchi Overview of mesozooplankton spatial distribution in the Mediterranean Sea
11:50–12:10	Tuba Terbiyik and Ercan Sarihan (Mutlu to present) Seasonal Composition and Abundance of Chaetognath Species off Coast Iskenderun Bay in the Eastern Mediterranean
12:10–14:00	LUNCH BREAK
14:00–14:20	Aziz Haffersass and R. Seridji Zooplankton abundance and community structure in the Algerian coasts and affinities with Atlantic fauna
14:20–14:40	Vera Vukanic Biodiversity studies of zooplankton community in coastal waters of southern Adriatic – Boka Kotorska Bay
14:40–15:00	Soultana Zervoudaki, Epaminondas D. Christou, Stamatina Isari, D. Lucic, Maria Grazia Mazzocchi, Mª Luz Fernadez de Puelles, Nejib Daly Yahia, Alexis Ramfos, N. Fragopoulu and Ioanna Siokou-Frangou Temporal and spatial variability of *Farranula rostrata* (Copepoda, Cyclopoida) in the Mediterranean Sea
15:00–15:20	Radhouan Ben-Hamadou, M. Alexandra Chicharo, Cristina Madeira, Pedro Morais, Joana Cruz and Luis Chicharo Zooplankton distribution in Algarve coastal zone (North East Atlantic Ocean)
15:20–15:40	Howaida Zakaria, A.A. Radwan and M.A. Said Influence of salinity variations on zooplankton community in El-Mex Bay, Alexandria, Egypt
15:40–16:30	SUMMARY DISCUSSION OF SESSION 2
16:30–17:00	COFFEE BREAK

17:00–18:00 THEME DISCUSSION 2: ZOOPLANKTON DATABASES AND DATA TREATMENT
Chair: Stéphane Pesant; Rapporteur: Damien Eloire
Among others the following subjects will be addressed:
1 – Treatment of the data – taxonomy vs. ecology
2 – Data exchange and inherent problems
3 – Use and utility of existing databases

Wednesday 29 October 2008

Session 3: The marine foodweb from microzooplankton to small pelagic fish
Chair: Roger Harris; Rapporteur: Nejib Daly-Yahia

09:00–09:20 Jurgen Alheit
Impact of climate variability on pelagic foodwebs in European shelf systems, with a focus on trophic relations between zooplankton and small pelagic fish

09:20–09:40 Costas Frangoulis, Epaminondas D. Christou and Ioanna Siokou-Frangou
Faecal pellet characteristics and production from mesozooplankton obtained in the Southern North Sea, Eastern and Western Mediterranean

09:40–10:00 Benjamin Kürten and Suzanne Painting
Terrestrial run-off and hydrography influence trophic relationships and pelagic foodweb structure in the central- and southern North Sea

10:00–10:20 Stéphane Pesant, Corinne Le Quéré, Gabriel Gorsky (and others –to be confirmed)
EUR-OCEANS meeting of experts on the consolidation of plankton datasets to validate Plankton Functional Types models

10:20–11:00 SUMMARY DISCUSSION OF SESSION 3

11:00–11:30 COFFEE BREAK

11:30–12:00 DISCUSSION PUBLICATION PLANS

12:00–13:00 LIGHT LUNCH

13:00–19:00 EXCURSION TO KNOSSOS AND AROLITHOS

20:00 WORKSHOP DINNER IN HERAKLION

Thursday 30 October 2008

Session 4: Appearance or disappearance of species vs. global warming
Chair: Ma Luz Fernandez de Puelles; Rapporteur: Claudia Halsband-Lenk

09:00–09:20 Alessandra Conversi, T. Peluso and Serena Fonda-Umani.
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

09:20–09:40 Nejib Daly Yahia, Mirna Batistic, Lukic Davor, Mª Luz Fernandes De Puelles, Priscilla Licandro, Alenka Malej, Juan Carlos Molinero, Ioanna Siokou-Frangou, Soultana Zervoudaki and Ons Daly Yahia - Kéfi.
Are the outbreaks timing of *Pelagia noctiluca* (Forskäl, 1771) getting more frequent in the Mediterranean basin?

09:40–10:00 Alexandra Gubanova and Denis Altukhov.
Influence of alien species on the seasonal dynamics of zooplankton of the coastal areas of the Black Sea (Sevastopol Bay)

10:00–10:20 Sami Lakkis and Vanda Novel-Lakkis
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?

10:20–10:40 Priscilla Licandro, Mirna Batistic, Nejib Daly Yahia, Oons Daly Yahia, Alenka Malej, Juan Carlos Molinero, Samy Souissi, Chema Touzri and Claude Carré
Muggiaea atlantica: an Atlantic indicator of hydroclimatic changes in the Mediterranean

10:40–11:00 Juan Carlos Molinero, Mohamad Nejib Daly Yahia, Mirna Batistic, D. Dulcic, Ma Luz Fernandes de Puelles, P. Licandro, Alenka Malej, L. Prieto, Ioanna Siokou-Frangou, Soultana Zervoudaki and Ons Daly Yahia - Kéfi
Climate and jellyfish outbreaks in the Mediterranean Sea

11:00–11:30 COFFEE BREAK

11:30–11:50 Erhan Mutlu
Black Sea ecosystem has been basically recovered as inferred from distribution of gelatinous organisms in the southern region

11:50–12:10 S.A. Piontkovski., A. Olita, Serena Fonda Umani, Lars Stemmann, Carmen Gazia Rubio, Stéphane Gasparini, Maria Grazia Mazzocchi, Ioanna Siokou-Frangou, Soultana Zervoudaki, Alexandra Gubanova and Denis Altukhov
The 2003 heat wave and marine plankton communities

12:10–14:00 LUNCH BREAK

14:00–14:40 SUMMARY DISCUSSION OF SESSION 4

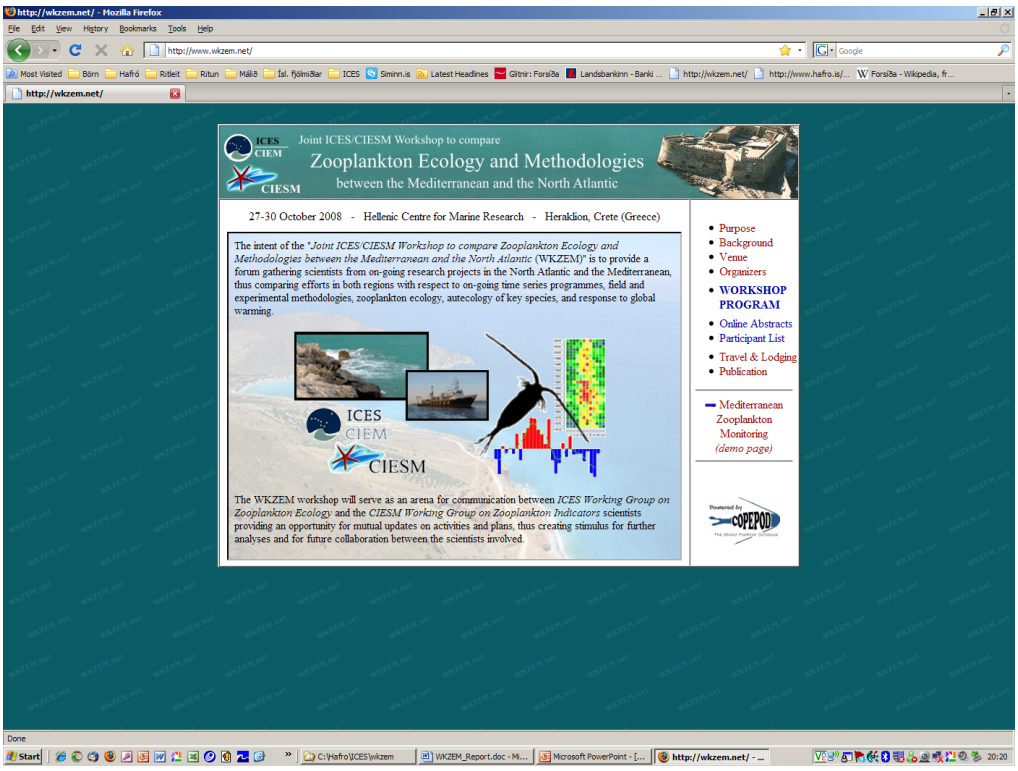
14:40–15:20 Posters presentations

1) S. Painting and B. Kürten: Structure of zooplankton communities at 3 contrasting sites in the North Sea
2) Sophie Pitois: A fine-mesh zooplankton time-series from the Dove Sampling station (North Sea)
3) Tamar Rachamim, G. Gal, T. Zohary, I. Berman-Frank: Nutrient recycling by zooplankton in Lake Kinneret – Israel
4) Meriem Khelifi-Touhami: The zooplankton from the Gulf of Annaba (SW Mediterranean) submitted to an estuary plume
5) Severine Boyer and D. Bonnet. A new comer in the Thau Lagoon (south of France). Paracartia grani (Copepoda, Calanoida): an increase of biodiversity or a real threat?

15:20–16:20 OVERALL DISCUSSION (perspectives and collaboration in future)
(Gabriel Gorsky, Astthor Gislason)

16:20–16:30 WORKSHOP CLOSING (Gabriel Gorsky, Astthor Gislason and Ionna Siokou Frangou)

Annex 3: Workshop website



http://www.wkzem.net/

Annex 4: Abstracts of presentations

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

Alheit, J.

Leibniz Institute for Baltic Sea Research, Seestr. 15, 18119 Warnemuende, Germany. Email: juergen.alheit@io-warnemuende.de

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, despite 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

Altukhov, D.A. and A. D. Gubanova

Plankton Department, Institute of Biology of the Southern Seas, 2, Nakhimova ave., Sevastopol, 99011, Ukraine. Email: dennalt@gmail.com

Seasonal dynamics of copepod *O. brevicornis* – the new component of the Black Sea zooplankton in 2005–2007 was investigated on the basis of biweekly 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 sin-

gle 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 50 000 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.

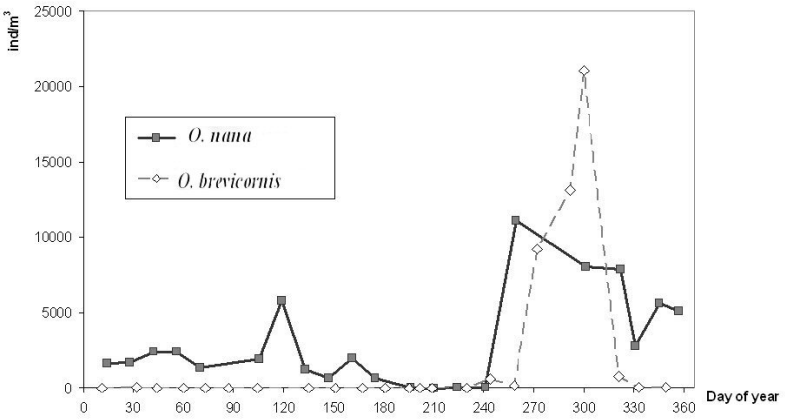


Figure. Seasonal variation in *O. nana* (1976) and *O. brevicornis* (2006) abundance in the mouth of Sevastopol Bay.

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

Angélico, M.M. and M. Silva

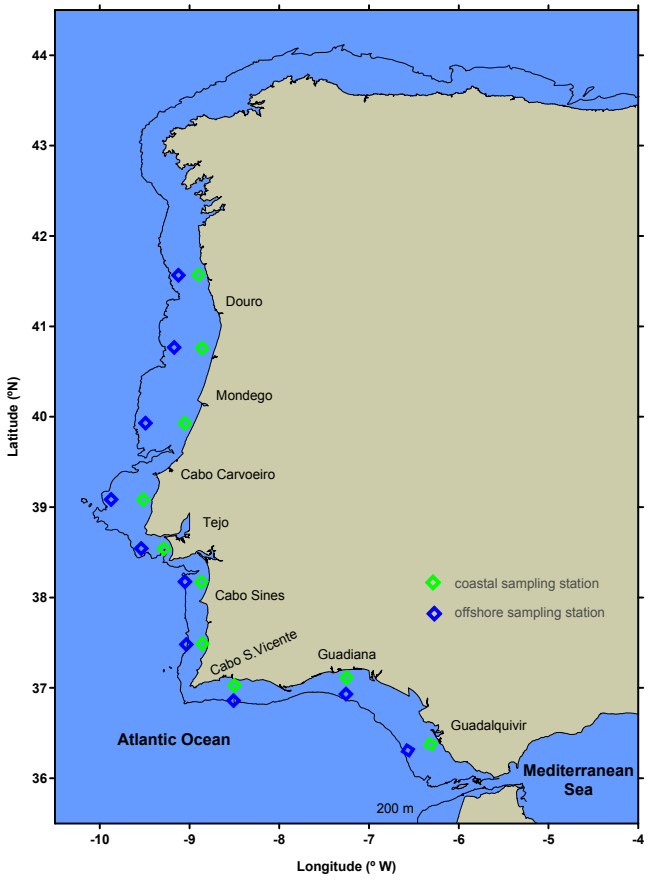
INRB/IPIMAR – National Institute for Fisheries and Sea Research, Lisboa, Portugal. Email: angelico@ipimar.pt

Zooplankton community analysis was conducted for spring (April-2006) and autumn (November-2006) 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. Altogether 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 echosounding research.

Zooplankton biomass was higher during spring period with peak values off the NW coast and the inner Gulf of Cadiz. For 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 among 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 displaying sampling location.

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

Antajan, E.[1], S. Lelièvre[2], C. Martin[2], C. Warembourg[2] and S. Vaz[2]

[1] *IFREMER, Laboratoire Environnement Ressources, BP 699, 62200 Boulogne sur Mer, France. Email: Elvire.Antajan@ifremer.fr*
[2] *IFREMER, Laboratoire Ressources Halieutiques, BP 699, 62200 Boulogne sur Mer, France.*

Since the late 1990'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 to understanding and forecasting fishery recruitment evolution and supporting ecosystem-based management.

This study aims to identify the location and characterize 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 trawlnet (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.

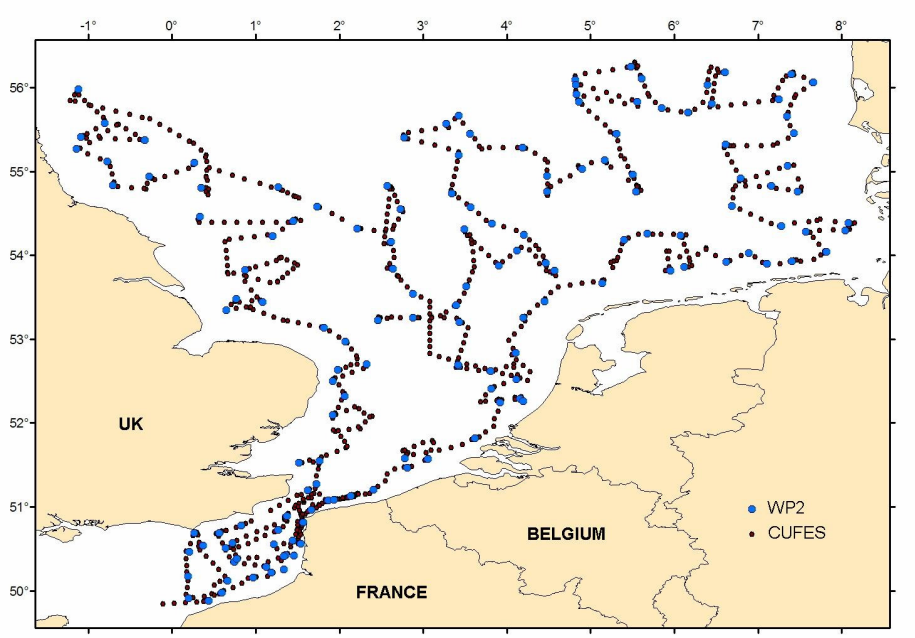


Figure 1. Spatial location of CUFES and WP2 sampling points taken by the "RV Thalassa" from 25 January to 22 February 2008.

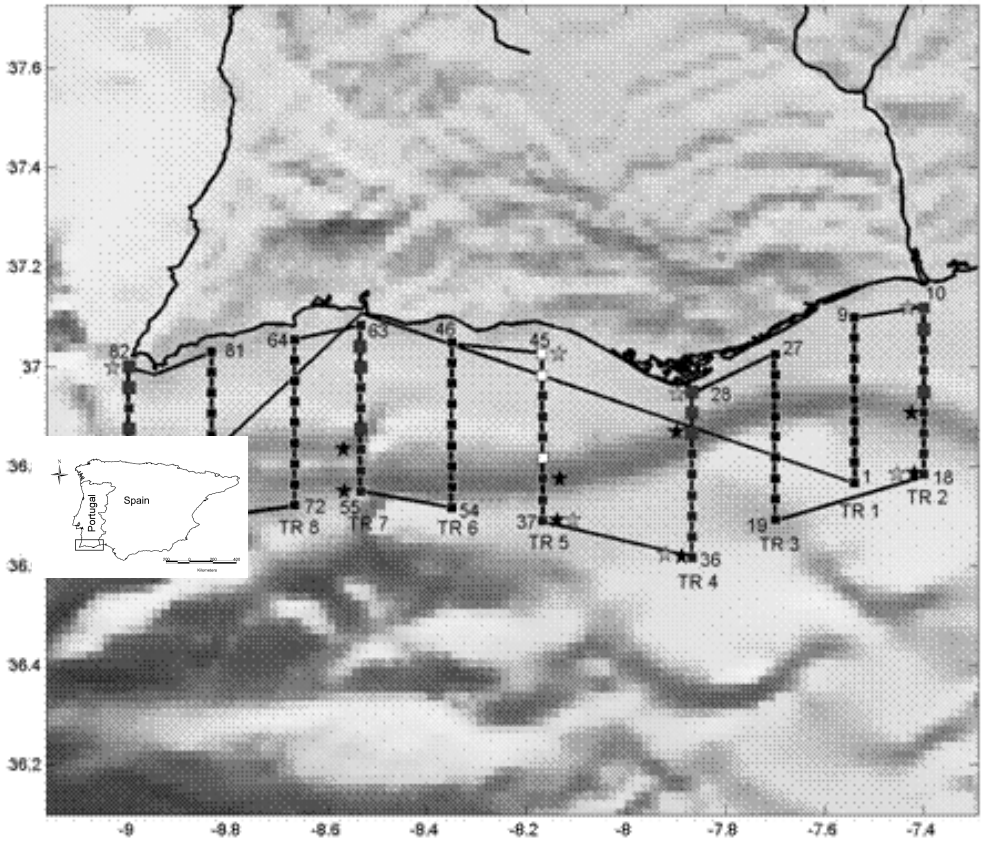
Zooplankton distribution in Algarve coastal zone (North East Atlantic Ocean)

Ben-Hamadou, R.[1], M.A. Chicharo, C. Madeira, P. Morais, J. Cruz and L. Chicharo

[1] *CCMAR - Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal. Email: bhamadou@ualg.pt*

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 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 (e.g. 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 × 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

smaller 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 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 countercurrent 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.



A new comer in the Thau lagoon (South of France). *Paracartia grani* (Copepoda, calanoida): an increase of biodiversity or a real threat?

Boyer, S. and D. Bonnet

Equipe REMI, Laboratoire Ecosystèmes Lagunaires, UMR5119, CNRS-IFREMER-UM2, Place Eugène Bataillon, 34095 Montpellier Cedex 05, France.

Since the last ten years, a new species *Paracartia grani* has appeared in the Mediterranean Sea. This copepod belongs to the Acartidae family which is the most abundant family in Thau.

Paracartia grani has a Northeastern Atlantic and North Sea distribution and is encountered on common shelf and coastal waters. It was observed for the first time in the Thau lagoon in 1998. A year before, it was listed in the western harbour of Genova in the Ligurian Sea and it can now also be found in the Ebro delta (Spain), in Barcelona Harbour (Spain) and in the Gulf of Thermaikos (Greece) where it has established.

The origin of *P. grani* in the Thau lagoon could be related to the oysters and mussels cultures in Arcachon and/or Marennes d'Oléron bay. Indeed, there are many oysters transfers from the Atlantic, where the oysters reproduce and originate in, and the Mediterranean, where they are sent to grow faster.

Furthermore, this copepod is an intermediate host for a paramyxean parasite *Marteilia spp.* which affects oysters and mussels survival. *P. grani* presence indicates most of the time the parasite occurrence and therefore a potential threat for oyster farms. The introduction of this species could have a major consequence on the oysters and mussels aquaculture in the Thau lagoon. Indeed, the production in this lagoon contributes to 10% of the French national production of oysters with 13 700 and 9 700 tons of mussels produced/year respectively.

Parcaratia grani apparition in Thau has certainly affected the zooplankton species diversity of the planktonic community. Indeed, since *P. grani* appearance, the congeneric *Acartia latisetosa* has disappeared. This alien species, that tends to become invasive in the Mediterranean, could be considered to be a direct driver of planktonic biodiversity loss in the Thau lagoon.

Our work presents the first study on *Paracartia grani* ecology and its role in the Thau lagoon ecosystem.

Zooplankton and phytoplankton monitoring in the North Sea, Nordic Seas, and Barents Sea – Sampling program and aims

Broms, C. and W. Melle

Institute of Marine Research, Nordnesgt. 50, N-5024 Bergen, Norway.

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 preselected 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 fishery 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

Conversi, A., T. Peluso and S. Fonda-Umani

[1] *CNR - Consiglio Nazionale delle Ricerche, ISMAR - La Spezia, Forte S. Teresa, Loc. Pozzuolo, 19032 Lerici (SP), Italy. Email: a.conversi@ismar.cnr.it*

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?

Daly Yahia, M.N.[1], M. Batistic[2], L. Davor[2], M. Fernandes De Puelles[3], P. Licandro[4], A. Malej[5], J.C. Molinero[6], I. Siokou-Frangou[7], S. Zervoudaki[7] and O. Daly Yahia–Kéfi[8]

[1] *University 7 November – Carthage. Faculty of Sciences of Bizerte. Laboratory of Aquatic Systems Biodiversity and Functioning. Bizerte, Tunisia.*
[2] *Institute for Marine and Coastal Research, Dubrovnik, Croatia.*
[3] *IEO Palma De Mallorca, Spain.*
[4] *SAHFOS, Plymouth, UK.*
[5] *Marine Biology Station Piran, Slovenia.*
[6] *IFM-Geomar, Kiel, Germany.*
[7] *HCMR, Athens, Greece.*
[8] *Institut National Agronomique de Tunisie, Tunis, Tunisia.*

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 suggests 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 strength 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

Eloire, D., A. De Olazabal, S.F. Umani, R.P. Harris, S. Hay, M.G. Mazzocchi, B. Mostajir, J. Rasmussen, P. Somerfield, V. Tirelli and D. Bonnet

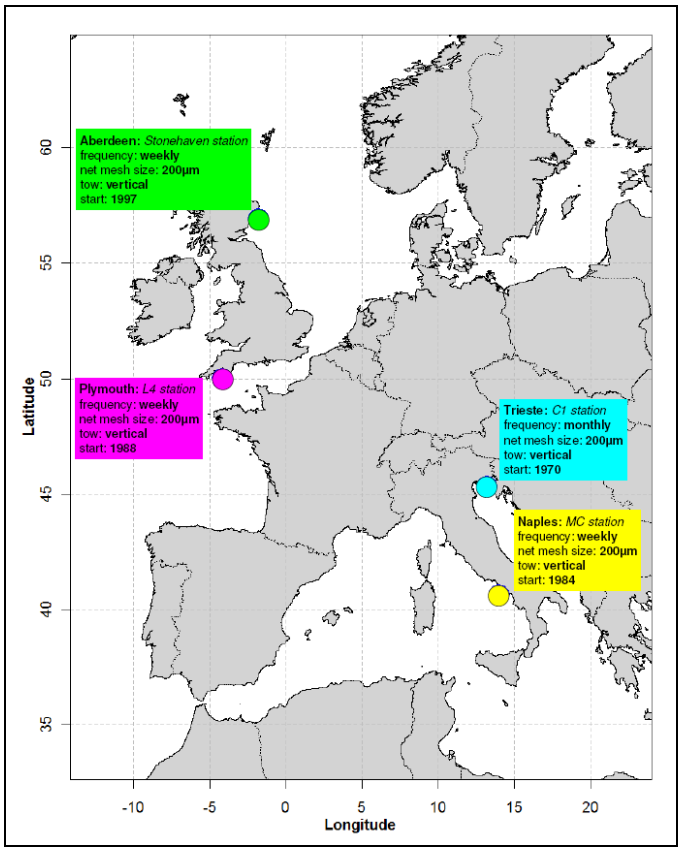
Plymouth Marine Laboratory, Prospect Place, Plymouth, PL1 3DH, Devon, UK. Email: dmelo@pml.ac.uk

Temporal patterns and structures of zooplankton communities have been studied at four European coastal stations: Stonehaven (northwestern 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

Fernandez de Puelles, M.L.[1] and Mazzocchi, M.G.[2]

[1] *Centro Oceanografico de Baleares. Muelle de Poniente s/n. 07015 Palma de Mallorca, Spain. Email: mluz.fernandez@ba.ieo.es*
[2] *Stazione Zoologica Anton Dohrn, Villa Comunale, 80121 Napoli, Italy. Email: grazia@szn.it*

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.

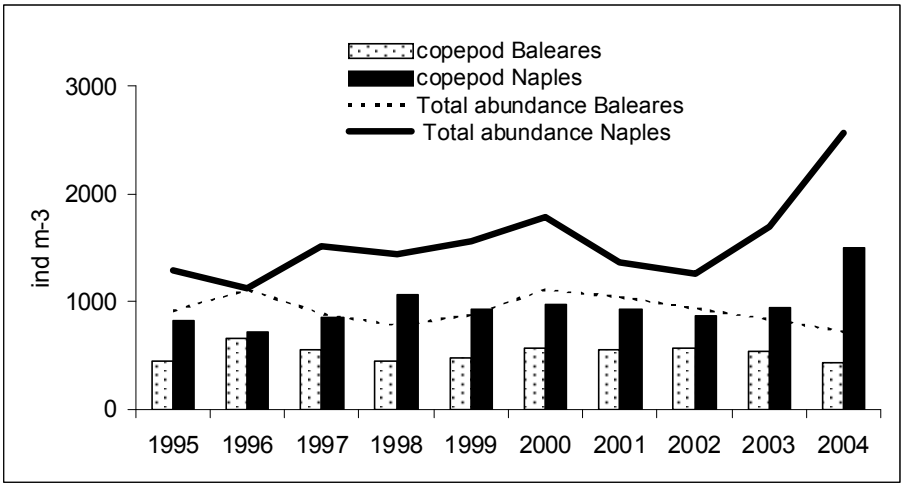


Figure 1. Total zooplankton and copepod abundance in Naples and Baleares site.

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

Frangoulis, C., E.D. Christou, and I. Siokou-Frangou

Hellenic Centre for Marine Research, Institute of Oceanography, PO Box 712, Anavissos 19013, Attiki, Greece. Email: c.frangoulis@ath.hcmr.gr

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 for 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

Garcia Comas, C.[1,2], X. Sun[4], L. Stemmann[2], P. Vandromme[2], L. Berline[3], E. Dos Santos[3], M. Picheral[3], S. Gasparini[2] and G. Gorsky[3]

[1] *Stazione Zoologica 'A. Dohrn', Villa Comunale, 80121 Napoli, Italy. Email: grazia@szn.it*
[2] *Université Pierre et Marie Curie-Paris 6, UMR 7093, Villefranche sur Mer, F-06234 France; Laboratoire d'Océanographie de Villefranche (LOV), France.*
[3] *CNRS LOV, observatoire Océanologique, 06234 Villefranche sur mer, France Observatoire Océanologique, BP 28, 06234 Villefranche sur mer Cedex, France.*
[4] *Institute of Oceanology, Chinese Academy of Sciences, 7 Nanhai Road Qingdao, 266071, China.*

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 standardized and homogeneous treatment.

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

Giannakourou, A.[1], P. Pitta, S. Zervoudaki, E.D. Christou and I. Siokou-Frangou

[1] *Hellenic Centre for Marine Research, Institute of Oceanography, P.O. Box 712, Mavro Lithari, Anavyssos, Attiki 19013, Greece. Email: agiannak@ath.hcmr.gr*

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)

Gubanova, A.D. and D. A. Altukhov

Plankton Department, Institute of Biology of the Southern Seas, 2, Nakhimova ave., Sevastopol, 99011, Ukraine. Email: adgubanova@gmail.com

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 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

Haffersass A. and R. Serdji

Faculté des Sciences Biologiques Université des Sciences et de la Technologie Houari Boumedienne (Alger, Algérie

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 *et 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 and Hafferssas, 2000). One originates from the Atlantic flow, the other is typically Mediterranean. Four surveys aimed at locating and characterizing 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 Southwestern Mediterranean basin, from Algerian coasts to Balearics Islands, the copepod fauna were represented by more than 200 taxa. By comparison, this inventory was lower than number (370) that found in East Atlantic Ocean (Razouls *et 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 characterizing 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 second group occupied the Inshore MAW system, and was characterized 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 characterized 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, Clausocala*nus sp.) was also found at Catalane front (Calbert *et al.,* 1996). In the Almeria-Oran front (east of the Alboran Sea, Southwestern Mediterranean Sea) zooplankton biomass was correlated with chlorophyll abundance (Youssara and 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 *et 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 *et al*., 1991). Similarly, along-transects in the Northeast Atlantic Ocean (48°N — 52°N) there was a marked latitudinal gradient in the distribution of abundance and biomass of zooplankton (Clark *et 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 the 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 *et 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 *et al.*, 2003).

In conclusion, the general results of this zooplankton comparison between Mediterranean Sea and Atlantic Ocean revealed evidence of 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.

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Zooplankton time-series analyses in the English Channel: potential for regional multimetric foodweb indices

Halsband-Lenk, C.[1] and E. Antajan[2]

[1] *Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, UK.*
[2] *IFREMER, Laboratoire Environnement Ressources, BP 699, 62200 Boulogne sur Mer, France.*

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 dataset 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 dataset 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 foodweb 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 foodweb indices at the gateway between the North Sea and the open North Atlantic.

Figure 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

Hannides, Cecelia C.S.[1], Michael R. Landry[2], Maria Saburova[3], Alexandra Gubanova[3], Elena Popova[3] and Tatyana Melnik[3], Brian Popp[4]

[1] *Energy, Environment and Water Resources Center, The Cyprus Institute, 15 Kypranoros Street, 1645 Nicosia, CYPRUS (cecelia.hannides@gmail.com)*
[2] *Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093, USA*
[3] *Institute of the Biology of the Southern Seas, 2 Nakhimov Avenue, Sevastopol 99011, UKRAINE*
[4] *Department of Geology and Geophysics, University of Hawaii at Manoa,1680 East-West Road, Honolulu, HI, 96822, USA*

We used species-level analyses and compound-specific stable isotope methods (CSIA) to assess multiyear 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 winter of 2000, indicating that entrainment of NO_3^- was enhanced over this 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)

Hecq, J-H. and A. Goffart

Oceanology, MARE Center, University of Liège, B4000 LIEGE Belgium; STARESO, Calvi Corsica. Email: jh.hecq@ulg.ac.be

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 foodwebs 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 time-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 windstress variability, the vicinity of Liguro-Provençal Front, the interactions with Posidonia seagrass and 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

Khelifi-Touhami, M., Z. Omar-Ramzi, A. Mounia, H. Hacène and O. Makhlouf

Faculty of Sciences, University of Annaba, BP 12 El Hadjar, Annaba, Algeria. Email: khelifi_meriem@yahoo.fr.

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 foodweb structure in the central- and southern North Sea

Kürten, B.[1,2,3], and S. Painting[1]

[1] *The Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Pakefield Road Lowestoft NR33 0HT, UK. Email: Benjamin.kurten@ncl.ac.uk*
[2] *School of Marine Science and Technology, Newcastle University, Newcastle upon Tyne NE 1 7RU, UK.*
[3] *Netherlands Institute of Ecology (NIOO-CEME), Korringaweg 7, 4401 NT Yerseke, NL.*

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 offshore 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 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 foodwebs at the OG and SG, including the microbial foodweb.

Different stable isotope ratios of POM and zooplankton between the southern and central North Sea sites suggest that pelagic foodwebs in the southern Bight may be influenced by terrestrial run-off, whereas foodwebs 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 foodwebs are active/dominant.

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?

Lakkis, S.[1] and V. Novel-Lakkis[1,2]

[1] *Section of Oceanography, Lebanese University, Beirut, Lebanon. Email: slakkis@ul.edu.lb*
[2] *National Centre for Marine Sciences (LNCSR), Batroun, Lebanon.*

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. Multidecadal 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 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

Licandro, P.[1], M. Batistic[2], M.N. Daly Yahia[3], O. Daly Yahia[4], A. Malej[5], J.C. Molinero[6], S. Souissi[7], C. Touzri[3] and C. Carrè[8]

[1] *Sir Alister Hardy Foundation for Ocean Science, Citadel Hill, PL1 2PB, Plymouth, UK. Email: prli@sahfos.ac.uk*
[2] *Institute of Oceanography and Fisheries, Dubrovnik, Croatia.*
[3] *University of 7 Novembre – Carthage, Faculty of Sciences of Bizerte, Tunisia.*
[4] *Institut National Agronomique de Tunisie, Tunis, Tunisia.*
[5] *National Institute of Biology, Marine Biology Station, NIB, Slovenia.*
[6] *The Leibniz Institute of Marine Sciences, IFM-GEOMAR, Kiel, Germany.*
[7] *Laboratoire d'Océanologie et de Géosciences, UMR CNRS 8187 LOG, Wimereux, France.*
[8] *LOV, Villefranche-sur-mer, France.*

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* compared 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 northwestern 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 winter period. Overall *M. kochi* dominates 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 subregions 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 subsystems characteristic of the Mediterranean Sea.

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

Melle, W.

Institute of Marine Research, Nordnesgaten 50, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway.

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 codend. Our objective was to design a trawl for representative sampling of macro-zooplankton, which could be used in combination with a modified multiple codend (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 codend. 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 codends 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

Molinero, J.C.[1], M.N. Daly Yahia[2], M. Batistic[3], D. Dulcic[3], M.L. Fernandes de Puelles[4], P. Licandro[5], A. Malej[6], L. Prieto[7], I. Siokou-Frangou[8], S. Zervoudaki[8] and O. Daly Yahia-Kéfi[9]

[1] *The Leibniz Institute of Marine Science, IfM-GEOMAR, Marine Ecology/Experimental Ecology, Duesternbrooker Weg 20, 24105 Kiel, Germany. Email: jmolinero@ifm-geomar.de*
[2] *University 7 November – Carthage. Faculty of Sciences of Bizerte. Laboratory of Aquatic Systems Biodiversity and Functionning. Bizerte, Tunisia.*
[3] *Institute for Marine and Coastal Research, Dubrovnik, Croatia.*
[4] *Instituto Español de Oceanografía, Palma De Mallorca, Spain.*
[5] *Sir Alistair Hardy Foundation for Ocean Science, Plymouth, UK.*
[6] *Marine Biology Station, National Institute of Biology, Piran, Slovenia.*
[7] *Instituto de Ciencias Marinas de Andalucia, Cadiz, Spain.*
[8] *Hellenic Centre for Marine Research, Athens, Greece.*
[9] *Institut National Agronomique de Tunisie, Tunis, Tunisia.*

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 Mediterranean 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 environ-

mental 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

Mutlu, E.

Institute of Marine Sciences and Technology, Dokuz Eylul University, Inciralti, Izmir, Turkey. Email: erhan.mutlu@deu.edu.tr

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 "RV 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 largest 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 millimetre. 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).

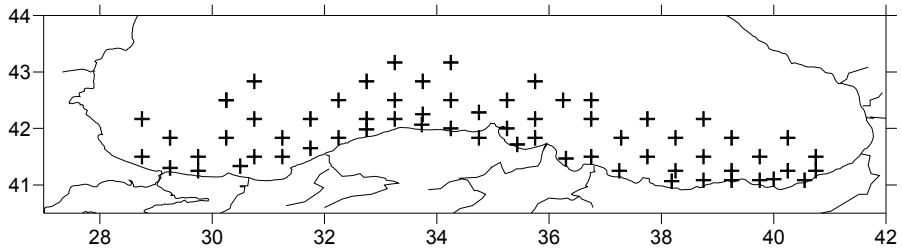


Figure 1. Sampling stations for distributions of the gelatinous organisms in June, October 2006 and May 2007.

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

Painting, S.[1] and B. Kürten[1,2,3]

[1] The Centre for Environment, Fisheries and Aquaculture Science (Cefas), Pakefield Road, Lowestoft, NR33 0HT, UK. Email: suzanne.painting@cefas.co.uk
[2] School of Marine Science and Technology, Newcastle University, Newcastle upon Tyne, NE1 7RU, UK.
[3] Netherlands Institute of Ecology (NIOO-CEME), Korringaweg 7, 4401 NT Yerseke, The Netherlands.

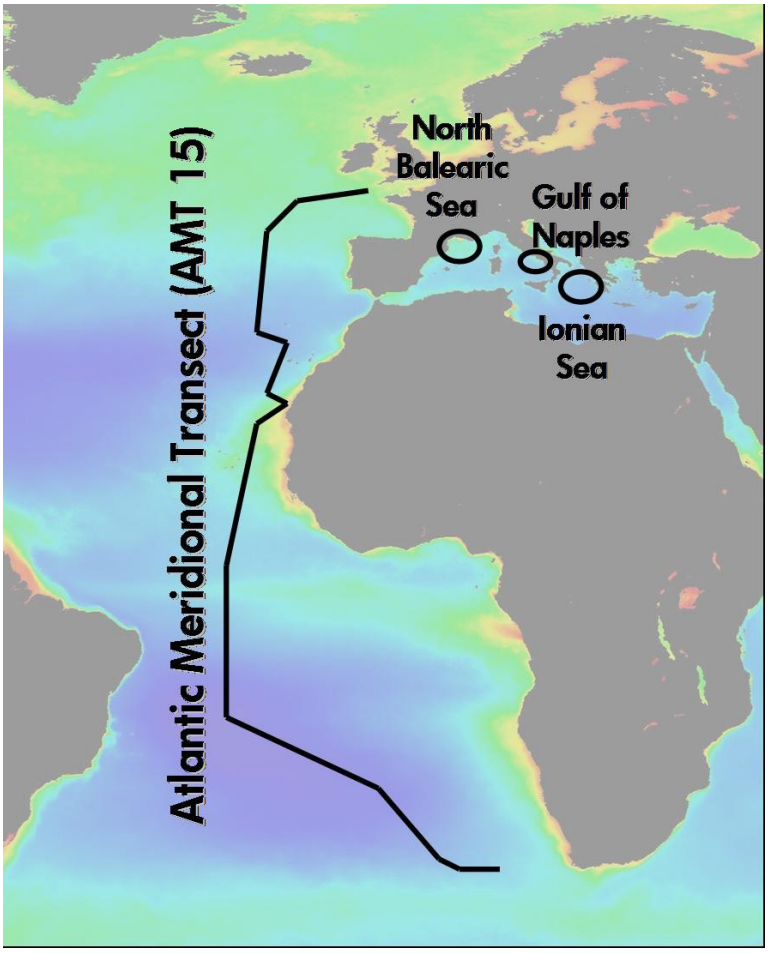
Zooplankton community structure was examined at 3 ecohydrodynamically distinct sites in the North Sea: in the southern Bight (SB), at the Oyster Grounds (OG) and north of the Dogger Bank (ND). Samples were collected during 5 cruises in 2007 using vertically hauled ringnets with different mesh sizes: 50 μm, 200 μm, 270 μm and 500 μm. Results from cruises before and after spring phytoplankton bloom (February to May) show that similar results were obtained with the 200 μm and 270 μm nets. Estimates of biomass were highest biomass (2.3 g C m^{-2}) at the ND site in May. Copepods dominated the zooplankton samples at all sites. In samples from the 270 μm net, small calanoid copepods (e.g. *Pseudocalanus* spp) contributed 70–95% of total copepod numbers (up to 0.5 x 105 ind. m^{-2}) at the SB and OG sites from February to May. At the ND site, small calanoid copepods were dominant (56%) in February, when total numbers were low. Large calanoid copepods (e.g. Calanus spp) contributed 79% of total copepod numbers in April (up to 1.7 x 105 individuals m^{-2}), after spring phytoplankton bloom. The potential grazing impact by the >270 μm fraction after spring bloom was <12% of phytoplankton standing stocks at the SB and OG sites, and 10–40% at ND. The contribution by zooplankton >50 μm may be significant (up to 1.8 g C m^{-2}, and 7 x 105 individuals m^{-2}), and may have been underestimated in previous studies. Similarly, abundances of large adult copepods may be underestimated by the 200 μm and 270 μm nets.

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

Peralba, À.[1], M.G. Mazzocchi[1] and R.P. Harris[2]

[1] *Stazione Zoologica 'Anton Dohrn' di Napoli, Italy.*
[2] *Plymouth Marine Laboratory, Prospect Place, PL1 3DH, Plymouth, UK.*

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 dataset of *Clausocalanus* occurrence and abundance was analysed in relation to the principal environmental parameters recorded in parallel with 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)

[1] CNRS, Laboratoire d'Océanographie de Villefranche, 06230 Villefranche-sur-Mer, France; Université Pierre et Marie Curie-Paris6, Laboratoire d'Océanographie de Villefranche, 06230 Villefranche-sur-Mer, France. Email: pesant@obs-vlfr.fr

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, and 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 organized 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 and 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).

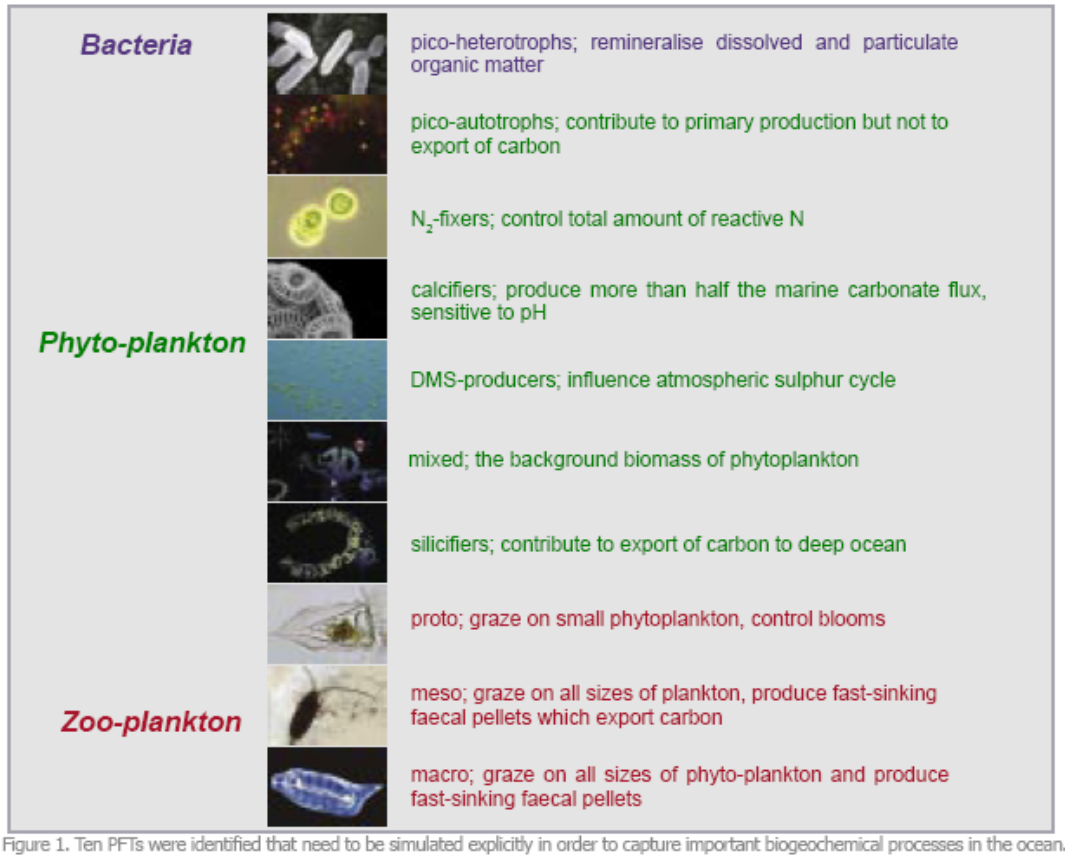


Figure 1. Ten PFTs were identified that need to be simulated explicitly in order to capture important biogeochemical processes in the ocean.

The 2003 heat wave and marine plankton communities

Piontkovski, S.A., A. Olita, S.F. Umani[1], L. Stemmann, C.G. Rubio, S. Gasparini, M.G. Mazzocchi, I. Siokou-Frangou, S. Zervoudaki, A. Gubanova and D. Altukhov

[1] *Department of Life Sciences, University of Trieste, v. Valerio 28/1 34123 Trieste, Italy. Email: s.fonda@units.it*

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 on-board 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 compared with "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)

Pitois, S.G.

Cefas, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, UK. Email: sophie.pitois@cefas.co.uk

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 ringnets (65 μm mesh). Up until now, only the catches from the coarse nets (WP3 and WP2) have been analysed and previous studies have focused 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 foodweb 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

Rachamim, T.[1,2], G. Gal[1], T. Zohary[1] and I. Berman-Frank[2]

[1] Kinneret Limnological Laboratory, Israel Oceanographic & Limnological Research PO Box 447, Migdal 14950, Israel. Email: tamarbsor@gmail.com
[2] The Mina & Everard Goodman Faculty of Life Sciences Bar-Ilan University Ramat-Gan 52900, Israel.

Lake Kinneret is the only natural fresh-water 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 summer, can thus represent a vital source for nutrients during this period of year.

Overview of mesozooplankton spatial distribution in the Mediterranean Sea

Siokou-Frangou, I.[1] and M-G Mazzocchi[2]

[1] Hellenic Centre for Marine Research, I.Oceanography, Anavissos, Greece.
[2] Stazione Zoologica, Villa Communale, Naples, Italy.

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 seawaters 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

Stefanova, K.[1], L. Kamburska[1,2], A. Gubanova[3] and D. Altukhov[3]

[1] *Institute of Oceanology, Bulgarian Academy of Sciences, P.O. Box 152, 9000 Varna, Bulgaria. Email: stefanova@io-bas.bg*
[2] *Institute for Environment and Sustainability, EC, DG-JRC, TP 272, 21020 Ispra (VA), Italy.*
[3] *Institute of Biology of Southern Seas, Sevastopol, Ukraine.*

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, overfishing, 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 interannual dynamics of mesozooplankton quantity revealed similarities in the timing of maximum abun-

dance 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

Terbiyik, T.[1] and E. Sarihan

[1] *Cukurova University, Faculty of Fisheries, Department of Marine Biology, 01330 Balcalı, Adana, Turkey. Email: tterbiyik@yahoo.com*

Distribution of chaetognaths species and their abundance were determined off the coast of Iskenderun Bay in the Eastern Mediterranean In the study. Altogether 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.

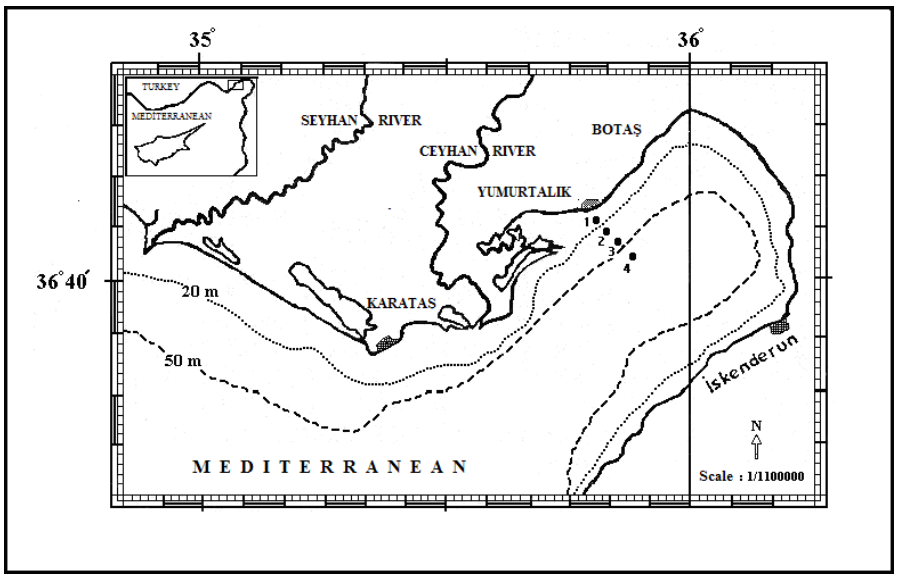


Figure 1. Research station in the Iskenderun Bay.

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

Vukanic, V.

Laboratory of zooplankton; Kotor, Montenegro, University of Novi Pazar, Technical faculty, Department of Biology; 36600 Novi Pazar, Serbia. Email: v_vukanic@yahoo.com

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 winter, the current brings water into the Adriatic, while during 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 seabed, 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 behaviour 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 zoo-

plankton, 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 large 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 allow a detailed overview of the hydrographic characteristics of the sea and the structure of zooplankton fauna.

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

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

Zaafa, A.[1], O. Ettahiri[2], N. Elkhiati[1], L. Somoue[2], am. Berraho[2], S. Zizah[2] and A. Mekaoui[2]

[1] *Faculté des sciences Ain Chock, Dép.Biologie, km 8 Route d'El Jadida, BP 5366, Casablanca, Marocoo.*
[2] *Institut National de Recherche Halieutique, 2 Rue de Tiznit, Casblanca 01, Marocoo.*

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.

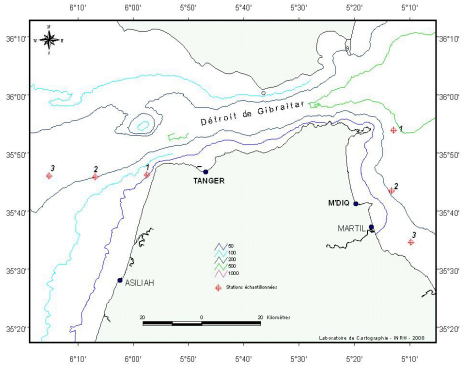
Spatiotemporelle analysis of Taxonomic richness of copepoda analysis in space and Eveness revealed that the largest number of species were 36, and found in Tangiers. Whereas, this number was only 30 in M'diq. Regarding temporal variation, the highest values of species richness were recorded in December 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 abundance in July, which is 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.



Map with stations indicated.

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

Zakaria, H.Y., A.A. Radwan and M.A. Said

National Institute of Oceanography and Fisheries, Kayet Bey, Alexandria, Egypt.

El-Mex Bay, west of Alexandria, receives a heavy load of wastewaters (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 seawater (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

Zervoudaki, S.[1], E.D. Christou[1], S. Isari[2], D. Lucic[3], M.G. Mazzocchi[4], M. Luz Fernadez de Puelles[5], N. Daly Yahia[6], A. Ramfos[2], N. Fragopoulu[2] and I. Siokou-Frangou[1]

[1] *Hellenic Centre for Marine Research, I. Oceanography. P.O. Box 712, Anavissos, 19013, Greece.*
[2] *Laboratory of Zoology, University of Patras, Greece.*
[3] *Institute of Oceanography and Fisheries, Dubrovnik, Croatia.*
[4] *Stazione Zoologica, Villa communale, Naples, Italy.*
[5] *Istituto Espanol de Oceanografia, Palma De Mallorca, Spain.*
[6] *University 7 November – Carthage, Bizerte, Tunisia.*

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 behaviour should be investigated in order in understand the ecological role of this species within the pelagic foodweb of oligotrophic areas.