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Editorial

Dawn Ashby, GLOBEC IPO, Plymouth, UK (d.ashby@pml.ac.uk)

The GLOBEC 3rd Open Science Meeting is the next big event in the calendar for the GLOBEC IPO. We have had a tremendous response, with over 300 abstracts submitted, which has resulted in a very exciting programme of workshops and plenary sessions (for further details see p.27). Due to the size of the venue we are limited in the number of participants, so I'd like to encourage you to register and pay your registration fee early to ensure your place at the symposium, reduced registration fees are available until 15 April.

I'd now like to ask for all of your help in producing a pictorial history of GLOBEC for display at the OSM. If you have any photographs of GLOBEC activities that you would like to share (including any of the national, multinational or regional programmes) could you please send them to the GLOBEC IPO (globec@pml.ac.uk), we would prefer photographs in a digital format but if this is not possible please mail the originals to the IPO and we will scan and return them. It would help us greatly if you could also provide a caption, including where and when they were taken and the names of the people in the photograph.

I look forward to receiving your photographs and seeing many of you in Victoria.

GLOBEC SSC meeting, Hawaii, USA, 2006

Focus 2 Working Group meeting, Rhode Island, USA, 2004

The first GLOBEC SSC meeting, Baltimore, November 1996

ENVIFISH meeting, Ispra, Italy, May 2001

A CORE PROJECT OF THE GLOBAL IGBP CHANGE INTERNATIONAL GEOSPHERE-BIOSPHERE PROGRAMME
Co-sponsored by: The Scientific Committee for Oceanic Research (SCOR)
and The Intergovernmental Oceanographic Commission of UNESCO (IOC)

GLOBEC-IMBER Transition Task Team

John G. Field

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The GLOBEC-IMBER Transition Task Team (TTT) was set up to recommend to SCOR and IGBP how the second phase of the IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) programme should proceed to accommodate new developments in marine ecosystem research that need addressing after the completion of the GLOBEC research programme at the end of 2009. The Task Team met in Reading, UK from 30 July–1 August, and in Washington DC from 15–17 December 2008 (Fig. 1).

Figure 1. TTT members: from left to right: Ken Drinkwater, Olivier Maury, Qisheng Tang, Roger Harris, Kathleen Miller, John Field (chair), Eileen Hofmann, Hugh Ducklow and Mike Roman.

The terms of reference are summarised as:
To make recommendations to SCOR and IGBP for a second phase of IMBER after 2009, bearing in mind:

- Key new scientific questions arising from GLOBEC
- Scientific results of IMBER to date
- New developments in marine ecosystem science
- Projects currently within GLOBEC that are planned to continue after 2009 (especially CLIOTOP and ESSAS)
- Recommendations for mechanisms to facilitate the transition, including representation in programmatic structures

The TTT decided that its report should include a draft Implementation Strategy for its second phase (2010–2014) and is seen as an Appendix to the *IMBER Science Plan and Implementation Strategy* (SPIS) published by the IGBP in 2005. The Appendix is built upon the *IMBER Science Plan*, and is intended to advance the existing *Implementation Strategy* (pp.47–56) by incorporating the plans described there plus new insights from the GLOBEC programme and the general marine scientific community. It is not a detailed implementation plan; rather these have been, or will be, developed by the regional programmes or topical working groups. It is noted that several potential regional programmes of IMBER are only just starting and most are planned as 10-year programmes running well after the present projected life of IMBER. Thus there may be a need for a follow-on SCOR/IGBP ocean research programme after IMBER ends in 2014.

With accelerating global change the urgency of achieving the IMBER vision and goal is even more apparent five years after the IMBER Science Plan was written and will build on the IMBER activities to date. The TTT identified areas that need new or renewed emphasis so that IMBER Phase II will achieve its scientific vision and goal.

These areas include:

- integrating human dimensions into marine global change research
- regional research programmes
- comparative studies within and across regional programmes, including ecosystem models that incorporate the human dimension of emerging scientific themes

The report lists IMBER activities to date, outlines some GLOBEC science highlights (taken from the GLOBEC synthesis book *Marine Ecosystems and Global Change* which will be published in 2009 by Oxford University Press) and lists some emerging scientific issues such as CO_2 enrichment and ocean acidification, new metabolic and biochemical pathways, the role of viruses, thresholds and surprises, and coupled biogeochemical-ecosystem model projections and the characterisation of uncertainty.

The main recommendations include a number of research approaches that could be adopted in the second phase of IMBER:

1. Innovative approaches
2. Innovative technologies
3. Process studies
4. Sustained observations
5. Palaeo-oceanography
6. Molecular genetics and functional groups
7. Integration of human dimensions in ecosystem models
8. Comparative approach between ecosystems
9. Synthesis and modelling

IMBER II will have regional programmes that were not established when the *IMBER Implementation Strategy* was written. The research approaches listed above have been adopted in several of the regional programmes. In order to achieve global coverage, we strongly recommend that seven regional programmes be incorporated into IMBER II, provided that they agree on terms of reference with the IMBER SSC.

These include:

- ICED (Southern Ocean)–already formally accepted as a regional programme of IMBER
- SIBER (Indian Ocean)
- CLIOTOP (Focus on top predators in the open ocean)
- ESSAS (Subarctic ecosystems)
- SPACC (Small Pelagic Fish and Climate Change, upwelling regions)
- BASIN (proposed North Atlantic comparative studies)
- FUTURE (proposed PICES North Pacific Programme).

Recommendations are also made with regard to funding, potential sponsors, data management, implementing mechanisms, and a timetable.

Timetable for transition

1 March 2009:	Community comments to TTT by 15 March 2009. Revised report to sponsors and principals for review.
30 May 2009:	Reviews to TTT.
24–26 June 2009:	Presentation of report to GLOBEC OSM.
27 June 2009:	Possible 1-day final meeting of the TTT, only if major edits are required by sponsors.
Sep.–Oct. 2009:	Final report considered by sponsors.
January 2010:	Commencement of IMBER-II.

The full report of the TTT is available from the GLOBEC website at: http://www.globec.org/structure/imber/TTT_Report_Feb09.pdf

Marine ecosystems and global change: towards policy options for human adaptations

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Reprinted from IGBP Newsletter, 2009.

The international Global Ocean Ecosystem Dynamics (GLOBEC) project, a core project of the International Geosphere-Biosphere Programme (IGBP), the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanic Commission (IOC), reaches the end of its more than ten years of intensive research at the end of 2009. This short article provides an overview of GLOBEC studies of marine biophysical systems, their associated human systems, and on the interactions between these systems and global changes. It also points towards some of the tools and policy options needed for humans to begin adapting to these changes.

The goal of GLOBEC has been to advance understanding of the structure and function of the global ocean ecosystem, its major subsystems, and its responses to physical forcing so as to develop a capability to forecast the responses of marine ecosystems to global change. GLOBEC accomplishments include advancing knowledge on the structure and function of marine ecosystems, physical and anthropogenic forcings, and improved understanding of physical, biological, and human interactions with changing marine environments. GLOBEC has also contributed to marine policy and management debates by providing conceptual understanding of how ecosystems respond to global changes, and by providing tools which incorporate uncertainties caused by climate-driven variability. Marine ecosystems (which can be called marine social-ecological systems when they include humans) are expected to be significantly affected by the interactive combination of climate change, overexploitation of resources, and habitat disruption.

General impacts to marine systems as a result of large-scale changes related to temperature, winds, and acidification can be predicted, in some cases with a high degree of confidence (Barange and Perry, in press). At "rapid" time scales (a few years) there is high confidence that increasing temperatures will result in changes in distributions of marine species. Changes in the timing of life history events, such as the timing of reproduction, are also expected, with short life span species such as plankton, squid, and small pelagic fishes being the most quickly affected. At intermediate time scales (a few years to a decade), temperature-mediated physiological stresses and further changes to life history processes will impact the recruitment success and therefore the abundances of many marine populations. These impacts will be most acute at the extremes of species' ranges and for shorter-lived species. Changes in abundance will, in turn, alter the species composition of marine communities, which is likely to affect the structure and productivity of these ecosystems. At longer time scales (multi-decadal), the predicted impacts of climate changes depend upon changes to the net primary production in the oceans and its transfer to higher trophic levels. Current models show high variability in results and so all these predictions have low confidence. Overall, the responses of wind-driven upwelling ecosystems, which are the most productive per unit area, to global climate change are the most uncertain because the effects on their wind forcing lack predictability.

Marine social-ecological systems, however, are impacted by other changes occurring at global and local scales in addition to climate: these include intensive fishing and habitat disruption. A key conclusion (Perry *et al.*, in press a) is that modern research and management of such marine systems must take account of the interactions between climate, fishing, and habitat disruptions rather than try to disentangle their effects and address each separately – hence the evolved emphasis on global change rather

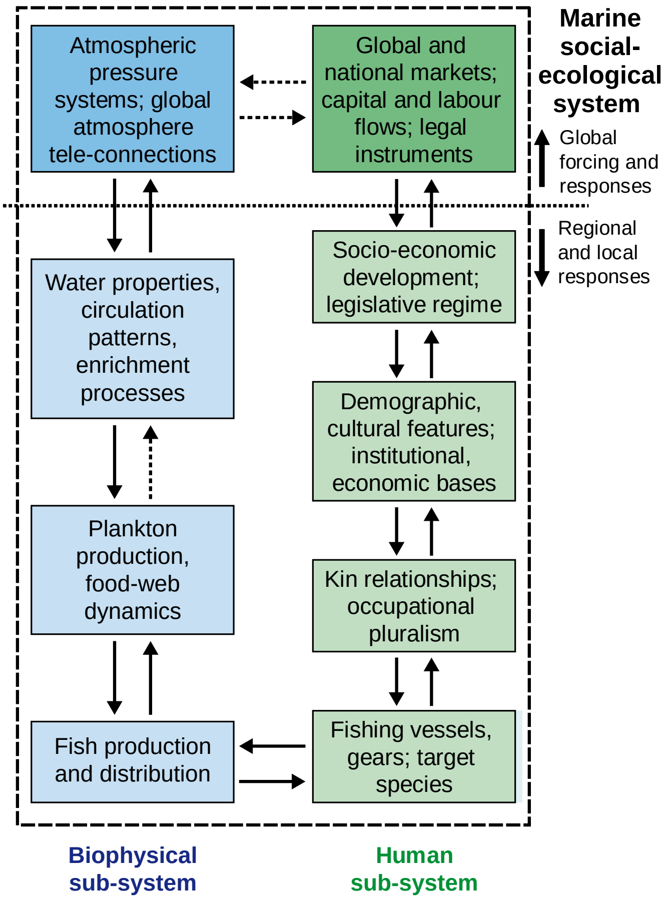

Figure 1. Characteristics and processes within the biophysical and human sub-systems of marine social-ecological systems, and their connections. Predominant connections between the biophysical (non-human) sub-system and the human sub-system occur at large scales (regional to global) and at the local scales (local to regional) at which fish production and distributions interact with fishing. Solid arrows represent stronger interactions; dashed arrows represent weaker effects. Modified from Perry et al., in press b.

than climate change alone. In the biophysical (non-human) sub-system, climate conditions and circulation affect the physical characteristics of the regional and local ocean, which influence the productivity of the upper ocean and ultimately the production of fish. In the human sub-system, the impacts of global and national markets, capital and labour, and legal agreements flow through successively smaller spatial and lower organisational scales from region, community, fishing fleet and, household to individual vessels and fishers. It is the fishing vessels, fishing gear, the target species selected by fishers (in the human sub-system) and the production and distribution of fish (in the biophysical sub-system) that interact most directly (Perry *et al*., in press b; Fig. 1). More diffuse interactions between sub-systems do occur at other levels, ranging from local impacts of point-source contaminant releases to larger-scale impacts such as anoxic "dead zones". But, along with acidification, it is intensive fishing which has the global reach. Fishing reduces the life span, reduces the age at maturity, and reduces the "richness" (numbers) of distinct marine populations. These changes combine, in sometimes surprising ways, to alter marine populations, marine communities, and marine ecosystems and to bring them into states which track climate forcing more closely.

From the human side, how human communities respond to marine ecosystem variability can ameliorate or exacerbate these changes (Perry *et al*., in press b). At shorter time scales, coping responses by both human and non-human marine systems have common elements, such as searching harder for prey, searching in new locations perhaps farther from home (and with greater exposure to predators or poor weather), diversifying to other sources of food, and migration. At longer time scales, however, many adaptive responses by human communities, such as networking, skills upgrading, political action, and closure of the community, have no analogues in non-human marine ecosystems. Such global changes can drive non-human systems to be more flexible and to adapt more quickly to variability, whereas these same changes may reduce the adaptive capacities of human systems. To achieve sustainability, marine resource managers must develop approaches which maintain the resilience of individuals, populations, communities and ecosystems to the combined and interacting effects of climate, fishing, and habitat disruptions. Overall, a less-heavily fished marine system, and one which shifts the focus from individual species to functional groups and fish communities, is likely to provide more sustainable goods and services when faced with climate variability and change than would a heavily fished system.

When faced with the interacting challenges of these global changes, a marine social-ecological systems approach to the management of marine resources is needed. Such an approach should involve all scales from local fishing sectors to regional and national governments in order to identify societal choices and to set objectives, which would include ecological, economic and social considerations (Barange *et al*., in press). Clear objectives need to be established recognising that the future may not be like the past. This will require identifying the appropriate scales (temporal, spatial, and organisational) and down- and up-scaling effects for both the problems and the solutions, identifying indicators and reference points for all the sectors expected to be impacted, close collaborations with multiple stakeholders, and monitoring for unanticipated surprises in other sectors and at other scales. Decision support tools and rules which evaluate their performance need to be established, which include explicit recognition of their uncertainties in such a world of change. Although the details of a future under climate change remain unknown, the outlines of appropriate adaptive responses for managing human interactions with marine ecosystems are becoming evident.

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Phytoplankton community structure from space

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Phytoplankton support zooplankton/fish production as a primary carbon source, and some phytoplankton species are even preferably grazed by zooplankton/fish. In addition, phytoplankton provide some biogeochemical functions which may feedback to the Earth's climate (e.g. DMS production by haptophytes/dinoflagellates could affect cloud/aerosol production in the atmosphere to alter the Earth's radiation budget; calcification by coccolithophores may locally increase partial pressure of CO_2 in the ocean to act as a potential source of CO_2 to the atmosphere). Primary production, zooplankton/fish grazing and the biogeochemical functions are taxonomy-dependent. Therefore identifying the community structure of the phytoplankton can provide useful information for the quantification and understanding of these processes. Observing the *in situ* taxonomic groups of phytoplankton at a global scale is a challenging task. Satellite observation is probably the only practical method of observing the global ocean synoptically. With increasing concern as to how climate variation is affecting marine ecosystems, there is a large expectation on satellite remote sensing to provide global observation of the taxonomic or functional groups of phytoplankton moving beyond conventional pigment biomass (i.e. chlorophyll-*a*, hereafter denoted Chla).

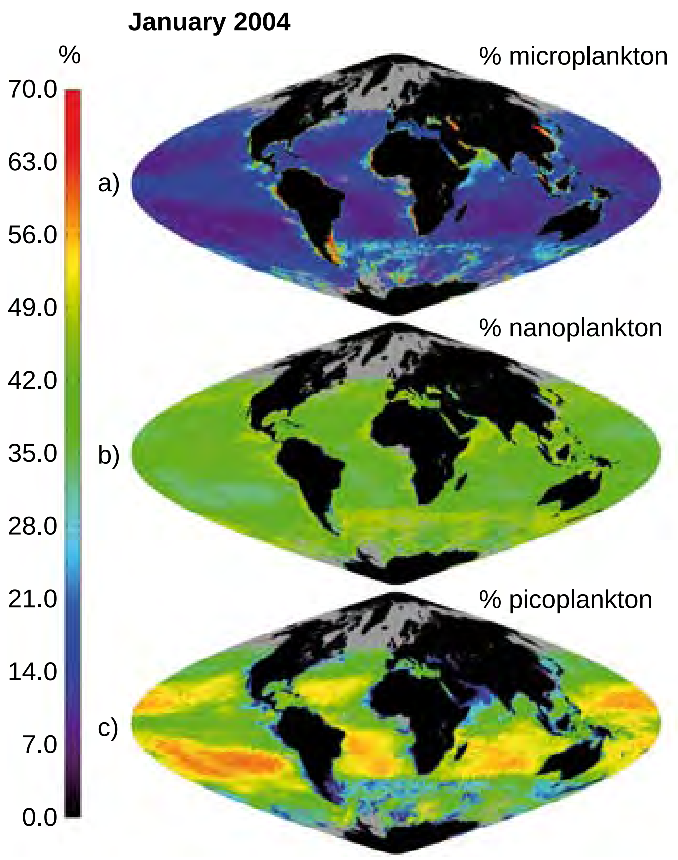

Figure 1. % Chla of each phytoplankton size class: a) microplankton; b) nanoplankton; c) picoplankton.

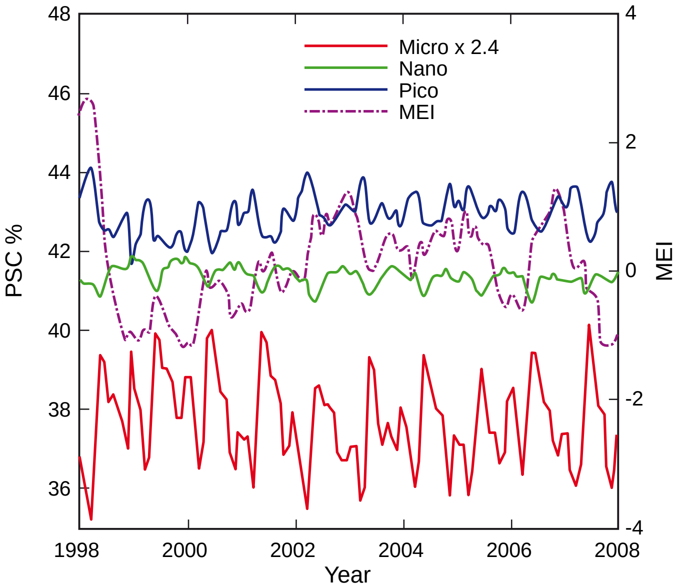

Figure 2. 10-year time series of Phytoplankton Size Classes relative to total Chla (%) and Multivariate ENSO Index (MEI).

Phytoplankton taxonomic and functional groups are closely related to Phytoplankton Size Classes, PSCs (Table 1). We have developed a satellite algorithm to derive PSCs (Hirata *et al*., 2008). The algorithm has been validated against *in situ* measurements of phytoplankton biomarker pigments (Brewin *et al*., 2008). Figure 1 shows % Chla of three size classes in January 2004. Microplankton is abundant mainly at mid-high latitudes and spatial distribution can be patchy. Nanoplankton are moderately abundant globally, acting as a "background population", but relatively higher at equatorial and mid-high latitudes and relatively lower in subtropical gyres. Picoplankton mainly dominate oligotrophic gyres. The approach allows for size-specific properties to be investigated, such as primary production (Hirata *et al*., accepted).

Table 1. Linkages between phytoplankton taxonomy, functional group and size class

Taxonomic group	Major biogeochemical function	Size class
Diatoms	C, Si	Micro (~ 20 µm)
Dinoflagellates	C, DMS	Micro (~ 20 µm)
Haptophytes	C, $CaCO_3$, DMS	Nano (2–20 µm)
Cyanobacteria	C, N_2	Pico (< 2 µm)

Figure 2 shows a time series of monthly global mean of % PSCs over 1998-2008. Due to a relatively large area of picoplankton dominated waters each month, the mean % PSC is highest for picoplankton. Microplankton show the lowest % PSC, because they dominate a relatively small part of the oceans (mainly mid and high latitudes), even though microplankton can have a

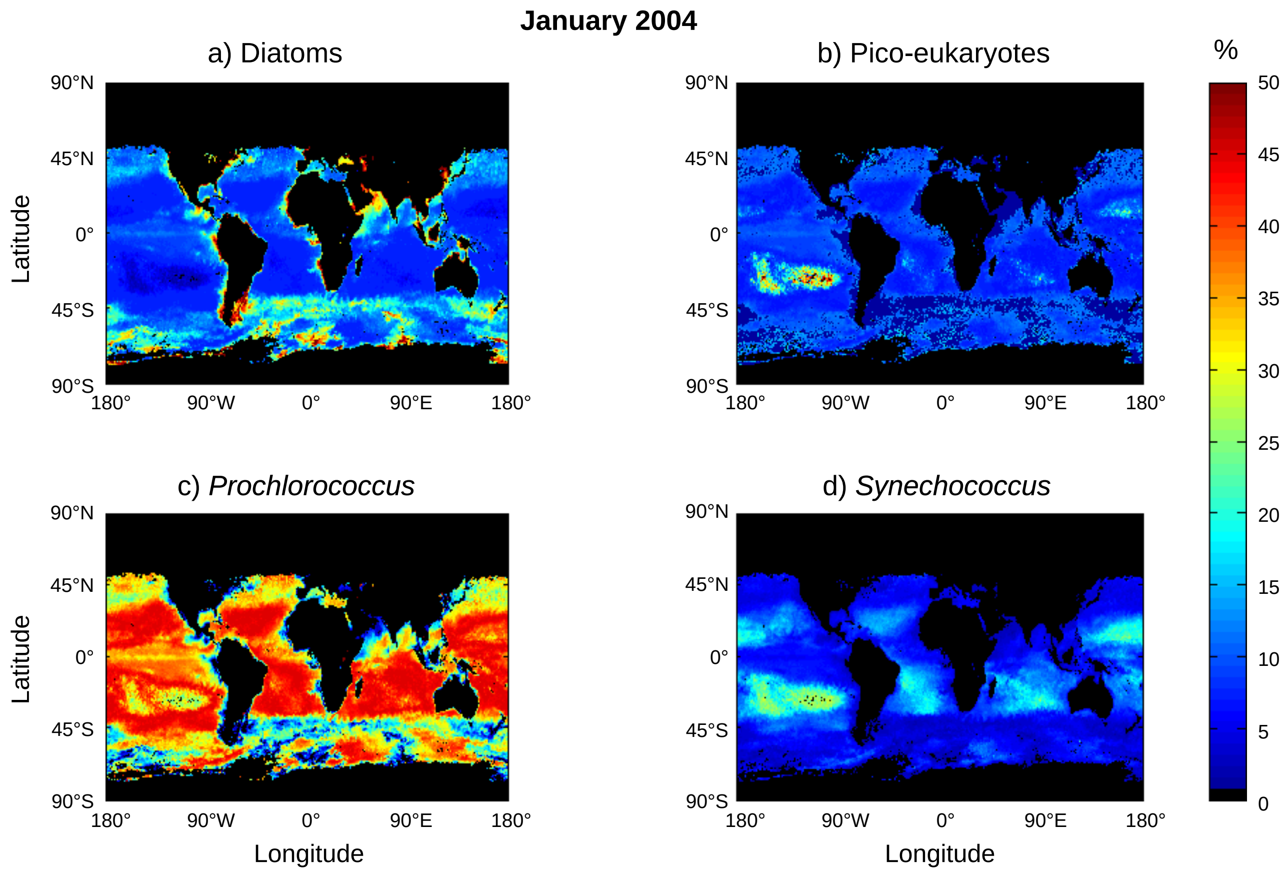

Figure 3. An example of phytoplankton groups derived from satellite ocean colour in % Chla; a) Diatoms; b) Pico-eukaryotes; c) Prochlorococcus *sp.; d)* Synechococcus *sp.*

very large % PSC at a localised scale. Nanoplankton show an intermediate average of % PSC. Lowest (highest) abundance of microplankton (picoplankton) is found in 1998, a year when a large ENSO event occurred, as indicated by the Multivariate ENSO Index (MEI).

Amplitude of variation in the mean % PSCs is however largest for microplankton, reflecting intensity of local seasonal blooms. The least variability is found for nanoplankton as a "background population". A reason why the amplitude of picoplankton variability is intermediate is not clear but is possibly due to the balance between a relatively small variation of picoplankton-dominance in the subtropical gyres and a relatively large variation of local picoplankton populations in other areas, affected by microplankton blooms for example (note the inverse correlation between the time series of % PSCs for pico and microplankton in Figure 2).

We have attempted to break down PSCs into some more groups. Figure 3 shows global distributions of diatoms, pico-eukaryotes, *Synechococcus* sp. and *Prochlorococcus* sp. While diatom distribution is not very different from total microplankton distribution (Fig. 1), decomposition of the picoplankton population into pico-eukaryotes, *Synechococcus* sp. and *Prochlorococcus* sp. showed an interesting feature; a "*Prochlorococcus* hole" in the south east Pacific where *Prochlorococcus* sp. abundance is relatively small accompanied by an elevated abundance of pico-eukaryotes and *Synechococcus* sp. populations. While these results still have to be validated and may be just an algorithm flaw in super-oligotrophic waters, it does show the potential of satellite observation to identify a large scale feature that may not be found otherwise from *in situ* observations which are limited in temporal and spatial scales.

Satellite remote sensing has been used to derive oceanographic parameters at the global scale since the late 1970s, with more satellite products becoming available, e.g. Chla, SST, PAR, SSH, SSW, sea ice etc. Nonetheless Chla is the only biological product derived operationally from satellites so far, despite increasing recognition of the importance of marine ecology/biogeochemistry in the wider context of climate change. We are currently extending the range of ocean products to address the operational requirements of ecological and biogeochemical research. Such an ambition cannot be achieved without a close communication between remote sensing and marine ecological/biogeochemical communities (modelling and observation), and requires integration/consolidation within the communities to achieve common goals in Earth system understanding.

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Is plankton the cause of the 2000s North Sea herring recruitment failure?

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A change in the plankton community could be related to the poor recruitment of autumn-spawning herring (*Clupea harengus*) which has unexpectedly occurred in recent years in the North Sea.

In the 20th century the North Sea herring fishery, which started in this region in the first century AD, has gone through alternate phases (Fig. 1a). After a period characterised by high fishing mortality and declining recruitment that led to the stock collapse in the late 1970s, a phase of recovery has occurred following the full closure of the fishery. That phase was associated with increasing stock productivity up to a relative high in the mid-1980s. Since then a 'normal' phase has started, during which heavy fishing pressure was brought under control with consequent good levels of the stock and good recruitment. Thanks to improved management from the mid-1990s, North Sea herring has been recognised as a stock exploited in a sustainable manner and for this it was awarded the Marine Stewardship Council accreditation in 2006.

Nevertheless, despite the high Spawning Stock Biomass (SSB), an unprecedented period of sequential poor herring recruitment has been observed since 2002 (Figs. 1b and d). The analysis of stock assessment data suggests that this time the succession of recruitment failures is not attributable to the fishery, since fishing mortality of both adults and juveniles is actually low (Fig. 1c). To explain the recent low survival of early stages of herring larvae, several hypotheses have been proposed. One such hypothesis is that changes which have occurred in the North Sea plankton have altered the availability of herrings' prey. The analysis of long-term data collected by the Continuous Plankton Recorder indicates a significant change in structure of the North Sea plankton around 2000, due to the increase of warmer water community species (Fig. 2). In particular, a decrease of herring prey could be related to the recent decrease of small copepods such as *Pseudocalanus* spp. and *Paracalanus* spp., which are typically very abundant in autumn. Further investigations are ongoing in order to verify this hypothesis, analysing the timing of the events and the areas of the North Sea in which the most significant plankton changes have occurred.

Although the real causes of the recruitment failure are still uncertain, herring SSB has started to decline since 2005, indicating that the current exploitation rates are above those considered sustainable. The recent failure in North Sea herring recruitment underlines the importance of developing an ecosystem approach to managing the North Sea fisheries.

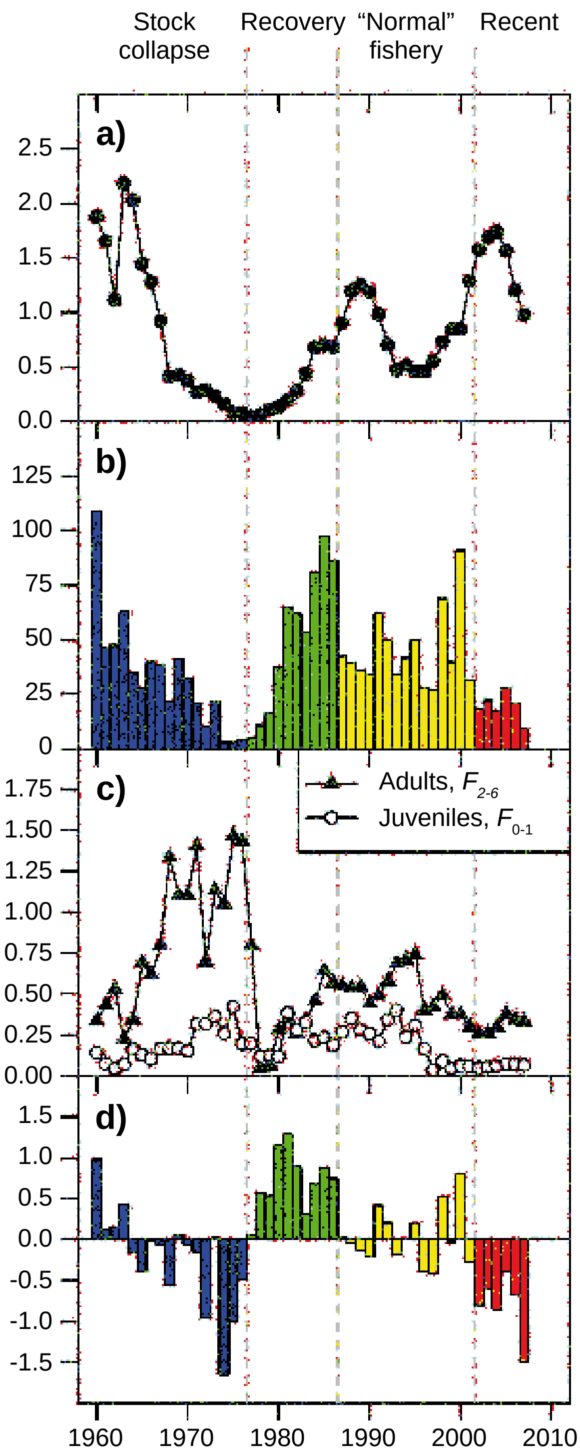

Figure 1. North Sea herring stock history: a) interannual changes in adult Spawning Stock Biomass (SSB); b) recruitment at 6-month old; c) mean annual fishing mortality of adults and juveniles; d) residuals from "hockey-stick" stock-recruitment model. Negative values indicate lower than the average recruitment. Modified after Payne et al., 2009.

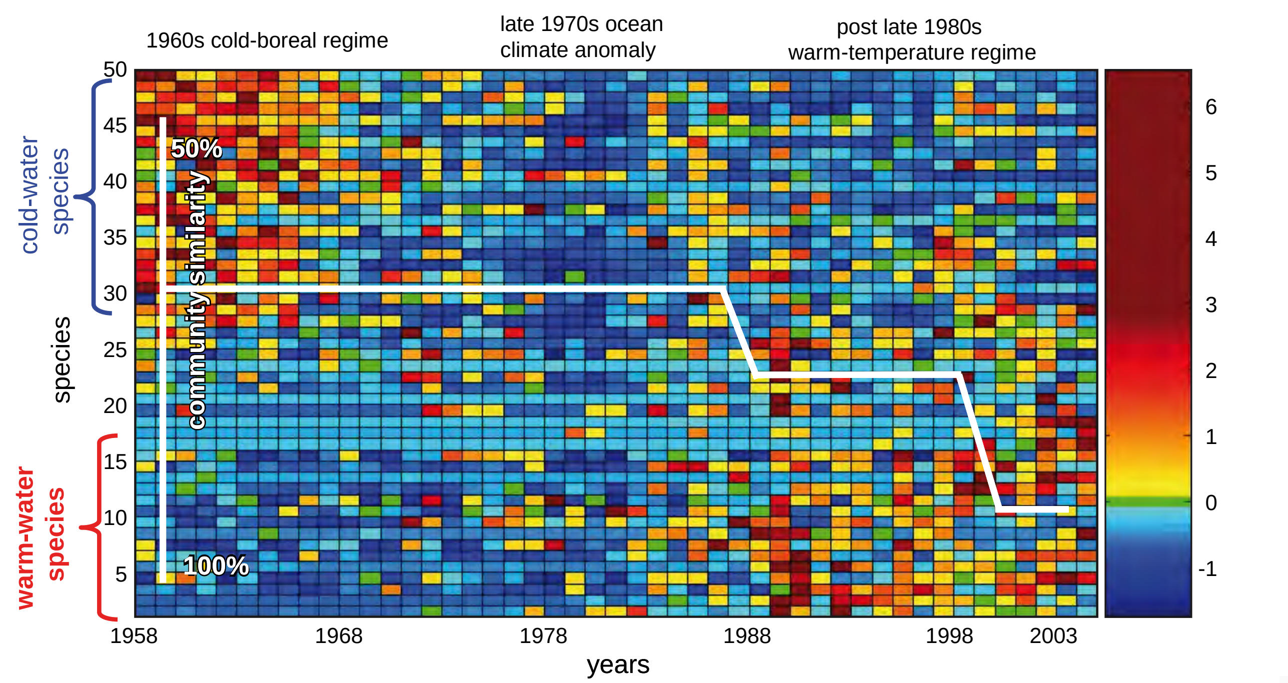

Figure 2. CPR data. 50 plankton species meta-analysis in the central North Sea (standardised abundance). The white line shows the community regime shift index based on the percentage similarity between 2006 and preceding years calculated using a displacement sequential regime detection (minimum regime shift = 10 years). Modified after Edwards et al., 2008.

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Intense bloom of a seaweed *Centroceros clavulatum* (Ceramiaceae) in the Muttukadu backwaters: a case study

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A bloom of *Centroceros clavulatum* was observed in the Muttukadu backwaters for the first time during May 2006. The Muttukadu backwater (12°47'N, 80°15'E) is located 36 km from Chennai city, runs parallel to the east coast of India and opens into the Bay of Bengal. Fishing and shrimp activities are plentiful in this backwater and the area is surrounded by many aquacultural farms. This study provides information on the fauna associated with the seaweed, *C. clavulatum* (Fig. 1).

Estuaries are the cradle grounds for phytoplankton growth because they receive a constant supply of nutrients from rivers and other land based discharges (Ketchum, 1967). Seaweeds are a source of agar agar, alginate, carrageenan and pharmaceutical compounds. Generally marine macrophytes contribute large amounts of organic carbon in coastal waters, which enhances the overall productivity. Macrophytes act as food for algivorous fishes such as damsel fishes, parrot fishes surgeonfishes and sea urchins, in coral reefs throughout the world (Chapman, 1987; Fishelson *et al.*, 1987). Seaweeds grow in the intertidal as well as in the subtidal area up to the depth where 0.1% photosynthetic light is available. They are one of the ecologically and economically important living resources of the world oceans. Being the oldest

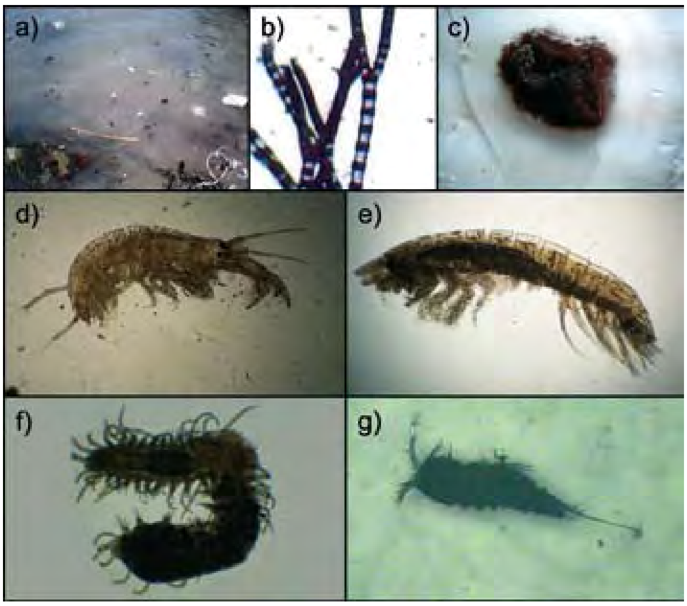

Figure 1. a) Bloom of seaweed at Muttukadu backwater, b) Centroceros clavulatum *microscopic view, c) seaweed collected, d)* Ampithoe ramondi, *e) amphipod, f) polychaete larvae, and g) harpacticoid species.*

family of plants on earth, they have qualities of being flexible, tenacious and prolific. They are continuously bathed in nutrient rich seawater; therefore, they absorb high levels of nutrients and thus form an important source of food, feed, fertilizer and chemicals. *C. clavulatum* is used commercially as a food product and for industrial purposes (Dhargalkar and Pereira, 2005).

The intertidal region is narrow along the Muttukadu backwater and the shore region is rocky and favours seaweed growth. Sand stone is common along the beaches which supports growth of calcareous species like *Centroceros* and *Ceramium*. Most of the seaweed species were collected in the lagoon from sand, pebbles and rocks. When the ecological conditions such as substratum, water transparency and irradiance were favourable, the growth of seaweeds and seagrasses will be sustained. The total harvest from the Indian coast is about 100,000 metric tonnes (wet weight), of which, small-scale industrial units utilise 35 to 40% of the seaweed raw material for extraction of phycocolloids.

Fifteen samples of seaweed were collected and taken for analysis. The samples were immersed in formalin for 10–15 minutes and the fauna was removed from the seaweed. The seaweed was then identified (James, 1987) and the fauna was washed and preserved in 70% alcohol (Fig. 1).

The physicochemical characteristics of surface water at four locations in the Muttukadu backwater were analysed (APHA, 1995) to note the variations in the water quality due to the bloom (Table 1). It is believed that the physicochemical and nutrient parameters may be the important factor governing distribution and abundance of living stock. But the physico–chemical parameters showed the least impact on the bloom of seaweeds.

Table 1. Physico-chemical parameters observed in Muttukadu backwater

Parameter	Range
pH	8.41–9.41
Temperature	29.5–31.5°C
Dissolved oxygen	2.21–2.86 mg l^{-1}
Total dissolved solids	5.80–7.82 mg l^{-1}
Salinity	31.48–32.40 ppt
Nitrate	0.153–0.180 mg l^{-1}
Nitrite	0.078–0.086 mg l^{-1}
Orthophosphate	0.022–0.033 mg l^{-1}
Total phosphate	0.085–0.098 mg l^{-1}
Silicate	0.548–1.014 mg l^{-1}
Chlorophyll *a*	0.080–0.091 mg l^{-1}
Primary productivity	0.40–1.40 C m^{-3} h^{-1}

Amphipods (*Ampithoe ramondi*) dominated the faunal assemblages associated with *C. clavulatum*, and polychaete larvae and harpacticoids were also observed (Figs. 2 and 3). Among the harpacticoids, the copepodite stages were found to be the most abundant along with few adult individuals.

Habitat-forming invasive plants and sessile invertebrates often support a high diversity and abundance of native fauna, suggesting some benefits of invasion. However, the fitness responses of these native fauna, and thus the net benefit from their association with habitat-forming invasive species are not

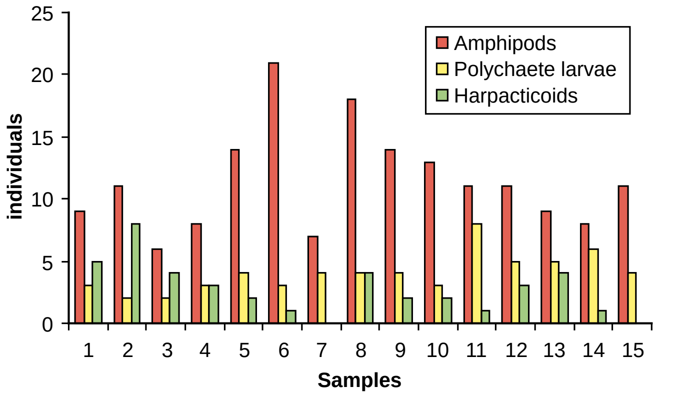

Figure 2. Faunal abundance in Centroceros clavulatum.

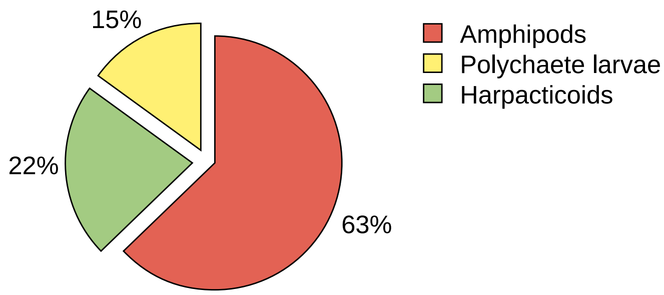

Figure 3. Percentage composition of fauna observed in Centroceros clavulatum.

well understood (Wright and Gribben, 2008). The species composition of macrofauna associated with floating seaweed rafts is highly variable and influenced by many factors such as spatial and temporal variation, period since detachment, and probably also the seaweed species. The presence of seaweed preferences was assessed by a combination of *in situ* seaweed sampling and multiple-choice aquarium experiments in a controlled environment, using the seaweed-associated grazing organisms *Idotea baltica* and *Gammarus crinicornis* (Vandendriessche *et al.*, 2006).

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The EUR-OCEANS Consortium: the major legacy of the EUR-OCEANS Network of Excellence

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From a Network of Excellence to a Consortium

From 2005 to 2008, the EUR-OCEANS Network of Excellence (NoE) has brought together 160 principal investigators, 300 associated scientists and 140 PhD students, from 66 research institutes and universities in 25 countries in Europe and beyond. During these 4 years, the main objectives of the Network were to develop tools to better understand and forecast the evolution of the oceans ecosystems in a global change context, in order to define a basis for sustainable development at global level, and to achieve long-term integration of European research efforts in this scientific field.

The EUR-OCEANS Network has been very successful in pursuing these objectives, in a collaborative and multidisciplinary way, under the scientific direction of Paul Tréguer (University of Western Brittany, France) and Louis Legendre (CNRS, France), and the executive direction of Caroline Gernez (CNRS, France). Building on the achievements and success of the Network, several major European partners in ocean, climate and marine resources sciences took the initiative to create the 'EUR-OCEANS Consortium', with the purpose of securing and furthering integration of Member Organisations that were involved in the EUR-OCEANS NoE, as well as other interested organisations.

On 12 July 2008, the founding agreement of the EUR-OCEANS Consortium was signed by the official representatives of Member Organisations, during a ceremony hosted by Oceanopolis, Brest (France), and chaired by Dominique Le Queau, Director of the National Institute of Science of the Universe (INSU/CNRS). The launch of the Consortium (scheduled for January 2009) was subsequently discussed during an informal meeting held in Rome on 25 November 2008 (Fig. 1), during the EUR-OCEANS (Network) final conference. Finally, the EUR-OCEANS Consortium held its first Council meeting in Brussels on 22 January 2009, thus marking the official launch of the Consortium activities.

Figure 1. EUR-OCEANS Consortium members at the EUR-OCEANS NoE final conference, Rome, Italy, 25 November 2009.

What will the Consortium offer?

The EUR-OCEANS Consortium aims – as its parent NoE – at facilitating the long-term harmonisation of the efforts of European marine research institutes and universities on ocean ecosystems research under anthropogenic and natural forcings.

The Consortium will facilitate the promotion of: 1) top-level scientific research on the impacts of anthropogenic and natural forcings on ocean ecosystems, fostering collaborations across the European Research Area; 2) optimal use of shared technical infrastructures and scientific facilities; and 3) activities to spread excellence (including training of scientific personnel and students, and dissemination of knowledge to the public at large and to socio-economic users).

The Consortium will select annually one or several EUR-OCEANS Flagship Institutions that will focus on progress to be made on a specific area of cutting-edge marine sciences. A EUR-OCEANS Flagship Institution is an institute/university (or a group of institutes/universities) which will host a small number of scientists at the top-level in their research domain, to work on cutting-edge science over several months. These scientists will write synthesis/position papers and disseminate new knowledge through workshops and/or summer schools. Expected outputs from these activities will help marine sciences in making rapid progress and will favour EUR-OCEANS leadership at European and international scale.

The Consortium will organise EUR-OCEANS conferences which will gather scientists together for one week to work on important multidisciplinary topics in the marine field. These conferences could support 'think tanks' and are ideal niches to launch new programmes, to prepare proposals for the European Research Council or for the European Commission Framework Programmes.

The Consortium will also organise 'EUR-OCEANS Foresight Workshops', training workshops and exchange visits (particularly for researchers from developing countries, for capacity building in these countries).

The Consortium will favour Doctoral networks such as MENTOR*. Such networks coordinate the PhD programmes of several organisations, and organise specific activities for PhD students such as mobility assistance, multidisciplinary education, and post-doc preparation.

*The Marine European Network for Training Of Researchers (MENTOR) is a collaboration among European post-graduate Schools in Oceanography based at the universities of Bergen (Norway), Bremen (Germany), Brest (France), Kiel (Germany), and Southampton (United Kingdom) in order to establish a network of education and research, thereby structuring existing high-quality initial research training capacity in Marine Sciences.

The Consortium will also develop transfer of knowledge to socio-economic users (fact-sheets, preparation of reports for policy makers, database of experts among other activities) and dissemination of knowledge to the public at large through a network of aquaria, http://www.eur-oceans.info).

Lastly, the Consortium should take over some of the integrating activities of the EUR-OCEANS Network of Excellence: databases and data rescue, Model Shopping Tool (MosT) containing datasheets on ecosystem models and data bases on computed vital rates and model equations including parameter values and references), Shared Facilities Portal giving access to 100+ facilities (mesocosms, seagoing gear, culture facilities and analytical equipment).

First scientific coordination mandate entrusted to IRD and Ifremer

During its Brussels meeting, the EUR-OCEANS Consortium Council entrusted the scientific coordination of the Consortium to Philippe Cury, from Institut de Recherche pour le Développement (IRD, France) for a two-year mandate (2009-2010). Dr Philippe Cury is the current Director of CRH (Centre de Recherche Halieutique Méditerranéenne et Tropicale), a joint institute of IRD, Ifremer and the University of Montpellier 2, and the Director of the newly formed joint research unit EME (Exploited Marine Ecosystems, UMR 212). Within the EUR-OCEANS Network, he coordinated the 'Ecosystem Approach to Marine Resources' activities (Work Package 6).

In a letter sent to member organisations, Philippe Cury announces a 'vision paper' outlining directions in the context of the post-Aberdeen process and the structuring of the European Research Area, in relation with key groups and programmes. His aim is to focus the Consortium efforts on scenarios construction for marine ecosystems in a context of global change, which would reinforce the Consortium visibility and its effectiveness in coordinating European activities. He hopes that a bottom-up, scientific approach within the Consortium would end up meeting the needs of the emerging IPBES (Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services).

CRH will host the Consortium Project Office. It will also offer office space for up to 8-15 potential visiting European researcher and students.

Launch of the Project Office

During its first meeting, the Council decided to hire an executive director for the Consortium. The successful candidate will be selected in March by a committee comprising representatives from at least four member organisations; the target starting date is 1 April 2009, for a swift launch of Consortium activities. The tasks of the executive director include: assisting the Consortium Scientific Coordinator in implementing the EUR-OCEANS strategy, organising and servicing meetings of the bodies of the Consortium, conferences, foresight workshops and other activities; liaising with international partners (including IMBER, ICES and other relevant organisations in Europe); seeking and managing project finances; representing the project at international meetings; maintaining the project website and interacting with the member organisations.

The Consortium will develop a new EUR-OCEANS website, but will strive to integrate in the latter relevant EUR-OCEANS NoE products, databases and tools. The NoE website will remain active in a transitional phase (Fig. 2).

Figure 2. Consortium section on the EUR-OCEANS NoE website: http://www.eur-oceans.eu/project/EUR-OCEANS_Consortium.php

2009 activities and funding opportunities

During its first meeting, and following a call for letters of intents launched in December 2008, the Consortium Council also selected a first set of scientific activities that will be funded and carried out in 2009-2010:

- EUR-OCEANS Conference on 'Integration of Biogeochemistry and Ecosystems: Comparison across Regional Programs' (IMBER and British Antarctic Survey), hosted by HCMR; venue: Crete (Greece).
- EUR-OCEANS Conference on 'Dynamics and role of mesoscale and/or sub-mesoscale activity in ocean productivity in a global change context' (IRD, Ifremer and UBO/CNRS), hosted by the Cluster of Excellence Europole Mer; venue: Brest (France).
- EUR-OCEANS Conference on 'Indicators for an ecosystem-based fisheries management (EBFM)'; venue to be determined.

These EUR-OCEANS conferences will leave significant room for discussions and they could represent platforms to build interdisciplinary, cross-European research projects.

A call will be launched in Spring 2009 to fund additional activities in the form of 'EUR-OCEANS Foresight Workshops'. A first foresight workshop should focus on the development of the concept of scenario testing for marine ecosystem studies, developed and implemented through the Consortium Coordinator over the next 2 years.

Beyond these first 2009 activities, and as it gains momentum, the Consortium should progressively launch all above mentioned activities ('Flagship', outreach and training activities, etc.).

Contacts

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BASIN Science Plan and Implementation Strategy

Peter Wiebe, Roger Harris, Michael St. John, Francisco Werner, Brad de Young and Pierre Pepin
The BASIN Steering Committee (pwiebe@whoi.edu)

The Basin-scale Analysis, Synthesis, and INtegration (BASIN) Science Plan and Implementation Strategy has recently been published (Wiebe *et al*., 2009). It provides a blueprint for an international initiative needed to build upon the results from programmes funded in the past by the European Union, the United States, and Canada that sought to understand the effects of climate variability on ocean ecosystems in regions of national interest around the North Atlantic basin. The imperative for BASIN stems from the fact that the North Atlantic Ocean and the adjoining shelf seas are critical for the ecological, economic, and societal health of the North America and Europe. The first BASIN meeting took place in Iceland in March 2005 (Wiebe *et al*., 2007) and provided the basis for two additional science workshops, one held in Hamburg, Germany in January 2007 and a second held in Chapel Hill, NC, USA in May 2007 (BASIN, 2007a,b).

BASIN is a joint EU/North American research initiative designed to elucidate the mechanisms underlying observed changes in North Atlantic ecosystems and their services. The overarching aim of the BASIN initiative is to understand and predict the impact of climate change on key species of plankton and fish, and associated ecosystem and biogeochemical dynamics in the North Atlantic basin and surrounding shelf seas, in order to improve ocean management and conservation. The Science Plan is designed to develop new and improved approaches to ecosystem-based management, based on improved system understanding and modelling.

The main components of the research programme include 1) coupled biological/physical models that will provide a means for synthesizing and integrating field and laboratory data sets, 2) a comprehensive effort to assemble, re-analyse, and synthesize relevant existing data sets to provide a context for model hindcasting and testing, as well as scenario development and identification of gaps in essential data modelling, 3) the technology and sampling strategies needed to provide basin-scale data on the distribution and abundance of key ecosystem properties for observing system simulation experiments (OSSEs), data assimilation, and model verification, and 4) the development of new information on key ecological processes through focused process studies (Fig. 1).

The programme is envisioned to take place in two 5-year phases with the emphasis on data synthesis and modelling in Phase I and the addition of new data acquisition and development of management applications in Phase II. The next steps in programme implementation are to create an International BASIN Steering Committee that can guide the overall programme development and to continue the planning in anticipation of funding opportunities. Additional information about BASIN and meeting reports are available at: http://www.globec.org/structure/multinational/basin/basin.htm

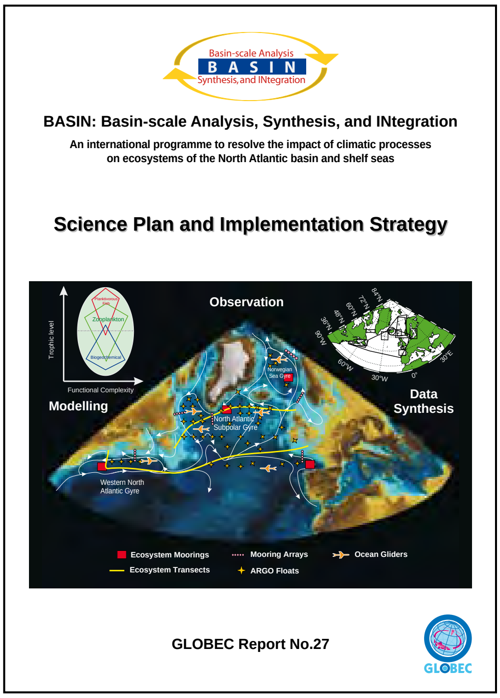

Figure 1. The BASIN Science Plan and Implementation Strategy (GLOBEC Report No.27). Available from http://www.globec.org/products/reports/report27.pdf

Acknowledgements
BASIN activities have been supported by the European Union through a 6th Framework Specific Support Action to Michael St. John and Roger Harris and a grant from the US National Science Foundation to Peter Wiebe. Further support has come from the European Union 6th Framework Programme Network of Excellence EUR-OCEANS. We thank all of the individuals that attended the workshops for their enthusiastic support and provocative discussions, and for providing essential input in the drafts of the science plan.

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Ecosystem Studies of Sub-Arctic Seas (ESSAS): Upcoming meetings and recent activities

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Since its 2008 annual meeting in Halifax last September (Hunt *et al*., 2008), ESSAS has been active on several fronts. Foremost amongst these is the planning of this year's annual meetings as well as workshops at the GLOBEC Open Science Meeting.

2009 ESSAS Annual Meetings

ESSAS will hold its 2009 Annual Science Meeting (ASM) and Scientific Steering Committee (SSC) Meeting 17-20 June in Seattle, Washington, USA, the week prior to the GLOBEC Open Science Meeting in Victoria, BC, Canada. Activities planned for the ESSAS 2009 Annual Science Meeting (Fig. 1) include:

- George Hunt (USA), host for the meeting and ESSAS Co-Chair, will convene a session on ongoing work initiated at annual ESSAS meetings held in Hakodate, Japan (2007) and Halifax, Canada (2008). This will include a presentation on "Hotspots: Areas of High Biomass Concentrations in sub-Arctic Seas" that focuses on where hotspots are located, and the physical/biological processes that determine such hotspots. Also, a report on the progress of a paper on ecological thresholds in sub-Arctic marine ecosystems will be given.

- Ken Drinkwater (Norway) will convene a half-day workshop on Advective Processes that will be conducted jointly with scientists from the Arctic Sub-Arctic Ocean Fluxes (ASOF) programme, a subprogramme of International Study of Environmental Arctic Change (SEARCH). ASOF has been measuring volume, heat, and salt exchanges between Arctic and sub-Arctic regions. In addition to presentations on advection and its effects on by both ASOF and ESSAS scientists, discussions will be held to develop greater cooperation and collaboration between ESSAS and ASOF.

- Earl Dawe (Canada) and Franz Mueter (USA), Co-Chairs of the new ESSAS Working Group on Climate Effects at Upper Trophic Levels, will co-convene a half-day workshop on gadoid-crustacean interactions. A number of sub-Arctic ecosystems have experienced major 'regime shifts' in fishery resources between demersal fish and crustaceans. The workshop will review gadoid-crustacean dynamics and the possible role of physical forcing and fisheries on population shifts between demersal and crustacean species in several of the sub-Arctic regions. A half-day closed session will be convened for Working Group members to initiate a comparative study of gadoids and crustaceans across multiple sub-Arctic marine ecosystems with the goal of producing one or more peer-reviewed publications.

Figure 1. The ESSAS Annual Science Meeting and Scientific Steering Committee meetings will be held in Seattle, 17-20 June 2009. Seattle Lake Union and Mt Rainer photograph courtesy of Tim Knight, University of Washington.

- Jim Overland (USA), Chair of the Working Group on Regional Climate Prediction, will present results of their research conducted on issues related to climate change, including the International Panel on Climate Change (IPCC) model-selection techniques for downscaling. In addition, Mike Wallace of the University of Washington will give an invited presentation on climate prediction issues.

- Bernard Megrey (USA), Chair of the ESSAS Working Group Modelling Ecosystem Response, will convene a workshop to report on the design and construction of a state-of-the-art, fully integrated biophysical ecosystem model. The proposed model will use a general ocean circulation model based on the Regional Ocean Model System (ROMS), include biogeochemical cycles, nutrient dynamics, and primary and secondary production using multiple functional groups and a spatially explicit individual-based model to represent upper tropic levels. The latter will initially include only fish but could be extended to include birds and marine mammals. A proposal to build such models for the eastern Bering Sea and the Barents Sea will be explored. In addition, this workshop will present an update on development of a manuscript to report comparative ECOPATH modelling results initiated at the 2008 Annual Science Meeting.

The ESSAS Scientific Steering Committee (SSC) will meet in Seattle on 17 June just prior to the (ASM), and for a half-day on 20 June. Major topics of discussion at the 2009 SSC meeting will include: proposal to join IMBER when GLOBEC officially comes to an end in 2009, planning for the ESSAS Open Science Meeting in Spring 2011, future funding for ESSAS, and planning for ESSAS activities in 2010.

ESSAS participation at the 2009 GLOBEC OSM

ESSAS will also be active in the 2009 GLOBEC Open Science Meeting (OSM) in Victoria, BC, Canada, 22-26 June 2009.

The workshop on "Comparison of processes and climate impacts in sub-Arctic and Antarctic marine ecosystems: observations and modelling approaches" was initiated by ESSAS and is co-sponsored by ESSAS and the Integrating Climate and Ecosystem Dynamics (ICED) programme, which focuses on the Antarctic. It takes place 22-23 June with convenors from the ESSAS SSC, George Hunt (USA), Bernard A. Megrey (USA), Hyoung-Chul Shin (Korea), as well as Sei-ichi Saitoh (Japan), and ICED co-chairs Eileen Hofmann (USA) and Eugene Murphy (UK). The workshop will consist of open papers and discussion to compare (or facilitate comparison) between maritime Antarctic and sub-Arctic seas including observations, modelling of ecosystem processes, and impacts of climate on higher trophic levels (fish, seabirds, marine mammals, and fisheries). Focus will be placed on mechanisms, expected changes, and identification of non-linear forcing factors (thresholds) of ecosystem change. Added focus will be given to physical and biotic themes such as: climate effects on stratification/mixing/frontal structures with implications for biota. Case studies will be used to examine the effects of physical processes (sea ice, wind, and advection) on lower and higher trophic levels, and their effects on interactions between trophic levels. This workshop will provide an opportunity for ecosystem modellers in Antarctic and sub-Arctic research communities to compare approaches and progress toward developing functional end-to-end models to illustrate the effects of climate change on marine ecosystems, and the ability of these models to support management of upper trophic level organisms, including sustainable fisheries. Comparisons at this level will help to establish baseline topologies of marine ecosystem useful to future GLOBEC and IMBER studies.

An ESSAS sponsored workshop on "Climate impact on ecosystem dynamics of marginal seas" will be held on 23 June. Co-chaired by ESSAS SSC member Yasunori Sakurai (Japan) along with Christian Möllman (Germany), it will examine the impact of climate (climate variability/climate change as observed through phenomena such as the North Atlantic Oscillation, the Arctic Oscillation and the Pacific Decadal Oscillation) on marginal seas and semi-enclosed ecosystems, which contribute substantially to world fisheries. Results from GLOBEC studies, mainly focusing on higher trophic levels (zooplankton and fish), will be presented. The goal is to facilitate synthesis of these results through comparison of ecosystems such as the Barents Sea, North Sea, Mediterranean Sea, Baltic Sea, Black Sea, East China Sea, Yellow Sea, Sea of Okhotsk, Sea of Japan, Georges Bank, Bering Sea, Gulf of Alaska, Scotian Shelf, and others.

In addition several ESSAS members will be participating in the workshop on "Modelling ecosystems and ocean processes: the GLOBEC perspective of the past, present and future" during 22-23 June. It will be chaired by ESSAS representative Enrique Curchitser (USA) along with Alejandro Gallego (UK), Michio Kishi (Japan) and Emanuelle Di Lorenzo (USA) and structured along four sub-topics: physical and biophysical models from regional to basin scale; advanced ecosystem models, statistical biological/physical models, and future modelling frontiers. The workshop will describe, compare, and contrast these different modelling approaches, and their ability to elucidate physical/biological dynamics. Invited speakers will discuss results from various GLOBEC regional programmes, national activities, and multinational programmes, as well as future directions in modelling. Speakers will also present modelling strategies to investigate critical aspects of ecosystem dynamics such as climate change and resource management.

Attendance at these workshops is open to all registered participants at the GLOBEC Open Science Meeting.

ESSAS activities at the PICES 2008 Annual Meeting

ESSAS was also busy on several different fronts during the last six months including involvement at the 17th Annual Meeting of the North Pacific Marine Science Organization (PICES) held 23 October - 2 November 2008 in Dalian, People's Republic of China.

IPY Workshop

ESSAS co-sponsored the workshop on "Status of marine ecosystems in the sub-Arctic and Arctic seas – Preliminary results of International Polar Year (IPY) field monitoring in 2007 and 2008". ESSAS Co-Chairs, Ken Drinkwater and George Hunt joined Sei-ichi Saitoh (Japan) and Jinping Zhoa (China) convened the workshop which consisted of 17 presentations and 4 posters. Dr. Bob Dickson (UK), the keynote speaker, discussed the Integrated Arctic Ocean Observing System (IAOOS), providing a synthesis of physical oceanographic data collected in Arctic and sub-Arctic regions as part of IPY. He stressed that collaborative efforts of nations participating in IPY allow us to view the Arctic ocean-atmosphere-cryosphere system as a complete unit for the first time. Of particular importance is the close connection and interaction between Arctic and sub-Arctic regions.

ESSAS coordinates the multinational IPY consortium, Ecosystem Studies of Subarctic and Arctic Regions (ESSAR), which includes 11 projects being conducted by 8 different nations plus one international programme. Most of the workshop's talks and posters presented results from projects within the ESSAR consortium, including studies by China, Japan, USA, Norway and the international Trans North Atlantic Sightings Survey (T-NASS) that focused on cetaceans. An overview of the work being carried out within ESSAR was presented by Ken Drinkwater.

T-NASS presented results from the first North Atlantic-wide cetacean survey in the North Atlantic and comparisons with earlier surveys (since the late 1980s and conducted approximately every 5 years). China reported on recent data collected during their 2008 survey crossing the Bering Sea and reaching into the Arctic to over 80°N, which illustrated the importance of inflowing Bering Sea water in modifying Arctic water mass conditions and structure. Of particular importance, the heat carried by this flow has played a significant role in the rapid melting of Arctic ice in recent years. Hydrographic data collected in the Bering Sea by China during 2008 indicate a large quantity of cold water below 40 m on the northern Bering Shelf between the 40-100 m isobaths that extends south onto the continental shelf. It was speculated that this cold water formed either in Anadyr Bay or south of St. Lawrence Island. Dr. Mizobata (Japan), an invited speaker, presented 2008 observations that extended north to 71°N in the western Arctic. He discussed the role of circulation and eddies in transporting shelf water into the Arctic deep basin and confirmed he role of heat flux through the Bering Strait on ice retreat in the Arctic. Other speakers noted increased primary production in open Arctic waters that were previously ice covered and that Arctic cod decreased in abundance and moved farther north in 2007. Another Japanese study noted the importance of Sea of Okhotsk as an important source of iron for the western sub-Arctic Pacific. Norway's IPY ecosystem programme in the Barents and Norwegian Seas examined the fronts between the cold Arctic waters and warm Atlantic waters and found the hydrography of the fronts seems to structure the biology, including fish and their feeding patterns. Dr. Lee Cooper (USA), another invited speaker, discussed approaches used in two US-based IPY programmes affiliated with ESSAS: the Bering Sea Ecosystem Study (BEST); and the Bering Sea Integrated Ecosystem Research Program (BSIERP). He highlighted the large changes since 1970 in benthic biomass and community structure in the Bering Sea, and discussed changes in primary production and biomass under different oceanographic conditions.

A short discussion at the end of the workshop focused on the need for scientists to meet to compare and contrast their data, and that these meetings should include not only scientist from NESSAR projects, but also scientists from other IPY programmes as well. ESSAS looks forward to promoting such collaboration.

On the social side, Dr. Jinping Zhoa, who grew up near Dalian, treated the other co-convenors, the invited speakers and several of his Chinese colleagues, to a special Chinese meal at one of the best restaurants in Dalian (Figs. 2 and 3). The meal truly was a delight to both the eye and the palate and allowed us to become more acquainted with one another.

Modelling workshop

ESSAS also co-sponsored the workshop on "Marine Ecosystem Inter-Comparisons" with co-convenors Bern Megrey (Fig. 4) and Masahiko Fujji and Shin-ichi Ito (Japan). This workshop was also part of the PICES working group on Marine Ecosystem Model Inter-Comparison, which was meeting for the first time. Comparative analysis is a powerful technique for understanding the important similarities and differences between and among ecosystems. The working group was organised to promote model comparisons using different models to develop forecasts of different ecosystems. The intention is to develop ensemble model forecasts to compare predicted and observed responses of marine ecosystem types to global changes.

Figure 4. Bernard Megrey (modelling "Cranberry"), Chair of the ESSAS Working Group on Modelling Ecosystem Response who led the Modelling Workshop at the PICES 2008 Annual Meeting.

The keynote presentation was by Dr. Fei Chai (USA) who discussed a model comparison conducted under US-JGOFS in which 12 lower trophic level biogeochemical models of varying complexity were objectively assessed in two distinct regions (equatorial Pacific and Arabian Sea). Dr. Icarus Allen (UK), an invited speaker, introduced the topic of model skill assessment and described several objective approaches of assessing model skill. Bill Petersen (USA), Hal Batchelder (USA), and Toru Kobari (Japan) reviewed krill and copepod biology and ecology. After the presentations, a lengthy discussion took place on five main questions intended to frame the preparation of a work plan: 1) identifying the objective of the models used for inter-comparison, 2) which models to compare, 3) identify location(s) for comparison, 4) identify comparison

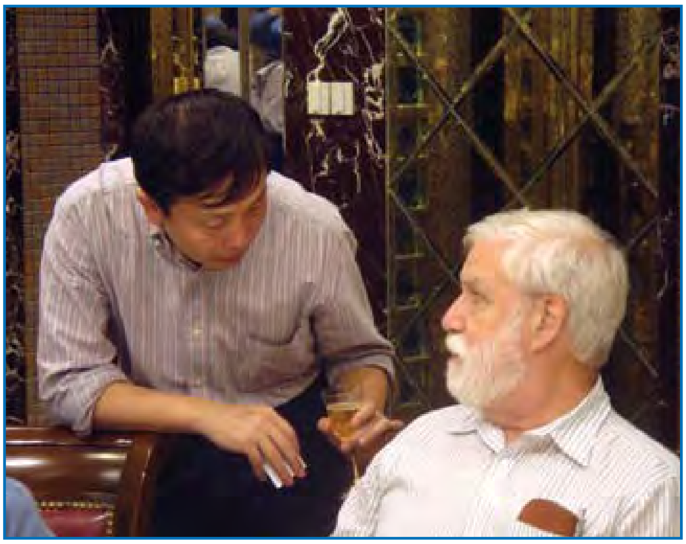

Figure 2. Jinping Zhoa and George Hunt in discussions over dinner.

Figure 3. Sei-ichi Saitoh and his wife enjoying the dinner in Dalian.

protocols (model skill assessment), and 5) identify indicator species. Plans were developed to solicit both active participation in the working group and model contributions. The objective of the model inter-comparison will be to apply several models to one location to identify important mechanisms that control secondary production abundance and variability as well as bounding the levels of uncertainty in model predictions by calculating ensemble statistics. This approach can be applied to several places simultaneously. The working group will hold future discussions to identify suitable locations where the models can be applied. During the meeting a schedule of activities was proposed and accepted. A hands-on modelling workshop will be convened at the next PICES Annual Meeting October 2009 in Jeyu, Korea to compile observational data and begin model construction, parameterisation, and comparison.

Session on end-to-end food webs: impacts of a changing ocean

Although not formally co-sponsored by ESSAS, George Hunt joined Hiroaki Saito (Japan) and Sinjae Yoo (Korea) to co-convene a day and a half PICES theme session that was co-sponsored by IMBER. The session consisted of four invited speakers, Chang-Keun Kang (Korea), Orio Yamamura (Japan), Angelica Peña (Canada), and William Sydeman (USA) plus 22 contributed talks and ten posters. The session focused on the need for a holistic end-to-end approach to study the impacts of global change in marine food webs, including the influences on biogeochemistry and feedbacks to climate. This food web approach includes the energy transfer and nutrient cycles of traditional food webs, but emphasizes the importance of understanding food web dynamics simultaneously at all levels and scales, including the activities of humans.

ESSAS contributions to ICES

During the 2008 ICES Annual Science Meeting in Halifax (Fig. 5), Nova Scotia, Gary Stenson (Canada), Ken Drinkwater and Kai Wieland (Denmark) co-convened a theme session on the role of sea ice in polar ecosystems with Gary Stenson (Canada). It consisted of 15 papers and 8 poster presentations, of which 5 presentations and 1 poster were products of the ESSAS Workshop on the role of sea ice in sub-Arctic seas that was held in Hakodate, Japan, in June 2007. Current climate models (and observations) indicate that polar ecosystems are rapidly changing are predicted to continue to lose sea ice. The reduction of ice cover has significant impacts on marine organism including: increased wind-induced vertical mixing, loss of habitat for ice-dwelling organisms, increased surface layer temperatures; lower salinity due to melting, higher stratification, and increased primary production. The meeting provided the opportunity to facilitate interaction between the ICES and IPY communities.

Figure 5. Michio J. Kishi and Bernard Megrey discussing business at the Halifax meeting.

ESSAS affiliated programme (MENUII)

The MENU (comparative studies of Marine Ecosystems in Norway and the US) project was one of the multinational activities within ESSAS, and part of the Norway-US bilateral agreement on cooperative research. The project consisted of a workshop funded by the Research Council of Norway that was held just outside Bergen Norway in 2006. The overall goal of the workshop was to initiate a comparative study largely based on observed data of variability in marine ecosystem structure and function in eastern Bering Sea/Gulf of Alaska, Georges Bank/Gulf of Maine, and Barents Sea/Norwegian Sea regions. From this workshop five comparative papers were written that will appear in a special volume of Progress in Oceanography in 2009.

Building upon this work, participants submitted full proposals to their national funding agencies in Norway and the United States during 2008 in an attempt to further these comparative studies, this time with a focus on modelling. The model comparisons fell within four categories: previous developed ECOPATH studies of different sub-Arctic regions; production models used in fisheries assessment such as virtual population models; biophysical models that consider 3-D hydrodynamic models and the lower ends of the food chain (phytoplankton and zooplankton); and system models that include fish and fisheries, in particular the ATLANTIS model.

The Norwegian proposal, entitled MENUII, has been funded (2009–2011) by the Norwegian Research Council. A similar US proposal was submitted under the NSF/NOAA CAMEO call for proposals but although it received high praise by reviewers, it was not funded. This was in part due to the much reduced funding for CAMEO in 2008 than expected. The US participants are planning to resubmit the proposal and are hopeful that funding will be secured this year. The two proposals contained extensive collaboration by jointly undertaking comparative studies. Such comparative studies are delayed but it is hoped that they will begin in 2010. Meanwhile the Norwegians will begin development of the ATLANTIS model for the Barents Sea and the Norwegian Sea, and begin comparative model studies between these seas and the North Sea.

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Parameter estimation of habitat driven spatial dynamics of Atlantic bluefin tuna with tagging data

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In the framework of the GLOBEC regional programme CLIOTOP (Climate Impacts on Oceanic Top Predators), the Large Pelagic Research Center (LPRC) of the University of New Hampshire, USA, is funding a one year project aimed at identifying the main sources of variability of Atlantic and Mediterranean bluefin tuna's spatial dynamics, through the combined use of a state of the art ecosystem and population model and movement data from electronic tags. Confronting data and models, via a dynamic, spatially explicit view of the oceanic habitat, should be fruitful in advancing our knowledge of the ecology of this species.

Atlantic and Mediterranean bluefin (*Thunnus thynnus*, or ABFT) is considered severely over-exploited and despite the recovery plan developed by the International Commission for the Conservation of Atlantic Tunas, this species may be already "on the way to collapse" according to McKenzie and Rosenberg (in press). Despite such a heavy exploitation and high commercial value, there remains key uncertainties about the ecology and biology of this species, in particular its stock structure, migratory routes and spawning behaviour. There is therefore a crucial need for data on the movement, environmental condition factors and genetic structure of ABFT individuals. Historical catch data, as well as results from recent tagging campaigns exhibit a large amount of variability in space and time, which makes their interpretation difficult in a non-spatialised context (Royer *et al.*, in press). A metapopulation structure has in particular been proposed as a possible cause to this variability, leading to possible strong interplay between ABFT's complex stock structure and the ocean's climate. It is urgent to untangle the effects of environmental variability and fishing pressure, to understand and rank these sources of variability.

SEAPODYM (Spatial Ecosystem And Populations Dynamics Model) will be the main tool to achieve the goals of this project. This model was developed to simulate the spatial dynamics of tuna populations in the pelagic ecosystem (Lehodey *et al.*, in press). It uses physical-biogeochemical environmental fields to simulate the upper trophic levels of marine ecosystem organised in two groups: the tunas or associated species and their prey species of the mid-trophic levels (i.e., micronekton). Modelling the habitat and vertical structure of micronekton distribution, as well as the age-structured spatial dynamics of tuna (through an advection-diffusion-reaction framework) is based on first biological principles, such as thermal habitat, oxygen tolerance, prey and predator interactions. The parameterisation of these components defines a movement index with seasonal switching between feeding and spawning habitats, defining in turn the spatial dynamics of the target species and its prey population. Parameterising the model is currently performed using assimilation of catch data (Senina *et al.*, 2008).

Our objective for this project is two-fold: i) extend the current data assimilation framework to tagging data, using sequential data produced by pop-up archival tags deployed on adult bluefin tuna, ii) use the resulting parameterisation to describe annual and inter-annual variability of ABFT's habitat. The emphasis will be put on defining the feeding habitat of bluefin tuna, based on mechanisms developed in the model for other tuna species, in order to recreate the key movement patterns of potentially mature individuals, as described by archival tags. Spawning habitat will be also investigated, but since the tagging data are mainly associated with feeding grounds, the parameterisation of spawning habitat will mainly rely on existing knowledge from independent studies, i.e. fixed values of spawning-related parameters (e.g. for optimal spawning temperature) will be tested in the framework of a maximum likelihood approach.

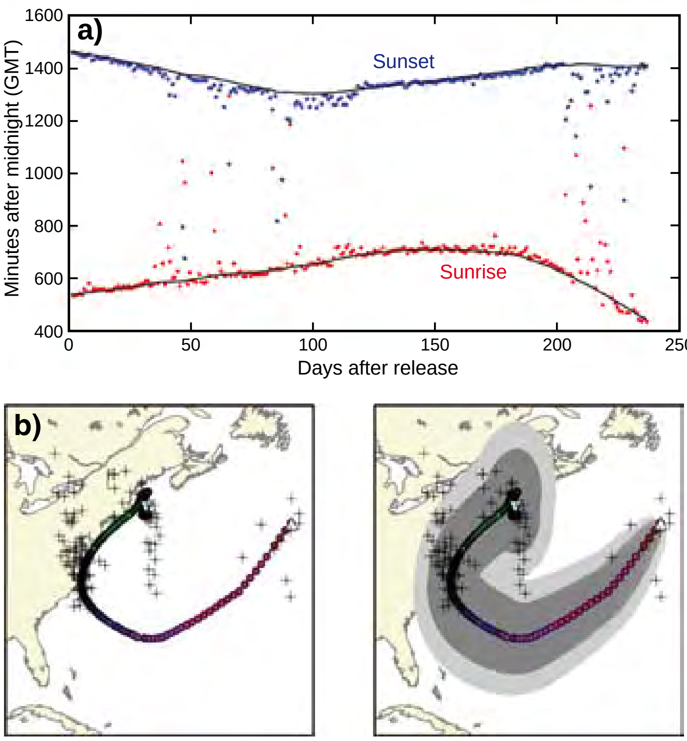

Figure 1. Improving geolocation of fish tagged with archival satellite tags. a) Filtered (solid line) versus tag-inferred sunrise (red dots) and sunset (blue dots) along the solution track, for a pop-up tag placed on medium-sized bluefin tuna in the Great South Channel of the Gulf of Maine, in minutes after midnight GMT. A robust error model is assumed; b) Corresponding trajectory estimate for the same tag, without (left panel) and with (right panel) posterior uncertainty (light grey indicates 50% ellipses, dark grey indicate 95% ellipses).

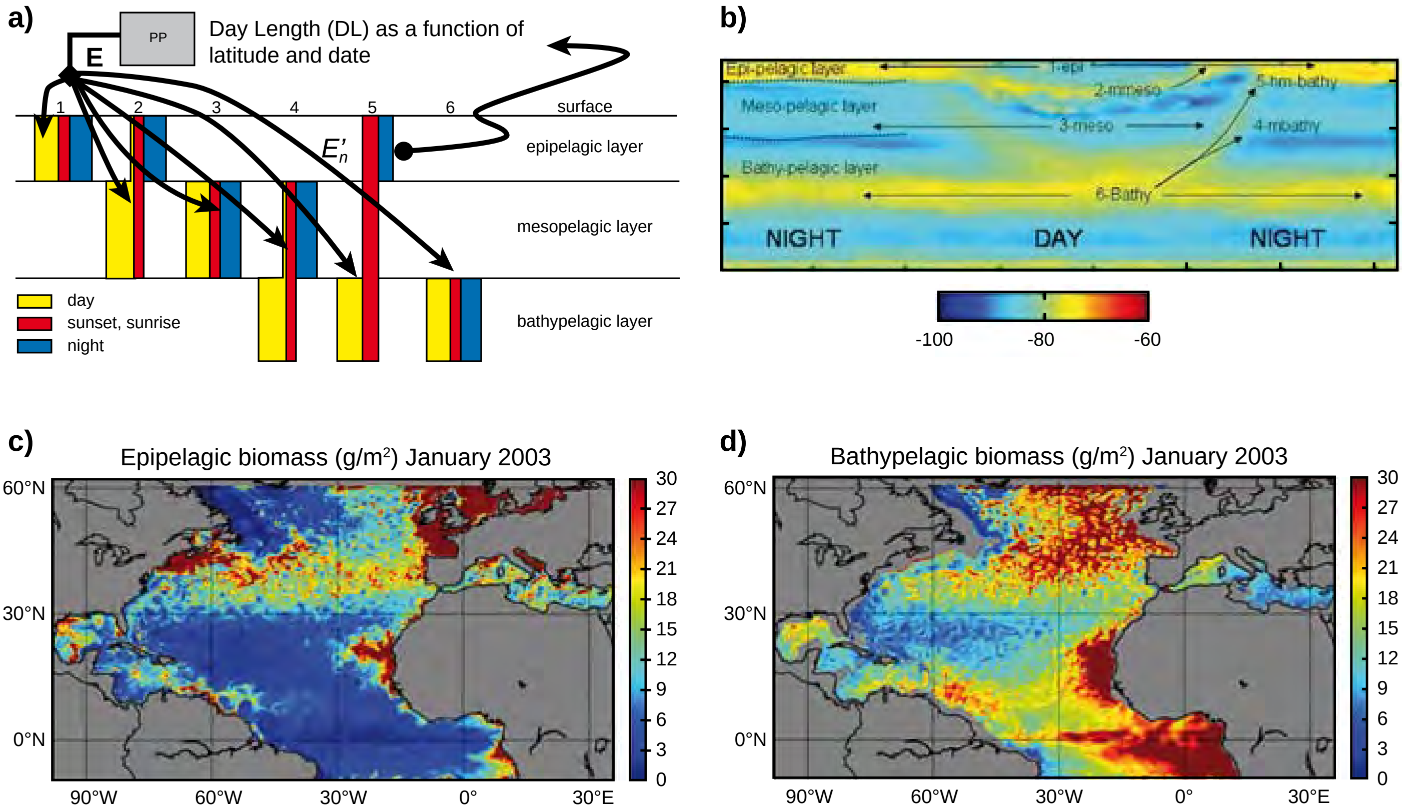

Figure 2. Mid-trophic functional groups. a) conceptual model of mid-trophic functional groups in SEAPODYM. b) echogram showing monthly average (Nov 2004) diurnal variation from the stationary lander located at the Mid Atlantic Ridge (MarEco project; kindly from Nils Olav Handegard, IMR, Norway) with identified mid-trophic groups (m- for migrant and hm- for highly-migrant). c) comparison between predicted biomass of epipelagic and d) bathypelagic mid-trophic functional groups at a resolution of 1/12°.

A first key issue to achieve these objectives is to improve the geolocation of fish tagged with archival satellite tags. The pop-up archival tags considered for the present study transmit timings of sunset and sunrise times. This is very bandwidth efficient for transmitting data to satellite, but may limit the accuracy of the resulting geolocations. However, it has been shown recently (Royer and Lutcavage, in press; Fig. 1a) that sufficient information was present in this data to correct for known error patterns (such as at the equinoxes). This geolocation process can also be applied in a filtering context, thus leveraging on the well known Kalman Filter equations (Fig. 1b). We thus expect to derive robust locations from this dataset, especially by combining ancillary information such as sea surface temperatures, and additional constraints such as bathymetry. While the astronomical model for geolocation is well understood, other important issues remain, such as modelling outliers and complex error patterns (and possibly sensor or hardware problems), how to properly include hard constraints due to land avoidance, and how to reliably estimate the resulting accuracy of a solution. A Markov Chain Monte Carlo approach is envisaged for this, in combination with the gradient-based estimation provided by the Kalman filter.

A second issue is to produce realistic predictions of the ABFT prey fields at a sufficient resolution to describe mesoscale dynamics that is the typical scale required to use individual movements of fish as inferred from satellite and archival tagging data. Therefore, we conducted a test simulation at a high resolution (1/12° x 6 day) with the mid-trophic level sub-model (Lehodey *et al.*, in press). This model considers six different groups characterised by their vertical behaviour, i.e. occurrence of diel migration between epipelagic, mesopelagic and bathypelagic layers (Fig. 2). Parameterisation of the dynamics of these components is based on a temperature-linked time development relationship. Then, a simple energy transfer from primary production is used, justified by the existence of constant slopes in log-log biomass size spectrum relationships. Recruitment, ageing, mortality and passive transport with horizontal currents, taking into account vertical behaviour of organisms, are modelled by a system of advection-diffusion-reaction equations.

The mid-trophic simulation of the North Atlantic and Mediterranean Sea has been produced during a EUR-OCEANS funded post-doctoral study using physical inputs from the MERCATOR Ocean model (http://www.mercator-ocean.fr/) and the primary production derived from the SeaWiFS satellite (http://www.science.oregonstate.edu/ocean.productivity/), following the VGPM model of Behrenfeld and Falkowsky (1997) for the period 1997-2004 (Fig. 2). A first parameterisation of spawning and feeding habitats was defined based on the general knowledge of the species and the mechanisms developed for tropical tuna species (Lehodey *et al.*, 2008). Comparatively to these latter species however, Atlantic bluefin show a strong natal homing behaviour for spawning, either in the Gulf of Mexico or in the Mediterranean Sea. Thus new mechanisms have also been

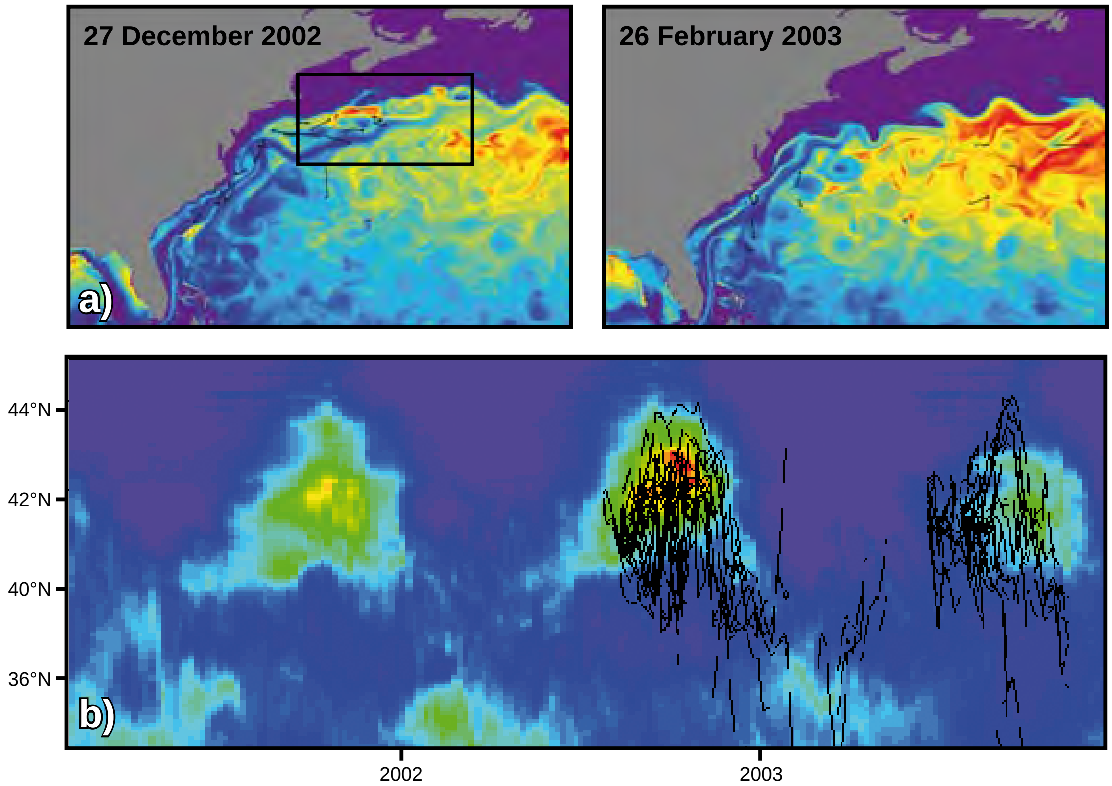

Figure 3. Modelling the spatial dynamics of Atlantic bluefin tuna in the north-west Atlantic Ocean. a) snapshots of predicted bluefin tuna feeding habitat, combining the constraint of temperature for the species (by age) to access the prey (mid-trophic level) groups, with superimposed individual tracks derived from satellite tags at two different dates in the north-west Atlantic. Individual tracks are shown with black lines representing movements for 6-day time steps, with a dot indicating the final position; b) time-longitude Hovmüller diagram for the geographical box identified in a) and showing the superimposition of all bluefin tracks on the predicted feeding habitat.

tested in the model to represent this particular behaviour. The feeding habitat combines the distribution of mid-trophic groups and the accessibility to them by the predator in relation to its temperature and oxygen limitations (Fig. 3).

Even though the physical reanalysis does not include data assimilation at this preliminary stage, the seasonal variability and mesoscale activity of predicted bluefin feeding habitat matches fairly well with the movements of individual bluefin (Fig. 3) deduced from satellite tags (Lutcavage *et al.*, 2000; Royer *et al.*, in press). These encouraging results suggest that model parameterisation could be achieved by assimilating these tagging data.

Acknowledgments

We are grateful to EUR-OCEANS and the Large Pelagic Research Center for their funding support. We also thank Mercator Ocean and Ocean Productivity teams for providing us with physical and biogeochemical data.

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Three important CLIOTOP events in 2009

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CLIOTOP is entering its fifth year of existence, its mid-term. Further to inter-sessional Working Group activities, two CLIOTOP workshops are scheduled in 2009 and the important CLIOTOP mid-term workshop will be held at the end of the year. Here is some information about these events.

CLIOTOP-WG2 Workshop: Development of new electronic devices to monitor animal behaviour and physiology

Swansea, UK, 28-30 July 2009, contact Rory Wilson (R.P.Wilson@swansea.ac.uk)

The primary purpose of the workshop will be to identify how we might best proceed in order to be able to model the movement and incidence of space-dependent behaviours of oceanic top predators (Fig. 1). Implicit within this is that we have the capacity to determine both the 3D movements of top predators and their behaviours accurately. So part of the workshop will be devoted to the methods available (and under development) that achieve this (with some emphasis on the viability of transferring taxon-specific methodologies between taxa).

All methodologies considered will be based on smart tag technology since this allows the movement of individuals to be documented over appreciable periods. Time will be devoted to consideration of vertical and horizontal movements (as separate and linked subjects) of top predators and the energetic and ecological issues to which these two elements relate. By the end of the workshop, we should have clear ideas with respect to what technology is best for which top predator type, the type of data that we envisage gaining from specific smart tag deployments and how these data might be modelled to show species-specific patterns as well as inter-taxon commonalities. Finally, we should aspire to producing a strategy for studying top predator movement with a truly global perspective.

CLIOTOP-WG3 Workshop: Inter-ocean comparisons of oceanic food webs

Sète, France, 6-10 July 2009, contact Frédéric Ménard (frederic.menard@ird.fr), Bob Olson (rolson@iattc.org) or Jock Young (Jock.Young@csiro.au).

Analyses of food web dynamics of tunas and billfish have been conducted separately in several regions of the Pacific, Indian and Atlantic Oceans. Data from these studies have been or are being incorporated into food web models to assess the impacts of fishing and ocean warming on trophic networks.

To date, no attempt has been made to look for similarities and differences of food webs in these various regions. Amongst its list of climate-related projects to be undertaken in the coming years, WG3 identified an inter-ocean comparison of pelagic food webs as one of the highest priorities. Such a comparative approach would undoubtedly bring considerable insights to our understanding of tuna and billfish ecology, and their response to future fishing and climate change scenarios.

This five day workshop in Sète will conduct analysis of stomach content data of a common subset of predators (especially tunas) from the Indian, Atlantic, and Pacific Oceans to examine similarities and differences in their trophic ecology in relation to differences in regional oceanography (Fig. 2). The approach, which has been applied recently by WG3 scientists during a one day meeting in Hawaii to a combined data set covering three distinct regions in the Pacific Ocean, revealed a number of important differences suggesting that large scale comparisons would be useful to interpret future responses to ocean warming.

The workshop in Sète will investigate how to incorporate food web data (both stomach and stable isotope data) from the three oceans into an interoperable database from which the global inter-oceanic comparative analysis will be based.

One of the goals of the workshop is to produce a collective draft manuscript summarising the main inter-oceanic differences of tuna feeding ecology and their ecological significance.

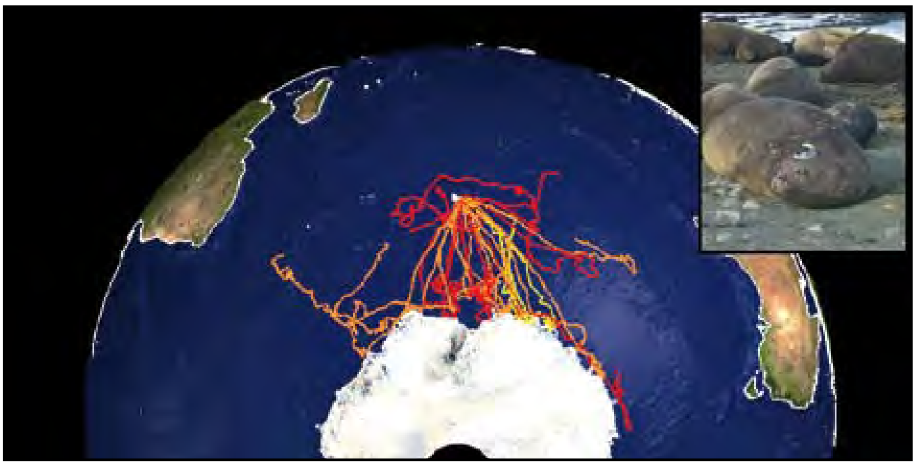

*Figure 1. Observed trajectories from tagged southern elephant seals (*Mirounga leonina*) in the southern Indian Ocean (data and picture from C. Guinet, CNRS Chizé).*

*Figure 2. A yellowfin tuna (*Thunnus albacares*) from the Indian Ocean showing its stomach and stomach contents (picture: M. Potier, IRD La Réunion).*

From GLOBEC to IMBER, the CLIOTOP Mid-term Workshop
Late 2009, contact Olivier Maury (maury@ird.fr) or Patrick Lehodey (PLehodey@cls.fr).

CLIOTOP has been operating since 2005 as a GLOBEC regional programme. It has been recently proposed that CLIOTOP operate for the next five years (2010-2014) under the IMBER umbrella. This schedule matches the implementation strategy of CLIOTOP which has been defined along two successive 5 year phases. The first phase (2005-2009) will end at the end of this year, synchronously with GLOBEC ending. The second and final implementation phase (2010-2014) will be planned during a "Mid-Term Workshop" to be held at the end of this year. The workshop, open to the community in a broad sense (i.e. not only scientists but also policy makers, RFMOs, NGOs, funders, etc.), will be devoted to the identification of the major future axes of the programme and drafting the addendum to the CLIOTOP Science Plan and Implementation Strategy for its second phase. As a preliminary estimate, the meeting would gather between 50 and 100 participants.

Further to the basic research activities on oceanic top predators conducted in the Working Groups, the CLIOTOP Scientific Committee will propose to the discussion during the workshop that the second phase of CLIOTOP be oriented toward the development of specific "scientific products" to help the implementation of an ecosystem approach to oceanic fisheries and the conservation of emblematic top predator species at the global scale. This includes the development of the:

- **CLIOTOP-MDST** (Model and Data Sharing Tool) gathering global data sets of different types and model outputs at the global scale and displaying them through a single web interface to stimulate comparative analysis,
- **CLIOTOP-MAAS** (Mid-trophic Automatic Acoustic Sampler) to deploy large scale arrays of autonomous drifting acoustic recorders,
- **CLIOTOP-ESM** (Earth System Modelling) framework coupling models from physics to fish to markets,
- **CLIOTOP-SEE** (Scenarios of Ecosystem Evolution) from short- to long-term including food security issues associated to oceanic fisheries and conservation of charismatic top predator species, and
- **CLIOTOP-SIP** (Synthetic Indicator Panel) for an ecosystem approach to oceanic fisheries in a climate change perspective.

Recognising that oceanic ecosystems and associated fisheries have global drivers such as climate changes, artisanal and industrial international fisheries and the associated global markets and international legal frameworks, one of the major goals of CLIOTOP during its second phase will be to establish formal partnerships with oceanic Regional Fisheries Management Organisations (tuna commissions, whaling commission, etc.) to provide them with useful science and products to help toward an integrated ecosystem approach to fisheries at the global scale, taking examples of the linkages between scientists and international policy makers that IPCC managed to put into effect.

Summarising and synthesizing the current activities and achievements of CLIOTOP as well as discussing, completing and specifying those potential new general directions for the programme will constitute the objectives of the mid-term workshop.

CLIOTOP (CLimate Impacts on Oceanic TOp Predators) is a ten year programme implemented under the international research programmes GLOBEC (2005 to 2009) and IMBER (2010 to 2014), two components of the International Geosphere-Biosphere Programme.

Through the work of its six Working Groups, CLIOTOP focuses on oceanic top predators within their ecosystems and is based on a worldwide comparative approach among regions, oceans and species. It requires a substantive international collaborative effort to identify, characterise, monitor and model the key processes involved in the dynamics of oceanic pelagic ecosystems in a context of both climate variability and change and intensive fishing of top predators. The goal is to improve knowledge and to develop a reliable predictive capacity combining observation and modelling for single species and ecosystem dynamics at short, medium and long term scales.

Seamounts in the Chilean Exclusive Economic Zone: Identification and Biodiversity

Eleuterio Yáñez[1], Claudio Silva[1], Rodrigo Vega[2], Fernando Espíndola[3], Lorena Álvarez[1], Nelson Silva[1], Sergio Palma[1], Sergio Salinas[1], Eduardo Menschel[2], Vreni Haussermann[4], Daniela Soto[1] and Nadín Ramírez[1]

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There is worldwide concern for the anthropogenic effects on vulnerable marine ecosystems such as seamounts. However, the global information about biodiversity and ecology of seamounts is very limited, especially for those with a depth of greater than 300 m (Tracey *et al.*, 2004). Although estimates indicate that there are several thousand seamounts throughout the world, no more than 200 have been subject to biological studies during commercial fishing activities (Probert *et al.*, 1997; Gálvez *et al.*, 2006). In the case of Chile there is a lack of information in relation to an undetermined number of seamounts in its Exclusive Economic Zone (EEZ). Therefore, taking into consideration the international demand (59/25 UN Resolution) a project looking at the geographical distribution and biodiversity of seamounts in the EEZ was carried out (Yáñez *et al.*, 2008), the main results of the study are presented below.

Since 1950 several different biodiversity studies on seamounts off the Chilean coastline have been conducted. Some of these were carried out by Russian researchers in the Nazca Ridge, outside the Chilean and Peruvian EEZ (Parin *et al.*, 1997). In the Juan Fernandez archipelago (33°S–78°W) the information available is limited to the scientific expedition of the H.M.S. *Challenger* in 1873–1876; the Swedish expedition in the Pacific in 1916–1917 and the B/I *Anton Bruu*n in 1966 (Rozbaczylo and Castilla, 1987); the oceanographic cruises MARCHILE VIII in 1972 and IX in 1973 (Cerda, 1977); the CIMAR six oceanic islands cruise in 1999–2000 (Rojas *et al.*, 2004); and the scientific exploration of the B/I *Koyo Maru* in 2004 (Zuleta and Hamano, 2004). As well as the information gathered in relation to the associated fauna in the bottom trawling fishing in the Chilean seamounts (Gálvez *et al.*, 2006).

Seamounts were determined through image analysis generated with "Smith and Sandwell" satellite altimetry data and "GEBCO" sounding data, according to the methodology of Kitchingman and Lai (2004). On other hand, an *in situ* assessment was carried out on two seamounts in the Juan Fernandez archipelago, JF1 and JF2 at 247 m and 292 m depth respectively, in two research campaigns carried out in July–August and November–December 2007. For this purpose, different fishing systems were used (vertical longlining, handline, fishing pots, surface longlining, zooplankton nets, dredging and submarine cameras) and oceanographic surveys were conducted in the water column (echosounder, CTD and Niskin bottles); while surface oceanographic characteristics were analysed with satellite information (NOAA, TOPEX and SeaWiFS). In addition, a bibliographic analysis was conducted in order to determine the species collected in expeditions, cruises and commercial fishing carried out on these seamounts. Finally the fishing effects index was assessed (O´Driscoll and Clark, 2005), based on the industrial trawling fleet data (2000–2006); and using the same data, the resource spatial structures in 2001 and 2003 were analysed with geostatistics for comparative purposes.

118 seamounts were identified: 35 around the Eastern Island (25–30°S; 105–112°W), 21 near San Felix Island (24–29°S; 76–84°W), 21 in the northern area of the country (18–30°S; 71–75°W), 15 around the Juan Fernandez archipelago (30–35°S; 76–82°W), 10 in the extreme southern area (50–58°S; 70°–77°W), nine in the southern area (40–50°S; 73–79°W) and eight in the central area of the country (30–40°S; 71–76°W). This identification included the location, surface area and top depth of these seamounts and also name assignment (Fig. 1).

JF1 and JF2 seamounts present a volcanic substrate, mainly composed of bare rocks and sand. These are influenced by the subtropical water masses (STW), subantarctic water masses (SAW), equatorial subsurface water masses (SSEW) and intermediate antarctic water masses (IAW), although the influence of STW and IAW is weak. The vertical distribution of the dissolved oxygen presents a two-layer structure; a surface structure of

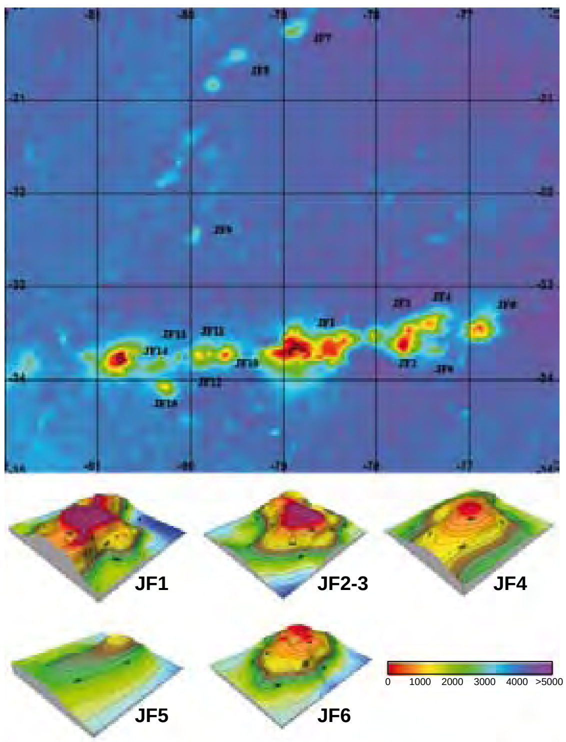

Figure 1. Location and name assignment to seamounts of Juan Fernandez archipelago, and images 3D of seamounts.

Figure 2. Benthic invertebrate samples obtained by dredging on Juan Fernandez seamounts.

Figure 3. Photographs of the seabed in the study area.

approximately 100 m, well oxygenated with concentrations greater than 5 mL·L^{-1} (90–100% saturation), being almost quasi homooxic. Beneath this layer, the dissolved oxygen quickly reduces to concentrations of less than 1 mL·L^{-1} (5–20% saturation) at approximately 200–300 m depth. In July–August (winter time) a light current was observed with surface temperature anomalies (SST) negative in JF1 and positive in JF2. The SST showed a characteristic cold condition of 10–17°C, surface salinity of approximately 34.3‰ and chlorophyll concentration between 0.09 and 1 mg/m^3. While during November–December (spring time) a greater number of mesoscale structures were observed, such as shifts and currents. SST presented a cold condition characteristic of the season, with values of 13–18°C, while surface salinity was near 34.1‰ and chlorophyll concentration was around 4 mg/m^3.

Phytoplankton on the surveyed seamounts presented 31 genera, including 23 identified species and other non-identified species: Acantharia (1), Bacillariophyceae (15), Cianophyceae (1), Ciliatea (19), Dictyochophyceae (3) and Dinophyceae (18). While in relation to zooplankton 26,964 organisms were identified, distributed in 16 taxonomic groups belonging to the phyla Cnidaria, Annelida, Chaetognatha, Arthropoda, Tunicata and Vertebrata. 88% of the organisms were chitinous (euphausiids, mysids, amphipods, ostracods, copepods, cirripedia and decapod crustacean larvae), and 11% were jelly and semi-jelly (jellyfish, siphonophore, chaetognaths, salps, appendicularians and polychaetes) and the remaining 1% correspond to eggs and fish larvae (*Hygophum brunni* and *Sardinops sagax*).

Fishing methods used allowed two pelagic species to be caught, blue shark (*Prionace glauca*) and Snoek (*Thyrsites atun*), two demersal species, croaker (*Helicolenus lengerichi*), depth conger (*Pseudoxenomystax nielseni*), and two crustacean species, golden crab (*Chaceon chilensis*) and Juan Fernández king crab (*Paromola rathbuni*). 409 invertebrates were collected with a dredge which represented important groups such as Echinoidea (Echinacea), Polychaeta, Porifera, Actinaria and Asteroidea. Different samples were sent to expert national and international laboratories for species identification (Fig. 2). On other hand, the bibliographic review allowed it to be determined that during the 2001–2006 fishing activities, 82 species were collected on the JF1 and JF2 seamounts which belonged to four phyla (Chordata, Arthropoda, Mollusca and Echinodermata), the predominant families being Macrouridae (9), Moridae (6) and Dalatiidae (4). It is important to mention the presence of black corals species (*Parantipathes fernandenzii*, *Trisopathes* spp. and *Leiopathes* spp.) caught on lobster traps employed in the Juan Fernandez archipelago.

Submarine images of the JF1 and JF2 marine substrate present characteristics attributable to the impact of the bottom dredges (Fig. 3). This coincides with the information from the trawling fleet, which shows that the activity is carried out mainly on the flat and surface area of the seamounts (Gálvez *et al.*, 2006). From the analysis of this information it can be inferred that the fishing activity was concentrated mainly on the JF2.

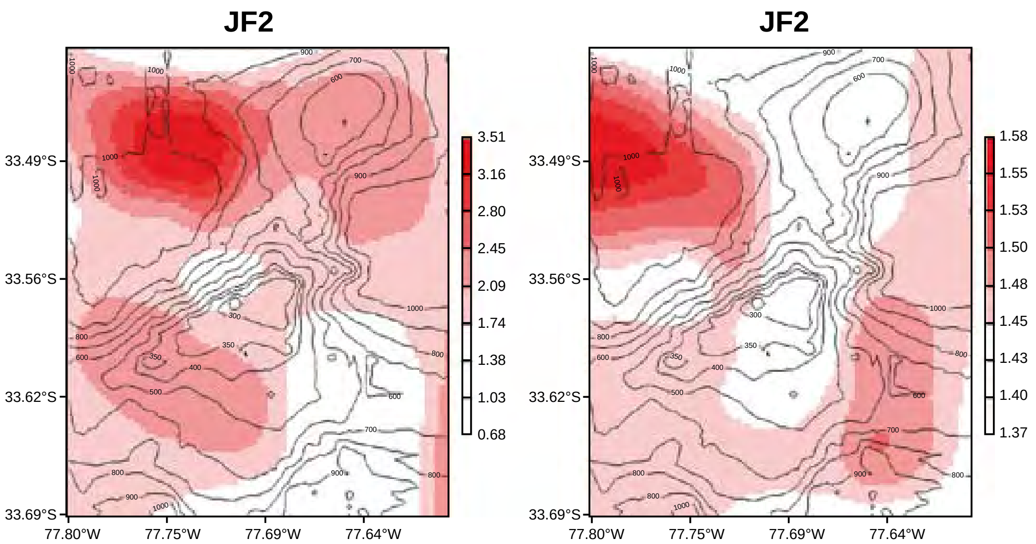

Figure 4. Distribution of the catch rate for the seamount JF2 by ordinary punctual kriging.

seamount, reaching 4,667 km of trawling, compared to the JF1 and JF4 seamounts where the trawling values were 1,526 km and 906 km respectively. However, the fishing effects index showed higher values for seamounts JF4 and JF2 of 11.7 km and 10.5 km respectively. Unlike seamount JF1 where a high fishing activity showed a low fishing effects index of 2.51 km due to a larger estimated area of 608 km^2.

The monthly fishing activity increased considerably during 2002, 2003 and 2005, reaching values above the 500 km of trawling; it then decreased considerably by the end of the period (2001–2006), reaching the initial values of fishing. The high values observed in the fishing activity modified the spatial structure of the resource aggregates in the JF2 seamount. In 2001 the JF2 seamount aggregates presented a symmetric spatial distribution until 4 km, however, in 2003 it presented a value lower than 1 km (Fig. 4). The spatial variability was affected by the reduction of the relative abundance of the main resources exploited in this seamount - orange roughy (*Hoplostethus atlanticus*) and alfonsino (*Beryx splendens*).

The extent of the knowledge needed for the appropriate conservation of the biodiversity of the seamounts in the Chilean EEZ is huge and the present project represents only a step in the right direction. Obviously, the main concern is related to those areas currently subject to fishing exploitation, where it is a priority to adopt conservation and development measures for sustainable activities.

Acknowledgements
We specially thank the captain and the crew of the *Barco Portugal II*, *Lancha Alborada* and *Bongo Cumberlam* used in the campaigns, we also thank the Chilean Fishing Investigation Fund for the financial support of the Project (FIP No. 2006-57).

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Bridging the gap between lower and higher trophic levels

Advances in Marine Ecosystem Modelling Research (AMEMR) Workshop

10-12th February 2009, Plymouth UK

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Over 40 scientists from the UK, Europe, North America, Australia and Japan gathered in Plymouth for the Advances in Marine Ecosystem Modelling Research (AMEMR) Workshop on bridging the gap between lower and higher trophic levels. The AMEMR conferences (and associated workshops) were initially conceived to provide a forum for marine ecosystem modellers to discuss and share problems and solutions. The purpose of this workshop was to examine current approaches towards coupling plankton (cellular) ecosystem models with those of higher trophic levels (HTL; e.g. zooplankton and fish) and make recommendations for future developments. The coupling of models of different trophic levels is one of the biggest challenges in modern marine ecosystem modelling. There is considerable evidence that environmental variability and microbial dynamics play a significant part in controlling both the distribution and abundance of marine populations and that fisheries can alter ecosystem function and state. Understanding both these bottom-up and top-down controls is essential if we wish to predict the response of marine ecosystems to future climate change.

The workshop opened with a series of presentations on the state of the art including modelling complex adaptive systems, the current state of plankton modelling, fish modelling, coupled end-to-end models and linking fish through to economics. The speakers had all been asked to be provocative and they all met this challenge, provoking lively discussion in plenary session. A series of breakout groups followed and the conclusions of those groups are summarised as follows. The discussion topics broke

Figure 1. AMEMR Workshop participants.

into two main areas, our confidence in existing models and the technical issues associated with model coupling.

The technical group discussed two topics, programming languages and data exchange interfaces. The programming language discussion was somewhat inconclusive, it being noted that the choice of a particular programming language is driven by several other reasons such as the aim of the model, the need for a graphical user interface and the modellers grasp of a particular language. For this reason, it is inappropriate to define a common standard language.

In contrast there was a strong recommendation that it could be very helpful to build some interface able to exchange data and synchronise simulations of models written in different languages. This interface should work as a “Data shopping centre” where any model saves (on disk or memory) their output, and where any model can go to load their required inputs. To make this interface general and not strictly dependent on the two models coupled, it is necessary to adopt some standard for handling data (e.g. same format, same name variables) and to provide a very complete documentation and a full set of metadata, together with the data that need to be exchanged.

The was some critique of current ‘dysfunctional’ approaches to modelling plankton which was something of an eye opener to those in the HTL community who had tacitly assumed that the nutrient-phytoplankton-zooplankton modelling approach was all that was required. Work is required to replace flawed assumptions in lower trophic level (LTL) models both overcoming inertia and proving the validity of alternative assumptions.

We have to bear in mind that the cellular models were generally developed to address questions about biogeochemical not ecosystem functioning and ask the question how do or even can we adapt these models for the new purpose? From the perspective of the HTL modeller, cellular models are required to represent the (carbon and nutrient) fluxes between trophic levels, at the correct spatial and temporal scales. The appropriate scales are defined by the questions being addressed. Forcing linkages by aggregating can change the behaviour of the model. Thus the effects of any aggregation should be fully explored. Some minimum requirements of cellular models for input into HTL models were identified including:

1. At least two zooplankton groups.
2. Ability to represent the size of particles that interact with HTLs.
3. Variable or multiple stochiometry.

It was noted that the outcome of trophic interactions is influenced by food quality hence variable stochiometry of plankton (i.e. decoupled carbon and nutrient dynamics) was identified as being particularly important. This requires the resolution of zooplankton on the basis of functionality or taxonomy. However resolving zooplankton on the basis of function might be incompatible with resolution on the basis of size.

Ultimately the minimum model requirements are defined by the question being asked. In some circumstances, a black box might be acceptable, but only for unidirectional linking or if the HTL model isn’t particularly sensitive to cellular inputs, and if the resulting model structure is not used for extrapolation or prediction. Models that include such black boxes will not be end-to-end models .

The evaluation of models was discussed at great length. Model validity can be assessed in a number of ways; using contrasting and complimentary methods should give greater confidence in model evaluation than using just one technique. The key points are that models should be parsimonious i.e. they should have the simplest structure necessary to represent the important processes at the correct temporal scales. Secondly the validation process should include structural evaluation (i.e. the assumptions and functions should be biologically realistic). Finally models should also be able to replicate system dynamics, including realistic patterns in contrasting conditions.

Strategies for modelling adaption were also discussed. There was recognition that existing models can model emergent properties arising from selection and aspects of behaviour. It was agreed that we should be able to model evolution to both develop efficient models and to model phenotypic plasticity. For model adaptation we ideally need to start from the observed state, so that we can model ecosystem response to environmental perturbations. We cannot model all adaptation as this would rapidly become intractable. Instead we must carefully choose which adaptive processes to model.

Outside of workshop the discussions were aided by a social programme which involved sampling the Plymouth Gin Distillery cocktail bar and dinner at the Barbican Kitchen.

This was the last of the current series of AMEMR modelling workshops and we thank the Natural Environment Research Council (NERC) for supporting the workshop series. The third international AMEMR symposium is tentatively scheduled for summer 2011. We will endeavour to find further funding to continue the AMEMR modelling workshop series.

With thanks to Yuri Artoli, Lan Smith and Simeon Hill for their notes and everyone who participated. This article reflects the discussions held and not necessarily the views of the author.

Climate Change and Small Pelagic Fish book

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The Small Pelagic Fish and Climate Change (SPACC) programme has been published by Cambridge University Press (Fig. 1). The book that presents the status of the field as of early 2008 and the editors are Dave Checkley, Jürgen Alheit, Yoshioki Oozeki, and Claude Roy. 82 authors from 22 countries came together to write fifteen chapters addressing the past, present, and future effects of climate change on small pelagic fish.

This book is a product of many of the efforts of contributors to the SPACC programme over the years. In particular, it represents the fruits of the labours of Jürgen Alheit and John Hunter, the co-founders of SPACC, as well as the continued support of Manuel Barange in the GLOBEC IPO. It is the hope of the editors and the authors that this book will provide a foundation for future research to further the understanding needed to inform management and policy under future, unprecedented change.

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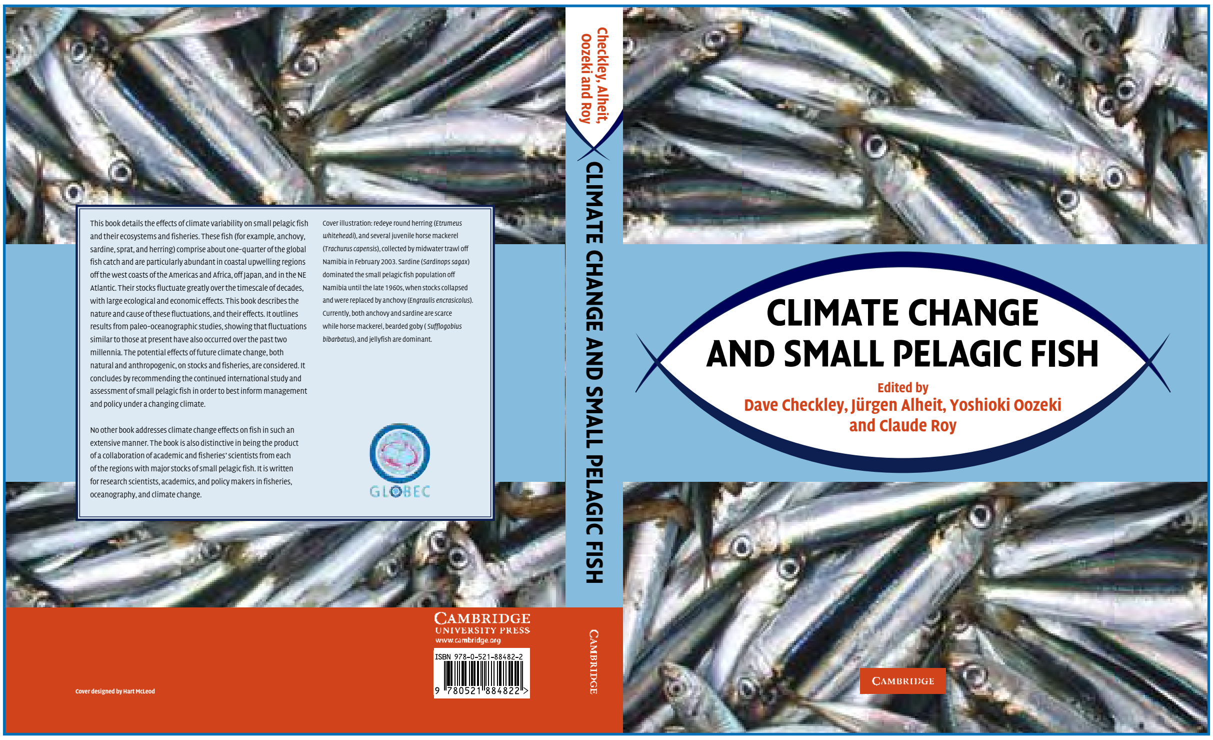

Figure 1. The Climate Change and Small Pelagic Fish book, published by Cambridge University Press, available to purchase from http://www.cambridge.org/uk/catalogue/catalogue.asp?isbn=9780521884822

This conference will culminate the integration and synthesis activities of the international GLOBEC programme by providing a new mechanistic understanding of the functioning of the marine ecosystem, in order to develop predictive capabilities and propose a framework for the management of marine ecosystems in the era of global change.

Symposium scope

The conference will comprise workshops/theme sessions, plenary and poster sessions. The first two days will be devoted to topical workshops proposed by the GLOBEC community. Three days of plenary sessions will follow, along these themes:

- GLOBEC achievements
- Ecosystem structure, function and forcing
- Ecosystem observation, modelling and prediction
- Ecosystem approach to management
- Marine ecosystem science: into the future

A poster session will also be included and a commercial fair is under consideration.

Key dates

15 April 2009 Early registration deadline
22-26 June 2009 Symposium
31 July 2009 Manuscript submission deadline

Convenors

Dr Ian Perry, Pacific Biological Station, Fisheries & Oceans Canada, Nanaimo, Canada

Dr Eileen Hofmann, Centre for Coastal Physical Oceanography, Old Dominion University, Norfolk, USA

Dr Manuel Barange, GLOBEC IPO, Plymouth Marine Laboratory, Plymouth, UK

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Workshop A: Modelling ecosystems and ocean processes: the GLOBEC perspective of the past, present and future

Monday 22 - Tuesday 23 June

Chairs: Enrique Curchitser (USA), Alejandro Gallego (UK), Michio Kishi (Japan) and Emanuele Di Lorenzo (USA)

One of the salient features of GLOBEC research has been the use of dynamical, statistical and conceptual numerical modelling techniques to investigate marine ecosystem processes and their link to ocean climate. A wide array of models has been developed and implemented, including community and individual based biological models, regional to basin-scale physical models and coupled physical-biological models. The goal of the workshop on "Modelling ecosystems and ocean processes: the GLOBEC perspective of the past, present and future" is to describe and compare different modelling approaches and their ability to elucidate physical/biological dynamics.

The workshop will be structured along the following four sub-topics:

1) Physical and biological modelling

2) Biological and advanced ecosystem models

3) Frontiers in ecosystem modelling

4) Climate change in regional marine ecosystems

Each sub-topic will be introduced by a 20 minute invited review talk, which will set the background of the session and serve as a review for the expert and an introduction for the non-expert, followed by a combination of 20 minute invited and contributed talks. There will be a 30 minute discussion at the end of each sub-topic session

The workshop chairs aim to produce a review paper on each of the four sub-topics, ideally led by the respective review speakers with the contribution of any interested participants. A publication from the workshop may be considered dependent upon the level of interest and preferences of the contributors.

Workshop B: Comparison of processes and climate impacts in sub-Arctic and Antarctic marine ecosystems: observations and modelling approaches

Monday 22- Tuesday 23 June

Chairs: Eileen Hofmann (USA), George Hunt (USA), Bernard A. Megrey (USA), Eugene Murphy (UK), Sei-ichi Saitoh (Japan) and Hyoung-Chul Shin (Korea)

This two-day workshop will compare observations and modelling of processes and climate impacts in the maritime Antarctic with those in the sub-arctic seas. It will be structured around the following topics and will consist of oral presentations, informal presentations and discussion sessions:

- Setting the stage - climate studies
- Arctic and Antarctic system comparisons
- Lower trophic level comparisons
- Arctic programme overview
- Arctic and Antarctic top predator studies

The workshop will provide an opportunity for the modelling communities in the Antarctic and the sub-arctic to compare approaches and progress toward functional end-to-end models of the effects of climate change on marine ecosystems and their ability to support upper trophic level organisms including sustainable fisheries. The first level of comparisons will help establish practical marine ecosystem topologies useful to GLOBEC and future studies. The workshop will explore the similarities and differences in ecosystem structure and function and what are the processes that lead to these differences. As well, comparisons between the impacts of physical forcing such as sea ice, winds, and advection will be investigated. The anticipated responses of each ecosystem to climate change and global warming will be compared.

The outcome of this workshop will be a paper synthesising the results of the workshop for the OSM special issue plus a white paper or blueprint for moving forward end-to-end modelling comparisons.

Workshop C: Worldwide large-scale fluctuations of sardine and anchovy: revisiting Schwartzlose *et al*. (1999)

Monday 22 - Tuesday 23 June

Chairs: Jürgen Alheit (Germany), Salvador Lluch-Cota (Mexico) and Carl van der Lingen (South Africa)

This will be a Dahlem style workshop where invited participants prepare background material which is distributed prior to workshop and there is discussion only during workshop.

A number of new and revised ideas about the causes of anchovy and sardine alternations have been proposed during the decade since publication of the landmark paper by Schwartzlose *et al.* (1999) that summarised the findings of SCOR WG 98 on "Worldwide Large-scale Fluctuations of Sardine and Anchovy Populations" which had a joint meeting with SPACC in 1997. Since then the subject of anchovy/sardine alternations has been discussed at several regional meetings organised by the GLOBEC Focus 1 group and SPACC. That some of these alternations are synchronous at basin scales has been taken as evidence for long-term oceanic forcing driven by shifts in global climate, but the mechanism/s linking global climate cycles and regional or local processes that impact on sardine and anchovy and may drive species alternations remains unresolved.

Changing physical regimes that result in food environments that favour one genus over the other because of their differing trophic ecologies have been suggested, as have differential optimal temperatures for growth rates of early life history stages of sardine and anchovy, and differences in spawning temperature optima of these and other small pelagic species. Alternative explanations for anchovy/sardine alternations are related to the "loophole hypothesis", boundary current flow or advection of different water masses.

This workshop will bring together participants who are familiar with and interested in this topic in order to:

1. Update and synthesize information collected over the past decade on anchovy and sardine alternations from a variety of systems,
2. Discuss and review recent hypotheses about possible causes of these alternations,
3. Attempt to attain consensus on such mechanism/s,
4. Identify new research areas, including meta-analyses and simulation models, to test hypotheses concerning such mechanisms.

Schwartzlose R.A., J. Alheit, A. Bakun, T.R. Baumgartner, R. Cloete, R.J.M. Crawford, W.J. Fletcher, Y. Green-Ruiz, E. Hagen, T. Kawasaki, D. Lluch-Belda, S.E. Lluch-Cota, A.D. MacCall, Y. Matsuura, M.O. Nevarez-Martinez, R.H. Parrish, C. Roy, R. Serra, K.V. Shust, M.N. Ward and J.Z. Zuzunaga. 1999. Worldwide large-scale fluctuations of sardine and anchovy populations. South African Journal of Marine Science 21: 289-347.

Workshop D: Krill biology and ecology in the world's oceans

Monday 22 - Tuesday 22 June

Chairs: Angus Atkinson (UK), Jaime Gómez-Guitérrez (Mexico), Bettina Meyer (Germany) and Bill Peterson (USA)

The workshop will be a gathering of krill biologists and ecologists from around the world to discuss the life history and population dynamics of all krill species. This is timely because krill have been important elements of a number of the GLOBEC core programmes and a great deal has been learned from the GLOBEC fieldwork that needs to be synthesized.

These discussions were first initiated at the International Zooplankton Production Symposium, in Hiroshima, May 2007 where the workshop was overwhelmed with presentations and attendance.

The aims of the workshop will include:

- Synthesis of krill research from GLOBEC fieldwork.
- Discussion of methods and approaches that have proved effective for one species and consideration of whether they can be applied to other euphausiid species.
- To make sure there is a degree of harmony in approaches to krill research and to improve technical aspects of specific methods.
- To generate ideas for future collaborations, for example laboratory/seagoing exchanges of personnel and of exchange and pooling of datasets to address wider-scale issues.
- To produce a tangible product, to show where krill research is at the moment, hurdles to progress and potential solutions.

Workshop E: Biogeochemistry of the oceans in a changing climate

Monday 22 June

Chairs: Francis Chan (USA) and Debby Ianson (Canada)

Geochemical processes, many of which are linked, are sensitive to global variations in climate forcing and its ocean signals. These processes affect individual marine organisms as well as populations and ecosystem structure. Ocean acidification, hypoxic "dead zones", carbon cycling, nutrient ratios, and methane hydrates are examples of the possible imprint of recent climate change in marine ecosystems. While we have a growing level of evidence – much the result of long-term GLOBEC measurements and research – that climate change is influencing these processes, and that ocean biogeochemistry will be very different under the projected future climate, we lack a comprehensive understanding of the mechanisms linking climate change to these critical ocean processes, and even less understanding of the consequences to marine populations and their ecosystems. Furthermore, most observing programmes are regional and short-term, limiting the prospects of comprehensive long-term monitoring necessary to understand and track future changes in these processes. This workshop will provide an overview of our understanding of the relationship between global climate change and marine biogeochemical processes, and identify the monitoring and research requirements for addressing how these processes will evolve in time and space under the future climate.

Workshop F. Continuous Plankton Recorder surveys of the global ocean

Monday 22 June

Chairs: Sonia Batten (Canada) and Peter Burkill (UK)

Continuous Plankton Recorders (CPRs) have been used for many years to sample plankton around the globe: in the North Sea for over 70 years, the North Atlantic for over 50 years, the Southern Ocean since 1991 and 2009 will mark the 10th year of CPR sampling in the North Pacific. These time series have each produced numerous publications and locally important studies. However, the focus now is turning towards global changes and global issues and this is a timely opportunity to discuss complementarity amongst the CPR time series (and with other regional sampling programmes), to highlight the need for consistency in sampling and to identify future directions. Recent advances in technology, analytical and statistical techniques have also broadened the applicability of the sampler and the data it generates. Raising awareness of the surveys, the samples and data available to address global issues would be a desirable outcome of this workshop. The workshop will consist of two sessions of presentations followed by a discussion period in each case to identify complementarities among regions, issues arising and future avenues for study.

The session titles are:

1. Recent results from CPR surveys around the world.
2. Novel approaches, applications and methodologies using CPR samples and data.

Workshop G: Cod and climate change: the past, the present and future challenges

Monday 22 June

Chairs: Øyvind Fiksen (Norway), Jeff Runge (USA) and Fritz Köster (Denmark)

This workshop will include an invited presentation summarising the state of the art within the field before the formation of the Working Group on Cod and Climate Change (WGCCC), several presentations on knowledge gained within the programme, and a summary and discussion session on questions for future research.

The presentations on knowledge gained during the programme will include:

- Results of comparative analyses (across cod stocks, geographical areas and with other species, e.g. pollock or Pacific cod) on growth, recruitment, distribution and processes important for early life stages and adults.
- Advances in modelling, e.g. hierarchy of models.
- Effects on stock assessment and management, implications on policy.

Discussions among Cod and Climate Change scientists and feedback from colleagues working on other systems will be very helpful towards steering future work on climate effects on fish stocks in the ICES area in the most fruitful direction.

Workshop H: Plankton phenology and life history in a changing climate: observation and modelling

Tuesday 23 June

Chairs: Rubao Ji (USA), Dave Mackas (Canada) and Martin Edwards (UK)

Phenology, the study of annually recurring biological phenomena in relation to climate conditions, is particularly useful in examining the system responses to major external disturbances. Such studies have been conducted extensively in terrestrial and freshwater systems, and begun to receive attention in coastal and open ocean systems. Increasingly available datasets from GLOBEC and other related programmes have revealed phenological changes in many aspects of plankton dynamics, including the timing and magnitude of phytoplankton blooms and zooplankton biomass peaks, species composition of plankton communities, as well as physiological and reproductive responses. Empirical analyses and quantitative modelling approaches have been used to identify and understand the underlying forcings that drive phenological shifts.

This workshop will bring together studies from various GLOBEC research sites around the world that contribute to 1) valuations of plankton phenological and life history changes in different ecosystems using existing datasets and/or models; 2) providing observational and/or theoretical approaches for identifying phenological changes over a range of temporal and spatial scales and underlying biological and physical driving forcings; 3) examining the linkages between phenological changes in lower and higher trophic levels including fisheries; 4) new statistical approaches to quantifying trophic mismatch; 5) providing evidence for phenotypic plasticity and potential adaptation of marine organisms to climate change impacts; and 6) reviewing/discussing current status and future observation/modelling needs for plankton phenological studies.

Workshop I: Climate impact on ecosystem dynamics of marginal and semi-enclosed seas

Tuesday 23 June

Chairs: Yasunori Sakurai (Japan) and Christian Möllman (Germany)

Marginal and semi-enclosed seas contribute a substantial share to the world fisheries catch. GLOBEC researchers have been very active in studying the impact of climate (climate variability and climate change) on these ecosystems. This work was mainly focused on higher trophic levels, particularly on zooplankton and fish. However, whereas our knowledge on single marginal seas and semi-enclosed ecosystems has very much progressed in these fields, what is missing so far, is a synthesis of the respective results by GLOBEC as is being carried out, for example, for eastern boundary currents.

Consequently, this workshop will seek to compare climatic influences on semi-enclosed and marginal seas on a global scale. As marine ecosystems are not amenable to experimental investigations with respect to climate impact, the comparative method is the best way to enhance our knowledge on the reaction of ecosystems and the populations embedded in them.

The geographic focus of this workshop will be traditional GLOBEC study areas such as the Barents Sea, North Sea, Mediterranean, Baltic Sea, Black Sea, East China Sea, Yellow Sea, Okhotsk Sea, Sea of Japan, Georges Bank, Bering Sea, Gulf of Alaska, Scotia Sea (or other southern ocean regions). Particularly rewarding periods for cooperative studies are the late 1980s and 1990s, when dramatic changes have been observed in the North Pacific as well as in the North Atlantic in association with changes in climatic indices such as the NAO, AO and PDO.

Workshop J: Socio-economic dynamics and ecosystems, governance implications

Tuesday 23 June

Chairs: Kathleen Miller (USA) and Anthony Charles (Canada)

Successful management of marine ecosystems requires good information, both about the socioeconomic factors driving exploitation, and about the status and dynamics of the exploited species and the ecosystems on which they depend. But even the best information may have little value in the absence of effective institutions for cooperative governance of those systems. Marine fisheries present particular management challenges due to the competing interests of the multiple resource users and nations benefiting from the fisheries. For open-ocean fisheries, the challenges are multiplied by the often wide-ranging movements of some fish stocks across both high seas areas and waters controlled by multiple nations. A central management problem for multi-national oceanic fisheries is the need to constrain competitive harvesting in order to avoid the depletion of fish stocks and the dissipation of potential resource rents that could otherwise occur. Ocean ecosystem governance encompasses not only the problem of effective management of single species fisheries, but also a much broader array of issues arising from multiple interactions across species, fisheries and other human activities.

This session will focus on questions pertaining to marine ecosystem governance, e.g. what constitutes effective governance for oceanic ecosystems and the fisheries that they support; how can this be achieved and maintained in the context of rapid socioeconomic change and a variable and changing climate; what type of information is needed from the science community to support effective resource governance; and what do we need to understand about the human dimensions of ecosystem use in applying the ecosystem approach to fisheries governance?

An outsider's view of GLOBEC

Ken Denman

GLOBEC can rightfully claim many scientific accomplishments, but perhaps its two key successes are socio-political rather than scientific. First, GLOBEC has created a global network of scientists outside national government organisations, whereby different fisheries ecosystems can be contrasted and compared relatively free from the self interests of individual nations. Second, GLOBEC has reached beyond traditional fisheries food web science both to embrace paleoclimatic science and to bring people into the food web ecosystems under study.

In the last two decades, fisheries food web research has diverged from ocean biogeochemical research, which is driven by the need to understand the ocean's role in climate. The recent 'End to End Food web' theme explored by GLOBEC/IMBER implicitly recognised the need to reintegrate these diverging themes. But, from a biogeochemical viewpoint, a more apt title might have been 'Back to Front Analysis' of parallel but connected elemental cycles in the ocean: C, N, O, P, S, Si, Fe, etc. These multiply-connected elemental cycles affect and are affected by marine food webs over a broad range of temporal and spatial scales. Two specific and connected issues that illustrate these interactions are the increase in ocean acidity (decrease in pH) caused by adding carbon dioxide to the oceans and the observed decrease in subsurface dissolved oxygen over large regions of the ocean. Of special importance to GLOBEC is the advection of low oxygen, low pH waters onto continental shelves in upwelling regions, where local remineralisation of organic matter in subsurface waters further reduces both the oxygen concentration and the pH. Forecasting the effects of such long term environmental changes on individual organisms or species is hampered by our lack of knowledge of how 'plastic' or adaptable they are in response to changing conditions.

Although considerable progress has been made in identifying and analysing 'regime shifts' in fisheries ecosystems, less progress has been made in understanding the drivers of regime shifts, which is required if we are to attempt to quantify the probability of abrupt change in marine ecosystems, both regionally and globally. Abrupt change can be considered in the context of dynamic systems, where the system may exist in two or more preferred states with rapid transition between them. Such systems are characterised by hysteresis, whereby a control variable may have to recover well beyond its value when the abrupt change was precipitated before the system reverts to its original state. The crash of the northern cod in the western North Atlantic appears to be one such example. Another case where we seem to have passed a 'tipping point' is the emergence of an ice-free Arctic Ocean during summer, which is now estimated to occur in one to several decades. However, we have yet to develop comprehensive food web models embedded in coupled climate models such that we can explore the possible food web ramifications of an ice free Arctic Ocean during summer.

Ken Denman is a Senior Scientist with Fisheries and Oceans Canada (DFO), since 2000 working at the Canadian Centre for Climate Modelling and Analysis of Environment Canada, located at the University of Victoria where he is an Adjunct Professor. His research involves the interactions between marine food webs, biogeochemical cycles and climate change. He was Coordinating Lead Author of Chapter 7 of the 2007 Intergovernmental Panel on Climate Change (IPCC) WG1 AR4 titled "Couplings between changes in the climate system and biogeochemistry"; and Coordinating Lead Author of Chapter 10 in the Second Assessment Report (1995) of IPCC WG1, titled "Marine biotic responses to environmental change and feedbacks to climate". The IPCC shared the 2007 Nobel Peace Prize with Al Gore for its work on climate change. Ken Denman is a Fellow of the Royal Society of Canada, and has received the President's Prize of the Canadian Meteorological and Oceanographic Society, the T.R. Parsons Medal for excellence in ocean science, and the Wooster Award of the North Pacific Marine Sciences Organization (PICES). He has served on the Steering Committees of the Joint Global Ocean Fluxes Study (JGOFS), the Global Ocean Observing System (GOOS), and the Surface Ocean Lower Atmosphere Study (SOLAS). He recently completed six years as a member of the Joint Scientific Committee of the World Climate Research Programme. He received a PhD in ocean physics from the University of British Columbia.

A history of GLOBEC

Roger Harris and Elizabeth Gross

This talk will review the evolution of this major international global change programme from its early beginnings to the final phase of integration and synthesis.

After an initial phase of development, particularly in the United States, GLOBEC was initially co-sponsored in 1991 by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission of UNESCO. Subsequently it was adopted as a core project by the International Geosphere-Biosphere Programme (IGBP) and for the ten year's duration of GLOBEC the three co-sponsors have provided valued support and guidance. Two Regional Programmes also benefited regional sponsorship from the International Council for the Exploration of the Sea (ICES) and the North Pacific Marine Science Organization (PICES).

From the outset GLOBEC research was organised around four foci: Retrospective analyses and time series studies, Process studies, Predictive and modelling capabilities and Feedback from changes in marine ecosystem structure. The work was initially developed within four Regional Programmes: Southern Ocean GLOBEC (SO GLOBEC), Small Pelagic Fishes and Climate Change (SPACC), ICES-GLOBEC Cod and Climate Change Programme (CCC) in the North Atlantic and the PICES-

GLOBEC Climate Change and Carrying Capacity Programme (CCCC) in the North Pacific. In the later stages two additional Regional Programmes were started: Climate Impacts on Top Predators (CLIOTOP) and Ecosystem Studies of Sub-Arctic Seas (ESSAS). National funding supported active GLOBEC programmes in many countries, for example, Canada, Chile, China, France, Germany, Japan, Korea, Mexico, Norway, Peru, Portugal, Spain, UK and USA.

International cooperation and coordination has been a hallmark of GLOBEC and this approach will be a continuing legacy after GLOBEC itself has ended.

Dr Roger Harris is a Senior Scientist at the Plymouth Marine Laboratory, UK. His main research interests are: the control of biological production by physical processes, the role of water column biology in global oceanic carbon flux and the ecology and physiology of calanoid copepods. He has considerable experience in international and interdisciplinary project management. He is past Chairman of the IGBP/SCOR/IOC GLOBEC Scientific Steering Committee and continues to serve on the GLOBEC SSC and leads the Focus 2 Process Studies Working Group. Involved in a number of editorial roles, currently principally as Strategic Editor of the Journal of Plankton Research and editing a Special Issue of ICES Journal of Marine Science for the 4th International Zooplankton Symposium. He has published over 100 peer-reviewed scientific papers.

Elizabeth Gross received a MSc degree in Marine Science at McGill University in Montreal in 1972 where her research focused on the distribution and reproductive ecology of calanoid copepods in the western basin of the Arctic Ocean. After teaching biology at McGill for three years Elizabeth became an Assistant Curator at l'Aquarium de Montréal and the affiliated Jardin Zoologique where she had special responsibility for education programmes. She then moved to Dalhousie University to continue teaching biology and in 1979 became the departmental administrator in the Oceanography Department and in 1980 was appointed Executive Secretary of SCOR, which initially she combined with her teaching duties. As SCOR grew Elizabeth became more involved and by 1985 was working full time for SCOR, and five years later was appointed the Executive Director. In 2000, Elizabeth decided to retire from the Executive Director's post but still maintains her association with SCOR as a part-time Finance Officer.

Physical/biological coupling in marine ecosystems

Eileen Hofmann (co-authors Francisco Werner and Eugene Murphy)

The GLOBEC programme led to a fundamental change in research into marine population variability. The use of coupled physical-biological models of marine ecosystem dynamics that are based on processes that influence individual organisms has been a core approach used in GLOBEC. As a result, integration of physical-biological modelling and observations was done from the outset in GLOBEC science programmes and the success of this approach has resulted in a shift in how marine ecosystem research is now structured. Mechanistic understanding of the variability in abundance and distribution of marine populations is now emerging, which is allowing linking of processes across local, regional and basin scales.

This presentation will provide an overview of the advances in understanding of physical-biological coupling and of the connectivity between the environment and organisms at a range of spatial and temporal scales that have resulted from GLOBEC science. Many of these advances underlie recent efforts to link marine population variability to climate change and to make projections of this response a feasible goal.

Eileen E. Hofmann is a Professor in the Department of Ocean, Earth and Atmospheric Sciences and a member of the Center for Coastal Physical Oceanography, both at Old Dominion University, Norfolk, Virginia. She received a BS degree in Biology from Chestnut Hill College in Philadelphia, PA and MS and PhD degrees in Marine Sciences and Engineering from North Carolina State University. She held a postdoctoral position at Florida State University and a faculty position in the Oceanography Department at Texas A&M University before moving to Old Dominion University. Her research interests are in the areas of understanding physical-biological interactions in marine ecosystems, climate control of diseases of marine shellfish populations, descriptive physical oceanography, and mathematical modelling of marine ecosystems. She has worked in a variety of marine environments, most recently the continental shelf region off the western Antarctic Peninsula.

She presently serves on the Editorial Boards for the Journal of Marine Research, Journal of Marine Systems, and Antarctic Science. She co-edited the book, Foundations for Ecological Research West of the Antarctic Peninsula, which is part of the American Geophysical Union, Antarctic Research Series. She was co-editor of two volumes of Deep-Sea Research II that are devoted to the results of the Southern Ocean GLOBEC programme.

She is a member of the US and International GLOBEC Science Steering Committees and the Science Steering Committee for the Chesapeake Community Modeling Project. She is Chairman of the GLOBEC Southern Ocean Planning Group and the US Southern Ocean GLOBEC Science Steering Committee and is Vice Chair of the Scientific Committee for Antarctic Research Southern Ocean Working Group.

IMBER

Julie Hall

IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) is a decade long international project that will develop new knowledge of ocean biogeochemical cycles and ecosystems. The project goal is to investigate the sensitivity of biogeochemical cycles and marine ecosystems to global change on time scales ranging from years to decades. To achieve this goal, IMBER will identify key interactions between marine biogeochemical cycles and ecosystems and assess how these interactions respond to complex natural and anthropogenic forcing factors in key areas of the world's oceans. The project is focused on the impacts of 1) physical drivers for example, stratification and circulation, 2) changes in CO_2 concentrations for example CO_2 storage and ocean acidification, 3) changing supplies of macro and micro nutrients and 4) harvesting. With the synthesis of GLOBEC research new questions have been identified and ongoing GLOBEC projects are considering becoming part of the IMBER project. An Addendum to the IMBER Science Plan and Implementation Strategy has been developed by the GLOBEC/IMBER Transition Team. The implementation of this plan will be discussed.

Julie Hall is a biological oceanographer and is currently the Assistant Regional Manager for NIWA, Wellington, New Zealand. Julie completed her BSc Hons in Zoology at Otago University, New Zealand and her PhD at the University of Manitoba, Winnipeg, Canada. Her marine research has focused on microbial food web structure and function and has included work on grazing impacts of both micro and macro zooplankton. She has worked in the coastal and open ocean and recently conducted experiments to assess the impacts of ocean acidification in the Ross Sea, Antarctica.

Julie was a member of the JGOFS Scientific Steering Committee and Chaired the joint JGOFS/LOICZ Continental Margins Task Team she has also been a member of the Coastal Ocean Observing Panel and the Global Ocean Observing System Scientific Committee. Julie is currently Chair of the IMBER Scientific Steering Committee and was Chair the Transition Team that developed the Science Plan and Implementation Strategy for the IMBER project.

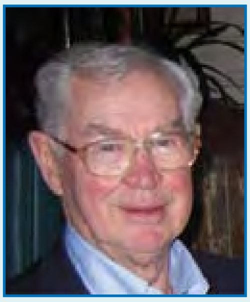
Beyond GLOBEC: Challenges and opportunities

John H. Steele

The past as prologue: GLOBEC was one of a group of "global" programs started in the 1980s. The divisions between WOCE, JGOFS and GLOBEC (and RIDGE) were disciplinary and the aims were scientific. Programmes starting in this century are expected to be quite different with societal objectives and with the individual aims problem driven.

Unfinished business: There are a large number of interesting individual challenges and opportunities arising from GLOBEC, and suggesting further research. But the central GLOBEC question remains – how can marine ecology or biological oceanography establish "global" generalisations about the overall dynamics of ecosystems within a wide range of habitats and, now, under increasing external forcing functions.

Looking forward: the problem is – how do we connect ecosystem dynamics with society's dynamics. The safe way is to stay well within the non-human domain and present a range of options or scenarios. An alternative that appears popular is to promote particular solutions, such as MPAs, ITQs, or ocean farming. These approaches are often divisive, setting conservationists against fishers or processors. The other option is to a) develop the science so that we can show the links between diversity, productivity and resilience; and b) couple these to social or economic patterns in conservation, capture and farming. The former is a very hard scientific problem; the latter is an even harder sociological issue. This should not mean that we should not attempt both. They provide the opportunities as well as the challenges.



John H. Steele started his education with a degree in pure mathematics at University College, London, followed by "national service" at the Royal Aircraft Establishment applying numerical methods to intractable mathematical problems. At this time he developed a passion for sailing. Research at the Marine Laboratory in Aberdeen, Scotland gave him the opportunity to fulfil both interests. Data collected in the North Sea and north-east Atlantic were used to test models of basic production cycles in the sea. But growing concern about over-fishing provoked increasing interest in the links between primary production and fisheries, and the limitation imposed on fisheries by their environment. In 1965 Steele produced the first quantitative description of the flux of biological energy through a large marine food web – the North Sea. In 1974, his book, The Structure of Marine Ecosystems, combined the description of food webs with the modelling approach to give a more rigorous basis to the applied side of marine ecology, and helped establish the significance of understanding ocean processes for fisheries management. This work led to the award of the Agassiz Medal of the US National Academy of Science, and Fellowship of the Royal Society.

In 1977, he became Director of the Woods Hole Oceanographic Institution. There he played a leading role in the development of major international marine programmes such as JGOFS (Joint Global Ocean Flux Study) and GLOBEC (Global Ocean Ecosystem Dynamics). After his retirement as Director in 1989 he started a second research career at Woods Hole, expanding the scope of his work on the ecosystem way of thinking, with a focus on the differences between terrestrial and marine ecosystems. Recent work on end-to-end modelling of the Georges Bank ecosystem, and the implications for resource management, continue his interests in linking theoretical concepts with applied issues.

Meeting - Invited speakers

Impacts of climate/global change
Svein Sundby

The regional GLOBEC projects all address impacts of climate/global change but with different foci. This reflects that structure and function of the various marine ecosystems are different, but also that scientists associated with the various regional projects have different perspectives and approaches to the problems of climate change. What are the common processes and food web features across marine ecosystems and what are the specific features different in each of them? A natural start to exploring impacts of climate variability and climate change is correlative studies between climate variables and ecosystem properties. But such studies are of limited value without a parallel development of the understanding of the governing processes behind the correlations. Subsequent extension of data sets or time series in such studies most often results in that the earlier significant established correlations break down, not necessarily because the possible mechanisms though of were wrong, but because new processes or factors might become critical under a different physical setting or a different state of the ecosystem. In high latitude marine ecosystems changes in temperature has been shown to have strong and extensive impacts on distribution and productivity for the organisms. But such strong responses have often multiple causes in addition to the temperature effect itself. In other marine ecosystems different climate variables than temperature might be critical for growth and distribution of the organisms. The recipe for advancing our understanding of the impacts of global climate change on marine ecosystems is already set in the objectives and scientific themes of GLOBEC, but a stronger emphasis is needed on the interaction between process studies in the field and development and validation of ecosystem models. Finally, established time series must be maintained, and new time series must be established.

Svein Sundby is research leader of the research programme on Climate and Fish at Institute of Marine Research and adjunct professor at Geophysical Institute, University of Bergen, where he is associated with a joint Nordic education in climate and marine ecology. He is associated as scientist with the Bjerknes Centre for Climate Research. He received his master degree in physical oceanography and doctorate degree in marine ecology. He has worked on developing physical-biological process model, particularly linked to fish eggs and larvae. He has worked with fish recruitment processes in arcto-boreal ecosystems and in upwelling ecosystems. A special emphasis has been on the impacts of climate variations and climate change on recruitment and growth in the Barents Sea cod. He worked together with professor Brian Rothschild within ICES to establish the Cod and Climate Change Programme in the early 1990s, and was part of the interim group that initiated GLOBEC at the same time. He was member of GLOBEC SSC 1995-1998, and again member of GLOBEC SSC from 2006.

Food web processes in marine ecosystems
Coleen Moloney

GLOBEC studies have focused on biological-physical interactions of target species in different study regions, emphasising responses of organisms to varying physical forces. Because of this focus, the importance of population-level processes for food web dynamics was highlighted, with responses often being ecosystem-specific. This presentation aims to describe some of the advances that have been made over the past decade in understanding food web processes. These include the effects of variability in the timing of biological events, which are susceptible to environmental change and which cause shifts in physiology, population dynamics and ecology. It is apparent that many species are able to adapt to change, especially in terms of their feeding modes and diets. Unfavourable conditions can also cause organisms to move elsewhere, changing the community composition and the vertical and horizontal linkages between ecosystems with unknown consequences. Trophic controls in food webs vary over time and space and food web structures also change, both over the short term and through shifts in regimes, sometimes irreversibly. There is an ongoing requirement to integrate ecological processes, from biogeochemistry to top predators, to understand the potential consequences of global change.

Coleen Moloney is a senior lecturer in the Zoology Department and Marine Research Institute at the University of Cape Town (UCT). She obtained her PhD in 1988 from the University of Cape Town, and spent two years as a post-doc in the US GLOBEC programme at the University of California, Davis. Returning to South Africa, she was employed for five years by Marine and Coastal Management (MCM), a branch of the South African Department of Environmental Affairs and Tourism, responsible for fisheries management. Since 2001 she has been based at UCT. Her research interests revolve around the study of marine ecosystems, with a focus on the marine pelagic ecosystem of the Benguela upwelling region off the west and south coasts of southern Africa. Her personal research interests involve modelling studies to understand the roles in the ecosystem of organisms from microbes to top predators. This research was initiated with size-based studies of plankton communities and extended to larger animals over time. In collaboration with colleagues and students from UCT and MCM, she has also been involved in a variety of species-based ecological studies and in providing information to underpin the ecosystem approach to fisheries management in the region. She is currently a member of the Scientific Steering Committee of IMBER and of GLOBEC's Focus 3 Predictive and Modelling Capabilities Working Group.

The human dimensions of global environmental change

Ian Perry (co-authors Manuel Barange and Rosemary Ommer)

GLOBEC began with a focus on the impacts to marine ecosystems of climate variability and change, and these are reflected in the early activities and successes of the programme. It was recognised, however, that human activities such as intensive fishing also have strong impacts on marine ecosystems, which may occur on more immediate time scales than those of climate change. This presentation reviews the human dimensions of global change in marine ecosystems, and expands on the concept of coupled marine social-ecological systems. Fishing and climate forcing interact on marine populations, marine communities, and ecosystems to bring them into states that are more sensitive to climate forcing. From the human side, how human communities respond to marine ecosystem variability can ameliorate or exacerbate these changes. At shorter time scales, coping responses by both human and non-human marine systems have common elements; at longer time scales, however, many adaptive responses by human communities have no analogues in non-human marine ecosystems. Marine resource managers must develop approaches which maintain the resilience of individual fish and individual people, of populations of both fish and humans, of communities of both fish and humans, and their coupled social-ecological marine systems to the combined and interacting effects of climate and fishing. Overall, a less-heavily fished marine system, and one which shifts the focus from individual fish species to functional groups and fish communities, is likely to provide more stable catches under normal conditions than would a heavily fished system, although under climate variability the whole ecosystem may alter in ways we cannot yet predict. In addition, it is becoming apparent that good fisheries management alone may not be able to recover a depleted stock under unfavourable environmental conditions, and poor management can prevent the recovery of a stock even if environmental conditions become favourable. A full social-ecological system approach to the management of marine resources would involve multiple-scale (from government to local fishing sectors) objective setting based on societal choices, including ecological, economic and social considerations. Operational objectives need to be established, requiring the identification of indicators and reference points for sector impacts. Decision support and performance evaluation rules need to be established, including their uncertainties. Future change in marine systems is not and will not be due to climate alone, but to the interactions of climate variability, climate change, and direct-human effects, and future marine research and management must take account of this reality.

Ian Perry is a fisheries oceanographer with Fisheries & Oceans Canada, in Nanaimo, BC, Canada. His research expertise includes environmental influences on the distributions and recruitment of marine organisms; the structure and function of marine ecosystems; developing ecosystem-based approaches to marine resources management; and the human dimensions of marine ecosystem changes. He is the Chair of the international Global Ocean Ecosystem Dynamics (GLOBEC) programme and has been a member of the Scientific Steering Committee since 1996. He is co-chair of GLOBEC's Focus 4 on the human dimensions of marine ecosystems, which considers "natural ecosystem" and human interactions in the context of marine ecosystem changes. He is also a past Chief Scientist for the North Pacific Marine Science Organisation (PICES), a former editor for North America and Oceania for Fisheries Oceanography, and has been a visiting lecturer at universities in Canada, Chile and Portugal. He is also currently an Adjunct Professor at the UBC Fisheries Centre in Vancouver, Canada. He currently co-leads DFO's Strait of Georgia Ecosystem Research Initiative.

Forecasting and predicting marine ecosystem responses to climate change

Yasuhiro Yamanaka

Since 1998 Dr. Yasuhiro Yamanaka has been an Associate Professor in the Faculty of Earth & Environmental Science, Hokkaido University and Sub-leader of the marine ecosystem modelling group at the Frontier Research Center for Climate Change, Japan Agency for Marine-Earth Science (JAMSTEC). He received his PhD from the University of Tokyo on research about marine carbon-cycle modelling in 1995, spent one year as a visiting researcher at Princeton University in 1997, and recently spent three months as visiting fellow at the University of East Anglia in 2007-2008. During his term as Assistant Professor of the Center for Climate System Research (CCSR), University of Tokyo, he developed the CCSR Ocean General Circulation Model and CCSR/NIES Climate Model contributing to IPCC TAR (2001).

He participated in the Ocean Carbon-cycle Model Intercomparison Project (OCMIP) and was a co-author of the study of ocean acidification by Orr et. al (Nature, 2005). His current research includes ecosystem dynamics linking climate change and variability of fisheries resources. His goal is to develop an integrated ocean model synthesizing the physical, chemical and biological processes and to clarify dynamics and feedbacks relevant to the impact of global warming on marine ecosystems. Recently, his group developed a 3-D high-resolution (1/4 x 1/6 degrees horizontally) ecosystem model coupled with a fish migration model.

He acts as a programme leader of the Global COE (Center of Excellence) programme "Establishment of Center for Integrated Field Environmental Science" funded by the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Pleurobrachia pileus (Ctenophora) from the Cooum estuary, Bay of Bengal

N.S. Bharathi Devi and R. Ramanibai
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The ctenophores, or comb jellies, are transparent animals belonging to a small and entirely marine phylum (Ctenophora) consisting of only 100–150 species, many of which are yet to be described. Ctenophores look like medusae, more or less transparent carnivores which use tentacles to capture their prey, however these similarities reflect a convergence in life styles rather than close evolutionary ties.

Ctenophores are common marine predators distributed throughout the world's oceans inhabit both surface and deep waters (Harbison *et al*., 1978). Copepods (Kremer, 1979; Mountford, 1980), fish eggs and larvae (Purcell, 1985; Monteleone and Duguay, 1988; Purcell *et al*., 1994) are consumed by coastal cydippid ctenophores.

From our routine water quality and zooplankton studies, we noticed the occurrence of comb jellies in the estuarine mouth of the Cooum River during April and September 2008. Our bimonthly sampling was initiated from December 2007 until today.

Comb jellies were collected using a 120 µm mesh plankton net and preserved in 5% formalin for identification along with morphometric measurements (Tables 1 and 2). These comb jellies were identified as *Pleurobrachia pileus* (Wrobel and Mills, 1998; Gibson, 2001).

Table 1. Classification of comb jellies

Phylum	Ctenophora Eshscholtz, 1829
Class	Tentaculata Eshscholtz, 1825
Order	Cydippida
Family	Pleurobrachiidae Chun, 1880
Genus	*Pleurobrachia* Fleming, 1822
Species	*Pleurobrachia pileus* (O.F. Muller, 1776). Sea gooseberry

Description

Pleurobrachia pileus, otherwise known as sea gooseberry is small in size ranging from a few millimetres to over a centimetre (Fig. 1). Colourless, slightly ovoid spherical in shape, flattened on two sides (Fig. 2). The two ends are known as oral and aboral poles. The mouth is present at the oral pole and the two anal pores are present at the aboral pole. It has eight evenly spaced comb rows arranged like meridians on the surface of the sphere. Each row is composed of a number of successive plates of large fused cilia and it functions as a paddle known as ctene, which is used for locomotion. (Fig. 3)

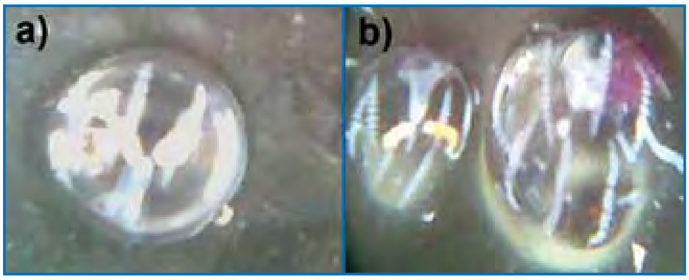

Figure 1. Pleurobranchia pileus.

Figure 2. Mass of comb jellies.

Figure 3. Dissected ctenes.

It has two feathery tentacles that can be retracted into specialised sheaths that are situated close to the pharynx. Numerous sticky side branches on the tentacles ensnare zooplankton prey when fully extended (Waggett and Costello, 1999). The comb rows are used to propel the jelly slowly forward as it fishes for prey.

Table 2. Measurements of preserved specimens

Length (from oral to anal pore)	0.7 mm - 1.2 cm
Diameter of the comb jelly	1.5 cm – 3 cm
Single ctene length	2 cm – 3 cm
Number of ctene (comb plates)	8 comb plates
Number of tentacles	2
Length of the tentacles	10 cm – 15 cm

The authors gratefully thank UGC, New Delhi for financial support.

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Switch in ecosystem functioning triggered by trophic cascades in low diverse pelagic systems: the Baltic Sea case

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Understanding how and under what circumstances marine ecosystems respond to climate and anthropogenic forces bears vast management implications (Brander *et al.*, 2007). A number of studies shown that climate change can affect entire food webs by acting on plankton productivity (e.g. Ware and Thomson, 2005). On the other hand, there is awareness about the consequences of the removal of large predatory fish whose effects may percolate down the food web, i.e. trophic cascades (Heithaus *et al.*, 2008). Changes in food web interactions can have dramatic consequences in the structure and functioning of ecosystems, especially in low diversity systems (Frank *et al.*, 2007). This note introduces novel results from a retrospective analysis of field observations for the period 1974-2005 in the central Baltic Sea. In particular, quantitative evidence is provided on how the underlying mechanisms of trophic cascade caused a switch between two alternative ecosystem scenarios separated by an ecological threshold (i.e. a certain abundance of zooplanktivorous fish) and characterised by different structure, functioning and stability. Identification of some of the potential causal mechanisms that have inhibited the recovery of the former ecosystem conditions in recent years is also provided.

In the Baltic Sea, the decline of seals and other marine mammals that occurred in the first half of the 1900s because of hunting and pollution (Österblom *et al.*, 2007), allowed the emergence of cod (*Gadus morhua*) as the top predator. However, excessive fishing pressure intertwined with unfavourable environmental conditions for cod recruitment (i.e. the lack of salt- and oxygen-rich water inflows from the North Sea into the Baltic Sea) triggered a sharp decline in cod populations in the 1980s. Since the early 1990s, the cod stock has been low. The removal of cod has percolated down the food web leading to a shift in the structure of the central Baltic Sea ecosystem. In fact, the low abundance of cod has allowed a substantial increase of the population of sprat (*Sprattus sprattus*), a pelagic fish species that feeds strictly on zooplankton. As a consequence, total zooplankton biomass has declined and phytoplankton increased (Casini *et al.*, 2008).

In addition to structural changes, the cod collapse has altered the strength of the ecological interactions and the functioning of the central Baltic Sea ecosystem during the last three decades. Food web links appear sensitive to an ecological threshold, identified through piecewise regression and threshold generalised additive model (TGAM) analyses, which corresponds to a total sprat abundance of 17×10^{10} individuals. This threshold separates two alternative ecosystem scenarios (cod-dominance scenario and sprat-dominance scenario) in which the ecological interactions change drastically. Below such an ecological threshold (i.e. in the cod-dominance scenario), the low sprat population is not able to significantly affect zooplankton which are driven by hydrological conditions. This scenario is favoured and maintained by cod predation on sprat. In contrast, and more importantly, when the cod population drops and sprat abundance exceeds the threshold (i.e. in the sprat-dominance scenario), sprat predation starts to control not only total zooplankton biomass but also zooplankton species composition, size composition and vertical distribution. In this scenario, the direct link between zooplankton and hydrological conditions disappears (Casini *et al.*, 2009). Therefore, our results indicate that sprat abundances above the threshold decouple zooplankton dynamics from hydrology and become the main forcing of zooplankton variations.

The alternative scenarios of the central Baltic Sea ecosystem are shown in Figures 1 and 2. The two scenarios are illustrated as the relationships between sprat abundance and zooplankton (Fig. 1), and between hydrological factors and zooplankton (Fig. 2). These changes in ecosystem functioning highlight the role top predators may have in maintaining resilience in marine ecosystems. In this particular case, it is clear that cod acts as a regulator of sprat abundance being also able to buffer stochastically high sprat recruitment events and their severe consequences on the lower levels of the food web (Casini *et al.*, 2009).

In recent years, hydrological conditions for cod recruitment have improved, not only in terms of favourable conditions for egg and larval survival, but also potentially enhancing the development of one of the key zooplankton prey for cod larvae, the copepod *Pseudocalanus* spp. Cod recruitment success, however, has not increased as expected and the cod stock has remained low, possibly because of the high sprat abundance driving the pelagic food web in the central Baltic Sea (Casini *et al.*, 2009). The feedback mechanisms potentially delaying cod recovery can be found not only in the top-down control by sprat on the food resources for larval cod (this study), but also in the changed size structure of sprat population and predation by sprat on cod eggs. Moreover, the fishing-related changes in age structure of cod spawning individuals cannot be discounted.

By neglecting a food web perspective it is difficult to understand the lack of recovery of previously over-harvested fish species in some parts of the world, despite thoughtful management controls of the fishery (Bakun and Weeks, 2006) or favourable climate conditions (this study). Here we have shown that empirical food web data can provide relevant information for disentangling the combined effects of human-induced disturbances (e.g. overfishing) and climate change on marine ecosystems. It should be noted that harvested species may be seen as part of a large and dynamic

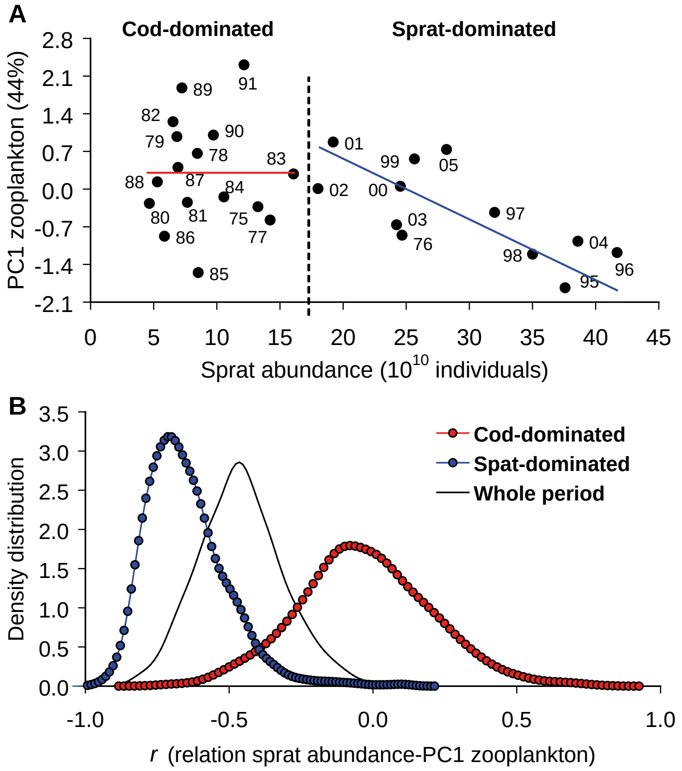

Figure 1. Alternative dynamics of the central Baltic Sea ecosystem related to the dominance and subsequent collapse of the cod population. When cod dominate the system, the low sprat population is not able to affect significantly zooplankton. This situation drastically changes in situations of low cod biomass, when the resulting high sprat population heavily controls zooplankton. a) The alternative dynamics are illustrated by the changes in the relationship between sprat abundance and PC1 of zooplankton parameters (i.e. total biomass, species composition, stage composition and vertical distribution) in the scenarios of cod- and sprat-dominance, respectively. The vertical dashed line represents the ecological threshold separating the two scenarios. b) The alternative dynamics are illustrated by the density distribution of the correlation coefficients between sprat abundance and PC1 of zooplankton parameters, obtained by bootstrap resampling (10,000 times), in the whole study period and in the two alternative scenarios.

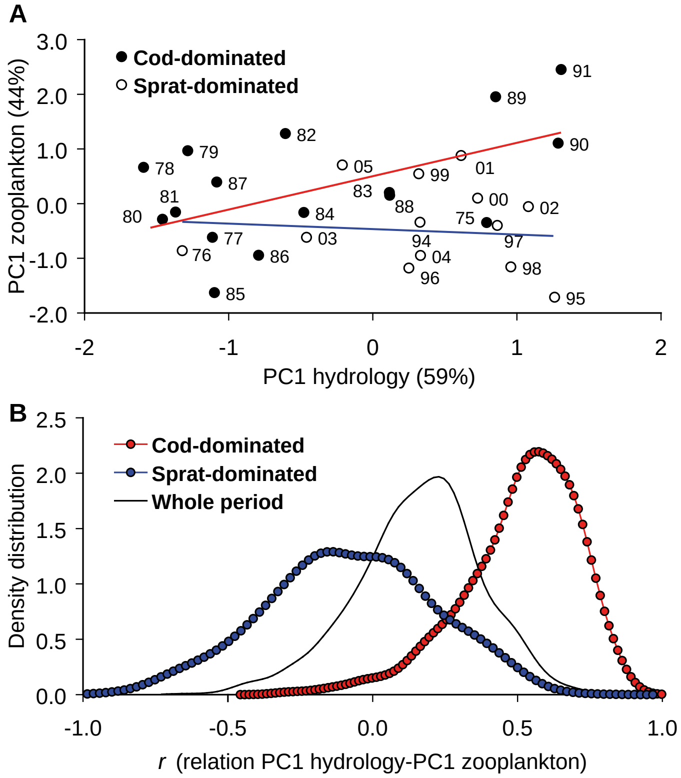

Figure 2. Dual relationships between zooplankton and hydrological conditions in the two scenarios. When cod dominates the system, and consequently the sprat population is low, zooplankton is driven by hydrological conditions. In situations of low cod biomass, on the other hand, zooplankton is decoupled from hydrological conditions because of the much stronger effect of sprat predation. a) The alternative dynamics are illustrated by the dual relationship between hydrological conditions (PC1 of salinity and temperature in spring and summer) and PC1 of zooplankton parameters in the scenarios of cod- and sprat-dominance, respectively. b) The alternative dynamics are illustrated by the density distribution of the correlation coefficients between PC1 of hydrological conditions and PC1 of zooplankton parameters, obtained by bootstrap resampling (10,000 times), in the whole study period and in the two scenarios.

trophic network, with a high probability of being susceptible to top-down control, generating cascading effects through the food web. This stresses that changes in ecosystem functioning, which are potentially difficult to reverse, can be a result of variations at higher trophic levels directly affected by human exploitation, and not only the consequence of climate change. Our study provides an important contribution to the ongoing intense debate on the consequences of top predator declines in marine systems.

Acknowledgements

The Latvian Fish Resources Agency (LATFRA) furnished zooplankton data. The Swedish Meteorological and Hydrological Institute (SMHI) SHARK database, provided hydrological profiles. Michele Casini was partially funded by Oscar och Lili Lamms Minne Stiftelsen. The research of Juan Carlos Molinero is a contribution to the priority programme AQUASHIFT (The impact of climate variability on aquatic ecosystems, IFM-GEOMAR).

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Towards general laws of marine ecosystem functioning

ASLO Aquatic Sciences Meeting, Nice, January 2009

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The ASLO meeting in Nice was attended by some 2400 scientists from over 60 countries (Fig. 1) and comprised excellent talks and posters as well as fantastic networking opportunities. Many of the participants surely left with great new ideas and prospects of future cooperation. I must say, as a PhD student, that this was probably the best meeting I have ever been to in terms of future career openings and "impact factor" of presenting my work. As the ASLO president Carlos Duarte wrote in his closing thoughts e-mail; "All participants agree that the meeting was superb, in its organisation, programme and venue..." and "successful meetings, such as that in Nice, are central to achieve ASLO's mission".

It would be hard, if at all possible, to summarise more than a hundred sessions, so here I focus on one of the sessions where I presented my own work; (024) "Towards general laws of marine ecosystem functioning", chaired by Roger Harris and Xabier Irigoien.

Session description

"*Major international programmes (IGBP, JGOFS, GLOBEC, ICES etc.) have generated a large amount of information on the biogeochemical foundations, functioning and structure of marine food webs. Parallel technological developments, ranging from satellite imagery to autonomous underwater vehicles, have increased by orders of magnitude the resolution and amount of data available on relevant properties of the ocean ecosystem. The resulting data represent a key resource to explore patterns of both the structure and functioning of ocean ecosystems. This vast resource remains largely unexploited, as these data have generally been used within a local and regional context. Few attempts have yet been made to synthesize and integrate these results to deliver a coherent, global perspective of the structure and functioning of marine ecosystems. Meta-analytical and comparative approaches have been used to tackle such issues in many other fields (e.g. economics, medicine, terrestrial and freshwater ecology) but only to a limited extent in marine ecology. The objective of this session is to bring together studies applying meta-analysis and comparative approaches to marine ecosystems in order to encourage the use of synthetic approaches. All applications of meta-analysis and comparative approaches to marine ecology, from bacteria to fisheries, particularly those revealing general laws, are encouraged.*"

This session comprised talks and posters that were organised more or less by organism size, from bacteria to fish. It provided a nice overview of topics aimed at revealing general laws (or perhaps generalisations are a better word, since laws are difficult to prove beyond doubt in the field of ecology, compared to e.g. the field of physics). Many of the talks and posters were from PhD students and some of them were part of the METAOCEANS project described in GLOBEC International Newsletter 14(1), 2008. Here I will give short descriptions of my understanding of the posters and talks, please see the book of abstracts for more information: http://www.aslo.org/meetings/nice2009/

Figure 1. ASLO participants outside the Centre de Congrés Acropolis.

Description of posters

Posters (first author only presented here) were:

- *Jan Bissinger*: a general model relating day length and microbial growth.
- *Florence Dufour*: a meta-analysis approach to reveal if spatial distribution of tuna is climate driven.
- *Nicolas Dupont*: combining long time series and modelling to reveal relationships between light and occurrence of jellyfish.
- *Linda Kuhnz*: analysis of video transect data aimed at tracking benthic megafaunal community shifts in the abyssal zone.
- *Juan-Carlos Molinero*: a meta-analysis approach assessing climate forcing on pelagic ecosystems.
- *Thaddeus Murdoch:* Testing a novel functional group approach for Caribbean hard corals by comparing their rank abundances across the Florida reef tract.
- *Adi Nugraha*: A box-model approach, investigating the role of upper trophic levels in N:P biogeochemical cycles.
- *Aurore Regaudie-de-Gioux:* Meta-analysis and *in situ* measurements, investigating the compensation irradiance for pelagic community metabolism.

Description of talks

The talks (first author and speaker only presented here) were:

- *David Atkinson*: meta-analysis of phytoplankton specific growth rate and temperature (focusing on activation energy).
- *L. Antonio Cuevas*: meta-analysis and modelling investigating global patterns in microbial ecology.
- *Maria Jose Juan-Jorda*: meta-analysis and modelling approach to quantify the response of Scombrids to fishing.
- *Thomas Lefort*: meta-analysis and experimental approaches revealing relationships between trophic level and bacterial taxa.
- *Irene Mantzouni*: meta-analysis and modelling techniques used to investigate temperature effects on herring carrying capacity.
- *Marcia Rocha*: analysis of plankton long time series in a lake to relate variability patterns to ecological characteristics and trophic interactions from functional groups to the food web.
- *Isabelle M. Rombouts*: exploring large-scale data sets to elucidate environmental controls on variation in copepod diversity
- *K.H. Patrik Stromberg*: combining satellite remote sensing data and modelling to produce plankton size distributions and metabolic scaling on a global scale.

Concluding remarks

All in all it was an excellent and well balanced session spanning many diverse subjects. Some of the presentations generated many questions and discussions off-line. These discussions even opened up potential future research partnerships in my case. The presentations had in common that they shown how general relationships can be found if existing data is analysed and combined with modelling or experimental approaches. This "recycling" of data provides very good value for the money already invested in often expensive and problematic collection of data. Furthermore it shows how absolutely crucial it is to maintain long time series and use consistent methods in sampling. Still, the ocean is very big and the data we have is tiny in comparison to the amount of information needed to better understand large scale patterns and further develop general laws.

I would like to acknowledge all the individual researchers hard work in collecting data and for sharing it with the rest of the scientific community. Furthermore, I would like to thank the chairs of this session, Roger Harris and Xabier Irigoien, for the opportunity to present my work and for organising the session. Last but not least I would like to congratulate the participants for their interesting contributions.

My research and attendance at the ASLO 2009 conference was funded by EU Marie Curie EST project METAOCEANS (MEST-CT-2005-019678).

Large-scale regime shifts of the pelagic fish assemblages over long years in the northwestern Pacific Ocean

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Good quality catch records for marine fisheries in Japan are available for a period covering 82 years from 1926 to 2007. These records have been analysed in relation to ocean climate to detect structural temporal shifts in terms of pelagic fish assemblages living in temperate waters. Most of Japan's catch has come from the northwest Pacific Ocean and its patterns of fluctuation can be regarded as reflecting fluctuations in biomass of the fish assemblages in the northwest Pacific area. The total marine fisheries production of Japan was 3.02 million tonnes (MT) in 1926, peaked at 11.50 MT in 1984 and was followed by a decrease to 4.38 MT in 2007. More than one third of the production in the peak years came from the Far Eastern sardine.

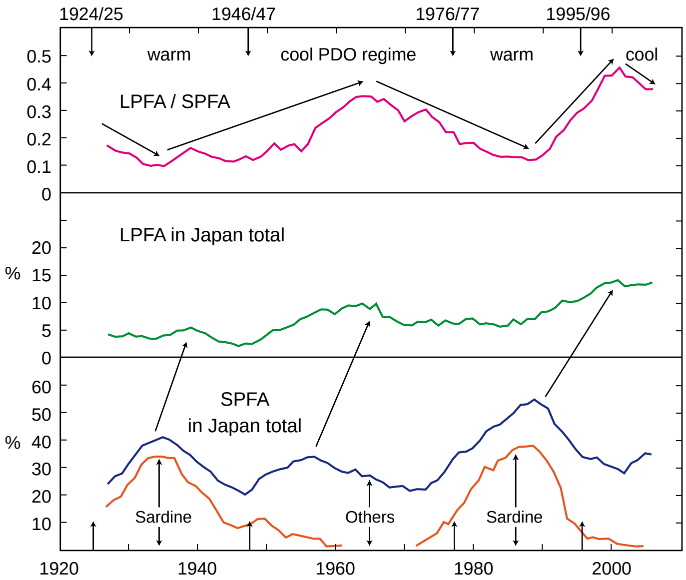

Figure 1. Long-term fluctuations in catch (three-year running means) in the northwest Pacific by the Japanese fisheries. Top: ratio of catch from LPFA to SPFA; middle: proportion of catch from LPFA in Japan's total production; bottom: proportion of catch from SPFA in Japan's total production; vertical arrows: PDO climate regime shifts.

Climate-driven fluctuations in the SPFA and the dependence of the LPFA on the SPFA

The small pelagic fish assemblage (SPFA) in temperate seas is comprised of sardine, anchovy, jack mackerel, chub mackerel and saury, while the large pelagic fish assemblage (LPFA) in temperate waters is made up of tuna species (including skipjack) feeding on the SPFA. The fluctuations in proportions of catch from both the assemblages in Japan's total production are illustrated in Figure 1 (bottom and middle), both revealing interdecadal regime shifts. The two assemblages are situated on different trophic levels, plankton-feeding fishes and their predators.

During the 82-year period, fluctuations in proportions of catch from SPFA show peaks in 1934, 1957 and 1989. As for the ocean climate, Mantua (2001) pointed out, " Several independent studies find evidence for just two full PDO (Pacific Decadal Oscillation) cycles in the past century: "cool" PDO regimes prevailed from 1890-1924 and again from 1947-1976, while "warm" PDO regimes dominated from 1925-1946 and from 1977 through the mid-1990s", which are demarcated by the vertical arrows in Figure 1. In the warm phase, sea surface temperatures (SSTs) tend to be anomalously cool in the west and central North Pacific coincident with unusually warm SSTs along the west coast of America.

The two peaks of fluctuations in proportions of catch from the SPFA in 1934 and 1989 were formed by the outbreaks in biomass of the sardine, fall in the 'warm' regimes. Another peak, in 1957, which was formed by the combined catch of the small pelagic fishes, falls in the 'cool' regime (Fig. 1, bottom). This indicates that the interdecadal fluctuations in biomass of the SPFA and the species replacement between the sardine and other pelagic species may have been driven by the climate regime shift in the North Pacific Ocean.

Another interesting point in Figure 1 is that the fluctuations in catch from the LPFA are behind those from the SPFA with several years lag, presumably showing a delayed effect due to the trophic dependence of the LPFA on the SPFA.

The top curve in Figure 1 reveals wide variations in the ratio of catch from the LPFA to that from the SPFA, a measure of trophic dependence of the former on the latter, which is similar to the curve of the LPFA (middle). The fluctuations show that the interdecadal regime cycle of the dependence of the LPFA on the SPFA was repeated twice in the past 82 years, and that the biomass of the LPFA increased remarkably since the late 1980s in contrast to the decline in the SPFA, resulting in a rise in mean trophic levels in the northwest Pacific.

Pauly *et al.* (2002) showed the global decline of trophic levels in global fisheries landings and attributed this to the gradual removal of large, long-lived fishes such as tunas by fisheries from the ecosystems of the world oceans. They used data for 29 years, 1970 to 1998, which, however, do not cover a full regime cycle and may be too short to make a decisive statement.

Changes in the fish assemblage structure in the Japan Sea

The Japan Sea is a semi-enclosed sea area connected with the outer oceans through narrow straits, which has unique fish assemblages that have undergone abrupt interdecadal shifts in their structure. Catch records for 39 years (1967-2005) have been analysed. The SPFA in the Japan Sea is composed of sardine, anchovy, jack mackerel and chub mackerel, whilst the LPFA is comprised of tunas, skipjack, yellowtail and Spanish mackerel.

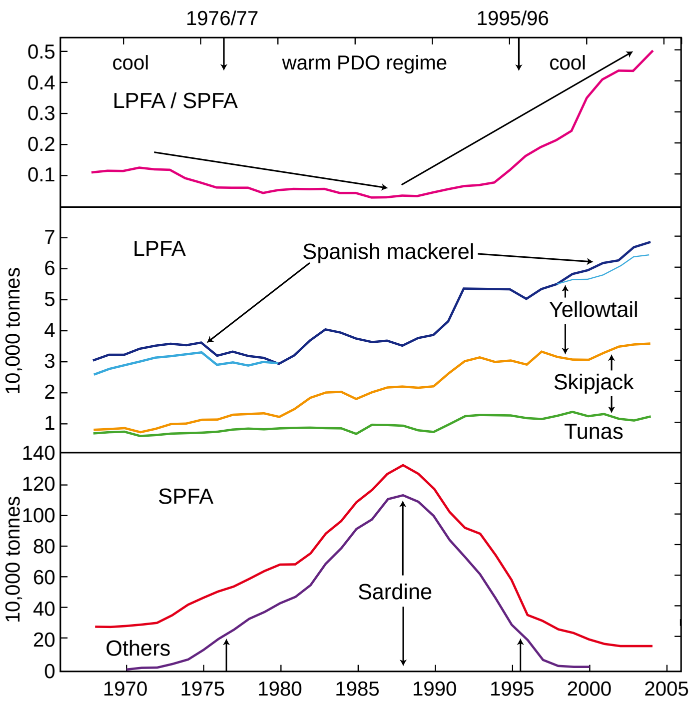

Figure 2. Long-term fluctuations in catch (three-year running means) in the Japan Sea. Top: ratio of catch from LPFA to SPFA; middle: catch from LPFA; bottom: catch from SPFA; vertical arrows: PDO climate regime shifts.

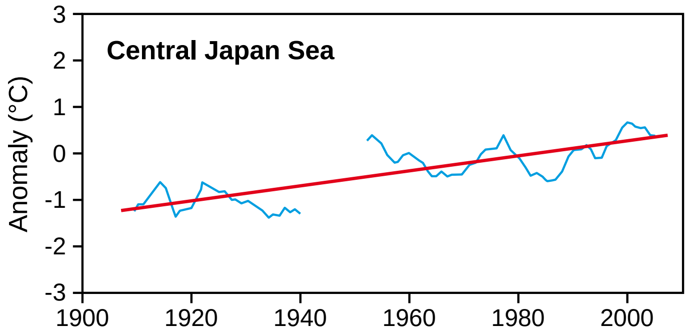

Figure 3. Long-period variations in anomaly of sea surface temperature in °C from normal in the central Japan Sea. Source: Japan Meteorological Agency.

A shift in the structure of the SPFA resulted from the rise and fall in sardine biomass (Fig. 2, bottom). Around 1970, the only major species in the LPFA in the Japan Sea was the yellowtail and the assemblage structure was simple, with a low abundance of tunas and Spanish mackerel (Fig. 2, middle). The first abrupt shift occurred in 1981 when the skipjack began increasing. The second shift started around 1990 when three major taxa, tunas, skipjack and yellowtail, started to rise parallel to each other and each attained comparable levels, with some abundance of Spanish mackerel, in the beginning of the 21st century, resulting in a diversified structure of the LPFA (Fig. 2, middle).

Variations in the ratio of catch from the LPFA to that from the SPFA (Fig. 2, top) underwent two shifts which corresponded to the climate regime shifts in 1976 and 1995. In particular, the rise in the ratio since 1995 is very steep, resulting from a rapid increase in biomass of the LPFA. This indicates an increase in mean trophic levels, triggered by the shift in ocean climate during the mid-1990s. The recent change in the Japan Sea pelagic ecosystem is comparable to the benthic community reorganisation from forage species to their predators in the Gulf of Alaska occurring in the late 1970s to the mid-1980s. This was driven by the 1976-regime shift and resulting in an extreme rise in the mean trophic levels (Anderson and Platt, 1999).

The recent rise in biomass of the LPFA may be partly influenced by the abrupt warming in the Japan Sea (Fig. 3). The warming trend in the central Japan Sea is extremely large (SST: +1.7°C/century) compared to the global average of +0.50°C/century, and the North Pacific average of +0.46°C/century (Japan Meteorological Agency, 2008).

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Results from US Southern Ocean GLOBEC Synthesis Studies

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The US Southern Ocean Global Ocean Ecosystems Dynamics (SO GLOBEC) programme is part of an international multidisciplinary effort (Hofmann, 2007) to understand the physical and biological factors that influence the growth, reproduction, recruitment and survival of Antarctic krill (*Euphausia superba*). The field study portion of the US SO GLOBEC programme took place in the austral autumn and winter of 2001 and 2002 in Marguerite Bay and the adjacent waters of the western Antarctic Peninsula (wAP) continental shelf (Fig. 1). The field programme consisted of studies of hydrography, circulation and mixing (Beardsley *et al*., 2007; Klinck and Dinniman, 2007), sea ice (Fritsen, 2007), and the physiology and ecology of zooplankton, including Antarctic krill (Torres *et al*., 2007; Wiebe and Lawson, 2007), and top predators (Costa *et al*., 2007).

The many and diverse data sets acquired from the US SO GLOBEC field programme are now the subject of synthesis, modelling and integration studies. Specific synthesis projects are focused on: 1) understanding habitat use and predator-prey interactions in the wAP; 2) understanding the mechanisms by which changes in sea ice and ocean variability in the wAP affect Adélie penguin (*Pygoscelis adeliae*) populations; 3) examining the relationships between sea ice, sea ice algae, phytoplankton, and Antarctic krill; 4) understanding the interactions among ocean circulation, vertical mixing, sea ice, and biological processes on the wAP continental shelf; and 5) developing understanding of features of the circumpolar distributions of marine birds and whales. The synthesis studies are designed to meld data and models from the individual programme components to develop a multidisciplinary understanding of the structure and complex function of the wAP ecosystem with a goal of understanding marine population variability in this region in response to climate change.

The US SO GLOBEC programme has advanced understanding of many aspects of the wAP system; see for example, papers in the SO GLOBEC special volumes of Deep-Sea Research II (2004: 51(17-19) and 2008: 55(3-4)). These results are now being extended through synthesis and integration studies to the larger Southern Ocean system.

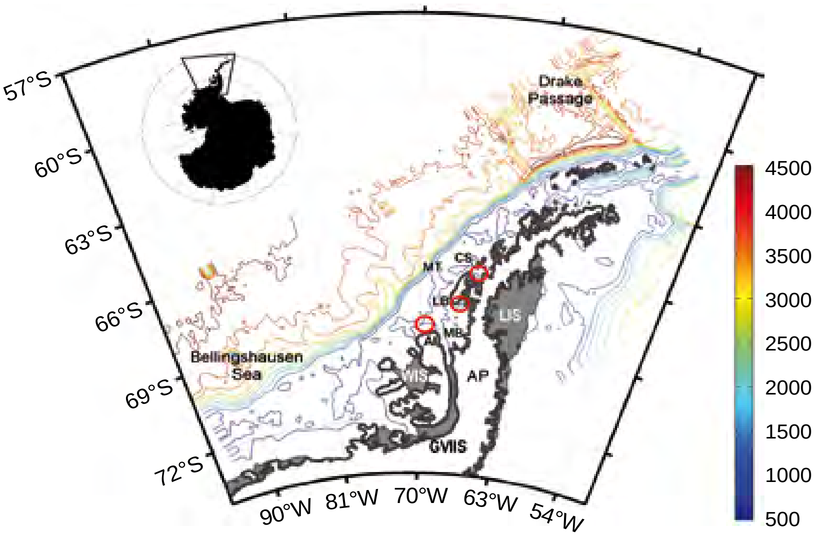

Figure 1. Map of the western Antarctic Peninsula (region outlined in inset map). Bottom bathymetry contours (depth colour bar to right), predator hot spot regions (red circles), and ice shelves (grey shading) are indicated. Geographic names (north to south) are abbreviated as: Crystal Sound-CS, Marguerite Trough-MT, Laubeuf Fjord-LF, Larsen Ice Shelf-LIS, Marguerite Bay-MB, Alexander Island-AI, Antarctic Peninsula-AP, Wilkins Ice Shelf-WIS, George VI Ice Shelf-GVIIS.

Two examples of this are given in this article. The first is the observed non-uniform distribution of predators that is characterised by certain regions where the abundance of these animals is much higher relative to other regions, i.e. predator hot spots. One suggestion for the occurrence of hot spot regions is that prey (e.g. planktonic organisms such as Antarctic krill) are more abundant in these areas as a result of behaviour and *in situ* growth or advective input from other regions. The second example is the use of ocean temperature and dive depth data obtained from instrumented seals to map continental shelf hydrography and bathymetry in regions not sampled by ship surveys. The value of these data is illustrated by summarising a study of the ocean contribution to the break-up of portions of the Wilkins Ice Shelf (Fig. 1) in 2008.

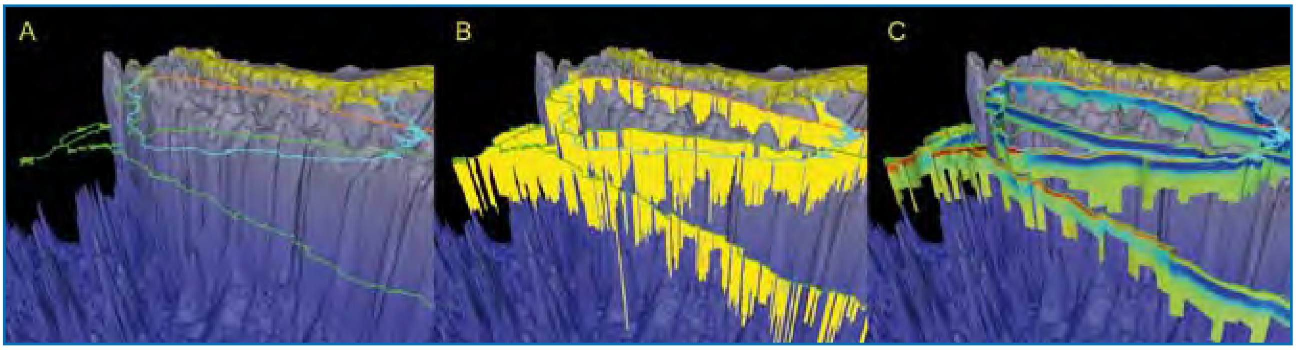

Figure 2. Tracks of southern elephant seals in the Bellingshausen Sea obtained using the Sea Mammal Research Unit (SMRU) CTD-Satellite Relay Data Logger (SRDL) 9000 showing: a) surface portion of tracks, b) surface tracks along with diving behaviour, and c) temperature fields acquired by the sensors on the instrumented seals (Costa, Goebel and McDonald, unpublished data).

Predator Hot Spot Regions

A clear association of resident pack-ice top predators with their prey was found during both winters (2001 and 2002) sampled during the US SO GLOBEC field studies (Costa *et al.*, 2007). Snow petrels (*Pagodroma nivea*) and Antarctic petrels (*Thalassoica antarctica*) were associated with low sea-ice concentrations independent of the Marguerite Trough (Fig. 1), while Adélie penguins occurred in association with this trough (Chapman *et al.*, 2004; Ribic *et al.*, 2008). Krill concentrations, both shallow and deep, also were associated with Adélie penguin and snow petrel distributions. During both winters, crabeater seal (*Lobodon carcinophagus*) occurrence was associated with deep krill concentrations and with regions of lower chlorophyll concentration. The lower chlorophyll concentrations occurred in areas with complex bathymetry close to land and heavy sea ice concentrations (Ribic *et al.*, 2008). Crabeater seals were able to take advantage of these prey hot spots to replenish their energy stores following reproduction and molt. Similarly, good body condition throughout the winters of 2001 and 2002 suggested that crabeater seals were successfully foraging throughout winter (McDonald *et al.*, 2008).

Additional tracking studies carried out during 2007 with southern elephant seals (*Mirounga leonine*; Fig. 2), crabeater seals and Weddell seals (*Leptonychotes weddellii*) confirmed the movement and foraging patterns observed during the US SO GLOBEC studies, but also showed clear niche separation between the species (Fig. 3). Crabeater seals have the shallowest dives and move widely over the continental shelf (Fig. 3). In contrast, elephant seals foraged deepest over the continental shelf and offshore regions (Figs. 2 and 3). The limited data on Weddell seals suggest that they remain in coastal inshore regions of the wAP (Fig. 3).

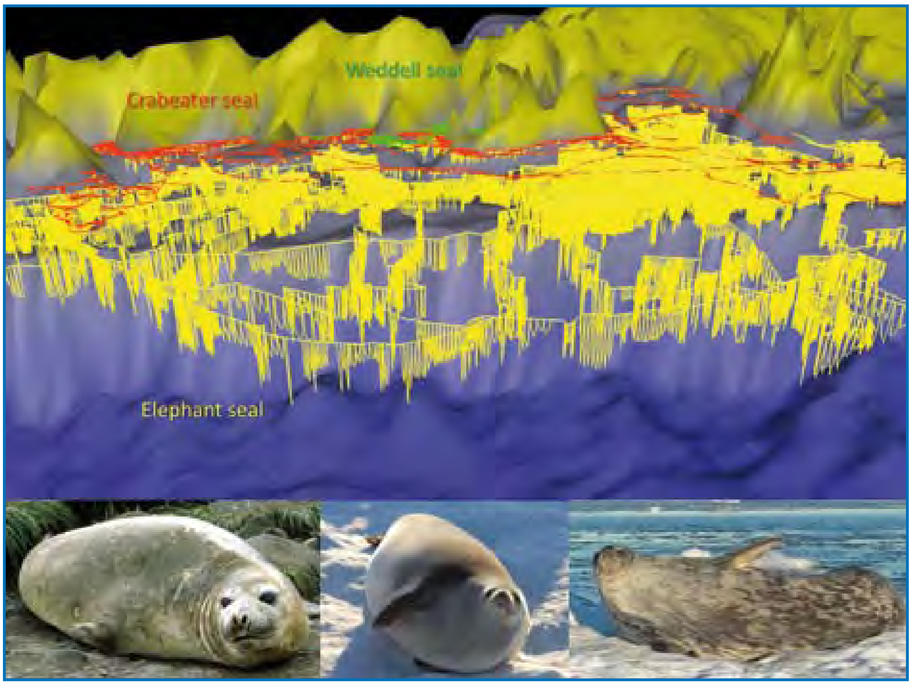

Figure 3. Comparisons of the movement patterns of southern elephant seals (yellow, lower left panel), crabeater seals (red, lower middle panel) and Weddell seals (green, lower right panel) along the western Antarctic Peninsula (Costa, Goebel and McDonald, unpublished data). The tracks cover the same time period during 2007.

Particle transport pathways

Understanding how ocean circulation and biological processes contribute to establishing predator hot spots is a priority for US SO GLOBEC synthesis activities. To address the relationship between circulation and predator hot spots, Lagrangian tracking experiments were done using particles embedded in simulations of the circulation obtained from a three-dimensional, time-dependent primitive-equation ocean and sea-ice model of the wAP, forced by realistic atmospheric variability (Dinniman and Klinck, 2004). In these numerical studies, particles were released at multiple locations and depths along the wAP continental shelf, tracked in space and time, and residence times and transport pathways determined (Piñones *et al*., submitted). The initial particle distribution was uniformly distributed over the wAP region and did not favour any particular portion of the shelf.

Analysis of the trajectories of particles at a range of depths (surface to 350 m) showed that each predator hot spot is an area that received inputs via the advective circulation from other regions. However, the particle source regions differed for each of the hot spots. As an example, Crystal Sound (Fig. 4) receives particle contributions from higher latitude regions of the Bellingshausen Sea, as well as from the adjacent wAP shelf. Laubeuf Fjord receives particles from Marguerite Bay and the local wAP shelf region and Alexander Island receives inputs primarily from the adjacent shelf region (Piñones *et al*., submitted). These results support the suggestion that the predator hot spots along the wAP are regions that potentially receive contributions of planktonic prey from advective inputs, thereby providing the predators a dependable prey supply.

Prey composition variability

Zooplankton distributions developed from samples collected during the US SO GLOBEC survey cruises in 2001 and 2002 showed considerable spatial variability in the relative abundance of species, shifts in their relative abundance between seasons, and spatial and temporal changes in the importance of Antarctic krill as a component of the zooplankton population (Lawson *et al*., 2004; Ashjian *et al*., 2004, 2008). One contributing factor to the observed differences in zooplankton relative abundance may be different food environments in the two years. An analysis of surface chlorophyll distributions for 2001 and 2002 derived from the Sea-viewing Wide Field-of-View Sensor (SeaWiFS) showed large differences in concentration in the two years; chlorophyll concentrations in the Bellingshausen Sea and Marguerite Bay in 2000/01 were a factor of 2-3 higher than those in 2001/02 (Marrari *et al*., 2008).

A follow-on analysis of net-derived zooplankton distributions (Marrari *et al*., submitted) showed differences in the length frequency distributions of euphausiid species between 2001 and 2002. Larvae (Daly, 2004) and adult (>30 mm) Antarctic krill dominated the length frequency distribution in 2001. The 2001 larvae recruited to juveniles (~20-30 mm) in 2002; thus,

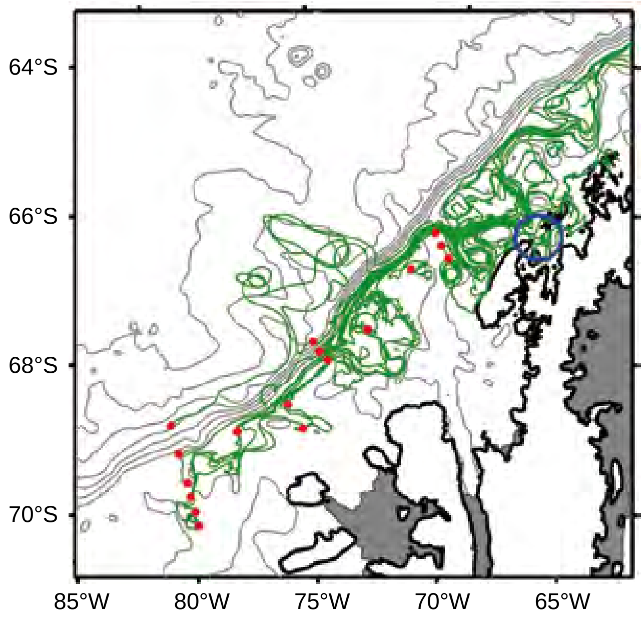

Figure 4. Trajectories of particles released in simulated circulation fields at 300 m depth. The red filled circles indicate the particle starting point and the blue circle indicates the predator hot spot region in Crystal Sound (see Fig. 1). The initial distribution of the particles at 300 m was uniform over the wAP continental shelf. Only those particles that were transported to the Crystal Sound region are shown.

a more even representation of sizes in length frequency distribution characterised 2002. Abundances of Antarctic krill were highest in Crystal Sound and Laubeuf Fjord, followed by waters around the northern end of Alexander Island. The relative abundance of other zooplankton taxa, such as copepods, also showed major changes between 2001 and 2002. The percent composition of species changed and abundances were significantly reduced in 2002 (Fig. 5). Marrari *et al*. (submitted) suggested that these changes were related to the reduced chlorophyll (food) concentrations in 2002 relative to 2001.

The Lagrangian simulations show that the circulation of the wAP continental shelf transports particles to the predator hot spot regions. However, predator abundance and composition in the hot spots probably depends on the volume, type and quality of prey transported to these regions. The results presented in Marrari *et al*. (submitted) show large interannual and spatial differences in zooplankton composition and relative abundance, which have important implications for the food web structure and trophic transfer of energy of the wAP region. Alternative pathways in the wAP food web (e.g. reduced presence of Antarctic krill and increased copepod abundance) may provide a diet that can sustain top predator populations in the short term, but if these conditions persist the result may be a change in the abundance and type of resident predator populations.

A system in which viable prey conditions are restricted to limited regions that are imposed by the circulation field

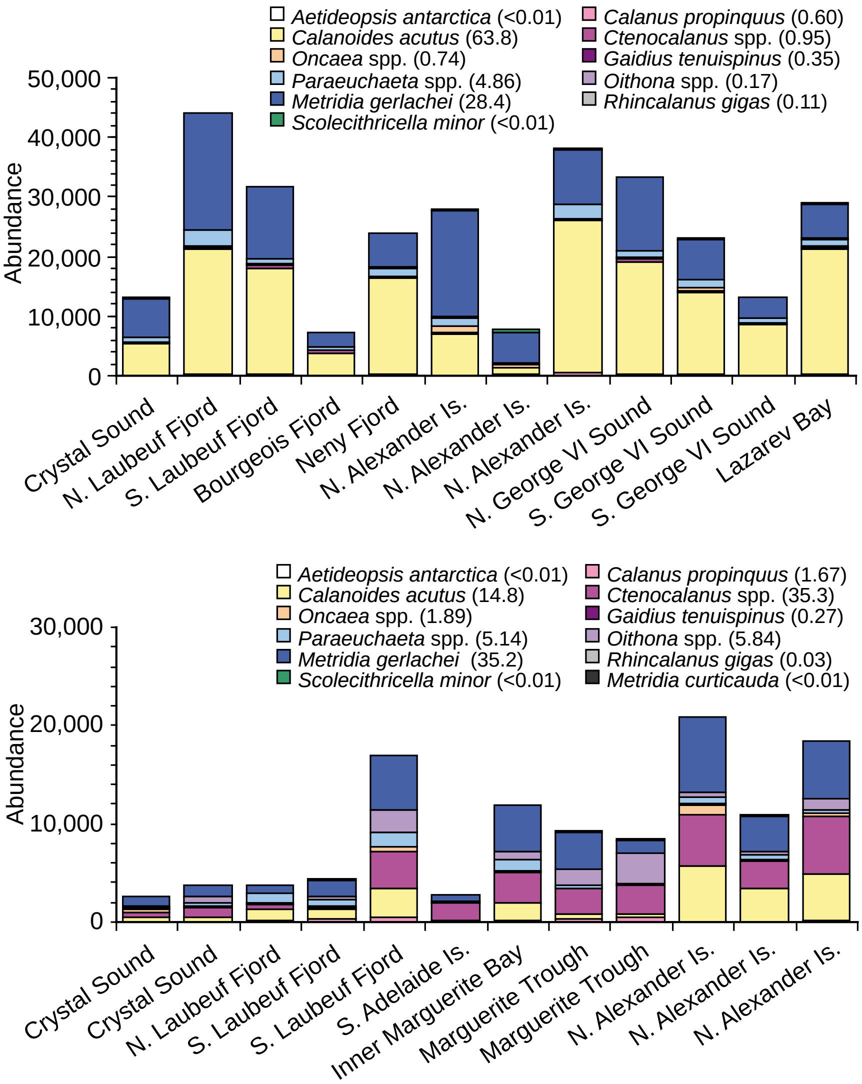

Figure 5. Water column integrated abundances (ind m^{-2}) of copepods from MOCNESS net hauls in the vicinity of Marguerite Bay during austral autumn 2001 (top) and 2002 (bottom). Numbers in parenthesis indicate the median percent contribution of each species to the total copepod community for each year. Note the change in scale of the y-axis between years. The predator hot spot regions are Crystal Sound, Laubeuf Fjord, and Alexander Island (see Fig. 1).

is perhaps more sensitive to climate-induced changes in circulation and prey growth than one with broadly distributed predator-favourable conditions. Thus, the wAP ecosystem merits further monitoring, especially during the rapid changes that are now occurring in regional atmospheric, ocean, and sea ice conditions (e.g. Meredith and King, 2005; Clarke *et al*., 2007).

Seal-going oceanography and the Wilkins Ice Shelf

Seals instrumented with sensors that collected temperature, salinity and depth data provided an important new technique used during the US SO GLOBEC studies for measuring the physical environment (Costa *et al*., 2008). The hydrographic data acquired by these seals significantly extended the area sampled by the US SO GLOBEC cruises, and provided an important data set for validation of numerical circulation model results (Costa *et al*., 2008). Instrumenting seals with sensors has continued beyond the US SO GLOBEC field study. These seal-derived measurements are extending the wAP hydrographic database and are providing data from regions that have not been sampled by ship (Fig. 6a).

The hydrographic data from instrumented southern elephant seals (Figs. 2 and 3) have been used to define the ocean conditions around the Wilkins Ice Shelf (WIS), which experienced several large break-up events in 2008 (Padman *et al*., submitted). Maximum depths recorded for each seal dive were used to map several deep troughs that extend from the outer to inner continental shelf near the WIS (Fig. 6a). These troughs provide conduits for the across-shelf movement of warm (>1°C) Upper Circumpolar Deep Water (UCDW) and for transport of water at all depths across the dynamical barrier imposed by the ice-shelf front. Padman *et al.* (submitted) proposed, on the basis of the three-dimensional distribution of temperature revealed by the seal data (Figs. 6b,c), that mass loss through basal melting on the WIS would be more sensitive to upper ocean variability than to the onshore flux of UCDW. Measured thinning of the WIS during the two decades prior to the 2008 break-up events may be explained by a reduction in summer sea-ice distribution leading to increased solar heating of the upper ocean.

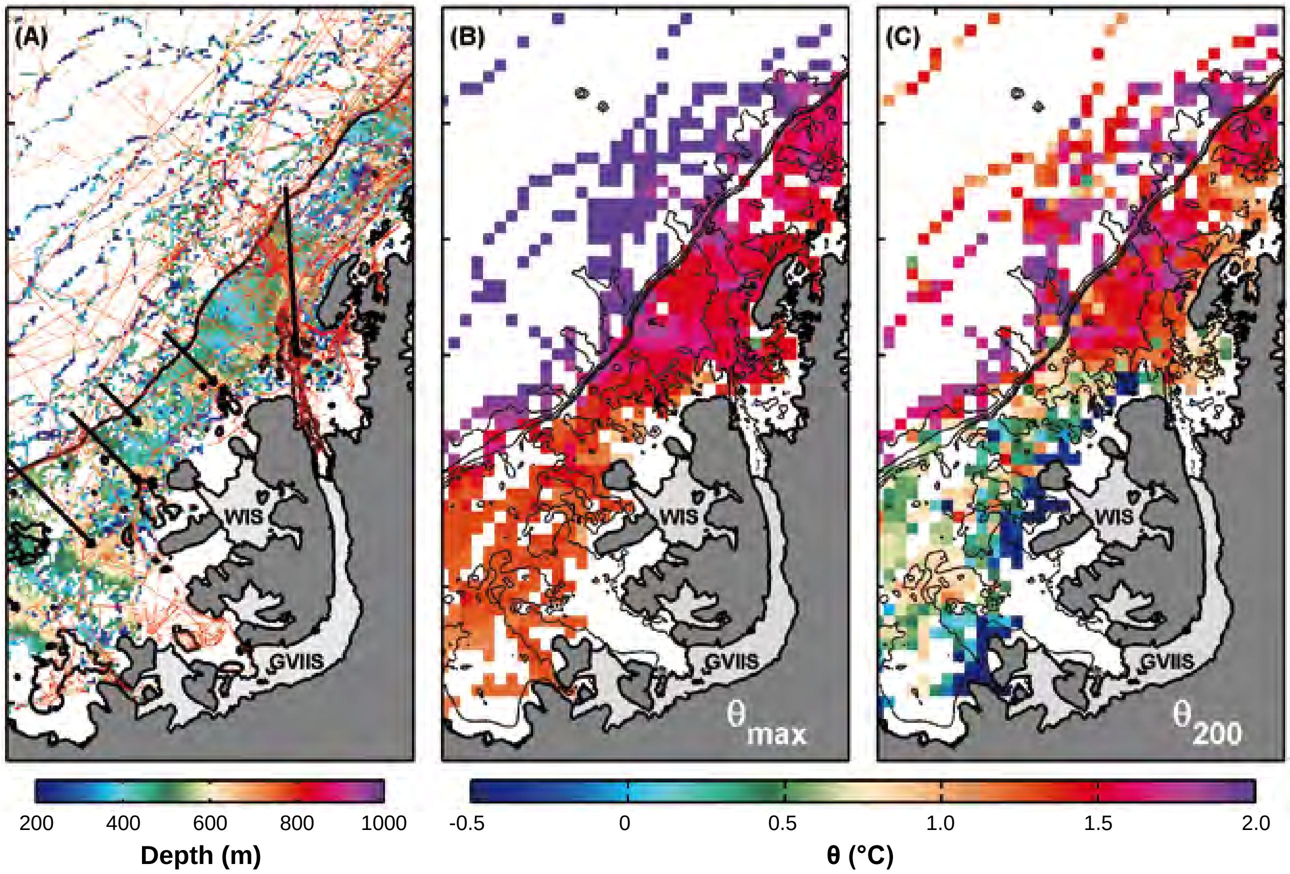

Figure 6. a) Distribution of ship-track bathymetry (red lines) and bathymetry estimated in 5x5 km squares from maximum dive depth of southern elephant seals instrumented during 2005-2008 (colour scale below). Troughs (black arrows) are orange; banks are cyan. b) Maximum potential temperature below 350 m (Θ_{max}) recorded by seal conductivity-temperature-depth satellite relay data logger (CTD-SRDL) sensors on instrumented seals during 2007 and 2008, sorted in 20x20 km squares. c) Potential temperature interpolated to 200 m depth (Θ_{200}). Common colour scale for (b) and (c) is below figures, in °C. In all plots, only cells with data in them have been coloured; there is no interpolation. Contours indicate 500, 1000, 2000 and 3000 m isobaths. The Wilkins (WIS) and George VI (GVIIS) ice shelves are indicated.

Feedback from ocean-ice interactions at the front and base of the ice shelf to the surrounding ocean is suggested by the "halo" of cold water at 200 m depth around the WIS (Fig. 6c). This cold halo implies a circulation pattern around the WIS that may resemble the seasonal Antarctic Peninsula Coastal Current (APCC) described by Moffat *et al.* (2008). This current is not well represented in the current wAP ocean model, and may provide different pathways for advection of lower trophic levels into the predator hot spots revealed by sampling during the US SO GLOBEC cruises.

The hypothesized influence of ocean warming on the ultimate break-up of the WIS in 2008, and the feedback from the WIS to the surrounding ocean, is necessarily speculative at this time. However, this study demonstrates the value of ongoing seal-based measurements as a mechanism for more routine monitoring of the oceans in this biologically active region, as it experiences some of the most rapid climate changes currently observed anywhere on earth.

Summary

The results emerging from the US SO GLOBEC synthesis studies are showing that the zooplankton populations of the wAP region result from a combination of local retention and contributions from other regions. The extent to which local and remote input regions contribute to the prey field has consequences for the structure and productivity of the upper trophic levels. The observed interannual variability in the composition and abundance of the zooplankton taxa reflects, in part, variability in primary production. Such bottom-up controls on the productivity of the wAP food web make this system vulnerable to changes in circulation, wind forcing and sea ice distribution and concentration as they impact nutrient inputs and upper water column structure. Studies ongoing as part of the US GLOBEC synthesis and integration effort are addressing the issue of bottom-up versus top-down controls on Southern Ocean food webs.

The seal–derived hydrographic measurements provide important information about habitat use by these animals, but also provide valuable information on how their physical habitat is changing. The use of seal-derived hydrographic data is only now being developed for physical oceanographic studies and for evaluation of numerical circulation models. Continued support of the collection of these data is needed as it provides information about remote areas of the Antarctic that are not accessible by any other means. The sometimes catastrophic effect of atmospheric and ocean warming on ice shelves and consequences for other parts of the system such as sea-ice distributions makes it imperative to maintain measurements in these remote regions.

The US SO GLOBEC data sets are a contribution to the larger SO GLOBEC programme that took place as part of the International GLOBEC programme (Hofmann, 2007). The results from regions such as the wAP provide a basis for comparative studies at a circum-Antarctic scale and with other GLOBEC regional studies such as the Ecosystem Studies of Sub-Arctic Seas (ESSAS) programme. The SO GLOBEC results also contribute to interpretation of related programmes within and outside of the Southern Ocean (e.g. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and Climate Variability and Predictability (CLIVAR)). Moreover, the SO GLOBEC data and results provide the basis for future investigations of physical controls of Southern Ocean food webs, end-to-end food web structures, and climate variability effects through programmes such as the Integrating Climate and Ecosystem Dynamics (ICED) in the Southern Ocean Programme (GLOBEC Report No. 26/IMBER Report No. 2).

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China GLOBEC receives the Excellent Group Award of the China 973 Program

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The China GLOBEC group, which has been studying global ocean ecosystem dynamics since 1994, has recently received the Excellent Group Award of the National Basic Research Program of China, also known as the China 973 Program. The awards are part of the celebrations of ten years of the national program and only 31 groups received the excellent award from 382 teams of 973 projects, with China GLOBEC being the only team focusing on oceanic research. Ms. Liu Yan-Dong, State Councillor, and other national leaders presented the awards at the 973 Program ten year celebration. The news was also reported by the Science and Technology Daily and Science Times on 8 October 2008 (Fig 1).

Figure 1. Ms. Liu Yan-Dong, State Councillor, Wan Gang, Minister of Science and Technology of China, Zhou Guang-Zhao, chief consultant of the 973 Program and former president of the China Association for Science and Technology and other leaders at the celebratory meeting of the 973 Program.

The China 973 Program is China's on-going national keystone basic research programme, which was approved by the Chinese government in June 1997 and is organised and implemented by the Ministry of Science and Technology of China. The 973 Program is created on the basis of existing research activities and deployments to organise and implement basic research to meet the nation's major strategic needs. The Program has gathered together strong expertise to launch innovative studies of major scientific issues relating to sustainable development such as agriculture, energy, information, resources and environment, population and health, materials, and synthesis and frontier science in line with the national goals and tasks for economic, social, scientific and technological development. 382 projects were set up and the central government invested 8.2 billion Chinese Yuan over the ten years of the Program.

The China seas and their marine ecosystems show inter-annual and decadal variability. At the same time, a continuous increase in anthropogenic influences, such as over-fishing and land-based pollution discharge have over-stressed the marine ecosystems of the China seas since the 1970s. Thus, knowledge of how the marine ecosystem functions and services of the China seas are needed to realise ecosystem sustainable development, which is the objective of the Chinese marine studies. The China GLOBEC study commenced with the investigation of a development strategy for Chinese coastal ocean ecosystem dynamics and the China GLOBEC committee was established in 1994. A science plan for the study of ecosystem dynamics in the China seas was developed in the mid-1990s, and then gradually implemented. The China

Figure 2. (left) China GLOBEC group photo taken on the beach in Snaya city.

Chief Scientist: Q. Tang, front left 5.

Scientific Consultant: J. Su, front left 3.

Key researchers: J. Zhang, front left 2, S. Song, front left 1, X. Jin, second line left 1, T. Xiao, front right 1, X. Ning, front right 3, Y. Sun, second line right 2, and D. Huang, H. Wei, and J. Fang absent.

Excellent Group Award certificate (above).

GLOBEC group is led by Prof. Qisheng Tang and Prof. Jilan Su and involves researchers from institutions affiliated with different national departments such as the Ministry of Agriculture of China, the State Ocean Administration, the Chinese Academy of Sciences and the Ministry of Education of China. Initially the group comprised around 20 researchers and it has expanded to over 60 participants (Fig. 2), covering a wide variety of marine disciplines including physical, chemical, biological and fisheries oceanography.

The scientific goal of China GLOBEC is to identify the impacts of anthropogenic forcing and climate change on the ecosystems of the coastal oceans of China. Six key scientific questions in the continental shelf are identified: 1) food web trophodynamics of key resource species; 2) population dynamics of key zooplankton species; 3) ecological effects of key physical processes; 4) cycling and sources of biogenic elements; 5) pelagic and benthic coupling, and 6) microbial loops contributing to the main food web. So far China GLOBEC has been successful in promoting three national research programmes which are China GLOBEC I: “Ecosystem Dynamics and Sustainable Utilization of Marine Living Resources in the Bohai Sea”, 1997-2000; China GLOBEC II: “Ecosystem Dynamics and Sustainable Utilization of Marine Living Resources in the East China Sea and Yellow Sea”, 1999-2004, and China GLOBEC III and IMBER I: “Key Processes and Sustainable Mechanisms of Ecosystem Food Production in the Coastal Ocean of China”, 2006-2010.

China GLOBEC, in step with IGBP-GLOBEC, is a new approach towards a holistic understanding of the ecosystems of the coastal oceans of China, one of the largest continental margins in the world. The implementation of China GLOBEC pays special attention to studies of key ecosystem processes in order to distinguish natural variability from that induced by human activities. Since the early development of China GLOBEC, the critical importance of cross-linkages between biogeochemistry and ecosystem dynamics in the continental margins have been noted. Thus biogeochemical cycling and nutrient dynamics are important components of the China GLOBEC study in terms of health of the food web. In fact, this aspect of the link between biogeochemistry and ecosystem dynamics is now the central focus of the ongoing China GLOBEC study, in consonance with the IGBP programme IMBER, known as China GLOBEC III with IMBER I research programme.

International symposium “Climate Change Effects on Fish and Fisheries: Forecasting Impacts, Assessing Ecosystem Responses, and Evaluating Management Strategies”

Anne Hollowed[1], Manuel Barange[2], Shin-Ichi Ito[3], Suam Kim[4] and Harald Loeng[5]

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[5]Institute of Marine Research, Bergen, Norway

Climate change is expected to impact many processes governing marine ecosystems. In response, scientists around the world have formed interdisciplinary research teams to improve our understanding of the linkages between climate forcing on marine fish and shellfish (Brander, 2007; Hollowed *et al.*, 2008; ICES, 2008; Lehodey *et al.* 2006). These groups are exploring techniques for quantifying the impacts of climate change on the reproductive success, growth and distribution marine fish and shellfish. ICES and PICES are facilitating these global research efforts through the formation of a joint ICES/PICES working group on Forecasting Climate Change Impacts on Fish and Shellfish (WG-FCCIFS; http://www.pices.int/members/working_groups/WG-FCCIFS/). Members of this working group will promote the development of quantitative forecasts of climate impacts on fish and shellfish in the world’s oceans by improving communication between international research teams. Anne Hollowed, Manuel Barange, Suam Kim, and Harald Loeng are the co-chairs of this newly formed working group.

Members of the WG-FCCFIS proposed, and ICES and PICES agreed, to hold an international symposium on “Climate Change Effects on Fish and Fisheries: Forecasting Impacts, Assessing Ecosystem Responses, and Evaluating Management Strategies” at the Sendai International Center, Sendai, Japan, 26-29 April 2010. The symposium is hosted by the Fisheries Research Agency (FRA) of Japan and local arrangements are made by the Tohoku National Fisheries Research Institute (TNFRI). This symposium will provide a forum for scientists and policy makers to discuss the potential impacts of climate change on marine ecosystems and our uses of these ecosystems, and of strategies that society can take to be prepared for anticipated impacts. Quantitative studies of the potential impact of climate change on fish and fisheries throughout the world will be featured. The symposium will:

- provide a forum to discuss techniques for investigating the impacts of climate change on population parameters, distribution, migration, production, fish and shellfish abundance and on food web processes supporting fish and shellfish;
- provide an opportunity for scientists to discuss their observational, analytical and modelling approaches with other research teams in order to stimulate methodological improvements;
- allow experts to identify analytical techniques needed to reliably forecast climate change impacts on marine fish and shellfish populations including methods for quantifying the uncertainty in projections and ways to address the uncertainty in policy and management;

- allow experts from diverse disciplines to discuss policies and strategies for society and users of marine resources to consider in the face of a changing climate and altered marine ecosystems.

Selected papers from the symposium will be published in a special issue of a peer-reviewed journal scheduled for publication in 2011, within a time-frame that will allow it to be considered by the Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC).

The format of the 3.5 day symposium (from Monday 26 April till noon of Thursday 29 April) will include plenary sessions on Day 1 (26 April) and Day 4 (29 April) and two parallel theme sessions on Day 2 (27 April) and Day 3 (28 April). The day preceding the symposium (Sunday 25 April) will be devoted to topical workshops proposed by the science, management and policy communities. Interested parties are welcome to send topic suggestions by e-mail to secretariat@pices.int, or to any of the symposium convenors (the authors of this article). A meeting of PICES/ICES Working Group (WG-FCCIFS) will be held immediately after the symposium (Thursday afternoon, 29 April) to discuss next steps, including the publication of the special issue.

Scientific sessions will include invited and contributed papers. Contributed papers will be selected for oral or poster presentation. Posters will be on display for the duration of the symposium. All coffee breaks and refreshments will be served in the poster area to maximise opportunities to see these contributions and to interact with the presenters. Evening poster sessions/receptions are planned for Day 2 or Day 3.

The themes of the plenary and parallel science sessions include:

- Forecasting impacts: from climate to fish
- Forecasting impacts: from fish to markets
- Downscaling variables from global models
- Assessing ecosystem responses: impacts on community structure, biodiversity, energy flow and carrying capacity
- Species specific responses: changes in growth, reproductive success, mortality, spatial distribution, and adaptation
- Comparing responses to climate variability among near shore, shelf and oceanic regions
- Impacts on fisheries and coastal communities
- Measuring uncertainty, identifying key unknowns and communicating risk
- Contemporary and next generation climate and oceanographic models, technical advances and new approaches
- Evaluating human responses, management strategies and economic implications
- Sustainable strategies in a warming climate

For further details on the symposium see: http://www.pices.int/meetings/international_symposia/2010/cc_effects_fish/, or follow the links from the PICES website http://www.pices.int.

Deadlines

31 July 2009:	Deadline for submission of proposals for workshops
30 November 2009:	Abstract submission deadline
15 January 2010:	Abstract acceptance notification
1 February 2010:	Early registration deadline
26-29 April 2010:	Symposium
28 May 2010:	Manuscript submission deadline

New GLOBEC Reports

Three GLOBEC Reports have been recently published by the GLOBEC IPO, copies are available to download from the GLOBEC webpages (http://www.globec.org) or as hard copy on request from the GLOBEC IPO (globec@pml.ac.uk).

GLOBEC Report 25: Benguela Environment Fisheries Interaction Training Programme, I. Hampton, N. Sweijd and M. Barange (Eds.).

GLOBEC Report 26: ICED Science Plan and Implementation Strategy, E.J. Murphy, R.D. Cavanagh, N.M. Johnston, K. Reid and E.E. Hofmann (Eds.).

GLOBEC Report 27: BASIN Science Plan and Implementation Strategy, P.H. Wiebe, R.P. Harris, M.A. St.John, F.E. Werner, B. de Young and P. Pepin (Eds.).

ICES Annual Science Conference 2009

21-25 September 2009, Berlin, Germany

The ICES Annual Science Conference 2009 promises to provide outstanding papers from world-renowned researchers, presented in 19 science theme sessions (see below). The conference will focus on new approaches to the study of ecology and biodiversity, current ICES ocean-change science, conclusions for future climate-related research, progress on implementing the ecosystem approach to management and reducing uncertainty, and finally the renewed attempts to include social and economic approaches in ICES science. The ASC will also address some of today's most challenging scientific issues, issues that urgently require solutions for better management of our seas tomorrow. See http://www.ices.dk/iceswork/asc/2009/index.asp for further details. The deadline for submission of abstracts is 20 April 2009.

Theme sessions

Biochemical, biogeochemical, and molecular approaches to the study of plankton ecology and species diversity
Convenors: Steve Hay (UK), Janna Peters (Germany) and Ann Bucklin (USA)

Beyond geolocation: inferring and explaining the behaviour of tagged fish
Convenors: Uffe Høgsbro Thygesen (Denmark) and Molly Lutcavage (USA)

Advances in marine ecosystem research: what we have learned from GLOBEC and what we can carry forwards in future climate related programmes
Convenors: Geir Ottersen (Norway), Keith Brander (Denmark) and Mike Fogarty (USA)

Trends in chlorophyll and primary production in a warmer North Atlantic
Convenors: Antonio Bode (Spain), Jon Hare (USA) and Luis Valdés (IOC, UNESCO)

Climate impacts on marine fish: discovering centennial patterns and disentangling current processes
Convenors: Brian MacKenzie (Denmark), Corinna Schrum (Norway), Myron Peck (Germany) and Skip McKinnell (PICES)

How does fishing alter marine populations' and ecosystems' sensitivity to climate?
Convenors: Benjamin Planque (Norway) and Miguel Bernal (Spain)

Comparative study of climate impact on coastal and continental shelf ecosystems in the ICES area: assessment and management
Convenors: Jürgen Alheit (Germany), Stephen Brown (USA) and Ken Drinkwater (Norway)

What do fish learn in schools? Life cycle diversity within populations, mechanisms and consequences
Convenors: Dave Secor (USA), Pierre Petitgas (France), Ian McQuinn (Canada) and Steve Cadrin (USA)

Monitoring requirements, observation technologies and methods (e.g. acoustics) for pelagic organisms at local and basin scales for input into ecosystem-based fishery management assessments
Convenors: Olav Rune Godø (Norway), Verena Trenkel (France) and Martin Dorn (USA)

Integration of individual-based information into fishery and environmental management applications
Convenors: David Somerton (USA) and David Righton (UK)

Habitat science to support stock assessment
Convenors: Thomas Noji (USA), Pierre Pepin (Canada) and Geir Huse (Norway)

Bringing collaborative science – industry research data into stock assessment and fishery management: evaluating progress and future options
Convenors: Mike Armstrong (UK) and Bill Karp (USA)

Avoidance of bycatch and discards: technical measures, projects, and state of data
Convenors: Lisa Borges (European Commission), Chris Zimmermann and Dominic Rihan (Ireland)

Quality and precision of basic data underlying fish stock assessment and implications for fishery management advice
Convenors: E. Jardim (Portugal), Philippe Moguedet (European Commission) and David Balfour (Canada)

Experiences in including economic and social information to fisheries analysis and advice: why, how, and by whom?
Convenors: Sakari Kuikka (Finland), Alyne Delaney (Denmark) and Rita Curtis (USA)

Ecological food web and network analysis: a tool for ecosystem-based management?
Convenors: Andrea Belgrano (Sweden), Christian Möllmann (Germany) and Ulrich Brose (Germany)

Interactions between aquaculture and wild stocks: comparative experiences for Atlantic cod and Atlantic salmon
Convenors: Edward Trippel (Canada), Terje Svåsand (Norway) and Einar Nielsen (Denmark)

Potential changes in the EU common fisheries policy: implications for science
Convenors: Poul Degnbol, European Commission and Martin Pastoors (the Netherlands)

Presenting scientific and advisory results: best practices
Convenors: Sarah Kraak (Ireland) and Martin Pastoors (the Netherlands)

Death in the sea - mortality in the zooplankton and early life stages of marine fish (estimates, processes and outcomes)
Convenors: Alejandro Gallego (UK), Edward D. Houde (USA) and Elizabeth W. North (USA)

The Joint ICES/CIESM Workshop held in Heraklion, Crete

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Scientists from the ICES Working group on Zooplankton Ecology (WGZE) and the Mediterranean Science Commission (CIESM) held a joint workshop - The Joint ICES/CIESM Workshop to compare Zooplankton Ecology and Methodologies between the Mediterranean and the North Atlantic (WKZEM) - at the Hellenic Centre for Marine Research, Heraklion, Crete, Greece, from 27-30 October 2008 at the kind invitation of Ioanna Siokou-Frangou from the Hellenic Centre for Marine Research, Greece. The workshop, co-chaired by Astthor Gislason and Gabriel Gorsky, was attended by 43 people, 28 from CIESM and 15 from ICES, representing 20 countries.

The workshop was proposed by Gabriel Gorsky, coordinator of the CIESM Zooplankton Indicators programme, at the annual meeting of WGZE in Lisbon 2005. It was felt that such a workshop was important to address and discuss issues of common interest and for comparative purposes, to explore the similarities and differences between the two ecosystems. It was also noted that some species are common to both systems and it would be of interest to compare their ecology between the two regions. Further, it was 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 evident.

The main aims of the workshop, as outlined in the workshop announcement, 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 served 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 workshop was divided into 4 theme sessions with a total of 34 presentations and 5 posters being presented. The topics were:

- Overview of ongoing time series programmes and methodology in the Mediterranean and the North Atlantic.
- Comparative zooplankton ecology of the North Atlantic and the Mediterranean and autoecology of key species.
- The marine food web from microzooplankton to small pelagic fish.
- Appearance or disappearance of species vs. global warming.

The four day programme included three days with presentations and discussions and a half day with discussions on perspectives and future plans. In addition, the workshop also included two informal theme discussion sessions, one on "Time series and sampling" and the other on "Zooplankton databases and data treatment". During the former, a discussion took place on new time series and sampling strategies, intercomparability of time series, and potential benefits of comparing northern and southern seas time series. During the latter, issues such as data treatment, data exchange and databases were discussed.

Figure 1. Participants of the Joint ICES/CIESM Workshop to compare Zooplankton Ecology and Methodologies between the Mediterranean and the North Atlantic (WKZEM) in Heraklion, Crete.

The workshop identified latitudinal and longitudinal differences in ecosystem structure and functioning, and addressed the issue of top down control of ecosystems in relation to climate change. It is evident that there are key species and indicator species to both ecosystems. While some species are common to them both, particularly in the epi- and mesopelagic layers, the bathypelagic species of the North Atlantic are excluded in the Mediterranean Sea by the Gibraltar Strait sill. There is also considerable exchange between basins (gene flow, species introduction, invasions, disappearance) with the North Atlantic being influenced by the Mediterranean and *vice versa*.

The discussions during the workshop were lively, with both groups recognising the ambitious agenda. The workshop concluded by identifying collective actions that need to be implemented in the future. They include:

- Reinforcing of time series.
- The creation of a virtual network of experts from both communities.
- Establishment of long-term connections between WGZE and CIESM.
- Continuation of co-operation and future meetings of the two groups.
- Maintenance of a common website.
- Other future collaborative actions such as training courses and summer schools.

In preparation for the meeting, a website has been set up (http://www.wkzem.net/) where most of the contributions are posted. A full report of the WKZEM Workshop can be found at http://www.ices.dk/workinggroups/WorkingGroups.aspx. The group is aiming that selected contributions be published in a scientific journal.

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

Towards a future strategy in oceanography and meteorology for the Basque Country

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This contribution sets out proposals towards 2012 for the oceanographic and meteorological strategy to be undertaken in the Basque Country region (northeastern Spain). This strategy, included within the Framework of ETORTEK Programme, funded by the Department of Industry, Trade and Tourism of the Basque Government, brings together climatological, oceanographic and meteorological institutions, in order to improve the way in which these services are currently working and to merge the products in a unique operational system. At the present time, the Basque Country marine observation system keeps six coastal stations and two offshore (600 m) buoys, measuring oceanographic and meteorological parameters, and a HF Radar array. The system integrates coupled ocean-atmosphere modelling, in order to provide hindcast, nowcast, and forecast of ocean and meteorological conditions.

A preliminary implementation of a wind-wave forecast model in the Basque Meteorology Agency for the Bay of Biscay area has been achieved using Wavewatch-III (Tolman, 1999). This is a third generation wind-wave model which solves the spectral action density balance equation for wavenumber-direction spectra. In this implementation, we use a first order scheme for spatial propagation (Gaztelumendi *et al.*, 2008). For the source term options, wind-wave interactions and dissipation from WAM-3, non-linear wave-wave interactions from Discrete Interactions Approximation, and wave-bottom interactions from the empirical linear JONSWAP bottom friction parameterisation are used. The required input data for gridded depth fields are derived from bathymetry data (two minute grid spacing) obtained from the National Geophysical Data Center.

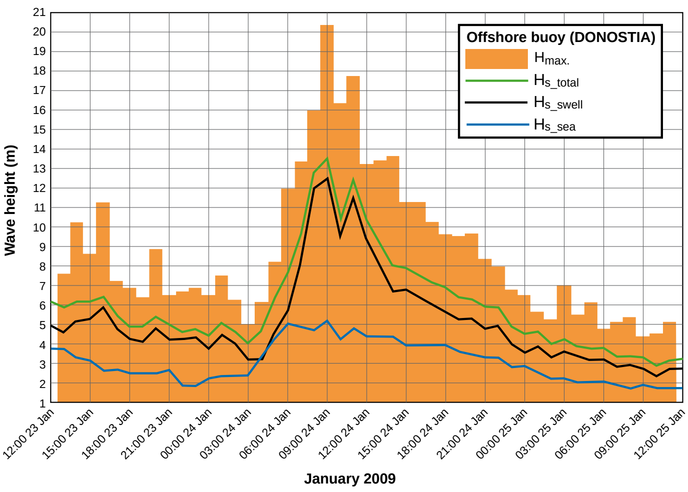

Figure 1. Evolution of maximum and significant wave heights (total, swell, and sea) at the Donostia buoy (43°33.8'N-2°1.4'W), 23-25 January 2009.

Input wind fields, at 10 m above mean sea level, are obtained from the National Center for Environmental Prediction (NCEP), Global Forecast System (GFS), and from the Euskalmet operational mesoscale system, based on the PSU/NCAR mesoscale model (MM5; Grell *et al.*, 1994). Three nested domains have been defined: 1) North Atlantic area (151 x 78 grid points, 100°W-35°E, 0°-69.3°N), with a resolution of 0.9°; 2) European North Atlantic area (133 x 88 grid points, 29.8°W-9.8°E, 34.9°-61°N), with a resolution of 0.3°; and 3) Bay of Biscay (151 x 103 grid points, 15.1°-0.1°W, 41.8°-52°N), with a resolution of 0.1°. Initial conditions for each domain come from restart files, when a previous execution is available (usually); if not, the model is initialised with a parametric fetch-limited spectrum based on the initial wind field.

The atmospheric outputs are used as input to the hydrodynamic ROMS model (Regional Ocean Modeling System; Song and Haidvogel, 1994). For the Basque Country region, the domain

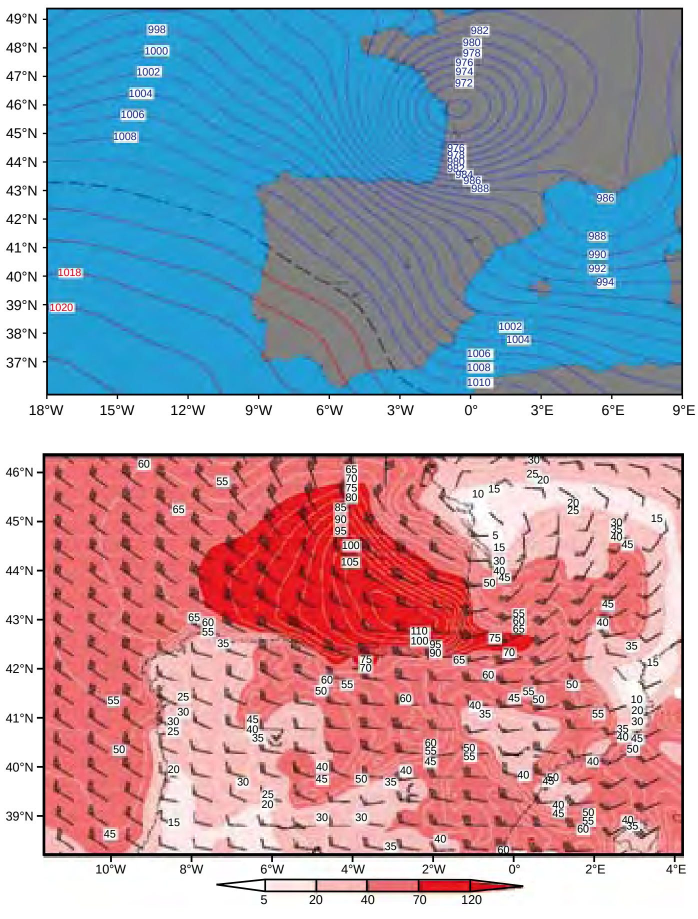

Figure 2. Sea level pressure (mb) and surface wind (km·h⁻¹) fields, 24 January 2009, 06:00 UTC.

extends from 43.2° to 45°N and from 5.3° to 1.1°W, with a resolution of 2.2 km. This domain is nested into a coarse grid (resolution of 6.6 km), which covers the Bay of Biscay, from 41.6° to 48°N and from 10.8° to 0.8°W. Vertically, the water column is divided into 32 sigma-coordinate levels. The surface forcing inputs used in the model are: wind and air temperature at 10 and 2 m above sea level, respectively; precipitation rate, relative humidity, and long and short wave radiation fluxes. The conditions applied to the open boundaries of the coarse grid of the Bay of Biscay are a combination of outward advection and radiation, together with flow-adaptive nudging, towards prescribed external conditions, estimated using monthly climatological data. For the tidal forcing, data from the TOPEX/Poseidon Global Inverse Solution Version 5.0 (TPXO.5, Oregon State University) are used.

The established strategy will allow us to create products in order to monitor several phenomena and routine activities such as: atmospheric pollution, storm and surge warnings, high waves, sediment transport, oil spills, main river plumes, aerial and maritime traffic, design of marine structures, and coastal water quality. For example, on 23-24 January 2009, a deep extratropical low pressure “Klaus” (forecasted days in advance), which was a consequence of an explosive cyclogenesis, crossed over the Bay of Biscay from west to east. The explosive cyclogenesis consisted of the deepening and intensification of a surface low pressure in a short period of time, due to the interaction with a perturbation in height with the baroclinic instability conditions. In our latitudes, the pressure fall must be equal or superior to 19-20 mb in 24 hours. In Figure 2, the deep low pressure, with 970 mb, is shown, reaching France on 24 January 2009, at 06 UTC. There was a very strong pressure gradient in the Basque Country, generating strong west-northwest winds (>100 km·h^{-1}). As the low centre translated eastwards, over the Bay of Biscay, the significant and maximum wave heights increased quickly over the Basque Country coast (>13 and 20 m, respectively; Figs. 1 and 3), together with the sea surface currents (Fig. 4).

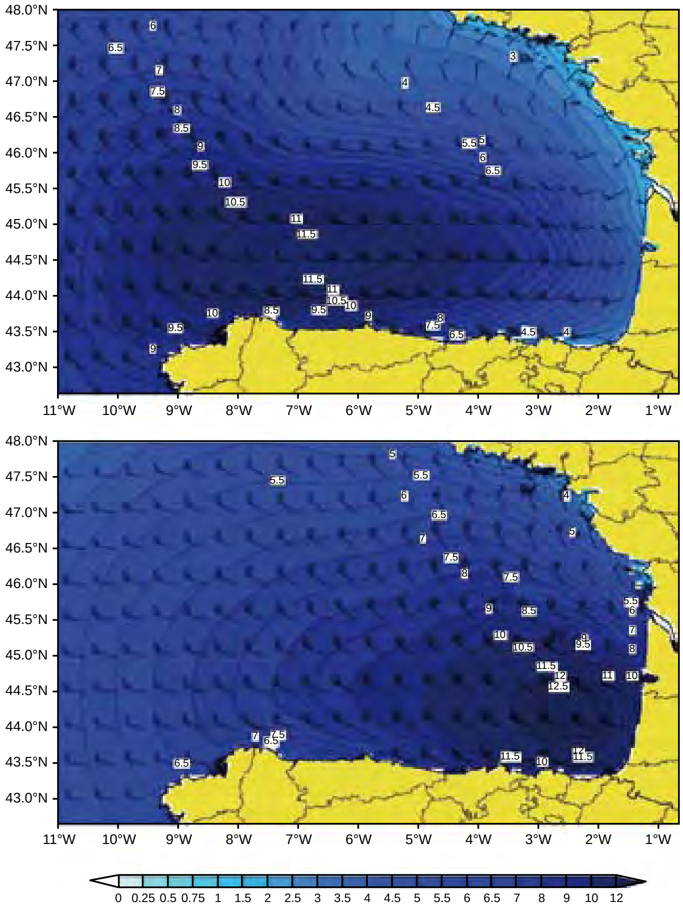

Figure 3. Evolution of significant wave height (m) and wind fields at 10 m height (knots), 24 January 2009, 03:00-09:00 UTC.

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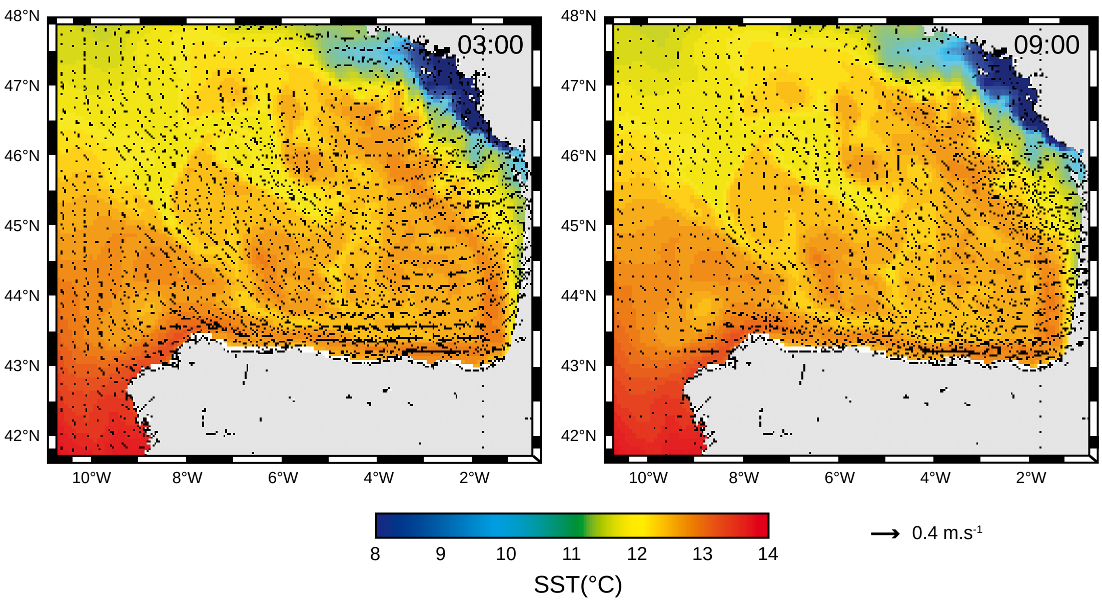

Figure 4. Evolution of sea surface temperature (°C) and current (m·s^{-1}) fields, 24 January 2009, 03:00-09:00 UTC.

CALENDAR

6-8 October 2008: SCOR/IAPSO Working Group 129 on deep ocean exchanges with the shelf, Cape Town, South Africa
https://www.confmanager.com/main.cfm?cid=1293&nid=9421

15-17 April 2009: IGBP SC meeting, Otaru, Hokkaido, Japan

20-24 April 2009: Monitoring climate change impacts: establishing a Southern Ocean sentinel program, Hobart, Tasmania, Australia
http://www.aad.gov.au/default.asp?casid=35088

27-29 April 2009: QUEST Annual Science Meeting, South Cerney, UK
http://quest.bris.ac.uk

15-25 June 2009: Automated plankton identification: state of the art, calibration and practice, University of Plymouth, MBA and SAHFOS
http://www.pleione.nocg.ciis.plymouth.ac.uk/API_Workshopdetails.htm#about

17-18 June 2009: World Ocean Council. Sustainable ocean summit, Belfast, Northern Ireland, UK
http://www.eventbrite.com/event/244536415

17 and 20 June 2009: ESSAS Scientific Steering Committee meeting, Seattle, Washington, USA

18-19 June 2009: ESSAS Annual Science Meeting, Seattle, Washington, USA

22-26 June 2009: 3rd GLOBEC Open Science Meeting, Victoria, BC, Canada
http://www.globec.org

6-10 July 2009: CLIOTOP WG3 Workshop, Sète, France

6-17 July 2009: SAHFOS and MBA marine phytoplankton taxonomy workshop, Plymouth, UK
http://www.mba.ac.uk/phytoplanktonworkshop/workshopdetails.php

28-30 July 2009: CLIOTOP WG2 Workshop, Swansea, UK

3-15 August 2009: 4th International SOLAS Summer School, Corsica, France
http://www.solas-int.org/summerschool/

3-14 August 2009: Summer colloquium: Ecosystems and climate: modeling and analysis of observed variability in marine ecosystems, Boulder, USA

16-18 September 2009: Workshop on ocean biology observatories, Mestre, Venice, Italy

21-25 September 2009: OceanObs'09. Ocean information for society: sustaining the benefits, realizing the potential, Venice, Italy
http://www.oceanobs09.net

21-25 September 2009: ICES Annual Science Conference. Including theme session on Climate impacts on marine fishes: discovering centennial patterns and disentangling current processes, Berlin, Germany
http://www.ices.dk/iceswork/asc/2009/index.asp

13-16 October 2009: Second DIVERSITAS Open Science Conference. Biodiversity and society: understanding connections, adapting to change, Cape Town, South Africa
http://www.diversitas-osc.org/

20-22 October 2009: 39th SCOR Executive Committee Meeting, Beijing, China
http://www.scor-int.org/2009EC/2009EC.htm

11-13 November 2009: GLOBEC SSC Meeting, Plymouth, UK

16-19 November 2009: SOLAS Open Science Conference, Barcelona, Spain
http://www.solas-int.org/

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