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NEWSLETTER

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International Geosphere-Biosphere Programme

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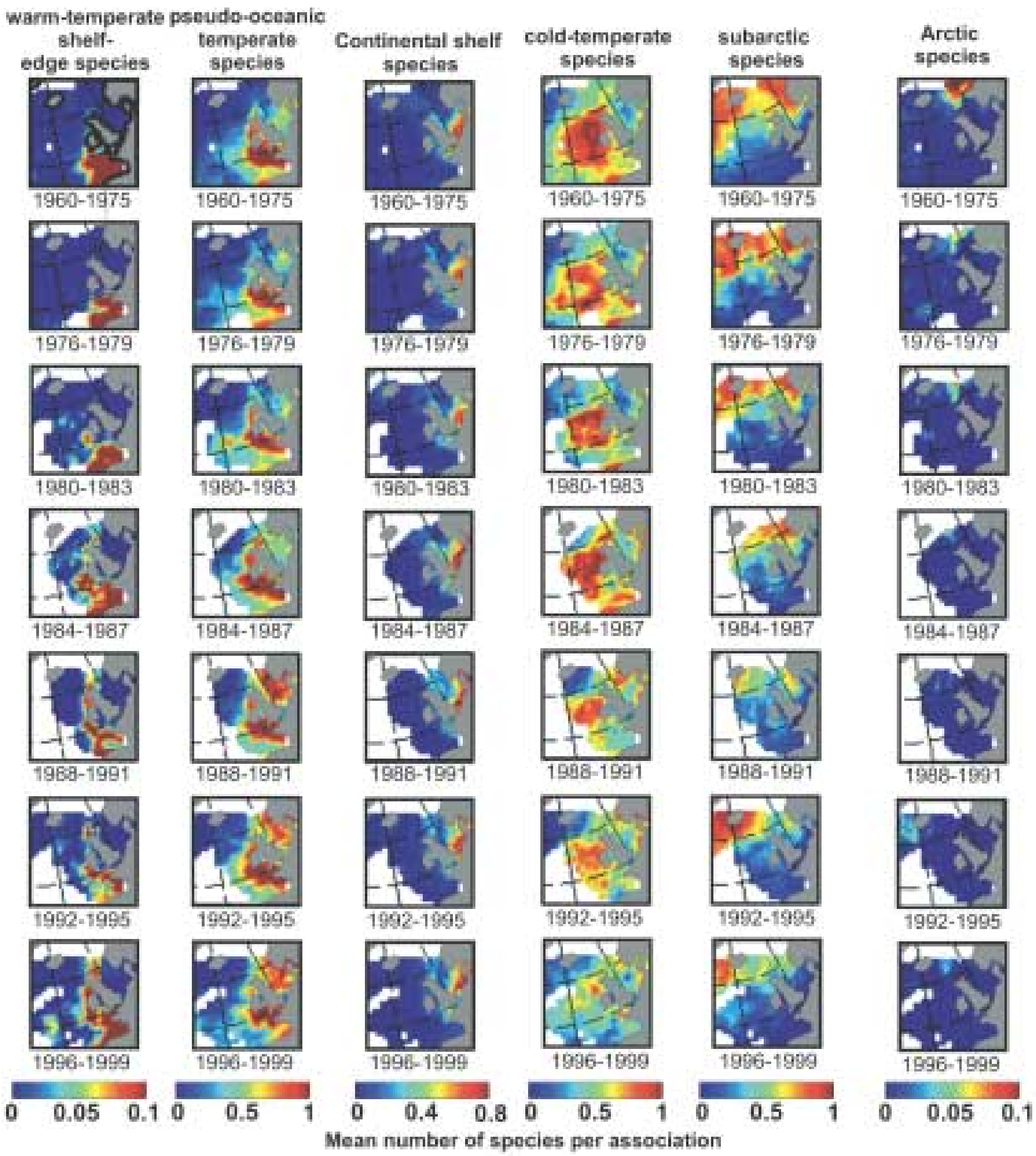


Figure 2. Long-term changes in the mean number of copepod species per association from 1960 to 1999, showing the northwards displacement of temperate copepod species and the reduction of cold and sub-arctic species over the last 40 years. Average maximum values were not superior to 1. This can be explained by the fact that for all the 4-year periods, every month was considered for daylight and dark periods. A number of species are not found near the surface during the daylight period (e.g. Pleuromamma robusta, Metridia lucens) while others overwinter in deep water (e.g. Calanus helgolandicus). Modified from Beaugrand et al. (2002b). *See full article on pages 30 - 33.*

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

EDITORIAL

Manuel Barange, Director GLOBEC IPO, Plymouth, UK (m.barange@pml.ac.uk)

This issue has been put together as we prepare for the 2nd GLOBEC OSM, which will take place in Qingdao, P.R. China, 15-18 October 2002. For us the OSM is the highlight of a month that will also see the 7th meeting of the GLOBEC SSC and meeting of three GLOBEC Foci working groups, back to back with the OSM. The XI PICES annual meeting follows these GLOBEC meetings, and several sessions in its programme will be conducted in collaboration with us. These meetings are a sign of the healthy period in which GLOBEC finds itself, of which this Newsletter is another testimony. In it we have news of research developments in the North and South Pacific, North Atlantic, Southern Ocean, Equatorial Atlantic, and Equatorial Pacific (the latter two introducing new multi-national GLOBEC activities). We have news from national programmes in Germany, Japan, Portugal and China, and a good selection of GLOBEC science. It is a pleasure to say that this is the first issue of the Newsletter that has not had any commissioned contributions, and it is the biggest issue so far as well. It may well be that the time has come to increase the frequency of publication from two to three issues per year.

It is my pleasure to inform the GLOBEC community that Drs Pierre Freon, Claude Roy and Philippe Cury, leaders of the SPACC-affiliated VIBES and IDYLE programmes, were recently awarded the prestigious Gilchrist medal for their contributions to marine science in Southern Africa. The medal is awarded only every 3 years and the first time that it is awarded to non-southern African scientists (the three are French and work for the French agency IRD). Claude Roy and Dave Checkley (Scripps, USA) are welcomed in this Newsletter as the new incoming co-Chairs of SPACC, taking over John Hunter and Jürgen Alheit, who took SPACC to what it is now. We are extremely thankful for their contributions over the years, and delighted that at least Juergen will remain in the GLOBEC family through his Chairmanship of our Focus 1 WG.

Finally, as you all know the Earth Summit on Sustainable Development was recently hosted in Johannesburg, South Africa. The press has had a flurry of articles on the Summit and its expectations. We would like to have a summary of the GLOBEC-relevant agreements/ recommendations taken at the Summit in the next issue of the Newsletter (April 2003). If you attended the Summit and/or would like to take this project on board please contact the IPO soon.

Some of you will read this Newsletter in Qingdao, at the 2nd GLOBEC OSM, but many of you will not attend this important meeting for GLOBEC. The PICES Secretariat and the GLOBEC IPO have agreed to publish a special issue of the PICES Newsletter in January 2003 in celebration of the GLOBEC OSM and PICES XI, which the entire GLOBEC mailing list will receive. Whether you will be in Qingdao or not you will find that issue a good summary of what was discussed and achieved. Thank you again for your support.

CONTENTS

VACANCY: GLOBEC / AMT International Project Officer

The GLOBEC IPO requires an International Programme Officer at its Plymouth Marine Laboratory (PML) headquarters. Duties will include maintenance and development of its website, management of its databases and liaison with GLOBEC's national and regional representatives (50%). The incumbent will also be the Programme Officer for the Atlantic Meridional Transect programme (50%), AMT (http://www.pml.ac.uk/amt/), also coordinated from the Plymouth Marine Laboratory. AMT aims to quantify ecological and biogeochemical variability in the planktonic ecosystems of the Atlantic Ocean. The programme officer's duties include website maintenance, organisation of meetings and liaison between the Steering Committee and the AMT research community. Applicants for this dual GLOBEC-AMT management post should have an MSc or PhD in the relevant fields, have appropriate science experience and be comfortable with webpage programming. Knowledge of web-based database systems would be an advantage. For additional information please contact the GLOBEC IPO.

Shelf-Edge Advection, Mortality and Recruitment

Steve Coombs, SEAMAR Project Co-ordinator, MBA, Plymouth, UK (shc@mba.ac.uk)

SEAMAR is an EU funded, GLOBEC-affiliated fisheries project which has recently been completed. This article outlines some of the project rationale and results.

The underlying aim of much of fisheries research is recruitment prediction. Although interesting academic advances have been made in our understanding of the processes involved, any practical application has remained frustratingly elusive; this is largely due to the complexity of the biological linkages between the scale of the physical forcing environment and the local perception of an individual fish or fish larva. While modelling studies are gross simplifications of the real world, they do at least provide a means to manipulate and study processes operating over such a wide range of scales.

Following this rationale, the SEAMAR programme was set-up to develop and apply a Bio-Physical Transport Model (BPTM) for mackerel (*Scomber scombrus*) in the eastern North Atlantic. The modelling scheme (Fig. 1) consists of a transport model for simulating the drift from the spawning grounds to the nursery areas with growth and mortality being incorporated in response to environmental conditions, principally temperature and food availability, to predict survival.

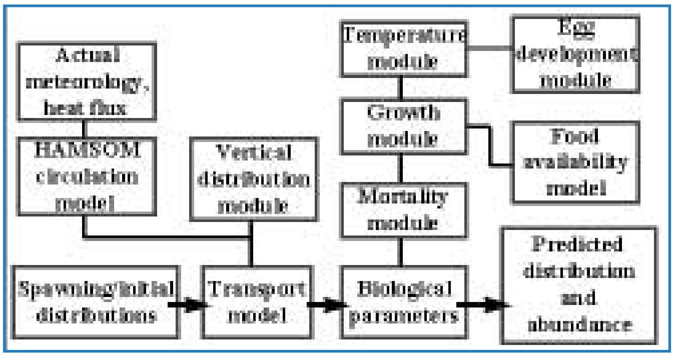


Fig. 1. The SEAMAR modelling scheme

Model components

Circulation and Transport models

The circulation model is based on the established HAMburg Shelf Ocean Model (HAMSOM – Fig. 2). Output from the circulation model is then used to drive the particle transport model.

The second stage of the modelling scheme is the main Bio-Physical Transport Model (BPTM) in which the drift of particles, representing mackerel eggs and larvae, is simulated while their growth and mortality are incorporated in response to environmental conditions. The BPTM is an i-space configuration in which large numbers of individuals are followed as discrete entities. The descriptive information for each individual particle in the BPTM includes: spawning time and location, geographical position over time, vertical position in the water column over time, temperature field at the spawning location, daily average temperature and food index field encountered during their dispersal, egg development time, age, length, absolute and specific growth rates, daily mortality rates and remaining numbers. Included in the BPTM are a number of modules determining the physical and biological status of the tracked particles. These include physical modules for advection, diffusion and temperature, and biological ones for the initial spatial and temporal horizontal egg distributions, egg and larval vertical distributions and migration, egg development, food distribution, as well as the growth and mortality.

The initial spatial and temporal egg distribution module used mackerel egg data from the 1998 ICES triennial surveys interpolated spatially and temporally by a GAM (Generalized Additive Model) to provide weekly input data for the BPTM. Model simulations were carried out for the years 1998 – 2001 with the egg stage and first 60 days of larval life being considered.

HAMSOM circulation model

Grid resolution:	10 x 15 minutes of latitude and longitude (~18.5 x 15.9 km)
Vertical resolution:	maximum of 12 layers, from 10m to 25m in the upper 100m, and increasing progressively in the deeper layers to a maximum depth of 5000m.
Forced by:	M_2 tide, 6-hourly wind stress and air pressure, monthly climatological density fields.
Time-step:	20 minutes with input data provided daily to the BPTM.

Fig. 2. The HAMSON model

Growth

In the growth module, larval growth rates are calculated as a function of temperature, length and food availability (Fig. 3). The index of food availability (MFI) is derived from estimates of larval searching capability and hence available food in relation to energetic requirements (Fig. 4).

Food availability

The food distribution module determines the daily average food concentration encountered and hence modifies growth (Figs 3 and 4) . Food availability (Fig. 5) was modelled from egg production rates of representative large (*Calanus*) and small (*Acartia*) copepods; gut contents analysis having shown that the developmental stages of copepods constitute 39-58% of the diet of larval and post-larval mackerel. The input variables for calculation of these egg production rates were satellite-derived sea-surface temperature and chlorophyll a concentration, thereby providing monthly fields interpolated to weekly averages for each year. Egg production rates per female were raised to population production rates using CPR and SEAMAR field sampling

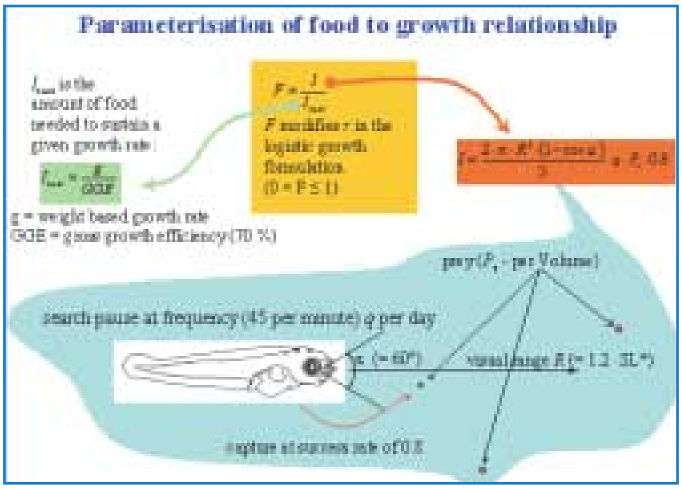


Fig. 4. Food availability and growth (M. Kloppmann, IHF).

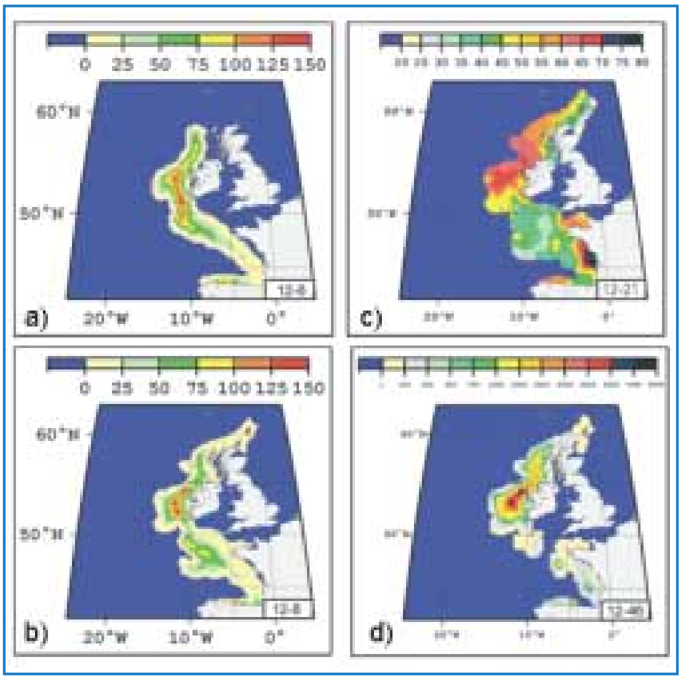
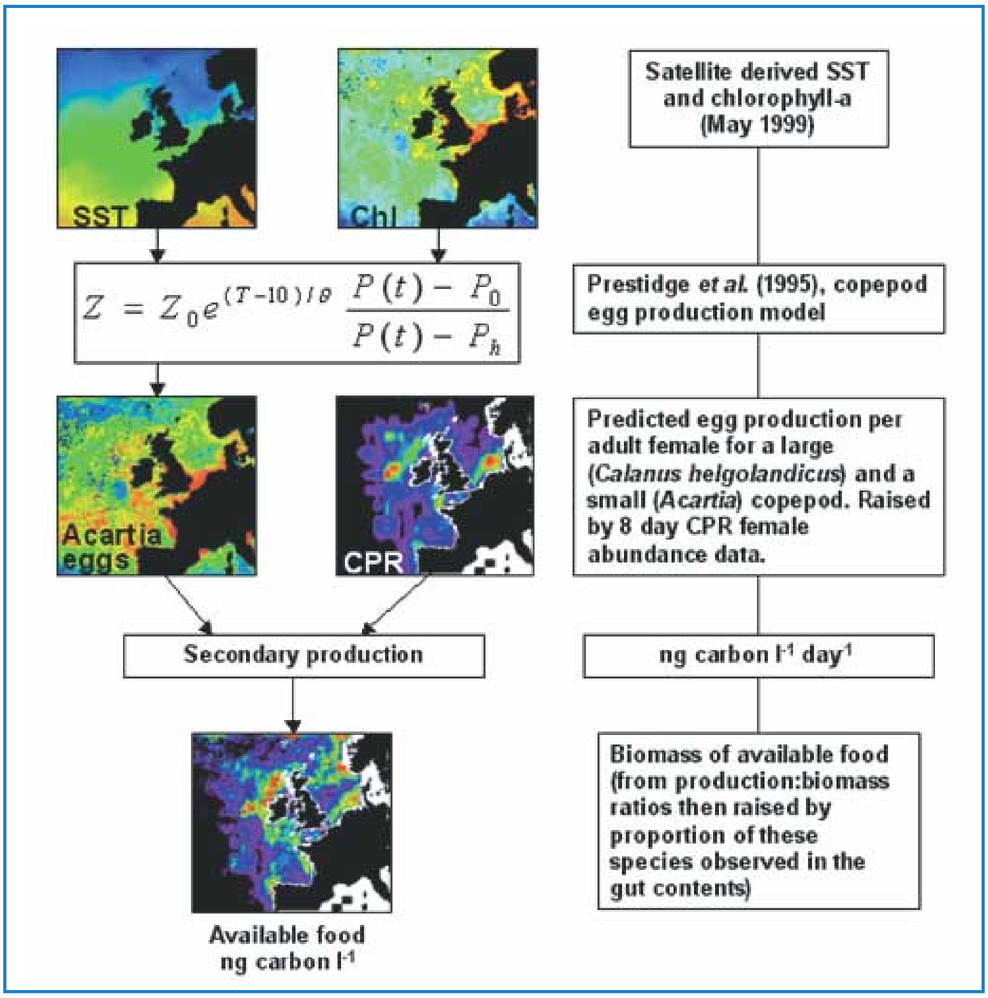


Fig. 6. Model results for 1999 for the main spawning period 23 April – 3 June. It should be noted that the resultant distributions do not represent the situation for a specific calendar date, but relate to an elapsed time (Figs. 6b and 6c) or a specific length reached (Fig. 6d) after introduction into the model domain. (J. Bartsch, HYDROMOD).
a) Start distribution (23 April – 3 June). b) Distribution of tracers after 60 days - – no mortality. c) Mean length (mm) after 60 days. d) Remaining nos of individuals at 50 mm with growth and mortality



data on sex ratio and relative abundance of copepodite stages. Finally, production was converted to biomass using published copepod demographics and raised proportionately to total biomass based on the observed fraction of plankton dry weight represented by *Calanus* and *Acartia*.

Mortality

Each tracer particle is treated as a super-individual representing 10^6 eggs at the start of the simulation which then declines according to the mortality function. Daily mortalities are calculated in the mortality module using a modified version of the Pepin (1991) function relating mortality to larval length and absolute growth rates, and thus implicitly dependent on temperature and food

Fig. 5. Food availability modelling scheme (T. Smyth, PML)

concentration: $M=5.0*G^{0.7}S^{1.3}$
where S is length and G is the absolute growth rate.

Logistic growth equation

$$S=S_{\infty}*(1+\exp(-r*t+c))^{-1}$$

S is the length at time t
S_{∞} is a constant, the maximum length attainable in the initial growth stanza (80 mm)
r is a constant and approximately equal to the specific growth rate at time t=0
c is a constant of integration
S = 3 mm at time t=0, i.e. at hatch.

The absolute growth rate is a function of length and the exponential parameter r:

$$S' = r*S*(1-(S/S_{\infty}))$$

Temperature and food mediation of the parameter r is carried out as follows:

$$r = r_{opt} - d*(T_{opt} - T)^2*F_m$$

r_{opt} is the maximum specific growth rate (r_{opt} = 0.125)
d is a constant (d=0.00085)
T_{opt} is the optimum temperature for growth (19°C)
T is the temperature encountered
F_m is the Model Food Index (MFI) scaled from F in Fig 4

Fig. 3. Growth equations (J.Bartsch, HYDROMOD).

Model results

Results from the BPTM considering particle transport only (i.e. no mortality) showed the initial continuous egg distribution (Fig. 6a) separating at around 50°N into two main areas of distribution together with localised concentrations along the North Coast of Spain. (Fig. 6b). The combined effects of temperature and food availability resulted in longer larval lengths (tracers reaching 65-75 mm after 60 days) to the Northwest of Ireland (despite lower temperatures) than in the Celtic Sea/Shelf areas (Fig. 6c); other areas of high growth rates were at points around the coasts of France and Spain. Finally, incorporation of the mortality module demonstrated the importance of high growth rates sustained by plentiful food, and hence low stage-specific mortalities, resulting in concentration of survivors in the areas to the West and Northwest of Ireland (Fig. 6d).

Considering the entire spawning season, the Porcupine Bank/west of Ireland area is by far the most important contributor to survivors (around 60% of the total) with additional support from the adjacent Hebrides region (around 14%). The Celtic Sea area generally makes a negligible contribution (< 6%).

Comparisons with field data

Growth

The success in catching post-larvae (usually an almost unknown phase of the life-history) by fine-meshed midwater trawls and in obtaining juveniles from commercial catches, allowed the detailed early growth history to be deduced from otolith daily growth rings. In achieving total lengths of around 200 mm in a similar number of days, initial growth rates, of around 0.2 mm/day immediately after hatching, increased to about 1.2 mm/day at 30 mm in length and then to remarkably high rates of up to nearly 3 mm per day at around day 60.

Comparison of modelled growth with otolith derived field data (Fig. 7) suggests that the model overestimates lengths of small larvae <20 mm in length and tends to underestimate lengths of large larvae. By day 60 of the model simulations, daily growth rates tend to be near their maxima in areas where growth is fast (e.g. nearly 1.7 mm/d at Porcupine Bank on day 45 and 1.3 mm/d on the Armorican Plateau on day 55) but have not yet reached their peak in areas of slower growth (e.g. around 1 mm/day at Great Sole Bank).

Mortality

In general terms, the modelled mortality rates progress from high rates (30-40% per day) to values around 10-15% per day by 25-35 days after hatching; faster growing individuals had higher mortality rates than slower growing ones, but had higher survival in terms of length-stage duration i.e. mortality per mm, consistent with faster growth being beneficial for survival. Field-derived rates for larvae (<10 mm) were very variable, ranging between 18% and 59% per day.

For specific comparisons of simulated mortalities and field observations from a discrete site, the field data gave mortality rates within the range of model values for the fastest growing super-individuals, but around 5-20% lower than the predicted model values for the slowest growing super-individuals (Table 1).

Table 1. Comparison of modelled and field mortalities.

	Field mortalities		Modelled mortalities	
	% per day	% per mm	% per day	% per mm
May 1999	19.6	42.9	19.3 – 23.3	42.6 –64.5
June/July 1999	31.5	49.3	21.7 – 25.9	31.5 – 52.0

Juvenile distribution and recruitment indices

Considering 0-group survey data (recognised as being very incomplete for mackerel) for comparison with the model output, high catches of juveniles were made mostly off NW Ireland where the model consistently

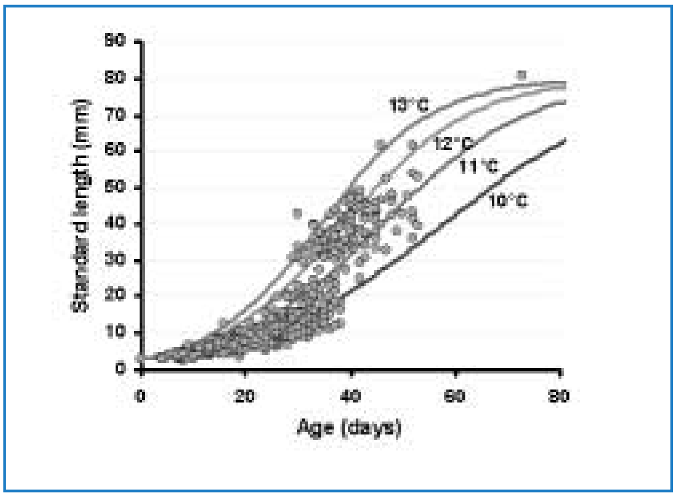


Fig. 7. Modelled growth curves at different temperatures and superimposed data points from field sampled larvae and post larvae (B. Villamour, IEO, P. Alvarez, AZTI, M. Kloppmann, IHF and M. Bailey, MLA).

predicts high numbers. In the south, most juvenile catches were made on the Armorican Plateau, again in accordance with model predictions. The low numbers of predicted recruits on the Celtic shelf is reflected in the 0-group data. In general, the juvenile nursery areas tend to be more inshore than the modelled distributions which implies that following the end of the passive transport phase, the young fish actively migrate to the nursery areas.

Over the three main years studied, the model output indicates that survival of the pre-recruit stages of north-east Atlantic mackerel increased by 28.5% from 1998 to 1999 and by a further 5% from 1999 to 2000. The juvenile survey catches also increased from 1998 to 1999, by 57%, but then fell by over 90% in 2000. However, the true strength of the 2000 year class will only be established once it starts appearing in the fishery from 2003, at the earliest.

Acknowledging that, at least for the benefit of the funding agencies, we highlight such indices as an applied end-point, it must be recognised that these types of modelling scheme are currently more usefully employed as exploratory tools. As such, they have an academic value in furthering our understanding of marine science which should not be dismissed in the haste to provide simplistic solutions to applied problems.

www.ieo.es/seamar/seamar.htm

The following organisations participated in SEAMAR with EU funding under contract FAIR CT98 3695:

MBA, Plymouth, UK; PML, Plymouth UK; IEO, Santander, Gijon, Madrid, Spain; IHF, Hamburg, Germany; AZTI, San Sebastian, Spain; MLA, Aberdeen, UK; NUI, Galway, Eire; IPIMAR, Lisbon, Portugal; BAH/AWI, Bremerhaven, Germany; CEFAS, Lowestoft, UK; HYDROMOD, Wedel, Germany.

Young scientists in German GLOBEC Project

Jürgen Alheit, Baltic Sea Research Institute, Warnemünde, Germany (juergen.alheit@io-warnemuende.de)

GLOBEC Germany (www.globec-germany.de) studies “Trophic Interactions between Zooplankton and Fish under the Influence of Physical Processes” in the North and the Baltic Sea (see GLOBEC International Newsletter, Vol. 8, No. 1). The project aims for a better understanding of the interactions between zooplankton and fish under the influence of physical processes in order to elucidate the principal mechanisms accounting for the high variability of copepod production and of the reproductive success of fish. A considerable part of the studies will be done by young scientists doing their PhD projects within the German GLOBEC. A real advantage for them is that they are carrying out their individual research within the large German GLOBEC community of more than 70 scientists from different disciplines such physical oceanography, planktology, fisheries biology and modelling so profiting from the experience of their colleagues. The young scientists are encouraged to present their own ideas and results on regular meetings of German GLOBEC which offer an excellent basis for interdisciplinary discussions. A large part of the field sampling and experiments at sea is carried out by the PhD students on frequent cruises (180 days at sea in 2002) of German GLOBEC. The individual projects investigate:

- Trophic relationships between phyto- and zooplankton (Christina Augustin, Helgoland)
- Influence of invertebrate predators on population dynamics of dominant copepod species (Kristina Barz, Bremerhaven)
- Consumption of planktivorous fish (Matthias Bernreuther, Hamburg)
- Food and feeding relationships of sprat and herring larvae (Miriam Dickmann, Warnemünde)
- Condition and trophodynamics of zooplankton in North and Baltic Sea (Janna Peters, Bremen)

PhD students of German GLOBEC Project with project co-ordinators Jürgen Alheit (left) and Axel Temming (right).

- Population dynamics of Pseudocalanus (Jasmin Renz, Bremerhaven)
- Importance of protozoans as food for copepods and fish larvae (Mario Schilling, Warnemünde)
- Abundance and spatial-temporal distribution of meso-zooplankton in Bornholm basin (Jörn Schmidt, Kiel)
- (Spatial and temporal variability in the distribution of sprat and herring in the Bornholm Basin, Daniel Stepputtis, Kiel)

The PhD students are fully integrated into the German GLOBEC project and the German GLOBEC relies to a large extent on their efforts. The PhD grants have been generously funded by the Federal Ministry of Education and Research of Germany (BMBF).

International Whaling Commission – Southern Ocean GLOBEC collaboration

Update from the Western Antarctic Peninsula

Deborah Thiele, IWC Scientific Committee Working Group on IWC-SO GLOBEC-CCAMLR collaboration, Deakin University, Australia (dthiele@deakin.edu.au)

The 2000/01 Antarctic season marked the start of field collaboration between the International Whaling Commission (IWC) and Southern Ocean GLOBEC. The IWC Scientific Committee identified a major objective to be pursued using a multidisciplinary ecosystem approach to data collection, analysis and modelling through collaboration with GLOBEC and CCAMLR:

"define how spatial and temporal variability in the physical and biological environment influence cetacean species in order to determine those processes in the marine ecosystem which best predict long-term changes in cetacean distribution, abundance, stock structure, extent and timing of migrations and fitness".

Our first step was to develop and trial visual survey protocols appropriate for use on a range of interdisciplinary cruises. Berth availability is often variable on these cruises so methodology needed to be operable on most vessel platforms with varying numbers of observers. A standard search technique was adopted, with data recorded using a laptop based sighting program (Wincruz Antarctic[1]). During 2001 and 2002 we participated in eight SO GLOBEC survey and process cruises in the Marguerite Bay, Western Antarctic Peninsula (WAP) study area (one German, and seven US cruises) (Fig 1.). The IWC program in the WAP included visual survey from ships, small boats and helicopters, tissue biopsy and individual photo identification studies (Fig 2.). This work was conducted in close collaboration with scientists from Scripps and NOAA who have been leading the development of projects to deploy expendable sonobuoys and moored passive acoustic recording packages (ARP's) with a focus on blue whales (Fig 3.). This collaboration has allowed us to explore the integration of cetacean data obtained at a wider range of spatial and temporal scales than was previously possible. The potential for these complementary data series in addressing some of the major gaps in our knowledge of the ecology of baleen whales, has led to the development of a broader program around the IWC – SO GLOBEC – CCAMLR collaborative framework.

Results from the WAP

The 'year round' SO GLOBEC study in the Marguerite Bay, WAP study site provided an unparalleled opportunity to use a range of historical and new cetacean research tools within a multidisciplinary research framework. Mooring, survey and process cruises were conducted during February through September in both 2001 and 2002. There was a marked difference in the extent and timing of sea ice cover in the WAP between years, giving us a unique comparative data set for preliminary investigations of linkages between variability in sea ice cover and whale distribution. Some results from our preliminary analysis are: baleen whale distributions are strongly associated with bathymetric features and hydrographic fronts; humpback whales remain in the WAP through autumn; minke whales remain through winter; fin whales occur over a relatively short season; and blue whales occupy the region year round. These and other preliminary findings will be presented as spoken and poster presentations at the International GLOBEC Open Science Meeting in Qingdao (15-18 October 2002).

Combining traditional and new census techniques in this collaboration greatly enhanced the potential of the data to address questions about mysticete distribution at an appropriate range of temporal and spatial scales. The collection of visual survey data is constrained to a spatially limited snapshot (to horizon). Sonobuoy data also has a radial range to the horizon but can be collected for up to 8 hours so long as the vessel remains in range of the antenna. The ARP's record calls continuously throughout the year over a larger radius. Each method results in differential rates of detection for each whale species (i.e. blue whales were not detected visually but were found to be present year round using passive acoustic methods; and while passive acoustics rarely detected definitive minke whale calls, this species was frequently detected visually).

Significant US ship time was dedicated to ARP deployments and recoveries, and 7 of the 8 ARP's deployed in 2001 were successfully retrieved and redeployed in 2002 (Fig. 4). Our participation in SO GLOBEC also benefited greatly from the provision of additional dedicated ship and small boat time (US SO GLOBEC), and helicopter survey time (German SO GLOBEC) during which we conducted finer scale studies. Individual identification photographs and tissue samples were collected from humpback (8 samples 2001, 27 samples 2002) and minke whales (6 samples 2001). ID photos will be used to determine habitat use and site specificity of individual animals throughout a season and between years, while genetic analysis of skin samples provides information on the sex of individuals and population dynamics.

What we learnt in the WAP

The SO GLOBEC WAP studies have verified what many scientists already expected: that key ecological processes are operating over long temporal scales (i.e. greater than the two years study in the WAP). In order to measure and understand the variability in these ecosystems at very large and finer scales, it is essential that much longer-term interdisciplinary studies be implemented. Programs of this nature are already being planned as a follow on to SO GLOBEC, and it is expected that the results achieved here will ensure the inclusion of cetacean research as a core component.

This series of surveys allowed us to trial a collaboration between traditional visual survey, biopsy and photo identification methods employed by the IWC and new passive acoustic tools developed and deployed by Scripps and NOAA recently in the Arctic. The collection of detailed sea ice data has not been given a high priority on many cetacean research programs in the Antarctic, nor has its collection been standardized. Yet sea ice is clearly a complex and dynamic environment that is important as habitat for marine mammals and in driving ecological processes. Our experience on the WAP SO GLOBEC program, which highlighted the integral role of sea ice in physical and biological processes, has led us to adopt a standardized sea ice data collection method that can be used during visual surveys. This will allow more comprehensive analysis of whale-sea linkages in future. Commencing 2002/03 season the 'Observing Antarctic Sea Ice' system will be integrated into the standard visual survey program.

In addition to the IWC's major objective, a broader range of objectives has been adopted under the collaborative 'ARPs around the world and IWC' program and includes:

- Deploying ARP's around the Antarctic and southern hemisphere ocean basins in collaboration with finer scale long-term cetacean ecology programs;
- Facilitating the development of national cetacean research programs in the Antarctic as a core component of marine science programs;
- Raising the profile of cetacean research in the Antarctic research community;
- Setting and encouraging the use of standard data collection protocols (for visual surveys and simultaneous sea ice surveys) throughout the southern hemisphere;
- Involvement in planning stages of participating national and international research programs to ensure the availability of dedicated ship time for cetacean research to maximize the potential of data collected;
- Involvement in all phases of analysis with participating national and international SO GLOBEC, CCAMLR and similar research programs.

'ARP's around the world and IWC' program

We have formed a core group (Hildebrand/Scripps, Moore/NOAA, Thiele/IWC, Deakin) and developed a broader joint program that builds on the IWC-SO GLOBEC – CCAMLR collaboration framework. This program has real potential to directly address some of the critical gaps in our understanding of the ecology of baleen whales in the southern hemisphere, with blue whales as the focal species. Some of these questions can only be answered with a very large (hemisphere) scale approach. Clearly the objectives are achievable over a much shorter time frame than would have been possible before the development of these new passive acoustic tools. This program plans to address ecological objectives and major gaps in our knowledge of basic distribution, movement, and variability issues through an integrated southern hemisphere scale program. While a major component of the program is the large scale deployment of ARPs around the Antarctic (Fig 5.), and in the southern hemisphere ocean basins, this will be done in parallel with fine scale research foci in East Antarctica (Australian SOCEP), the Antarctic Peninsula (US), and coastal southern hemisphere sites where long term ecological studies with core cetacean components operate.

Current activities

Participation by 'ARPs around the world and IWC' program is already planned with Antarctic and southern hemisphere coastal studies including: British Antarctic Survey SO GLOBEC/CCAMLR Scotia Sea cruise (January to February 2003); final mooring cruise US SO GLOBEC (2003); the German SO GLOBEC Lazarev Sea surveys 2004; the Australian Antarctic Marine Living Resources long term at sea study (2003 - 2013) and krill flux SO GLOBEC study (2003); US NSF follow on to SO GLOBEC (2005 – 2010); Brazilian humpback/minke/blue whale project (2003); Chilean blue whale project (2003/4?); SE Australian blue and southern right whale projects (2003); Argentinean southern right whale project (2003); and South African Bryde's and blue whale project (2003).

Acknowledgments

The IWC-SO GLOBEC collaboration in the WAP is the result of the timely enthusiasm and persistence of many people, notably Eileen Hofmann and Steve Reilly. The current program and update presented here is the work of a large team of people (Sue Moore, John Hildebrand, Mark McDonald, Ana Sirovic, Ari Friedlaender, Debra Glasgow, Rebecca Pirzl, Sean Wiggins, Alan Souter) as well as the author – all of whom would like to thank US and German SO GLOBEC, the NSF; the Captains and crew of vessels; marine support teams; cruise leaders and scientific colleagues for their support in this work.

[1] Wincruz Antarctic is a free software program developed by Robert Holland at the Southwest Fisheries Science Centre, La Jolla, USA for cetacean surveys in the Antarctic. The software is available at http://mmdshare.ucsd.edu/software.html

MarProd- UK GLOBEC NEWS

The fourth and final research cruise of the UK-GLOBEC Marine Productivity series is planned for 5 Nov-17 Dec 2002, with a mid-cruise port call in Reykjavik on 27-29 Nov. The sampling area will be the Irminger Sea and parts of the Iceland Basin, on board *R.V. Discovery.* Interested parties please contact John Allen (jta@soc.soton.ac.uk)

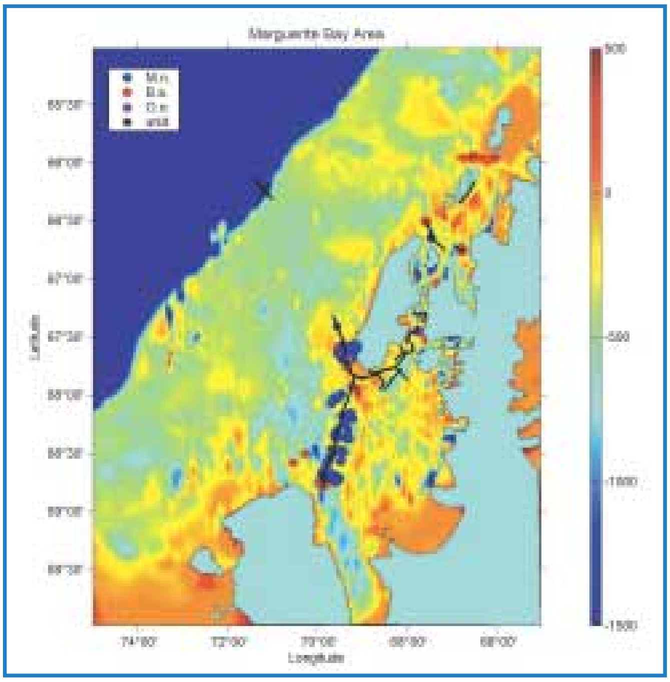


Figure 1. (Thiele, page 7) Map of Marguerite Bay, WAP study area showing autumn 2002 distribution of cetacean species from the LM Gould 0203 process cruise (M.n. = Megaptera novaeangliae (humpback), O.o. = Orcinus orca (killer whale), B.a. = Balaenoptera acutorostrata (minke)) over relative bathymetry (m).

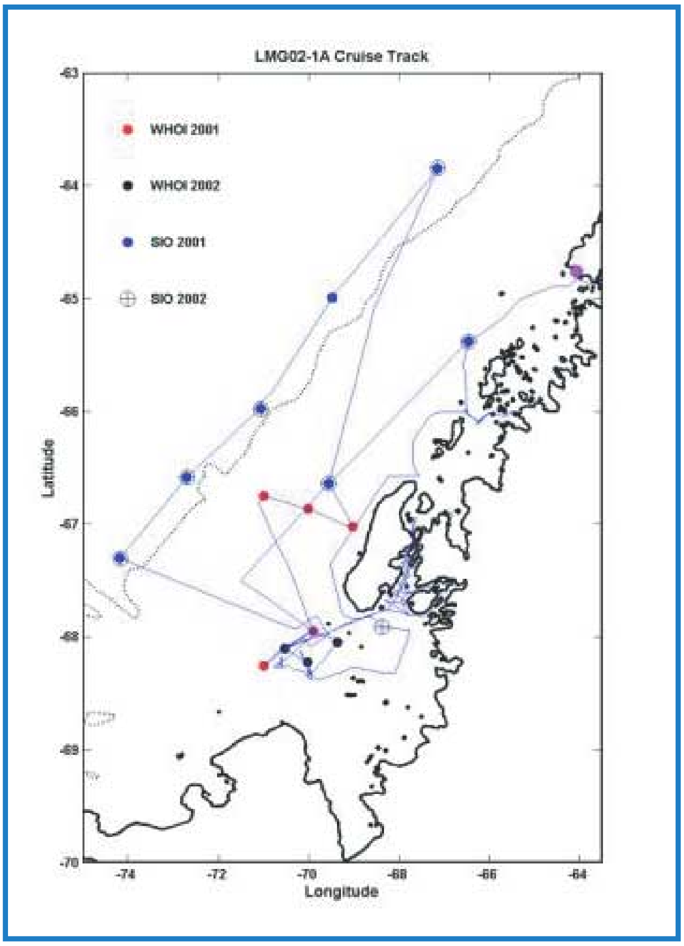


Figure 3. (Thiele, page 7) Cruise track for LMG02-1A from Palmer Station (February 11) to Palmer Station (February 26). The blue dots show the ARP mooring positions used in 2001, and the black circle with cross the positions where ARPs were deployed on the 2002 cruise. Not shown is SIO S1, located north of Palmer Station, which was recovered and redeployed.

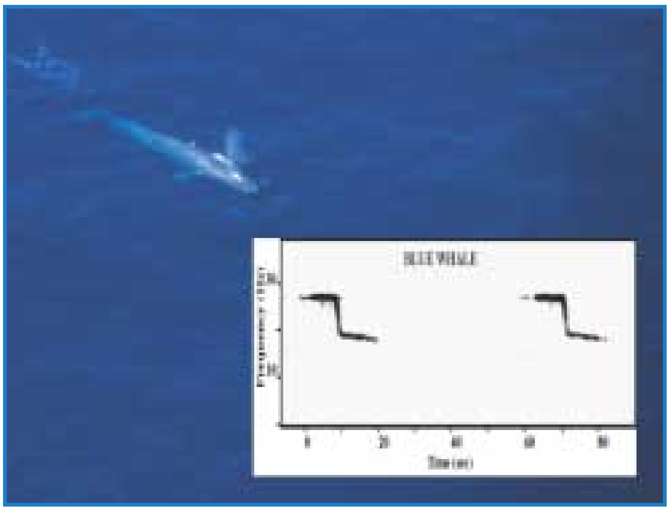


Figure 2. (Thiele, page 7) blue whale and blue whale call frequency

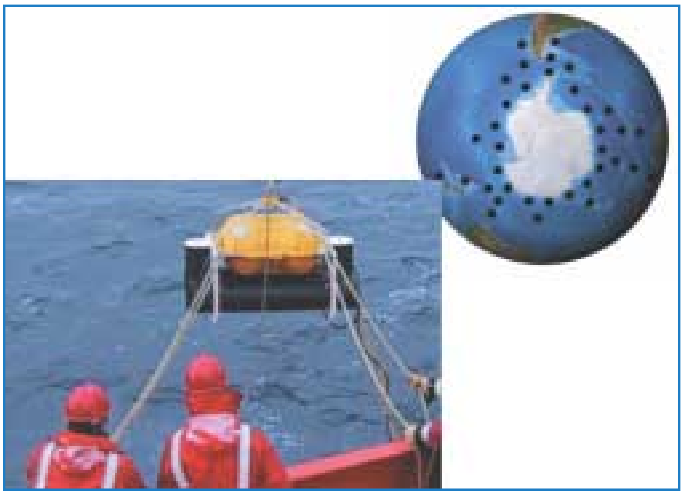


Figure 4. (Thiele, page 7) Deploying an ARP from the L M Gould and proposed Antarctic deployment sites for 'ARPs around the world/IWC' program

News from GLOBEC-PORTUGAL: ProRecruit, A study of shelf processes and coastal/estuarine crustacean recruitment

A. Miguel Santos, IPIMAR, Lisbon, Portugal (amsantos@ipimar.pt)

Many coastal and estuarine invertebrates produce planktonic larvae. At the end of this period of development the late-stage larvae (e.g., megalopa and cyprid larva in crustacean species) must migrate back to shore/estuary in order to complete their development and settle. This onshore migration is a critical stage in the life cycle of these organisms.

The project "Shelf processes controlling recruitment to littoral populations in an eastern oceanic boundary: using barnacles and crabs as models (ProRecruit)" started on October 01, 2001 and is a 3-year project funded by the Portuguese Foundation for Science and Technology (FCT). ProRecruit intends to be a contribution at the national level for GLOBEC. The main objectives of the project are to describe the temporal patterns of settlement (or recruitment) of coastal invertebrate species with planktonic larval phases in their life cycle, and to understand the bio-physical interactions that control the supply of larvae to coastal systems. This project will take place in the Western Iberian coast. This is a strongly wind-driven system, where the shelf circulation tends to be dominated by upwelling and downwelling events controlled by along-shore winds. The project is coordinated by Dr. Henrique Queiroga (hqueiroga@bio.ua.pt) of the University of Aveiro, and has the participation of the Portuguese Institute for Fisheries and Sea Research (IPIMAR), the Universities of Lisboa and Évora.

The work programme is divided into 3 main tasks (Temporal and spatial patterns of larval recruitment, Shelf physical oceanography and 3D distribution of larvae, and Numerical modelling of coastal processes).

A workshop on "Dispersal and recruitment of invertebrate larvae: sampling and modelling methodology" took place in from 6-8 March 2002 at the Marine Science Laboratory of the Univ. of Évora, Sines. The objective of the meeting was to develop sampling protocols and discuss methodologies to couple biological and physical models. Besides the participation of the members from the project team, 3 experts were also invited (Drs. Steve Hawkins, Jack Blanton and Brian Grantham).

An oceanographic cruise to further ProRecruit took place from 9-22 May 2002 off the north-western Iberian Peninsula. The sampling was divided in 3 parts: (i) a grid of 58 CTD+fluorometer (Fig. 1) stations; (ii) a smaller grid of 38 stations using CTD+fluorometer and several plankton nets (Pro-LHPR Spartel system, bongo and WP2); and (iii) a 69 hours anchored station with hourly CTD+fluorometer sampling and plankton sampling (LHPR and neuston nets) each two hours. Before the latter, a plankton trap mooring was deployed and recovered at the end of the cruise. During the entire cruise, wind data were acquired on board and on the coast using meteo-stations installed by the Environmental Dept. of the Univ. of Aveiro. A mooring system (Fig. 2) consisting of currentmeters, Microcat C-T, and a thermistor chain was deployed/recovered about 15 days before/after the cruise.

A poster about ProRecruit cruise will be presented at the GLOBEC 2nd Open Science Meeting, Qingdao, China, 15-18 October 2002.

Fig. 1. CTD and fluorometer

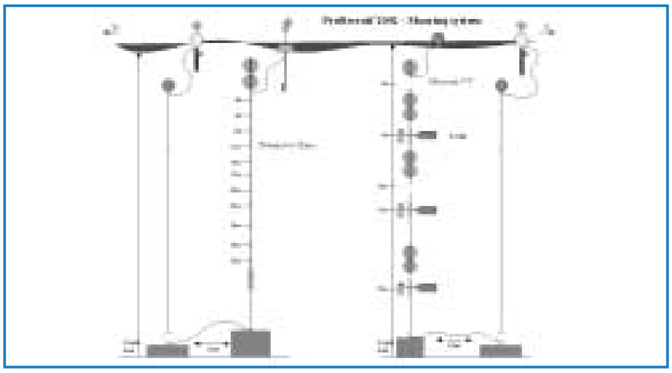


Fig. 2. ProRecruit 2002 mooring system

3rd International Zooplankton Production Symposium

in Gijón, Spain, 20-23 May 2003. Sponsored by ICES, PICES and GLOBEC

Sessions will be held on the following topics:

- Physical variability and zooplankton population dynamics
- Role of zooplankton in biogeochemical cycles
- Climate influences – what are long-term zooplankton data sets telling us?
- Progress in molecular biology
- Application of new technologies
- Comparative life cycles and life histories of zooplankton populations within and between the North Pacific and North Atlantic
- Role of microzooplankton in the sea

More details can be found on the co-sponsors websites: www.ices.dk, www.pices.int, www.globec.org or contact the PICES Secretariat with any queries, secretariat@pices.int

ENVIFISH, a summary of achievements

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Frank Shillington, UCT, Cape Town, South Africa (shill@physci.uct.ac.za)
Leo Nykjaer, JRC, Ispra, Italy (leo.nykjaer@jrc.it)
Anthony Richardson, SAHFOS, Plymouth, UK (anr@mail.pml.ac.uk)

Envifish (Environmental conditions and Fluctuations in Recruitment and Distribution of Small Pelagic Fish Stocks) was a 3-year research project in the Benguela-Angola Region. During the lifetime of the project several communications have been forwarded to the GLOBEC Community either through the Newsletter (1) or as contributions to the GLOBEC reports (2).

While the scientific results will be published both in peer reviewed journals and on a CD-ROM (contact the authors for further details) it may be opportune to summarise the results in line with the previous communications mentioned above.

The objective

The main objective of *Envifish* was to develop appropriate methodologies for improving the sustainable management of small pelagic fisheries in the Benguela-Angola Region. To achieve this, work focused on the identification and quantification of key environmental conditions that influence fluctuations in fish recruitment and distribution.

The data

A large database of satellite remote sensing and *in situ* data have been compiled for the South Atlantic coast of Africa through the *Envifish* project. The primary data set was an 18-year (1982-2000) time series of sea surface temperature (SST) images from AVHRR satellite sensors, processed specially for the project by the European Union's Joint Research Centre in Italy under a data-sharing agreement with NASA. Other remote sensing data sets used include SeaWiFS chlorophyll a and TOPEX/Poseidon and ERS-1/2 sea surface height (SSH). Wind speeds and direction were provided by the European Centre for Medium-range Weather Forecasting from a combination of satellite data and model output. *In situ* oceanographic and meteorological measurements from the region were pooled in a regional database with help from the Norwegian *Nansen* programme and have been used throughout the project.

The environmental data was related to fisheries data, such as acoustic survey data of fish distribution and biomass for adults and recruits, larvae/egg surveys and spawner biomass estimates.

The approach and main results

A range of analytical methodologies were applied to investigate and help interpret relationships between small pelagic fish and their environment.

Time series analysis and multivariate statistics were used to identify key environmental features, and to describe their spatio-temporal variability. Features described are shown in Figure 1 and include the Congo River plume, Angola current, Angola-Benguela front, Cape jet current, Agulhas current and upwelling cells. Principal Components Analysis (PCA) was particularly useful for highlighting the major large-scale features of the region and the dominant modes of temporal variability associated with them. An example of PCA output is given in Figure 2.

One novel modelling approach that proved particularly useful was the neural network technique Self-Organising Maps (SOMs). It was used to investigate temporal variability of a number of dominant spatial patterns. Two examples are the description of the seasonal behaviour of chlorophyll profiles in the Southern Benguela (Fig. 3) giving insights into the development of subsurface chlorophyll maxima (2,3) and the categorisation of key environmental processes for sardine recruitment, identified from SSH data in the Northern Benguela, and tracked through time giving an environmental index of recruitment success which matches recruitment data (2,4).

Environmental indices were constructed to give integrated measures of complex environmental processes, such as frontal transport length or upwelling (5). These were used as input into general regression modelling. First, General Additive Models (GAMs) were constructed, describing the non-linear relationships between biological and environmental processes. The non-linear relationships were then parameterised through the construction of a General Linear Model (GLM), providing predictive relationships.

An example of the use of these techniques is in modelling relationships between environmental variables and spatial distribution of pelagic fish species (2). Results from this research, showed anchovy catch rates to peak at intermediate temperatures (14-17°C) and decline with increasing SST variability (Fig. 4). Sardine catch rates showed no consistent trend with SST or SST variability.

Finally, one of the most important outputs of *Envifish* was the education and scientific training of Honours, Masters and PhD students from Southern African countries, a number of which have been employed by the fisheries research institutes in the region.

Interaction with other activities

Throughout the *Envifish* project, there has been valuable collaboration with the South African-French initiative 'Interactions and Spatial Dynamics of renewable resources in upwelling Ecosystems' (IDYLE – for further details see http://sea.uct.ac.za/idyle/). Two joint workshops have been arranged with IDYLE, and both IDYLE and *Envifish* are affiliated to GLOBEC-SPACC. The *Envifish* project has also worked in collaboration with the regional BENEFIT programme that started in 1997. A

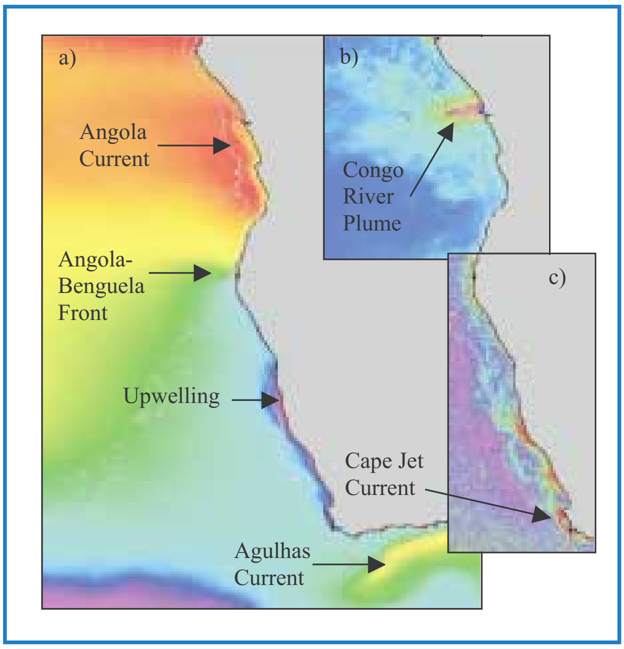

Figure 1. a) Mean SST in the Envifish region, b) Chlorophyll a along the Angolan coast and c) SST gradients along the Benguela coast with major oceanographic features identified.

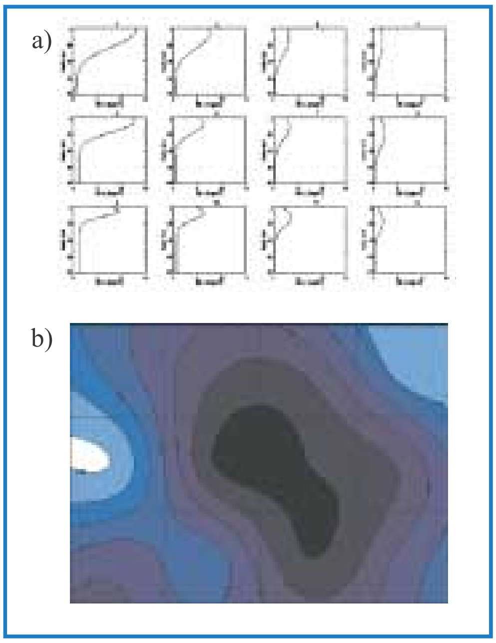

Figure 3. (a) A 4x3 SOM of vertical chlorophyll patterns. Note chlorophyll is on the x-axis and depth on the y-axis. (b) Map showing the frequency of occurrence of each of the patterns in (a). Note that each grid square on the frequency map represents a pattern in the SOM.

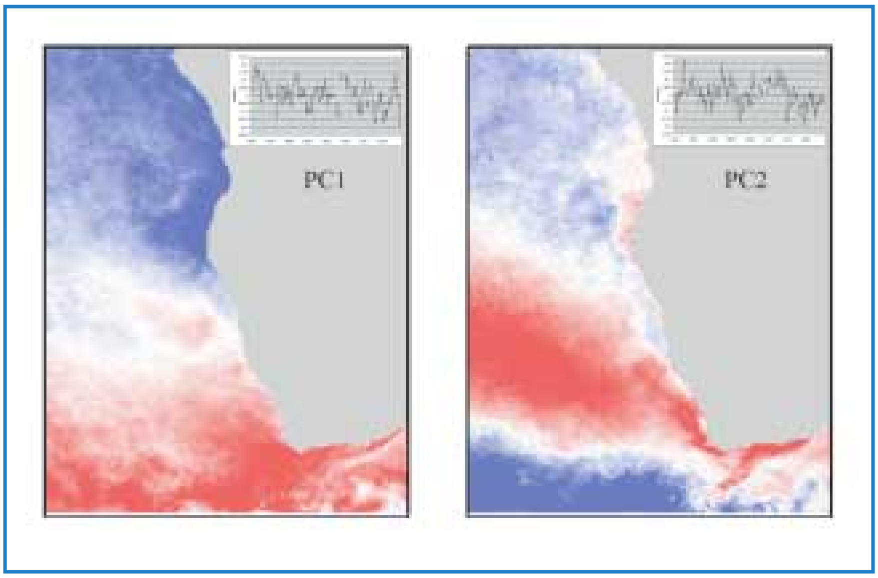

Figure 2. The first two principal components of SST anomalies (maps) for the Envifish region with loadings inset (graphs).

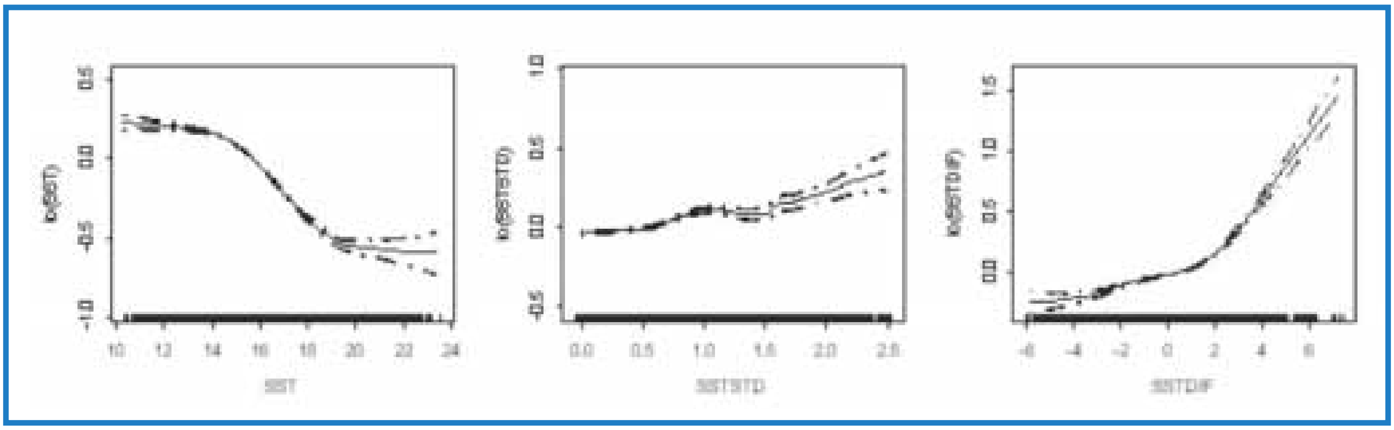

Figure 4. GAM relating anchovy catch rates to SST, standard deviation of SST and spatial variability of SST for the Agulhas Bank.

major new initiative in the Benguela region for the next five years, the Global Environment Facility (GEF) funded Benguela Current Large Marine Ecosystem project, provides hope that the capacity built up in the region and the knowledge collated over the last few years will not be lost.

(1) GLOBEC International Newsletter 6.1: 11; 7.1:28-29; 8.1: 4-5.

(2) GLOBEC Report no. 16: Report of a GLOBEC-SPACC/IDYLE/ENVIFISH Workshop on spatial approaches to the dynamics of coastal pelagic resources and their environment in upwelling areas (6-8 September 2001, Cape Town, South Africa).

(3) Richardson, A.J., M.C. Pfaff, J.G. Field, N.F. Silulwane and F.A. Shillington (2002). *Journal of Plankton Research,* in press.

(4) Hardman-Mountford, N.J., A.J. Richardson, D. Boyer, A. Kreiner and H. Boyer (submitted). *Progress in Oceanography.*

(5) Hagen, E., R. Feistel, J.J. Agenbag and T.Ohde (2001). *Oceanologica Acta* **24**: 557-568.

Acknowledgments

Envifish was funded by the European Union INCO-DC programme (ERBIC18-CT98-0329). Partners were: Joint Research Centre, Italy; Institute of Fisheries Research, Angola; National Marine Research and Information Centre, Namibia; Marine and Coastal Management, South Africa; University of Cape Town, South Africa; Institute for Baltic Sea Research, Germany; Institute for Marine Research, Norway; Plymouth Marine Laboratory, UK; Food and Agriculture Organization, Italy. Many thanks to all who have advised and supported us throughout the project, especially Manuel Barange at GLOBEC.

NAT-FISH, a SPACC affiliated project in the Northwest African upwelling area

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NAT-FISH (Natural variability of a coastal upwelling system and small pelagic fish stocks) is a 3 year project funded by the European Commission. The project is formally associated with GLOBEC-SPACC to assure a proper positioning of data and results at international level. The geographic area of interest for NAT-FISH is the Northwest African upwelling area adding another spot on the globe for SPACC regional activities.

Objectives:

The main objective of NAT-FISH is to identify and quantify environmental variability in the Northwest African upwelling area during the last decade relating the significant changes in abundance and distribution in small pelagic fish stocks to the environmental variability with emphasis on 3 specific topics:

- Moroccan decline in sardine abundance from 1995 to 1999
- Fluctuations of chub mackerel and horse mackerel stocks particularly off Mauritania from 1995 to 1999
- Abnormal occurrence of sardines off Senegal and sardinella off Morocco in the 1990s.

The objective is divided into suitable sub-objectives. Of particular note are the training objectives, which allow young scientists to develop skills in manipulating and understanding environmental data as an integral part of the project

Methodology:

NAT-FISH is carried out as a retrospective analysis of environmental, biological and fisheries data with focus on the decade 1990-2000. The first part of the analysis has 3 distinct actions:

- A documentation of the environmental variability associated with the major changes in fish population for the three case studies. This will be carried out over the entire period from 1990 to 2000. Special emphasis will be given to searching for characteristic patterns in environmental data that are believed to be important in influencing the fluctuations in recruitment and distribution of small pelagics, such as fronts, upwelling intensity and duration.
- An investigation of upper ocean dynamics through application of an existing hydro-dynamic model. Such analysis will be carried out during particular periods of the case studies using real winds and meteorological data as forcing functions, with the aim of identifying favourable/unfavourable conditions for transport of eggs and larvae

Fig.1. Participants at the first project meeting. The author is the third from the left.

- An examination of the influence of oceanographic key parameters on the distribution and biology of small pelagics. This examination will inevitably lead to the difficult discussion on the fishing pressure versus environmental factors in determining success or failure of fish populations to maintain their biomass. However as a minimum it is expected to make a ranking of environmental parameters according to their influence on the availability of small pelagics.

The final part of the study will be an assessment of which environmental parameters of importance for fisheries can be monitored and/or calculated from regularly collected observations and models, and how such information could be incorporated into responsible fisheries management.

Partnership:

The partnership of NAT-FISH is:

Joint Research Centre of the EC, Italy

Institute for Marine Research, Norway

Centre de Recherches Océanographiques de Dakar-Thiaroye, Senegal

Institut National de Recherche Halieutique, Morocco

Institut Mauritanien de Recherches Océanographiques et des Pêches, Mauritania

The project is assisted by an advisory board with representatives of FAO, IOC and SPACC.

Meetings and reporting

NAT-FISH had its first meeting at the JRC, Ispra, Italy 11-13 March 2002. The meeting was an occasion to review the status of the pelagic fisheries in the Northwest African upwelling area and to set the strategies for the methodologies and approaches to be used in the project. The first annual meeting will be held in Mauritania in November 2002.

For more information please contact the author.

Small Pelagic Fish and Climate Change (SPACC) Executive Committee met in Dartington (UK)

Dave Checkley[1] and Claude Roy[2]

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[2] Institut de Recherche pour le Développement (IRD, Paris - France and IDYLE-BEP-V Program, University of Cape Town , South Africa (croy@uctvms.uct.ac.za)

Introduction

In May 2002, a two-day meeting in Dartington (UK) brought together the members of the Small Pelagic Fish and Climate Change (SPACC) Executive Committee. The meeting offered the opportunity to review past activities of the program and to plan for 2002-2005.

SPACC has gone a long way since 1994 when two internationally renowned scientists, John Hunter and Jürgen Alheit, teamed up to draft the outline of an international program that would focus on climate change and small pelagic fish population dynamics and would become a core component of GLOBEC International. The two founding fathers of SPACC initiated the elaboration of a science plan by organizing a meeting in La Paz, Mexico in 1994, where 54 scientists and experts from a wide range of disciplines and regions exchanged ideas and designed what would become the scientific backbone of SPACC. The report of this meeting (GLOBEC Report No.8) was then used during subsequent meetings in Namibia (1995) and Mexico (1996) to produce the SPACC implementation plan (GLOBEC Report No.11). Since its inception, SPACC was planned as a major component of GLOBEC with the aim of identifying the physical forces that control the growth of small pelagic fish populations and the linkages between these processes and population dynamics. Small pelagic fish were chosen for many reasons: they constitute up to 30% of the total world fish catch; they have a wide range of distribution, covering the Exclusive Economic Zone of both developed and developing countries; they are key components of marine ecosystems; they have been subject to great variations in productivity; and they may be particularly sensitive to climate variability. Small pelagic fish populations are also ideal for comparative studies of ecosystems, thus fulfiling one major objective of GLOBEC. Under the leadership of the founding fathers, SPACC has grown to maturity. The program now sustains a wide spectrum of activities, including working groups, conferences, and field work, and contributes actively to GLOBEC, as seen in the SPACC-related contributions published over the years in the GLOBEC Newsletter, GLOBEC Reports, and the refereed literature.

In 2000, a review of SPACC activities lead to a partial restructuring of the program, which became organised along four major research themes. A SPACC Executive Committee was also constituted in 2000 with the mandate of managing the program under the leadership of the two co-chairs. The Executive Committee is presently formed by: J. Alheit, M. Barange, T. Baumgartner, L. Castro, D. Checkley, J. Hunter, L. Motos, H. Nakata and C. Roy.

Brief review of SPACC recent past (2000-2002) and planned (2002-2005) activities

New regional developments

An important step forward regarding SPACC activities in Asia was the organisation of a SPACC-APN workshop on pelagic fish productivity in SE Asia, held in Kobe in August 2001. The meeting included scientists from Japan, China, USA, Russia, Korea, among others. The outcome was published in GLOBEC Report 15.

An EU-sponsored project, lead by L. Nykjaer from JRC (Ispra, Italy), has been set up to investigate natural variability of the coastal upwelling system and small pelagic fish stocks off Northwest Africa. This project, called NATFISH, had its start-up meeting in March 2002 and had requested affiliation to SPACC. The SPACC Executive Committee welcomes this initiative as it brings on board SPACC a major eastern boundary system where small pelagic populations contribute significantly to sustain the local fisheries and related activities.

Theme 1 - Long-term changes in ecosystems

Three meetings related to Theme 1 were held over the last two years. "Major Turning Points in the Structure and Functioning of the Benguela Ecosystem" was the topic addressed by a GLOBEC-SPACC/IDYLE/BENEFIT meeting (Cape Town, South Africa, 12-16 February 2001). This meeting was the first of a series of similar workshops that will investigate turning points in other regions of the world that support large populations of sardine and anchovy. The Cape Town meeting was followed by a GLOBEC-SPACC/IAI workshop on "Comparative Studies of Long-Term Variability of Small Pelagic Fishes in the Humboldt and California Current Ecosystems" (Lima, Peru, 29 May-1 June 2001). Finally, a SPACC/GLOBEC Workshop on Paleoceanography (Munich, Germany, 10-13 October 2001) had the objective of bringing together research teams carrying out high frequency analyses of sediment cores from different anoxic sites in order to compare and cross-calibrate methodologies and co-ordinate future co-operation and comparisons. Overviews of the outputs of those three meetings were published in the April 2001 and April 2002 issues of the GLOBEC Newsletter.

Future activities considered for Theme 1 include:

- A workshop on historical time series of the Iberian Peninsula (Spain and Portugal), to be discussed at the GLOBEC OSM and for activation after 2003.
- A funds request in 2003 for a 2nd APN GLOBEC/SPACC workshop. This will focus on producing comparable data sets to be used in a comparative study of pelagic fish productivity in three major ecosystems in East Asia.
- A regional meeting in Japan on long-term data series.

Theme 2 - Comparative population dynamics

A review paper emanated from the outcome of a workshop in Dartmouth, Canada (Jacobson *et al*., 2001). The focus of the paper is on surplus production, variability and climate change in the great sardine and anchovy fisheries. The more recent activities related to Theme 2 are part of an IOC/SPACC Study Group on "Use of Environmental information on the management of pelagic fish populations" (see GLOBEC Special Contribution No.5). The group met for the first time in Cape Town (3-5 September 2001) and a range of activities has been planned for 2002. The group will have its second and final meeting at IOC/UNESCO in Paris, December 2002, and would focus its activities in 2003 towards drafting papers. Theme 2 activities are related to other international activities such as the SCOR/IOC WG 119 on ''Quantitative Ecosystem Indicators for Fisheries Management'. A contribution of the IOC/SPACC Study Group to the WG 119 symposium in 2004 will be investigated.

Theme 3 - Reproductive habitats

Activities related to Theme 3 have a wide geographical range and cover the Humboldt, Benguela, and California Current Systems and the Bay of Biscay. A SPACC/IDYLE/ENVIFISH workshop held in Cape Town (September 2001) focused on spatial approaches of the dynamics of coastal pelagic resources and their environment in upwelling areas (see GLOBEC Newsletter, April 2002). The outcome was published in GLOBEC report 16.

In Southern Africa, ENVIFISH, an EU project involving several partners from Southern Africa and Europe, completed its activities in 2001 and the outcome of the project will be published in a special issue of a major journal. The 5th phase of the Benguela Ecology Programme (BEP) and the joint South-African/French IDYLE programme teamed-up to form the IDYLE-BEP-V. The scientific focus of the project is on modelling the spatial dynamics of the Southern Benguela ecosystem.

An overview of activities related to the Continuous Underway Fish Egg Sampler (CUFES) was provided under this theme. On-going CUFES sampling is currently taking place in California (16 cruises 1996-20002), Mexico (10 cruises 2000-2002), Peru (5 cruises 1999-2001) and Chile (4 cruises 1999-2001), thanks to IAI funding. CUFES is also used by South Africa (Benguela), Spain and France (Bay of Biscay), and Canada (East Coast). The automation of detection and counting of fish eggs in CUFES in real-time by use of machine vision is nearing completion.

Future activities of Theme 3 include:

- A meeting of users of the Continuous Underway Fish Egg Sampler (CUFES) in late 2003 aimed at comparing characteristics and variations of spawning habitats. This would follow a meeting on IAI-funded work with CUFES by Chile, Peru, Mexico, and the United States, which took place in Miami, June 2002. CUFES will also soon be implemented in Chile thanks to a grant from IAI-EPCOR.
- CUFES is to be tested off Namibia in winter 2003 on the *RV Dr. Fridtjof Nansen.*
- CUFES is soon to be implemented in southern Chile thanks to a grant from IAI-EPCOR.
- Funding has been requested for a workshop on "Spawning Habitat Dynamics and the Daily Egg Production Method" (Concepcion, Chile, January 2004).

- Plans were discussed for a workshop on "Comparative analysis of the carrying capacity of the Humboldt, California and Benguela EB systems". It will be aimed at climatologists and circulation modelers mostly. Contact with the GLOBEC Focus 3 WG will be sought to follow up on this initiative.
- Discussions, led by the IDYLE-BEP-V programme, are underway to investigate the feasibility of a comparative study of the major eastern boundary ecosystems using a common modelling platform as well as satellite data.

Theme 4 - Economic implications of climate change

This theme has not been activated yet, but a workshop is planned to examine the economic impacts of climate change on small pelagic fish. Some of the issues to be discussed at this workshop would be (a) effects of low- and high-frequency climatic events on fish productivity; (b) impacts of climate change on harvesting and processing capacity and fisheries investments; (c) economic benefits of cooperative management of transboundary stocks; (d) impacts of the international trade of small pelagic fish and their substitutes; and (e) the value of improved long-range climate prediction. A scoping workshop on the economics of small pelagic fish has been requested for 2003.

Management issues

J. Alheit and J. Hunter both expressed their desire to vacate their positions as co-chairs after the October 2002 GLOBEC OSM in Qingdao, China. This represents a major challenge for SPACC given the tremendous energy devoted by John and Juergen over the last eight years to set up and run the program. The SPACC Executive Committee nominated David Checkley and Claude Roy as new co-chairs. The GLOBEC SSC will be asked to officially appoint Checkley and Roy as the new Chairs during the OSM in October 2002.

The two new chairs have quite different backgrounds, with Checkley being a biological oceanographer and Roy a physical oceanographer by training. They both share a strong interest for the ecology and dynamics of small pelagic fish populations and fisheries, as well as complementary expertises ranging from larval fish ecology and fisheries oceanography to climate and physical oceanography.

A review of the SPACC related activities shows that many field programmes have officially received affiliation to SPACC, but that some groundwork still needs to be carried out to harness SPACC research that is currently being conducted without SPACC affiliation but following SPACC philosophy. This is seen as particularly important in order to be able to follow up developments, foster co-ordination and networking within the fields of research covered by SPACC. Members of the SPACC executive will play a key role in organizing the link between national or regional activities and SPACC.

Challenges and priorities

Fisheries oceanography is a central theme for SPACC. Today, the limitations of the traditional approach based on simple direct correlation between fish population characteristics (e.g., abundance or recruitment) and climate or environmental variables is becoming more obvious. There is an urgent need for fisheries oceanography to include process studies and modelling experiments. Achieving this in SPACC is a major challenge as many partner countries have limited resources to devote to new field studies or lack the expertise to develop appropriate modelling experiments. To move SPACC in that direction, adequate training as well as an extensive network of relevant institutions or programs must be promoted.

Consideration must be given to standardisation of methods of data collection and analysis in different regions over time. Such comparable data are necessary to address SPACC objectives on a global scale over the long term. Ensuring the continued use of such methods to create comparable time series is an additional challenge.

Scientific issues related to global warming are of great concern for SPACC and are a major goal for the GLOBEC synthesis. The response of the open ocean to major climatic signals is extensively studied and documented but the regional manifestations and especially consequences at smaller scales, such as that of the ocean's continental shelves, remain poorly documented and understood. Climate and ocean basin-scale analyses tend to submerge coastal responses within those of the adjacent larger-scale oceanic environment. Surprisingly, the impact of large-scale climate variability on the ecology of coastal ecosystems is quite often better known than its impact on their physics. A comparative research focus on the impact of the dominant large-scale climatic signals on coastal ecosystems might be particularly relevant for SPACC. A good candidate for a pilot study would be the eastern boundary regions of the Pacific and Atlantic oceans where atmospheric forcing plays a dominant role in controlling key ecosystem processes such as coastal upwelling. It could start by investigating the local signature of the major climatic signals in atmospheric forcing fields as well as at the oceanic boundaries of the coastal regions. A next step would be to implement higher-resolution regional-scale coastal models over the continental shelf. These models, when coupled with biogeochemical and IBM models, can be used to start exploring the response of the dynamics and structure of coastal ecosystems to major, basin- or global-scale climate variation.

A second, large-scale, anthropogenic effect on small pelagic fish are fisheries, as the demand for fish will continue to increase worldwide while the catch appears to be constant or in decline. Aquaculture will require evermore small, pelagic fish as food. Large-scale removal of fish from low trophic levels affects other components of pelagic ecosystems, from nekton to birds to mammals. Hence, a challenge for SPACC is to understand the effects of such fisheries on the dynamics of the exploited populations for use in management and policy.

The effects of climate change and fisheries on small, pelagic fish and their role in ecosystems will remain the main research topics which will occupy SPACC over the coming years. To reach its goals, SPACC will have to face several challenges and opportunities. The global coverage and active participation of scientists from both developing and developed countries makes SPACC unique when compared with the other GLOBEC regional programs. Many SPACC scientists belong to fisheries institutes and are directly involved in assessment and management activities. Funding for SPACC research comes from fisheries and science agencies. As a result, networking with national and international programs and institutes is seen as a key issue for the SPACC community. Such links will benefit all participants.

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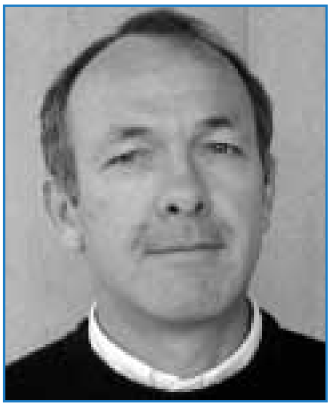
Claude Roy

Claude Roy is a senior scientist at the Institut de Recherche pour le Développement (IRD-France) and is currently assigned to the University of Cape Town and the Marine and Coastal Management unit (South Africa) as part of the IDYLE-BEP-V program. He obtained his PhD from the University of Bretagne Occidentale (France). He joined ORSTOM (now IRD) in 1981 and he has been working for extended periods of time in France, Côte d'Ivoire, Sénégal, United States and South Africa. His research interests cover coastal oceanography, climate variability, fish ecology and fisheries oceanography. Within the IDYLE-BEP-V project, he coordinates the hydrodynamic modelling component and contributes to the remote sensing and fisheries oceanography activities. He has been involved in SPACC since its inception in 1994. Claude is a member of the GLOBEC Focus 2 working group since 2000 and he is also involved with the French National Program on Coastal Environment (PNEC).


Dave Checkley

Dave Checkley is Professor at the Scripps Institution of Oceanography (SIO) of the University of California, San Diego (UCSD). He obtained his PhD from SIO in 1978, was a NATO Postdoctoral Fellow at the Marine Laboratory, Aberdeen, Scotland, and, thereafter, held academic positions at the Universities of Alaska and Texas, North Carolina State University, and, since 1992, UCSD. His research interests include the ecology of marine zooplankton and fish and fisheries oceanography. He is co-inventor of CUFES and, since 2000, Editor-in-Chief of *Fisheries Oceanography*. His work in recent years has included implementation and use of CUFES worldwide to study the spawning of small, pelagic fish. Dave joined the SPACC Executive Committee in 2000.

Report from Japan GLOBEC committee

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The committees of Japan GLOBEC and JGOFS had a joint meeting on the 18th and 19th of August, 2002, in Nagoya, Japan. Profs. Takashige Sugimoto and Toshiro Saino were co-chairs of the meeting. We discussed the future of Japanese marine science in relation to the OCEANS project of IGBP. As the Japanese funding system is different from USA's or EU's, we necessarily do not need terms of reference or recommendations from international committees of OCEANS or GLOBEC. Once they receive funding and begin a project, principal investigators can decide for themselves: 'This research belongs to GLOBEC' or ' This is for OCEANS'. This means that we should apply funding based on what is important for marine science (of course considering which themes are likely to be accepted). From this perspective, we discussed what should follow JGOFS and what is important for GLOBEC-related science. Many themes were suggested by participants; i.e., can we forecast the future change of pelagic fish stocks based on lower trophic level models and continuous observation of lower trophic level compartments (nutrients, primary production, larvae, and so on)?, many kinds of iron in the ocean should be continuously observed, comparison between northern hemisphere and southern hemisphere should follow east-west comparison.

One of the key phrases used was 'Frog in a pan'. This phrase is based on Chinese proverb. If we boil a frog in a pan slowly, it won't be aware of what is happening, and will die without jumping out. If seawater temperature increases, will plankton and fish move to their favorite temperature region or will they still remain in their geographical area?

Climate variability and pelagic fisheries in the South-Eastern Pacific

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The Humboldt Current is one of the most productive systems and, as other eastern boundary systems, it shows a low diversity of pelagic species with abundant but variable stocks. In general, this variability is associated with both exploitation intensity as well as changes of environmental conditions. Peru and Chile, with P.R. China, are the most important fishing countries of the world, with pelagic resources representing more than 90% of landings.

Pelagic fisheries are carried out first on common sardine (*Strangomera bentinki*) in the center-south of Chile and mainly on anchovy (*Engraulis ringens*) in Peru and northern Chile. These species are distributed within 60 nm offshore, they have small size, short life span and high fecundity. In mid 1970s these fisheries collapsed, being replaced by the sardine (*Sardinops sagax*) in northern Chile and Peru, and jack mackerel (*Trachurus murphyi*) particularly in the center-south of Chile. These species have bigger size and longevity, smaller fecundity and more oceanic distribution, particularly jack mackerel. Nevertheless, these fisheries show a drastic decrease of yields (CPUE) after 1985; while at the same time a remarkable recovery of the common sardine and anchovy fisheries was observed.

Common sardine and anchovy landings show decreases associated to the El Niño events, particularly the 1972-1973 phenomenon (Fig.1). The El Niño represents an interannual climatic variability and produces effects in abundance (for recruitment and growth), distribution (horizontal and vertical) and aggregation (schools and strata) of resources. Acoustic cruises classified according to NOAA categorization (cold and warm episodes by season), show the highest anchovy biomasses associated with cold and normal events and a distribution area that can increase up to five times; during the El Niño, the biomass diminishes and contracts toward the coast and the south, and deepens presenting disintegrated echo-traces.

However, the non-recovery of these fisheries after 1976 was coincident with the drop of the Southern Oscillation Index (SOI) and the presence of a long-term warm period reflected in the sea surface temperature (SST) of Chile and Peru, without ignoring the fishing effort effects (Fig. 2a). Warm periods and particularly the regime shift observed after 1976, would be unfavourable to anchovy; while these would favour sardine (Fig. 2b), on which important fisheries were developed in northern Chile (maximum 2.5 millions of tons in 1983) and Peru (maximum 3.5 millions of tons in 1988). In the center-south of Chile jack mackerel landings also increased with this regime shift, associated with the development of a remarkable fishing effort, up to 4 million tons in 1995.

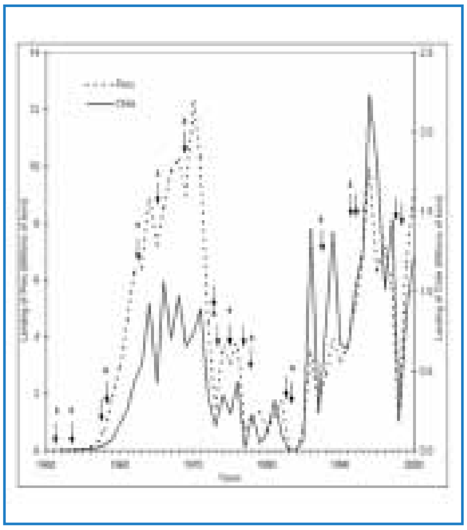

Figure 1. Anchovy landings in Peru and northern Chile between 1950 and 1999. The arrows indicate the El Niño events and the intensity.

However, the catch per unit effort (CPUE), after an important increase during this long-term warm period, shows a decline from 1987 (Fig. 3). Acoustic information available from 1990 shows that during autumn of the El Niño jack mackerel increased their distribution area; while during La Niña they were particularly aggregated toward the south. On the other hand, during cold and normal years jack mackerel school size inside the cluster is bigger than the individual schools; while during the El Niño events the situation is inverse.

On the other hand, the Chilean artisanal swordfish (*Xiphias gladius*) fishery, the predator of jack mackerel and hoki (*Macruronus magellanicus*), showed a remarkable decrease of yields after 1987, associated to the re-establishment of similar cold conditions to those observed before 1976 (Fig. 4). On the other hand, the hake (*Merluccius gayi*) fishery of central Chile showed a remarkable recovery in the new regime observed after 1987 (Fig. 5).

This high variability is associated with atmospheric pressure fluctuations between the Eastern and Western Pacific, reflected in the SOI. Nevertheless, the new regime shift observed after 1987, in the coastal SST and in the catches of these resources, is not clearly observed in this South Pacific climatic index.

It is necessary to point out that a climatic regime shift is also observed in the North Pacific in 1976-1977, and this change produced great consequences in the marine ecosystem. A regime shift was also identified in 1989, in some components of this ecosystem, but it does not reflect a return to the previous conditions at 1977. Also, although the shift of 1989 is observed with relative clarity in the biological registrations, this neither is reflected in the Pacific climatic indexes, like the Pacific Decadal Oscillation (PDO).

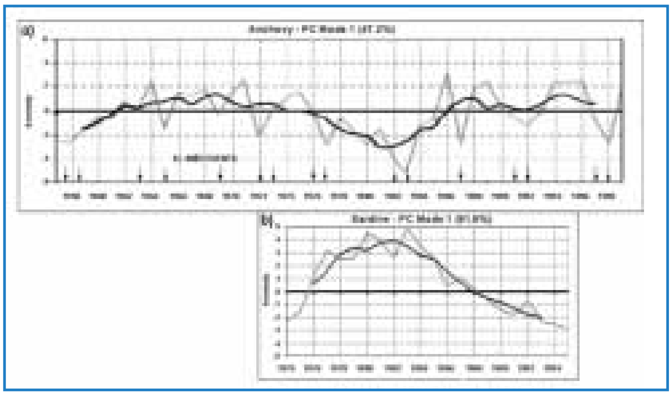

Figure 2. EOF time series analysis of catch, fishing effort, SST and SOI for anchovy; and recruitment, biomass, SST and upwelling index for sardine.

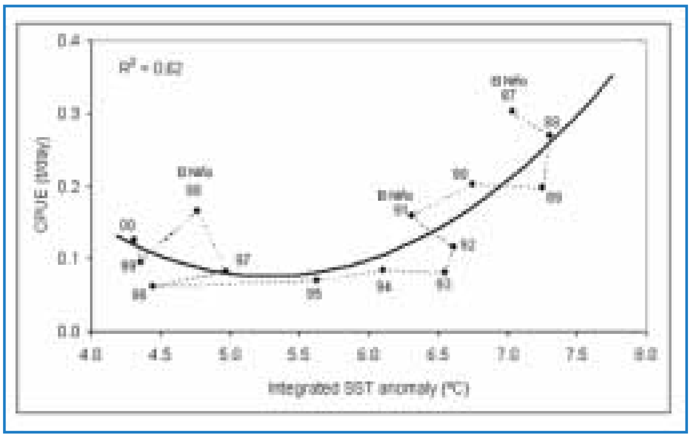

Figure4. Relations between swordfish fishing effort, CPUE and integrated SST anomaly.

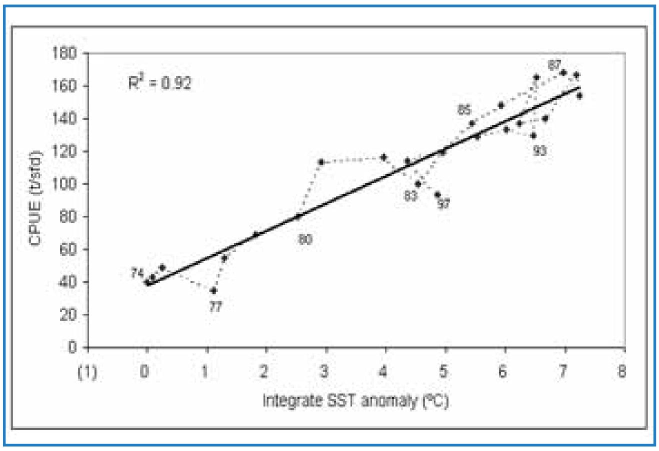

Figure 3. Relation between jack mackerel CPUE and integrated SST anomaly in central-south Chile.

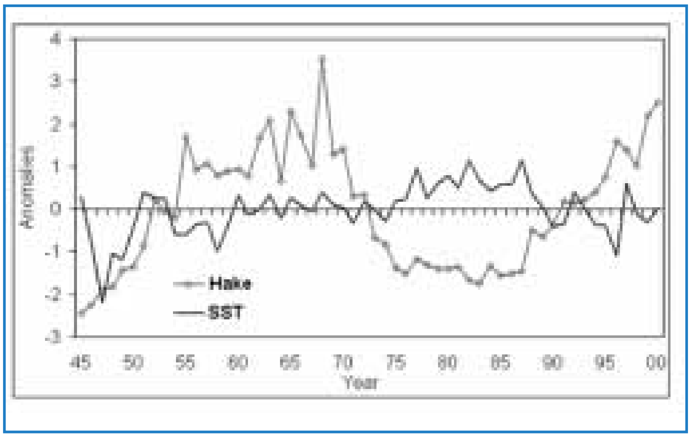

Figure 5. Hake landings in central-south of Chile and SST anomalies in Talcahuano coastal station.

In situ investigations of gelatinous zooplankton and marine snow.

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Gelatinous zooplankton fauna can constitute a significant fraction of the macroplankton biomass. Most species are easily damaged and often destroyed by conventional sampling with plankton nets. The predatory roles of groups such as ctenophores, siphonophores and medusa are well known in shallow marine food webs. However, reliable, quantitative data on their distribution and population dynamics in deeper waters are scarce.

Macroscopic particles (marine snow aggregates) are an essential food resource in the ocean's interior and also serve to transport nutrients and various chemical compounds vertically and horizontally at all ocean depths. These particles are delicate and easily disrupted. Consequently, it is virtually impossible to obtain useful data on their distribution and abundance by other than *in situ* methods.

The Underwater Video Profiler (UVP) was developed to record images of macroscopic organisms (> 5 mm) and marine particles (> 0.1 mm) as deep as 3000 m depth. The instrument was conceived in the Laboratoire Océanographique de Villefranche sur mer, France and is distributed by Metal Process Ltd (www.metalprocess.com). The UVP can be used as a stand-alone vertical profiler or as a part of instrument packages (fig. 1).

The monotube UVP version can be mounted on a CTD-rosette system or on horizontally towed gear. It can also be configured for long-term moorings. The digital image data are treated in real time *in situ* and the physical attributes of particles are stored or transferred via modem onboard (fig. 2).

The UVP can operate from one to three cameras simultaneously. A pressure sensor is incorporated in each unit and the images are depth and time indexed. The laterally placed infra-red (IR) illumination is adapted for visualization of transparent objects. The entire record or only the interesting images are compressed and saved (fig. 3). The system has been utilized successfully during several oceanographic cruises and the results are

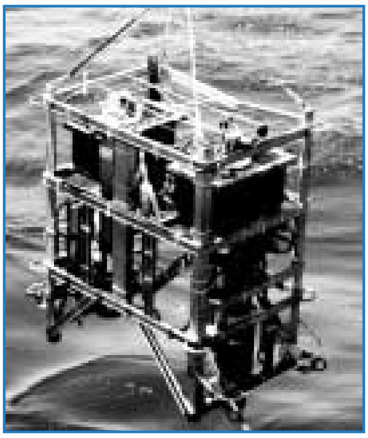

Figure 1. The Underwater Video Profiler (UVP) instrument package presented here includes the underwater imaging system, an SBE CTD, a fluorometer and nephelometer both from Chelsea Instruments.

published in various scientific journals, such as:

Echevarría, F., *et al*. (2002) Physical- biological coupling in the Straits of Gibraltar. *Deep Sea Res.* 49, 10-9, in press.

Gomez F., *et al*. (2001) Ecological implications of the interface oscillation and the North Atlantic Central Water in the Strait of Gibraltar. *J. Mar. Syst.,* 30: 207-220.

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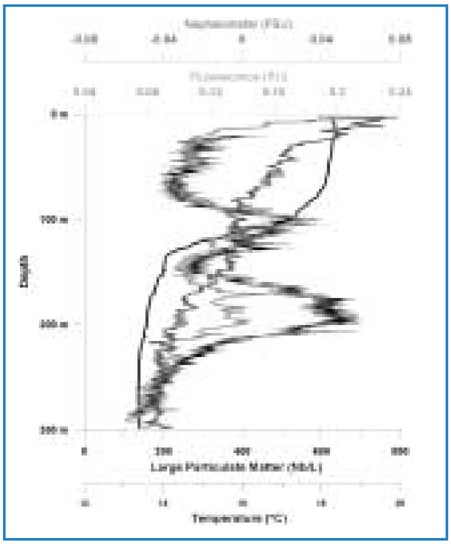
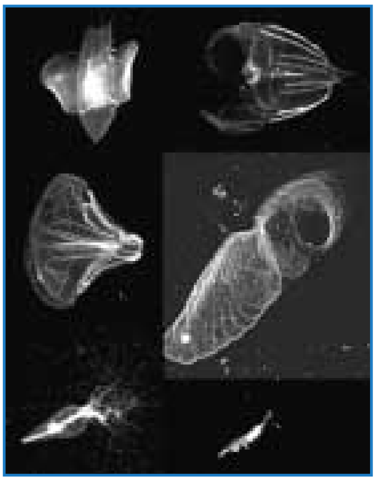


Figure 2. Vertical profile data obtained by the UVP instrument package.

Figure 3. Macrozooplankton from the northeast Atlantic Ocean recorded during the French POMME oceanographic cruises in 2001.



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Video Plankton Recorder reveals environmental problems of marine copepod

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The copepod *Pseudocalanus spec*. is an important link in the energy transfer between primary and fish production in the Central Baltic deep basins. It is an essential food item for pelagic planktivorous herring and sprat, and strongly influences growth, survival, and eventually recruitment of fish in the area (Möllmann and Köster 2002, Hinrichsen *et al.* 2002). Consequently, *Pseudocalanus* is one of the target species of the German Globec Project (www.globec-germany.de, funded by the *German Federal Ministry for Education and Research*), whose goal is the clarification of trophodynamic interactions between zooplankton and planktivorous fish in relation to reproductive success under the impact of physical forcing.

Previous long-term investigations documented large interannual fluctuations in the standing stock of *Pseudocalanus* with a pronounced decrease especially in the 1990s (Figure 1). This development has been attributed to significant changes in the hydrographic

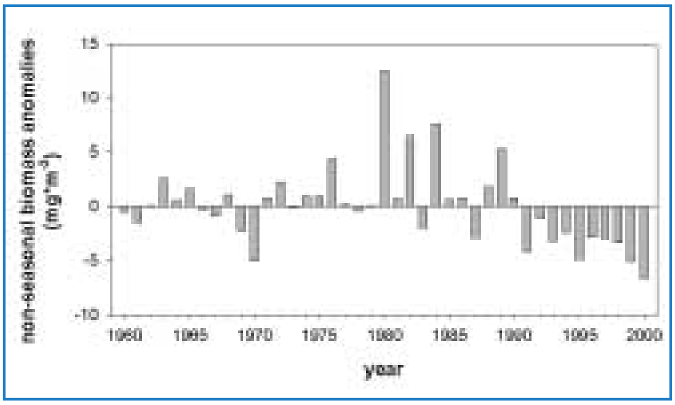

Figure 1. Long-term development of Pseudocalanus biomass in the Central Baltic Sea (Data by the Latvian Fisheries Research Institute, Riga).

environment over the last two decades, such as decreasing salinity due to reduced frequency of salt water intrusions from the North Sea and increased temperatures due to a series of mild winters (Möllmann *et al.* 2000). The mechanisms and processes behind this remain, however, unknown and are now a main focus of the German Globec Studies.

Spatio-temporal patterns of zooplankton have been investigated in 2002 in the Bornholm Basin by conventional net sampling as well as by operating the Seascan Videoplanktonrecorder (VPR, Fig. 2). First trial runs on board of the *RVs ALKOR* and *HEINCKE* in April and May 2002 revealed a surprisingly deep and narrow band of distribution of reproducing *Pseudocalanus* females in the permanent halocline of the Bornholm Basin. Figure 3 shows a VPR-picture of these animals which are easy to identify as they are the only copepods with egg-sacs in the area. So, *Pseudocalanus*, a marine species dwelling in the brackish water of the Baltic Sea, tries to stick to high salinity layers whereby it is forced to endure extremely poor oxygen conditions of < 1 $ml \cdot l^{-1}$

Figure 2. The Seascan Videoplanktonrecorder (VPR) towed from the German RV HEINCKE.

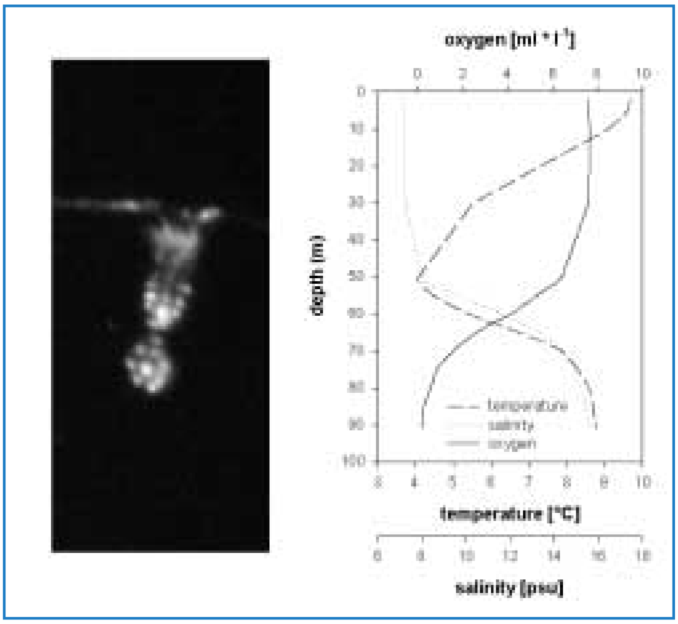

*Figure 3. VPR-Image of Pseudocalanus female with eggs (left) recorded in May 2002 at 55°16.60'N and15°43.77'E in the Bornholm Basin, and hydrographic profile (right) with arrow indicating oxygen content (0.77 ml*l-1) at depth of the animal (76.5 m).*

(Figure 3). This indicates that the decrease of salinity and oxygen concentrations as observed over the last decades in the deep basins of the Baltic has resulted in a degradation of suitable habitat for reproduction of *Pseudocalanus* and most likely diminished survival chances. This hypothesis will be further addressed in the context of climate variability by targeted process studies within the German Globec Project . The new findings would not have been detected by using conventional plankton samplers. Only the operation of sophisticated equipment such as the VPR gives insight into the impact of sharp physical gradients on the life history of zooplankton.

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Oceanic Fisheries and Climate Change Project OFCCP GLOBEC

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http://www.pml.ac.uk/globec/Structure/Multi-national/multinat.htm
http://www.spc.int/OceanFish/Html/Globec/index.asp

In recent years, the annual world catch of the four main tropical tuna species (skipjack, yellowfin, bigeye, albacore) approached 4 million tonnes, with two thirds of the production coming from the Pacific Ocean. Economical rather than biological factors limit the catch increase of skipjack, as illustrated by the spectacular drop of skipjack prices (-60%) between 1998 and 2000, due to exceptional high catches following strong recruitment related to the powerful 1997-98 El Niño event. Conversely, we can predict that the La Niña sequence of 1999-2001 has negatively affected the recruitment of skipjack and should lead to lower biomass in 2002-2003.

Similar trends occurred for yellowfin tuna (Fig. 1), the second tuna species by volume of capture. However, a longer life-span for this species produces lower-frequency fluctuations in the population biomass. A potential direct implication for management was highlighted at the 15th Standing Committee on Tuna and Billfish that was held in 2002, in Hawaii (http://www.soest.hawaii.edu/PFRP/sctb15/sctb15.html). The most recent population assessments of yellowfin tuna show that lower recruitment in recent years have produced a significant decline of around one third in overall stock biomass since 1997 (Hampton 2002). Biomass levels in 2000 and 2001 are estimated to be the lowest since the mid-1970s. If a shift to a lower productivity regime is confirmed, it is believed that present catches may not be sustainable.

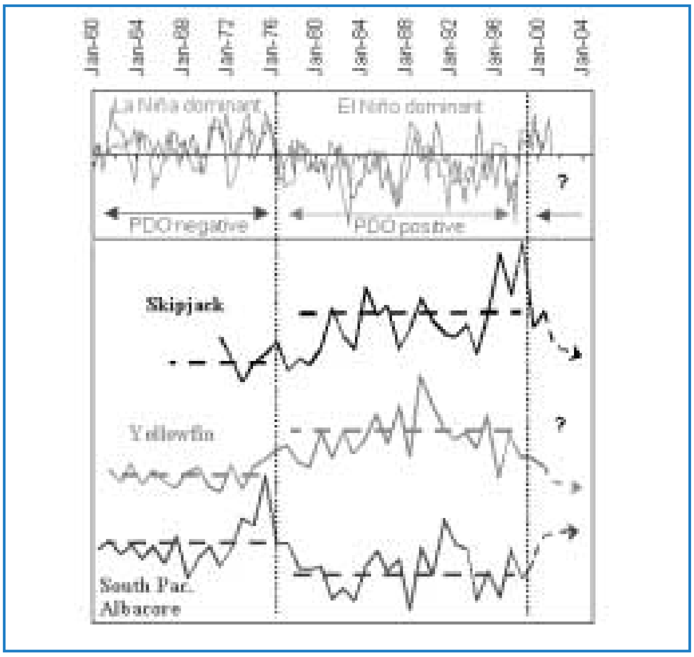
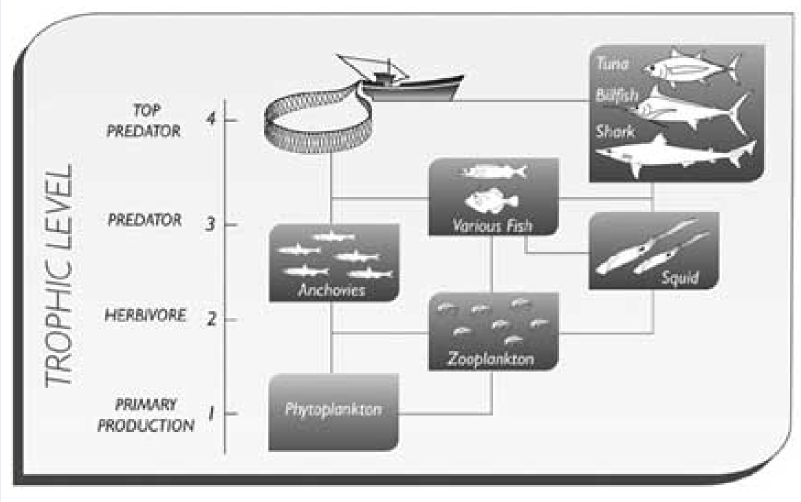


Fig. 1. Fluctuation of the Southern Oscillation Index (SOI) and Pacific Decadal Oscillation (PDO), and annual recruitment of skipjack, yellowfin and south Pacific albacore tunas (Hampton 2002). There are apparent correlations between the recruitment of these species and the interannual ENSO and decadal PDO signals that suggest a possible new regime for the next coming years. The albacore series has been back-shifted by two years and the yellowfin and skipjack series by one year to account for the age of recruitment of these species.

Interestingly, this pattern seems to be reversed for the temperate albacore tuna that presents recruitment estimates generally higher prior to the mid-1970s. Opposite trends in recruitment series of these species are apparently correlated with the last two different climate regimes of the Pacific Decadal Oscillation (PDO), and characterized by a high frequency of either La Niña or El Niño events (Fig. 1). The last regime shift occurred in 1976 and there is increasing evidence that another regime shift may have occurred in late 1998. Given the very high global socio-economical importance of tuna fisheries and their well-structured international trade, predicting even simple overall trends of how the climate variability could impact the pelagic ecosystem and tuna populations would be of major interest for resource management and would have rapid and direct socio-economical consequences.

Predicting the effect of short to long-term climate changes on the productivity and distribution of oceanic tuna stocks and fisheries will be the objective of the new multi-national project OFCCP GLOBEC (Oceanic Fisheries and Climate Change Project). The ultimate goal of the project is to conduct simulations with ecosystem models that include the main tuna species, using an input data set predicted under a scenario of climate change induced by greenhouse warming as defined by the IPCC. However, analyses of simulations based on retrospective series of oceanic and fishing data sets (i.e., hindcast simulations) will serve to test the predictive capacity of the models, particularly at seasonal, inter-annual (ENSO) and decadal (PDO) time scales.

In addition, diverse studies are needed to improve the parameterization (e.g., energy transfer from primary to secondary production), the modelling of key processes (e.g., recruitment, movements, and feeding), to validate the results of the simulations, and to investigate the socio-economical consequences of predicted changes. Studies are supported either through self-funded collaborations between scientists and research institutes or with external fundings (see examples in boxes 1 and 2). Four major components have been identified to achieve these objectives.



Box 1. Trophic structure and tuna movement in the cold tongue-warm pool pelagic ecosystem of the equatorial Pacific. (Allain V., Olson R., Galvan Magaña F., Popp B., Fry B.)

Project supported by the Pelagic Fisheries Research Programme of the University of Hawaii, USA.

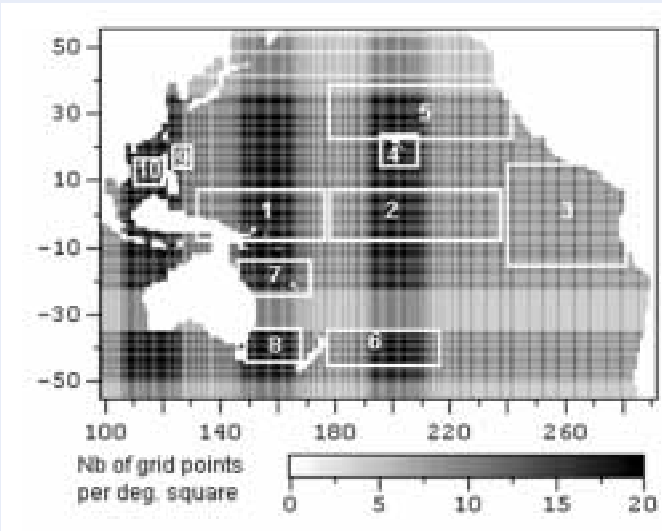
This project proposes to test how regional variations in primary productivity relate to production of tunas in the cold tongue-warm pool system of the equatorial Pacific Ocean. The objectives are to define the trophic structure, to establish an isotope-derived biogeography and to characterize large-scale tuna movements in the ecosystems of the pelagic tropical Pacific.

Predator-prey interactions will be quantified using stomach-contents analyses, while stable-isotope ratios will be used to assess the relative trophic positions of the ecosystems' functional groups. The Ecopath with Ecosim model will be used to represent the trophic flows among the ecosystem components.

Carbon and nitrogen stable-isotope composition of the different component groups, from phytoplankton to tunas, will provide an isotope cartography of the Pacific pelagic ecosystems to characterize the trophic structures in different production regimes. Food-web and isotope characterization of body tissues with slow and fast turnover rates from different geographic areas in the Pacific will form the basis for testing the potential interest of isotopes to study tuna movements.

1 - Monitoring the upper trophic levels of the pelagic ecosystem

Existing and new instrumentation and technologies will be used for monitoring the upper trophic levels of the pelagic ecosystem. Observation will combine both extensive studies at ocean basin-scale and intensive studies in some sub-areas and key sites. At each scale of observation correspond a modelling development, e.g., large-scale ecosystem models, population models or individual-based models.



Box 2: Mixed-resolution models for investigating individual to population spatial dynamics of large pelagics (Lehodey P., Kirby D., McClatchie S., Murtugudde R., Dagorn L., Holland K., Polovina J., Sibert J.).

Project supported by the Pelagic Fisheries Research Programme of the University of Hawaii, USA.

The mixed-resolution modelling project proposes to develop or improve two classes of models: Individual Based Models (IBMs) and Advection Diffusion Reaction Models (ADRMs). Both approaches will be combined by using the same predicted environment to constrain tuna behaviour of individuals (IBMs) and population dynamics (ADRMs).

Predicted fields describing the ocean environment will be provided by a coupled physical-biogeochemical ocean model developed at the Earth System Science Interdisciplinary Center (ESSIC, University of Maryland, USA). This model uses a stretched grid with greater resolution at one or multiple locations of the model domain.

The vertically integrated micronekton (tuna prey) biomass distribution is modelled with the tuna (predators) population dynamics in a spatial environmental ADRM (SEPODYM) developed at the Oceanic Fisheries Programme (SPC, Noumea, New Caledonia). Movements of individual tunas predicted from IBMs will be compared to observations derived from electronic tagging and to density population movements generated by ADRMs.

Mixed-resolution grid used as an integrative framework for the different OFCCP case-studies and projects associated to focus areas (1: warm pool, 2: cold tongue, 3: EPO, 4: Hawaii, 5: Cholorophyll Front Transition Zone, 6: Sub-Tropical Convergence Zone, 7: Coral Sea, 8: Tasman Sea, 9: East Philippines - Luzon Sea, 10: South China Sea)

2 - Food web structure in pelagic ecosystems

It is essential for modelling the pelagic ecosystem to identify the functional groups, how energy and matter flow through these groups and how they are affected by physical and biological changes as well as by human activities (fisheries). Two kinds of analyses will be helpful in this task. A classical approach based on the study of stomach contents to establish the prey-predator interactions, and the more recent isotope-ratio approach, that appears a promising way for describing the energy transfer through the food web. The success of this approach also relies on the multiplicity of studies in different regions of the ocean(s) and in different periods of time to establish an isotope-derived biogeography of the pelagic ecosystems (cf. box 1).

3 - Modelling from ocean basin to individual scale

Models have a pivotal roles in the project and will provide a general framework to integrate studies at different time and space scales. There is a large range of models represented in the project covering global to individual scales. At global or basin scales, predictions from different coupled physical-biogeochemical models will be used to run the ecosystem models of upper trophic levels on which the economical and social analyses rely. One of the physical-biogeochemical models will provide prediction at high resolution in several identified sub-regions where intensive process studies are conducted (cf box 2).

4 - Socio-economical impacts

Economical models developed for fisheries will use the prediction from spatial tuna populations dynamics models or will be directly coupled to such models to investigate the impact of climate variability on the tuna fisheries and their socio-economical consequences. Issues that will need to be modeled include multi-fleets interactions, the presence of fishing vessels from multiple political jurisdictions, that will imply different costs of fishing through differences in material and labor costs. The impacts of feasible management measures will be simulated.

For more information, please contact the author.

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New Books Published on China GLOBEC Studies

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China GLOBEC studies started in synchrony with the development of GLOBEC International. Through Prof Q. Tang's involvement in the GLOBEC SSC in 1991, Chinese scientists participated in framing the Global Ocean Ecosystem Dynamics Science Plan and Global Ocean Ecosystem Dynamics Implementation Plan. China's national strategic research on marine ecosystem dynamics was developed in 1994. Chinese GLOBEC studies focus mainly on the shelf ecosystem dynamics in Chinese waters which is an area affected heavily by global change and human activities. The experimental fields are characterized by particular physical, chemical and biological shelf environment and are sensitive to global change. The Bohai Sea, Yellow Sea and the East China Sea are the study fields of China GLOBEC. The past and present national GLOBEC programme activities cover two projects: Ecosystem Dynamics and Sustainable Utilization of Marine Living Resources in the Bohai Sea (BoSEC,1997-2000) is China GLOBEC Project 1, which was lead by Profs. Jilan Su and Qisheng Tang. The second China national GLOBEC project is entitled Ecosystem Dynamics and Sustainable Utilization of Marine Living Resources in the East China Sea and Yellow Sea (EYSEC, 1999-2004). Chief scientists of the project are Profs. Qisheng Tang and Jilan Su.

In the last 6 year of China GLOBEC research a total of 254 papers have been published in scientific journals, most of them in Chinese with English abstracts. Two books in Chinese on China GLOBEC studies were published recently by Science Press, Beijing. One book was entitled Study of Ecosystem Dynamics in Coastal Ocean I: Key Scientific Questions and Development Strategy, edited by Qisheng Tang and Jilan Su in 2000. The second book is printed under the title of Study on Ecosystem Dynamics in Coastal Ocean II: Processes of the Bohai Sea Ecosystem Dynamics, edited by Jilan Su and Qisheng Tang in 2002.

The first book describes the development of China GLOBEC and discusses the six key scientific questions to be answered, which are closely related to the dynamics of ecosystems in the continental shelf. The goal was to study the functioning of Chinese coastal ecosystems which are strongly influenced by climate variability and human activities. Process studies are the most important part directly implemented in the research. The six scientific questions are: 1) food web trophodynamics of key resources, 2) recruitment of zooplankton populations, 3) recycling and renewal of biogenic-elements, 4) ecological effect of key physical processes, 5) coupling of pelagic and benthic systems and 6) microbial loops contribution to the food web. All six questions emphasize the interaction and coupling of physical and biological dynamic progresses in the continental shelf. In the book each question composes a chapter.

China GLOBEC has four main themes:

1. influencing mechanisms of key physical process on biological production,
2. nature of biogenic-elements recycle and settlement input,
3. primary production processes influencing zooplankton dynamics and
4. trophic dynamics of food web and alternation principle of dominate resources

Multidisciplinary and synthesis studies are encouraged to provide breakthroughs in understanding ecosystem dynamics and recruitment mechanisms of living resources. *Calanus sinicus* and *Engraulis japonicus* are identified as key species.

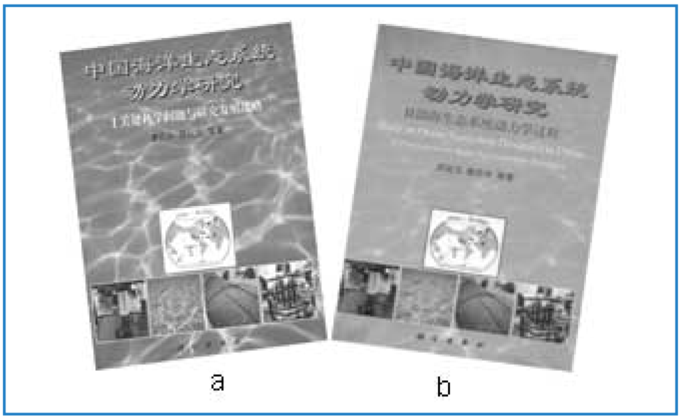

Figure 1 New books on China GLOBEC

a: Study on Ecosystem Dynamics in Coastal Ocean I of 252 pages

b: Study on Ecosystem Dynamics in Coastal Ocean II of 455 pages

The second book describes research products of China-GLOBEC Project 1 (BoSEC, 1999-2000). The project focused on the studies of environmental processes on the habitat of *Penaeus chinensis* and its early life biomass change, population dynamics of zooplankton and its controlling effects, trophodynamics and species shifts, and ecosystem modelling. The book has 4 chapters. Chapter 1 is on environmental processes of the habitat of *Penaeus chinensis* and their influence on its early life biomass (including stock dynamics of *Penaeus chinensis*, relevant physical and biogeochemical processes in its habitat, and long-term variations of atmospheric parameters and hydrographic properties and their influence on the marine ecosystem). The second chapter deals with population dynamics of zooplankton and its controlling effects in the marine ecosystems (including phytoplankton composition, primary productivity and new production, bacterial production, community structure and population dynamics of zooplankton, feeding pressure on phytoplankton, ecological conversion efficiencies and secondary production, and benthos and benthic productivity). Chapter 3, entitled 'Trophodynamics and dominant species shifts' covers feeding relationships and food web structure, trophodynamics in higher trophic levels, community structure and biological productivity, and influence of human activities on living resources. The last chapter focuses on two ecosystem models of the Bohai Sea: a 3-D primary production model and a box model of pelagic-benthic in ecosystem dynamics study.

Report of the 2002 PICES MODEL/REX Task Team Workshop to Develop a Marine Ecosystem Model of the North Pacific Ocean Including Pelagic Fishes: NEMURO.FISH

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The oceans' response to changes in climate may result in energy shifts from higher trophic levels to lower trophic levels, resulting in less food and consequently reduced growth rates for pelagic fish. The use of coupled lower trophic level (LTL) models that include nutrients, phytoplankton and zooplankton and higher trophic model (e.g., fish), together with long-term datasets, and defined climate change scenarios provides a way to study these changes quantitatively. In this report we describe steps the PICES MODEL Task Team has taken in coupling lower and higher trophic models focusing on North Pacific species.

The North Pacific Marine Science Organization (PICES) organizes and promotes an international science program, Carrying Capacity and Climate Change (CCCC), in the temperate and subarctic regions of the North Pacific Ocean. Ecosystem modelling is one of five key research activities defined by the CCCC Implementation Panel. The PICES MODEL Task Team is given the role to encourage, facilitate and coordinate modelling activities within the member nations with respect to the goals and objectives of the PICES-CCCC Program. At the 2000 Nemuro workshop the MODEL Task Team developed NEMURO, a LTL marine ecosystem model (see PICES Scientific Report No. 15, Megrey *et al.* 2000, and Kishi *et al.* 2001).

At the PICES IXth Annual Science Conference in Hakodate, October 2001, the REX (Regional Experiments) and MODEL Task Teams met and agreed to extend NEMURO to include higher trophic level components. Here we report the results of a joint MODEL-REX workshop. Objectives of the workshop were to: develop a bioenergetics-based fish model for Pacific herring (*Clupea harengus pallasi*) and Pacific saury (*Cololabis saira*), and couple this model with output from the NEMURO lower trophic level model developed earlier. The name of the model was chosen to be NEMURO.FISH (NEMURO.For Including Saury and Herring).

The organizing committee included Drs. Michio J. Kishi, Bernard A. Megrey (co-Chairmen) and Francisco E. Werner. Twenty-six scientists from China, Korea, Russia, Japan, Canada and the United States convened in Nemuro, Japan, between January 25 and 27, 2002, to participate in the workshop which was continued at the Frontier Research System for Global Change in Yokohama on January 29, 2002. The Heiwa-Nakajima foundation of Japan, PICES, and the city of Nemuro provided financial support.

The fish bioenergetic model. We chose to use bioenergetics/biomass modelling to represent growth of Pacific herring and saury following the approach used by Rudstam (1988) for Atlantic herring *(Clupea harengus)*. The growth rate of a non-reproductive individual is calculated as weight increment per unit of weight per time and is defined b

$$\frac{dW}{dt} = \left[C - (R + S + F + E)\right] \cdot W$$

where C is consumption, E is excretion or losses of nitrogenous excretory wastes, F is egestion or losses due to feces, R is respiration or losses through metabolism, S is specific dynamic action or losses due to energy costs of digesting food, W is the weight of the fish (g wet weight), and t is time (days). All energetic terms of the model are in units of g prey·g fish-1·d-1. Detailed descriptions of the terms and their dependencies on fish weight, prey concentration and type, water temperature, etc., are provided in PICES Scientific Report 21 (in preparation).

Linking the models. The NEMURO LTL model and the fish bioenergetics model were developed independently. Presently, the models are linked statically, i.e., only a one-way linkage exists (Fig. 1), where the NEMURO LTL model is run and the output time series of small, large and predatory zooplankton abundances are stored. These zooplankton series are used as the input file for the fish bioenergetics model. There is no feedback between the two models. In a dynamic linkage, not yet implemented, the models are fully coupled. Zooplankton prey groups will contribute to the consumption term of the fish bioenergetics governing equation and the zooplankton state variables of the NEMURO LTL will be reduced by the amount eaten by herring (i.e. negative feedback). Fish excretion and egestion wastes will be added to the nitrogen and DOM (Dissolved Organic Matter) pools, respectively which provides positive feedback to the NEMURO LTL model.

Pacific herring. Specific data for many physiological parameters of Pacific herring are lacking. The first task of configuring the herring version required modifications of the existing Atlantic herring bioenergetics model formulations and parameters of Rudstam (1988). Three main focus areas in the implementation of the Pacific herring model at the workshop were: 1) modifying temperature dependence function for consumption and cutoff temperature values where swimming speed changes in the Atlantic herring model compared to those of Pacific herring, 2) inclusion of known differences in larval and juvenile fish physiology (age-0) from adults, and 3) incorporating known seasonal changes in energy density of adult Pacific herring.

An example of the results obtained for Pacific herring is shown in Figure 2, where observed size (weight) at age is compared to size at age predicted by the herring bioenergetics model. Observed herring size at age data were taken from 1973 year class from the Straight of Georgia, British Columbia herring data (seen as age 1 in 1973 and present in the fishery until age 12 in 1984). The model includes young-of-the-year improvements, age-specific rates, multi-species (prey) functional responses, location-specific water temperature, sensitivity to temperature, and seasonal and age dependent energy densities for fish.

Pacific saury. Configuring the bioenergetics model to Pacific saury also required modification of the Rudstam's (1988) Atlantic herring model to incorporate model parameters appropriate for Pacific saury in the manner described above for Pacific herring. An additional component unique to the saury implementation is that the life-cycle of saury, a highly migratory species, requires coupling the proposed saury bioenergetics model with a three-box ecosystem model, with boxes corresponding to the Kuroshio, Oyashio, and mixed water or transition region. Initially, only an ecosystem model with one box was implemented with the same bioenergetic governing equations used for Pacific herring. Figure 3 shows an interannual multi-cohort simulation of the NEMURO.FISH saury model forced with observed environmental time series values from station A7 (Station 7 of the Akkeshi line off Hokkaido, Japan). The model results show the influence of changing interannual environmental conditions (i.e. water temperature) on the growth trajectories of different cohorts underscoring the importance of climate-change-induced environmental variability in modulating fish growth.

Future activities. Our goals over the coming months include the development of site-specific applications with improved data for the Sea of Okhotsk and Vancouver Island (for herring) and to examine the latitudinal dependence of growth in western Pacific (for saury). Initially these models will only be a one-way static link described in Fig. (1), but we also intend to implement a fully coupled dynamic link in NEMURO.FISH. The

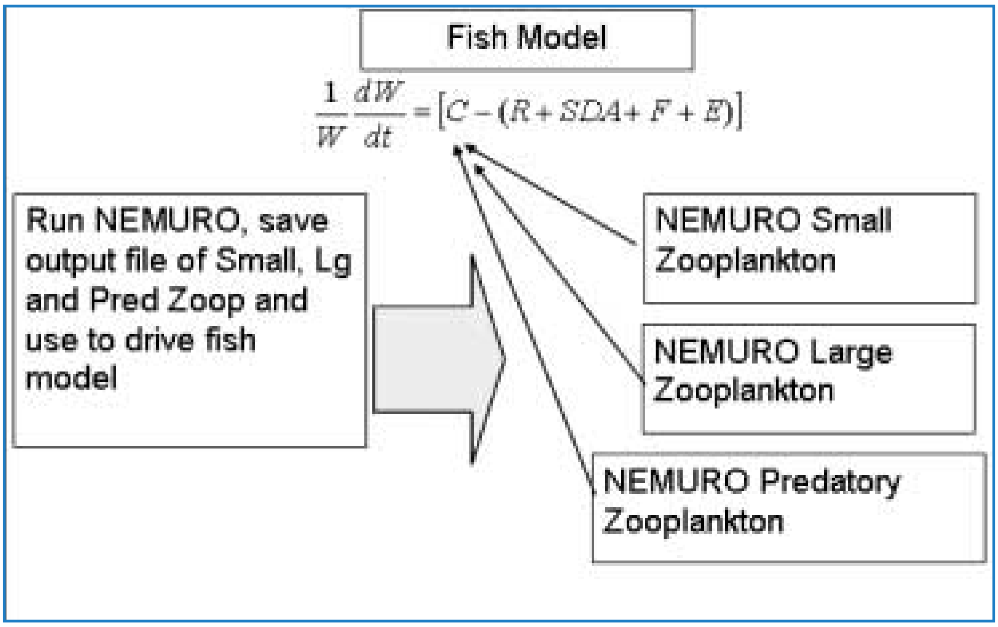

Figure 1. Static (one-way) linkage between the NEMURO LTL and the bioenergetics fish model.

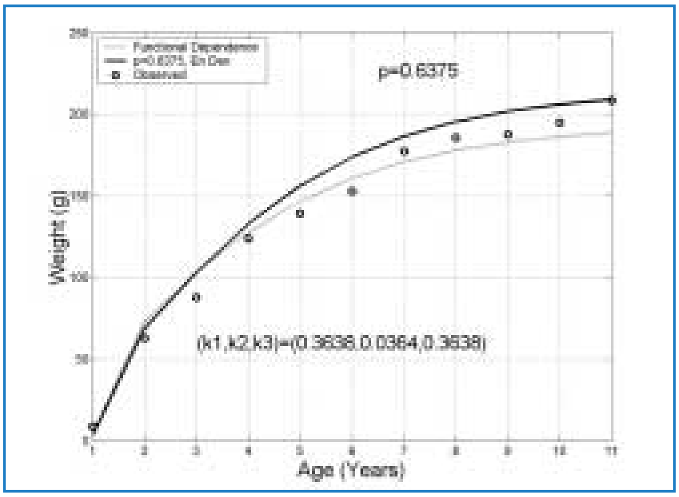

Figure 2. Example Pacific herring growth simulation (solid lines) incorporating temperature dependent growth, ingestion, respiration values (seasonal range 8-14 ºC) and the seasonal energy density (En Den) algorithm. Comparisons are made of observed size at age (circles) to different formulations of prey ingestion (line and dotted line). See PICES Scientific Report No. 21 for additional information.

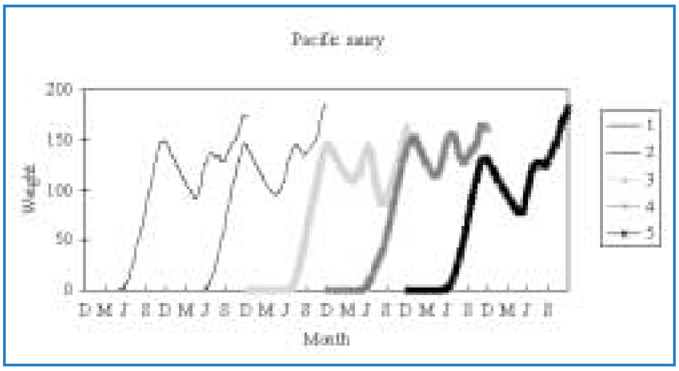

Figure 3. Result of Pacific saury bioenergetics model simulations forced with observed environmental time series over a 6 year period (1991-1996). The legend shows cohort number.

MODEL Task Team will meet at the upcoming PICES Annual Science Conference in Qingdao in October 2002. Strategies for implementation of a basin-scale version of NEMURO LTL and NEMURO.FISH is the subject for discussion at a meeting in Yokohama in January 2003.

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U.S. GLOBEC Research in the Northeast Pacific

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The Northeast Pacific (NEP) Project of the US GLOBEC Program is investigating physical and ecosystem responses to climate forcing at several spatial and temporal scales. On the longest scales, marine ecosystems in the eastern North Pacific demonstrate dramatic changes, or "regime shifts", in a number of parameters. These regime shifts are related to changes in large-scale atmospheric forcing (pressure patterns affecting winds and temperature). US GLOBEC researchers are comparing ecosystem response to these changes in the California Current System (CCS) and the coastal Gulf of Alaska (CGOA). To examine mechanisms responsible for these changes, major process-oriented studies on seasonal and intraseasonal scales are being carried out in both systems. Field years for the CCS were 2000 and 2002; for the CGOA, the major field years are 2001 and 2003. Extensive ship-based long term observation programs (LTOPs) were initiated in both systems in 1997 and will continue for the next 1-2 years as the process studies are completed. These LTOP efforts include ship-based measurements, moorings, coastal radars and satellite observations.

As part of the intensive field observations in the CCS in 2000 and 2002, multivessel operations were conducted for approximately 3 weeks each in June and August. These observations will complement LTOP cruises conducted in Feb, Apr, Jul, Sept, and Dec 2002. One large vessel was used to conduct extensive spatial surveys using a towed undulating sampler (SeaSoar) and an acoustics package to measure physical, chemical and biological conditions. Figure 1 shows a plot of chlorophyll fluorescence at 5-m from the August 2002 survey. Cold, nutrient rich water predominated near-shore -- indicative of active coastal upwelling. The spatial structure revealed by the survey fields showed strong heterogeneity at the mesoscale for nearly all fields measured (temperature; currents; phytoplankton and zooplankton biomasses estimated from acoustic backscatter and optical properties). Seabird and marine mammal abundances were also estimated by dedicated observing teams on the survey vessel and likewise showed the patchiness associated with the underlying mesoscale variability. Several bio-optical drifters were deployed by the survey vessel, which then conducted repeated optical sampling near the drifters as they advected through the mesoscale structure in the region. A second large research vessel was used for extensive station work (MOCNESS sampling; CTD casts) and to conduct experiments which evaluated rates of grazing, egg production and development of several of the key target species (copepods and euphausiids). The third vessel was a commercial salmon trawler dedicated to sampling the larger nekton and juvenile coho and chinook salmon. Fish sampling in 2000 indicated that juvenile salmon were restricted to the continental shelf and nearshore regions, with chinook being located more inshore than coho. Data from this past summer will be used to evaluate whether that pattern held true in 2002.

During the August 2002 cruise, the US GLOBEC NEP office provided a stipend to support an outreach effort in conjunction with the Hatfield Marine Science Center (HMSC) Visitor Center in Newport, OR. A high school physics teacher participated on the surveying cruise and communicated research activities to the general public through a web site (http://globec.oce.orst.edu/~jhercher/). Text, digital images and videos were posted on this web site and were also used to produce twice daily 30 minute presentations for visitors at the HMSC. The teacher is developing a curriculum lesson on coastal oceanography for high school classes based on his GLOBEC cruise experience this summer.

The 2000 and 2002 research activities provided an immense wealth of data that will take many years to analyze fully and incorporate into ecosystem models. The CCS Scientific Investigators will meet in mid-November 2002 to share their results from the field programs of 2000 and 2002 with other investigators, including those conducting modelling and retrospective analyses.

In the CGOA system, the intensive process study years are 2001 and 2003. In 2002, however, the CGOA PI's were far from idle, conducting seven LTOP cruises in which 4-5 standard sampling lines are occupied for CTD, MOCNESS, and acoustic measurements. Several moorings are in place collecting nearly continuous data on physics, bio-optics, nutrients, and in one case, bio-acoustics. In addition, five cruises are sampling juvenile salmon and other fish in the CGOA. Next year (2003) is the second, and final, major field year for the GOA. In addition to the standard LTOP activities that occurred in 2002, there will be multiship operations in May and August. One ship will conduct process and station based sampling and measure vital rates of planktonic processes (as in 2001). The other vessel will be operated in survey mode (as in the CCS) to provide maps of the alongshelf and cross-shelf spatial heterogeneity of the physical and biological fields. This will be a new activity in the CGOA. The CGOA Scientific Investigators will meet for a week in Anchorage, AK in January 2003 to discuss the logistics and coordination of the 2003 sampling and to present analyses and syntheses of previous sampling, including the 2001 field season. During the first day of the Anchorage meeting, the CGOA scientists will participate in a public symposium (an outreach effort) in conjunction with two other large research programs in the Gulf (GEM - The Gulf Ecosystem Monitoring Program of the Exxon Valdez Oil Spill Trustee Council; and SSL - the Steller Sea Lion Initiative).

Further details on the many activities of the US GLOBEC NEP program can be found on the US GLOBEC NEP website: http://globec.oce.orst.edu/groups/nep/

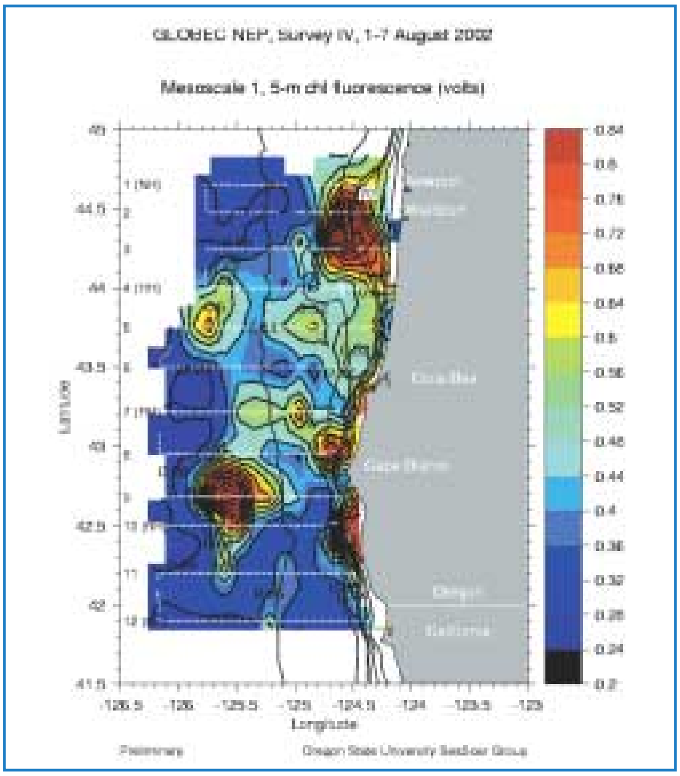

Figure 1. (Batchelder and Strub, page 28) GLOBEC NEP survey area showing Chlorophyll fluorescence.

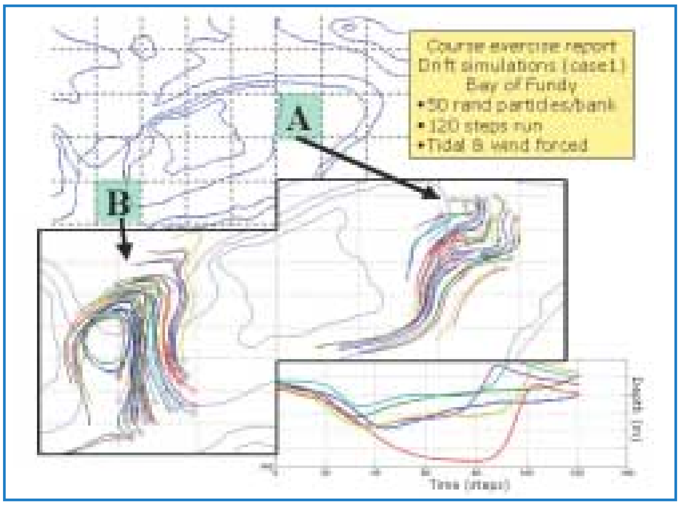

Figure 1. (Werner and Lluch-Cota, below) Horizontal and vertical particle trajectories (simulating scallop drift) over Georges Bank released at sites A and B. See Tremblay et al. (1994) for details on the study site.

Course on Coupling Physical Circulation Models and Individual Based Models held in La Paz, Mexico

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The utility of individual based models (IBMs) is that properties of ecological systems can be derived by considering the properties of individuals constituting them. Individual differences may be physiological, behavioral or may arise from interactions among individuals. The differences result in unique life histories. Recent advances in ocean circulation models that include realistic temporal and spatial variation of currents, turbulence, light, prey, etc., have enabled IBMs to be embedded in model flow fields and for unique, sometimes behaviorally modified, Lagrangian trajectories to be computed. The explicit consideration of realistic spatial heterogeneity provides an additional factor that contributes to the differentiation among individuals, to variances in population structure, and ultimately to our understanding of the recruitment process. This is particularly important in marine environments where fronts, boundary layers, pycnoclines, gyres and other smaller spatial features have been hypothesized to play a significant role in determining vital rates and population structure (e.g., see Werner *et al.* 2001).

The purpose of the course "Modelling tools for the study of larval drift processes of scallops and its influence on the availability of recruits for aquaculture (Bases de modelación para el estudio de procesos de deriva larval en pectínidos y su influencia en la variabilidad de la captación de semilla para cultivo)" was to initiate modelling applications to the study of scallops. The course was held at the Centro de Investigaciones Biológicas del Noroeste (CIBNOR), La Paz, Mexico between April 26 and May 1, 2002. The course instructors were Cisco Werner (Marine Sciences Department, University of North Carolina – Chapel Hill) and Alejandro Parés-Sierra (Centro de Investigación y Estudios Superiores de Ensenada; CICESE), with technical support from Alfredo Aretxabaleta (UNC-CH) and Carlos Pacheco (CIBNOR). Salvador Lluch-Cota (CIBNOR) was the local host, and the attendants included Eugenia Bogazzi (Argentina), Julio Moraga (Chile), Antonio Mata (Spain) and Jesús Bautista and Verónica Morales (Mexico).

Alfonso Maeda, coordinator of the sponsoring project (CYTED II.6) and researcher at CIBNOR, opened the course with a lecture on scallops recruitment variability and its consequences for fisheries and aquaculture. Further, he provided a framework on current research efforts being carried out by different Latin American and Spanish groups mainly devoted at evaluating natural population abundance and genetic flows between stocks; but recognized linking the physical coastal environment to the dynamics of the reproduction remains a main research task.

Model code was provided for modelling hydrodynamic processes, larval drift and development of IBMs based on an earlier study on Georges Bank by Tremblay *et al.* (1994). The physical model was the frequency-based finite element model "Fundy" developed by Lynch *et al.* (1992) and the particle tracking model was that described in Blanton (1995); all written in FORTRAN. Pre- and post-processing was MATLAB®-based, using tools developed by B. Blanton. These codes are also publicly available from http://www-nml.dartmouth.edu and http://www.opnml.unc.edu.

A simple but illustrative exercise was carried out by the trainees where different environmental (forcing by winds, tides and baroclinicity) and biological (sources of larvae, high and low survival areas, losses due to advection, and growth rates) scenarios were tested based on the solutions computed for the Georges Bank study of Tremblay et al. (1994). All model runs were carried out on desktop PCs running Windows. Figure (1) is an example showing horizontal and vertical drift trajectories of larvae released at two sites (A & B) on Georges Bank. See http://www.cibnor.mx/grupo/gmd/ for a more detailed report of the results and other relevant information and links.

The outcome of the course included: (a) that the students were able to assess the strengths and limitations of these approaches using already existing flow fields, imposed behaviors, etc., and (b) that they were able to determine the feasibility of implementing these methods in their own study-sites. Over the next months we intend to follow-up on the projects that this course has spawned through the creation of a website (http://www.cibnor.mx/grupo/gmd/) to promote the exchange of experiences, problems, new developments, and opportunities. We also intend to look for additional funding to build on this introductory course by incorporating new people to the group with participation of different countries and disciplines, to carry a follow-up meeting for the group already formed, and to promote work visits of scientists and students between labs.

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GLOBEC SCIENCE

A column for scientific notes of relevance to the GLOBEC community

Major reorganisation of North Atlantic pelagic ecosystems linked to climate change

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Human activities have now become so pervasive that they influence all Earth's compartments and processes. In particular, the atmospheric concentration of carbon dioxide has risen from 280 ppm (parts per million) in 1750 to 367 ppm in 1999 (IPCC 2001). The effects of this increase in CO2 concentration are very likely to be responsible for the global increase in temperature seen over the last 50 years.

Effects of both the increase in CO_2 concentration and global warming on the ecosystems have just started to emerge. These may influence organisms in a direct way by acting on the physiology (e.g. photosynthesis, Keeling *et al*. 1996, Myneni *et al*. 1997) or on the species phenology (e.g. seasonal cycle, Crick *et al*. 1997, McCleery & Perrins 1998). It may also hit biological systems through indirect ways by modifying abiotic factors, in turn affecting the spatial distribution of species.

To investigate the potential impact of climate change on marine ecosystems, a new kind of biological indicators was needed, which allow the whole community structure to be monitored. Beaugrand *et al*. (2002a) have recently decomposed the diversity of calanoid copepod, one of the best taxonomic group sampled by the Continuous Plankton Recorder (CPR) survey, into species assemblages. This decomposition was done utilising geostatistics and multivariate analyses, in combination with the method 'Indicator Values' designed by Dufrêne and Legendre (1997). At the scale of the North Atlantic basin and a spatial resolution approaching the meso-scale, nine species assemblages were identified using three criteria: (1) spatial distribution of species, (2) similarity in the seasonal variability of species and (3) diel and ontogenic variations. The nine species assemblages were closely related to a stable-biotope component or a substrate-biotope component (van der Spoel 1994). As a result, a new partition of the North Atlantic pelagic environment was outlined (Fig. 1). This led Beaugrand *et al*. (2002a) to propose using the mean number of species belonging to each species assemblage as an indicator to monitor modifications in the structural organisation of North Atlantic marine ecosystems.

Using those species assemblage indicators, Beaugrand *et al*. (2002b) have recently reported substantial changes during the period 1960-1999 in the spatial distribution of calanoid copepod assemblages at an ocean basin scale and have provided evidence that this might have been influenced by the combined effect of the climatic warming of the Northern Hemisphere and the North Atlantic Oscillation. The number of species per assemblage was used as an indicator (1) of change in the biogeographical range of copepod communities and (2) of ecosystem modification.

Maps of the mean number of species present in an area for all species assemblages (Fig. 2, see cover) demonstrate that major biogeographical shifts for all species assemblages have taken place since the early 1980s to the south-west of the British Isles and from the mid 1980s in the North Sea. The mean number of warm-temperate, temperate pseudo-oceanic species increased by about 10° of latitude. In contrast, the diversity of colder-temperate, Subarctic and Arctic species have decreased towards the north. All the biological associations show consistent long-term changes, including neritic species assemblages. These changes have been linked to Northern Hemisphere Temperature (NHT) anomalies and to a lesser extent the winter North Atlantic Oscillation (NAO) index. Other studies have also revealed a northward extension of the ranges of many warm-water fish in the same region (Quero *et al*. 1998, Stebbing *et al*. 2002). This evidence tends to indicate a shift of marine pelagic ecosystems towards a warmer dynamic regime in the north-eastern North Atlantic.

West of the mid-Atlantic ridge, especially in the Labrador Sea, the trend is opposite and the number of both subarctic arctic species has increased while the number of warm-water oceanic species has decreased (Fig. 3). This result indicates a possible move of north-west Atlantic ecosystems towards a cooler dynamic regime.

To better understand how large-scale hydro-meteorological processes may have influenced the biogeographical shifts observed in the studied area, long-term changes in Sea Surface Temperature (SST) were investigated. Figure 4 displays the first two eigenvectors and principal components representing 40.9% of the total variability. The region south of a line from 40°N, 45°W to 60°N, 5°E and especially in the West European Basin was characterized by a decrease in SST from 1960 to about 1975 and then a strong continuous increase until 1997. Long-term changes in this signal are correlated positively with NHT anomalies. In the subarctic gyre the second principal component negatively covaried with the NAO, showing a decrease until 1993 and then an increase.

This analysis suggests that the shift in north-east Atlantic marine ecosystems towards a warmer dynamic regime has been influenced by the increasing trend in Northern Hemisphere temperature. However, the positive influence of the NAO on SST in the North Sea (Dickson & Turrell 2000) must have played a synergistic role with NHT anomalies. Our results are concordant with other biological changes reported for the European region in the terrestrial realm (Beebee 1995, Parmesan *et al*. 1999, Thomas and Lennon 1999). In the subarctic gyre, the shift in north-west Atlantic marine ecosystems towards a colder dynamic equilibrium tends to be more related to the influence of the North Atlantic Oscillation.

Climate warming therefore appears to be an important parameter that is at present governing the dynamic equilibrium of pelagic ecosystems in the north-east Atlantic. If the increase in Northern Hemisphere temperature predicted by the Intergovernmental Panel on Climate Change (2001) continues, a marked change in the organization of pelagic ecosystems from phytoplankton to fish can be expected with a possible impact on biogeochemical cycles.

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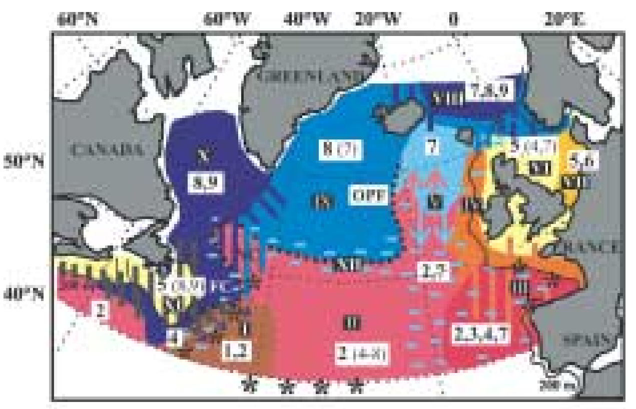

Figure 1. Scheme of the geographical position of centres of distribution of the associations, ecosystems and ecotones. A number identifies each association. In some areas such as in the Bay of Biscay, several assemblages overlap. Asterisk indicates the location where very rare species were found during the 40 years CPR sampling. Grey arrows (west of Great Britain) denote the seasonal change in the northern position of Species Association 2. Black arrows (above the Canadian shelf) indicate that extrusion of water related to the high hydrodynamics of this region happen and lead to expatriation of species belonging to assemblages 4, 5, 8 and 9 towards the Gulf Stream Extension region. The thick black dotted line indicates the position of the Oceanic Polar Front. Numbers into brackets indicate the possibility to find species belonging to adjacent species association. OPF: Oceanic Polar Front; FC: Flemish Cap; NC: Worthington's Northern Corner. Species associations 4 and 7 seasonally progress northwards with a high aggregation of species in the south in spring and in the North in autumn. Modified. From Beaugrand et al. (2002a).

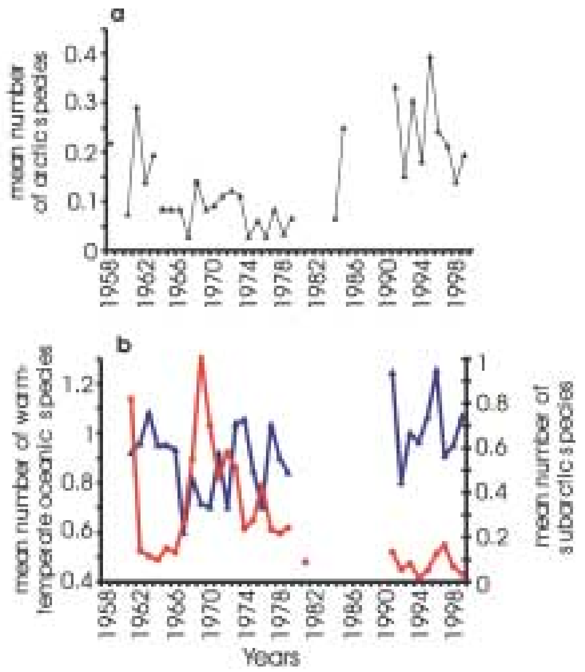

Figure 3. Long-term changes in the mean number of arctic species in the Labrador Sea (a) and the mean number of subarctic (blue) and warm-temperate (red) species in an area around the Oceanic Polar Front area (b). Modified from Beaugrand et al. (2002b).

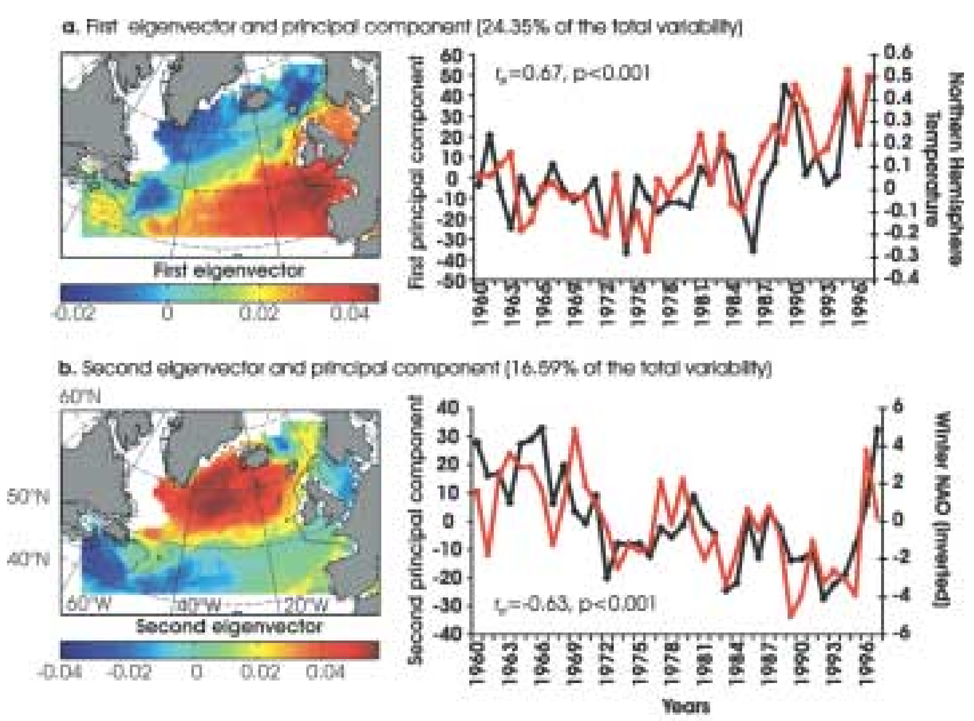

Figure 4. Standardised Principal Component Analysis of long-term changes in sea surface temperature in the North Atlantic Ocean. a) First eigenvector and principal component. Long-term changes in NHT anomalies and Pearson correlation coefficient between the first principal component and NHT anomalies are indicated. b) Second eigenvector and principal component. The long-term changes in the winter NAO and the Pearson correlation coefficient between the second principal component and the NAO index are indicated. The signal displayed by the first principal component (PC) is highly correlated positively with NHT anomalies ($r_p=0.69$, $p<0.001$). In the subarctic gyre, the values of the second PC decreased until about 1993 and then increased. The long-term change in the second PC is highly correlated negatively with the NAO index ($r_p=-0.63$, $p<0.001$). Probability was corrected to account for temporal autocorrelation using the method recommended by Pyper & Peterman (1998). Modified from Beaugrand et al. (2002b).

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The main support for this work was from the United Kingdom, the Netherlands, the Atlantic Salmon Trust, the French PNEC art 4 Programme and the EU MAST-III programme. Consortium support for the CPR survey is provided by agencies from the following countries: Canada, the Faeroes, France, Iceland, the IOC, Ireland, the Netherlands, Portugal, the United Kingdom, USA. SAHFOS is affiliated to GLOBEC.

Cod and Climate Change Workshop on Transport of Cod Larvae Hillerød, Denmark 14 - 17 April 2002

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Cod (Gadus morhua) are widespread over most shelf seas of the North Atlantic where the annual mean temperature is between about 2 and 15oC. They migrate and concentrate to spawn, often over distances greater than 1000 km. The eggs are slightly buoyant and are transported with the water masses in which they are spawned. The larvae and early juveniles remain pelagic for the first 3-5 months of life, during which time they may be carried long distances away from their spawning site. In some cases spawning occurs in areas where transport is slow or there is a gyre which retains the eggs and larvae close to the position of spawning.

The workshop attracted 25 participants from 9 countries, representing a range of disciplines. Much of the material, in the form of working documents, references, data sets and charts, was assembled on the ICES/GLOBEC website (http://www.ices.dk/globec/workshops/transport) prior to the meeting. The aim was to exchange information and ideas in advance so that the three days could be spent in discussion, synthesis and report writing.

The aims of the workshop were to:

- evaluate the effects of variations in transport during early life on subsequent recruitment
- examine the coupling of circulation models with early life history models to determine the physical and biological processes responsible for the transport or retention of cod larvae;
- develop interannual transport indices based on physical variables that reflect the magnitude of the larvae drift or retention;
- attempt to incorporate these indices into the cod assessment process;
- collate and synthesize existing direct and indirect observational information about egg and larval transport for all stocks and years

The workshop dealt with interannual variability in transport within a stock as well as transport across stock boundaries. Rapid advances in circulation models at a variety of scales have improved the prospect of developing scenarios for changes in circulation under different conditions of climate change. There are also improving prospects for operational now-casting and forecasting of circulation.

A compilation of the data on variability in recruitment and distance travelled during the pelagic stage shows no obvious relationship between them. In other words longer distances travelled do not seem to result in more variable survival. The Icelandic cod stock has the lowest variability in recruitment (coefficient of variation 39%) and the Greenland stock the highest (136%), but these two stocks are in fact linked by very regular transport of larvae across the Denmark Strait, which on average carries 17% of Icelandic pelagic juveniles to E. Greenland. Variability in survival at Greenland probably arises due to extreme temperature conditions, which are at the limit of survival for cod. This is an area where advances in coupled bio-physical modelling and observation may help to provide us with much better operational information about the conditions which young cod experience and which affect their survival. Cod which survive there not only improve the fisheries at Greenland, but the return migration of maturing fish to spawn increased the stock at Iceland by about 50 million fish per year, each weighing around 2.5kg, during the 1970s.

New information was presented about the distribution of spawning and of larvae off W Greenland during the period 1961-1970, when the stock there was very large. An analysis of drogued drifters (at 15m) also gave a velocity field, which suggested that the likely destination for many of the larvae off Greenland at that time may have been Hamilton Bank, off the coast of Labrador. This, and a number of similar piece of evidence, raises intriguing questions about the connections which there may be between stocks in different areas.

The workshop recommended that model flow fields should be used more extensively to run particle tracking simulations with initial distributions based on the observed occurence of cod eggs and larvae. In addition to investigating possible trajectories and their variability from year to year, the models should track the evolving temperature fields, which the developing cod experience.

The Workshop report will appear as an ICES paper (ICES CM 2002/C:13). Please contact Keith Brander (keith@ices.dk) for further information.

GLOBEC Focus 4 Workshop Report: "Global Changes In Marine Communities: Who Done It?"

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Rosemary Ommer, University of Victoria, Victoria, Canada (ommer@uvic.ca)

PHOTO. Participants at the workshop. Back row, left to right: Ujjayant Chakravorty, Manuel Barange, Nigel Haggan, Patrick Lehodey, Cisco Werner, Mike Brklacich, Ian Perry. Front row, left to right: Rosemary Ommer, Molly McCammon, Barbara Neis.

The goal of GLOBEC is to "advance our understanding of the structure and functioning of the global ocean ecosystem … and its responses to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change". For the most part, "global change" has been interpreted to mean "climate change", and the majority of GLOBEC activities to date have examined marine ecosystem responses to natural climate variability and change. But for many places the more immediate causes of change, at least to fisheries systems, are direct human interactions such as contaminants, habitat degradation, and intensive fishing. The big challenge for GLOBEC will be to distinguish between ecosystem changes caused by the impacts of climate change, and those due to direct human interventions. In addition, there are important feedbacks from changes in marine systems (whether caused by the natural or human drivers) which affect human communities and societies. Examples include the societal impacts of the collapse of the northern cod off Newfoundland and Labrador, the social transitions resulting from shifts in the composition of marine resources in historical Greenland, and the implications to the fishery and to society of effective dissemination of climate information in Peru during the recent El Nino.

Ecosystem, and human societal, changes are usually investigated by separate disciplines, which tend to examine only one set of circumstances, e.g., natural scientists consider the impacts of fishing on marine ecosystems, whereas social scientists consider the societal impacts of changes in fisheries resources. Human – marine ecosystem interactions are, however, bi-directional. This is recognised in the GLOBEC Implementation Plan (GLOBEC 1999), under its Focus 4 "Feedbacks from changes in marine ecosystem structure". However until now this Focus has remained under-developed. In order to more forward with this topic, in particular with Activity 4.3 on "Social impacts from changes in marine ecosystems", GLOBEC convened a planning workshop with the theme: "Global changes in marine ecosystems and coastal communities: Who done it?". The objectives of the workshop were:

(1) *To define the key questions regarding marine ecosystem changes and human society interactions; and*

(2) *To develop proposals to address issues of marine ecosystem changes and human society interactions.*

The workshop was held 26-28 June 2002 at Dunsmuir

Lodge, Sidney, BC, Canada. There were 10 participants at the meeting (see photo), with an additional two who participated by correspondence before and after the workshop. The disciplines represented included physical and biological oceanography, fisheries, economics, environmental studies, marine policy and public affairs, sociology, anthropology, and history. A complete report describing the workshop results and brief summaries of the presentations made by the participants is available on the GLOBEC website under Focus 4.

Working Group Goal

The goal for this Focus 4 activity was recommended as:

1) *To understand the interactions between marine coastal communities and global changes in marine ecosystems;*

2) *To understand the capacity of these communities to adjust to these changes;*

3) *To understand the consequences of these adjustments for marine ecosystems.*

It was agreed that the initial, although not exclusive, focus should be on "coastal communities". Societal impacts of marine ecosystem changes may be felt much more broadly than in just the coastal communities, but it is in the coastal communities that the impacts are felt first. It is also these communities which have a long tradition of working with the marine environment, and hence a depth of ecological knowledge of it.

Central Questions

Changes in marine ecosystems occur continuously, on a variety of temporal and spatial scales. Some are so short that they go unnoticed by human observers, whereas others may be longer than a human generation, in which case they also often go unnoticed, except perhaps in societies with a long tradition of marine observations, such as do First Nations. All marine ecosystem changes may be classified as either:

i) not apparent to coastal communities;

ii) apparent but not detrimental to coastal communities;

iii) not apparent but eventually detrimental to coastal communities; or

iv) apparent and detrimental to coastal communities.

"Apparent" has an implicit time scale, which for this discussion can be taken as annual to decadal, i.e., a human working life span. There is a need to identify the types of marine ecosystem changes which fall into each of these categories – and the same type of ecosystem changes may be placed in different categories depending on the structure of the coastal community or human society which interacts with the change. Note that categories (i) and (ii) represent *resilience* to marine ecosystem changes on the past of coastal communities, whereas categories (iii) and (iv) represent *vulnerability*. These concepts are represented in Figure 1 (modified after M. Brklacich, pers. comm., Carleton University, Ottawa, Canada), in which the degree of marine ecosystem change is balanced against the ability of the community to cope with these changes. In the top panel, the coping capacity of the community for marine ecosystem change is large and the change relatively small, so that there is little negative impact ("resilience"). The bottom panel, however, represents a situation of large marine ecosystem change, perhaps due to climate changes or intensive fishing, where the ability of communities to cope with these changes has decreased, perhaps due to loss of technical capabilities to catch different species of fish or to migrations of young people out of the community. The result in this case is severe impacts, i.e. "vulnerability".

These points lead to two key questions:

1) How do marine ecosystem changes affect coastal communities?

a) What types of marine ecosystem changes create these different responses as defined above?

b) What are the strategies (as either conscious responses or innate characteristics) on the part of coastal communities that lead to resilience or vulnerability to marine ecosystem changes?

2) What are the reciprocal effects of human responses on marine ecosystems?

a) When and under what conditions might coastal community responses to marine ecosystem changes exacerbate, intensify, or ameliorate these changes in marine ecosystems?

b) What are the characteristics of, or mechanisms within, marine ecosystems that result in vulnerability or resilience to these human responses to change?

Issues

The process of addressing these questions raises a number of significant issues.

Scale

Identifying the appropriate spatial and temporal scales for analyses of these problems is a major issue. The importance of scale is recognised in ecological problems and in social research. Valid questions include: what are the scales at which marine ecosystems and coastal communities interact? How do different groups or users perceive and use "scale", e.g. among oceanographers, biologists, fisheries managers, economists, business, and communities? There is also likely to be a mismatch of the scales of environmental change compared with the scales on which human systems have the ability to change and adapt. There is the further problem of "down-scaling": how to ask global-scale questions when the issues may be locally-based.

Knowledge

Knowledge issues can be critical for decision-making. There are various forms of knowledge systems, some of which may be "open", i.e. generally not based in a particular group, whereas others may be group or culturally-based and not usually shared outside of the group. One of the central roles of GLOBEC is to generate, interpret, and convey information and, ultimately, knowledge of the marine environment. How this is best done, whether through public fora or through intermediaries such as marine resource managers, is an unresolved question. Knowledge of the marine ecosystem and its changes ultimately relates to the resilience and coping strategies of human societies to offset or adapt to these changes at community, regional, national and global scales. Combining these various knowledge networks is likely to result in much greater collective understanding of responses of the marine and social systems to global changes, and therefore provide an opportunity to improve policy and decision-making.

Tools and Units

The tools and units that are used to derive observations are often significantly different among marine natural scientists, social scientists, and coastal communities. Some understanding of the scale, tools, and units used by each group is necessary to facilitate communication. Models are highly simplified but useful tools to help frame issues and to facilitate the integration of many of the natural science observations. These include coupled biophysical models, trophodynamic models, and economic models which examine socio-economic responses to changes in marine ecosystems. Other tools include mapping of local ecological knowledge, especially when it is integrated over many communities and over time. The results of mapping can be included into models to further integrate this information with that derived from other sources.

Values

What value to place on various aspects of the natural and human environments is an extremely difficult question. Ultimately it is probably a "political" and ethical question to be resolved by discussion and understanding. For example, how does one assign value to various marine ecosystem states? Is an ecosystem state which supports cod inherently "better" than a state which supports crabs and shrimp? In economic terms, the problem is to determine the discount rates (i.e. what value to put on

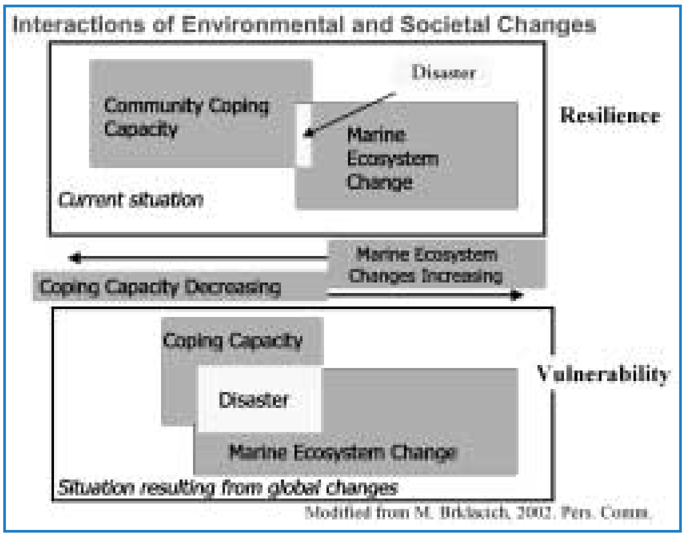

Figure 1. Diagram illustrating the concepts of community coping capacity and marine ecosystem change. Modified from M. Brklacich (pers. comm.).

future resources). There are the further problems of potential cultural differences in discount rates (or even whether other groups discount the future value), and that different social groups are likely to value the marine ecosystem in different ways.

Working Group Approach

Considering the goal, central questions, and issues described above, the Workshop determined that an approach which included the following elements would be most appropriate to make progress on this theme of marine ecosystem change and human societies:

1) Develop a review/appraisal paper on the topic "What are the impacts of marine ecosystem changes on coastal communities?". This would examine what has been done on these issues and determine the critical gaps, methodological issues, etc. The most appropriate approach would be to select case studies, which might include: Pacific tuna (several species); the Arctic; Peru and changes induced by El Nino oscillations; NW Atlantic groundfish collapses and replacements by invertebrates; NE Pacific, including changes among groundfishes, invertebrates, and large pelagic species (e.g. salmon); Lofoten Islands and large whales; Atlantic herring and historical changes recorded by the Hanseatic League; small pelagic fisheries fluctuations in California and South Africa/Namibia.
2) Explore the "significant issues" in detail, starting with the issue of scale.
3) Develop models which couple marine ecosystem changes with the socio-economic system, to begin to explore potential changes and their outcomes and consequences to coastal communities.
4) Develop a series of activities for the Focus 4 Working Group at international meetings, which will advance and explore these issues and will develop collaborations with other disciplines and international global change programs. An active series of possible meetings has been proposed.
5) Develop active links with relevant programs, in order to gather information and experience for Focus 4 projects, and to facilitate exploration of these issues by these other programs. Appropriate programs include Coasts Under Stress (Canada) for the Northeast Pacific and the Northwest Atlantic; Exxon Valdes Oil Spill/Gulf Ecosystem Monitoring program (Alaska) for the Gulf of Alaska and Northeast Pacific; Global Environmental Change and Food Security (IGBP, IHDP) to co-participate in exploring these issues with small pelagic fishes in Peru; and other IHDP global change programs including Global Environmental Change and Human Security, and the Institutional Dimensions of Global Environmental Change.
6) The centrepiece of the work of Focus 4 should be a major inter-disciplinary symposium on this topic, e.g. loosely defined as "Natural and human societal

implications of large-scale changes in marine systems". The format remains to be developed, but might include selected case studies to contrast and compare ecosystem changes and human societal interactions. Tentative timing would be in late 2004 or early 2005.

Next Steps

The next meeting of the Focus 4 Working Group was chosen as Banff, Alberta, Canada, in conjunction with the 3rd IGBP Congress, in June 2003. Your thoughts and expressions of interest in these topics are welcome, either to the GLOBEC IPO or directly to one of the Focus co-chairs.

Online Data Portals: Organizing ocean data for the scientific community*

NASA's Global Change Master Directory, Greenbelt, MD USA, holland@gcmd.gsfc.nasa.gov

** Modified from a paper presented at the Seventh International Conference on Remote Sensing for Marine and Coastal Environments, Miami, Florida, 20-22 May 2002.*

Finding data related to ocean science online can be an overwhelming task while using internet search engines. Although search engines adequately provide links to ocean related web sites, finding appropriate links to data sets can be laborious. Conducting a search for ocean data using NASA's Global Change Master Directory (GCMD), an online Earth science directory (http://gcmd.nasa.gov), explicitly provides data set sources, direct access links to data sets, and additional Earth science resources.

The GCMD's "search engine" directs users to over 3,000 ocean data set descriptions and over 10,634 Earth science descriptions. The search for ocean data (as well as other Earth science data) is a simple task when using the GCMD. Searching from the GCMD home page allows users to select from controlled keywords or search using free-text. The data descriptions within the GCMD comprise a collection of metadata fields, which provide specific information about the data. Metadata, defined as data about data, distinguishes how, when, and by whom a particular set of data was collected, and how the data are formatted (Webopedia, 1997). The metadata standard used to create the records within the directory is based on the Directory Interchange Format (DIF) (Olsen, 2002).

The controlled keyword search is based on a hierarchical set of Earth science keywords. Each metadata record, has one or more keywords to ensure that the user can find a data set of interest. The controlled keyword search includes a topical list of Earth Science categories (*Agriculture, Atmosphere, Biosphere, Human Dimensions, Hydrosphere, Land Surface, Oceans, Paleoclimate, Radiance/Imagery , Snow or Ice, Solid Earth, and Sun-Earth Interactions*). Choosing the Oceans topic keyword from the homepage narrows the search to ocean terms that are arranged in a hierarchy (http://gcmd.gsfc.nasa.gov/Data/portals/gcmd/param_search/OCEANS.html). The number of records, as well as a definition, are displayed for each of the terms. An icon ℹ, provides a link to the definition for the ocean term.The free-text search provides an option for a user to search the GCMD using any term(s). A query from the free-text search simply requires typing a descriptive word or phrase within the free-text box on the home page. An enhanced free-text search allows Boolean, fielded, geospatial or temporal searches.

DATA DESCRIPTIONS

The data set description presents pertinent information to help the user determine if the data may be relevant for their research interest. A complete list of the types of descriptors (DIF Fields) that may be used within a data set description are documented in the DIF Writer's Guide Version 8 (http://gcmd.nasa.gov/User/difguide/difman.html). Two display formats, the *Brief Record* and the *Full Record* are available to the user. Within the *Brief Record*, the interface display includes only the *Summary*, the *Data Center*, the *Data Set Citation*, the *Geographic Coverage* and the *Related_URL* sections. The *Full Record* display includes additional detailed descriptors, which may clarify or expand upon the information about the data set.

Through the controlled keyword search, resulting DIF records can be navigated using a tabbed layout. The tabbed layout provides the option to display the *Full Record*, specific segments of the DIF (i.e. *Distribution, Attributes, Coverage, and Personnel*), or an option to update the record using an online DIF modification tool (see Figure 1).

Figure 1. DIF Tab Layout

The user can expand their search within the record using hyperlinked fields that are associated with other data set descriptions within the GCMD database. For example, parameters are hyperlinked within the DIF to include a link to all of the data sets that have the same parameter

ACCESS TO DATA

Accessing data is possible through the Related_URL field within the record. Through this field, the user can directly link to the data. Providing direct access to the data source enables the user to locate additional data set related resources outside of the GCMD website. The

Related_URL field provides the URL, a description about the URL, and a URL_Content_Type field where appropriate. Another way the GCMD provides access to data is through the *Data Set Citation* field. The *Data Set Citation* for the data set properly credits the data set producer.

PORTALS : COMMUNITY BUILDING

Customized subset views of the GCMD ("Portals") have made it easier for partner organizations to maintain and document their data sets in one place, without duplicating the effort to create another online directory. The GCMD has recognized the importance of customization for participating organizations and is generating subset views of the directory through a simple "niche portal". The term "niche portal"(or vertical portal; vortal) describes a website that caters to a given demographic (Kleinschmidt *et al*, 2001). "Niche portals" have increased in popularity and have been identified as "natural community building machines" (Ozersky, 2000). The integration of customized portal searches with the ability to organize data make the portal a powerful tool (Ozersky, 2000). GCMD offers customized subset views for the following partners

(http://gcmd.gsfc.nasa.gov/Data/portals/index.html):

- Antarctic Master Directory (AMD), Joint Committee on Antarctic Data Management (JCADM)
- The Committee on Earth Observation Satellites (CEOS)
- Climate Variability and Predictability (CLIVAR)
- The Distributed Oceanographic Data System (DODS)
- The Earth Science Information Partners (ESIP)
- **The Global Ocean Ecosystems Dynamics programme (GLOBEC)**
- The Global Observation of Forest Cover (GOFC)
- The Global Observing System Information Center (GOSIC) (including G3OS; the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), and the Global Terrestrial Observing System (GTOS))
- The Rosenstiel School of Marine and Atmospheric Science (RSMAS)
- The World Data Centers (WDCs).

Two of the largest ocean-related data providers are GLOBEC and DODS. The GLOBEC and DODS portals are used as a metadata directory, ensuring long-term stewardship for related data set descriptions (GLOBEC, 1999).

GLOBEC

The common interest in global change data management has attributed to the international collaborative effort between GCMD and GLOBEC. GLOBEC data managers decided to use the GCMD as a metadata inventory as a secure way of preserving a record of the results and achievements of the GLOBEC program (GLOBEC 1999). GLOBEC 's portal is used within the international GLOBEC website (http://www.globec.org) as a key resource in disseminating information to their scientific community (GLOBEC 2002). The GLOBEC data policy includes the adoption of the DIF metadata format as the recommended format for all data set descriptions. Currently, over 110 metadata records have been contributed to the portal by using an online tool (DIFBuilder). DIFBuilder prompts the user to enter in required fields to create an online data set description. The DIFBuilder tool is available on the GCMD website (http://gcmd.gsfc.nasa.gov/cgi-bin/difbuilder/difbuilder).

The success of the portal can be attributed to the high quality of metadata, and its open accessibility to the GLOBEC community. The GLOBEC portal can be accessed online here:
http://gcmd.gsfc.nasa.gov/Data/portals/globec/

CONCLUSION

The GCMD continues to assist the scientific community in the discovery of and linkage to Earth science data, as well as to provide data holders a means to advertise their data to the Earth science community (Olsen, 2002). The ocean science portal is effectively serving the GLOBEC community by increasing the visibility of their data holdings. The GCMD staff is working with other ocean related organizations including: Distributed Oceanographic Data System (DODS), Rosenstiel School of Marine and Atmospheric Science (RSMAS), Global Observing System Information Center (GOSIC), and Antarctic Master Directory (AMD), Joint Committee on Antarctic Data Management (JCADM). The customized subset views of their datasets descriptions are also available (http://gcmd.gsfc.nasa.gov/Data/portals/index.html).

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SAHFOS PAGE

SAHFOS AND THE CPR SURVEY

Use of CPR derived plankton indicators to monitor response of pelagic ecosystems to climate change

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The biodiversity of marine ecosystems is being altered by many human-induced factors including overexploitation of marine resources, chemical pollution, physical alterations, eutrophication and invasion of exotic species. Human alterations of the marine environment are difficult to quantify. Although it does not seem that the extinction rate is as evident in marine ecosystems as it is on land, evidence is growing that the resilience of marine species and ecosystems is not as great as previously thought. Substantial extinction may have already occurred in marine ecosystems and simply remained unnoticed because of the difficulty of investigating this environment.

With this multitude of direct or indirect anthropogenic influences, in addition to the confounding effects of the natural variability of the marine environment related to hydro-climatic forcing, managing marine ecosystems and achieving sustainable exploitation represents a real challenge.

The Continuous Plankton Recorder (CPR) survey has monitored more than 400 species or taxa on a monthly basis since 1946 in the North Atlantic Ocean. It is, therefore, possible to derive many kind of plankton indicators, which can be used over extensive spatial coverage and time scales. Species indicator, indicator of primary and secondary production have been often used from the CPR survey. But more recently, new kind of plankton indicators have been developed. Indicators of dynamic regime of ecosystems (e.g. diversity indicator of a taxonomic group) are very sensitive to subtle changes in the ecosystems. For example, the major change seen in the copepod composition and abundance in the North Sea after circa 1987 is detected using an index of species diversity of calanoid copepod (Fig. 1).

Species assemblage indicators have also been developed (see Beaugrand *et al.,* this issue). The indices have shown that the regime shift in the North Sea may be part of a larger-scale feature which may have started at the beginning of the 1980s over the region of the Bay of Biscay and have then progressively spread northwards until 60°N in the mid 1980s when it may have contributed to trigger the regime shift in the North Sea. This type of indicator may allow such catastrophic (meaning of the mathematical theory of catastrophe) changes to be forecast. It is argued here that the concept of species assemblage indicators should be more largely used. It is rich in information and sensitive. Furthermore, it may lead to a better understanding of the resilience of North Atlantic pelagic ecosystems and thus allow future changes to be anticipated.

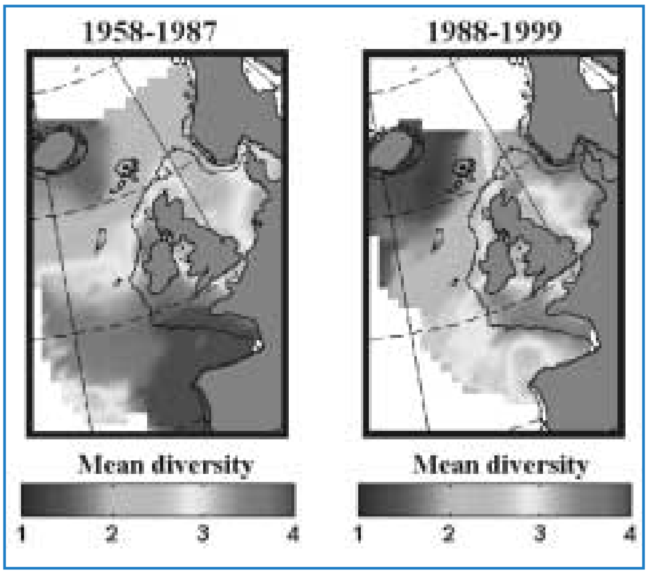

Fig. 1. Mean diversity of calanoid copepod around the United Kingdom

Based on about 180,000 samples collected by the CPR survey, these indicators are being implemented into a geographical information system which will allow monitoring of pelagic ecosystem in the context of climate change using an extensive range of both spatial and temporal scales.

GLOBEC CALENDAR

2002

9-13 September 2002: 10th Biennial and Centenary Conference of the Challenger Society for Marine Science. Plymouth, UK.

1-5 October 2002: 26th SCOR General Meeting. Sapporo, Japan. Invitation Only.

1-5 October 2002: ICES ASC (ICES Centenary). Copenhagen, Denmark.

13-14 October 2002: GLOBEC WG Meetings. Qingdao, P.R. China. Invitation Only.

14 October (pm) and 19-20 October 2002: GLOBEC SSC Meeting. Qingdao, P.R. China. Invitation Only.

15-18 October 2002: OSM2 - 2nd GLOBEC Open Science Meeting. Qingdao, P.R. China.

19 October (am) 2002: Joint GLOBEC Foci WG/PICES Task team Meetings. Qingdao, P.R. China.

21-26 October 2002: PICES XI. Qingdao, P.R. China.

November 2002: NATFISH Annual Meeting. Mauritania.

9-11 December 2002: IOC/SPACC Study Group Workshop on Use of Environmental Information on the management of pelagic fish populations. Paris, France. Invitation Only.

2003

7-10 January 2003: OCEANS Open Science Meeting. Paris, France.

13-17 January 2003: GLOBEC-NEP/CGOA Symposium on Marine Sciences in the Northeast Pacific: Science for Resource Dependent Communities. Anchorage, Alaska.

April 2003: LOV/IOC Workshop on Regime Shifts. Villefrance-sur-mer, France.

April 2003: BENEFIT-GLOBEC Forum 2003. Swakopmund, Namibia.

Spring 2003: GLOBEC-ICES CCC Synthesis Workshop. TBA

5-8 May 2003: 3rd JGOFS Open Science Meeting - A Sea of Change: JGOFS accomplishments and the Future of Ocean Biogeochemistry. US National Academy of Sciences, Washington D.C., USA.

21-23 May 2003: GLOBEC-PICES-ICES Zooplankton Production Symposium. Gijón, Spain.

19 and 24 June 2003: GLOBEC SSC Meeting. Banff, Canada. Invitation only.

19-24 June 2003: IGBP Congress. Banff, Canada.

15-19 September 2003: International Conference on Earth System Modelling. Hamburg, Germany

GLOBEC INTERNATIONAL

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