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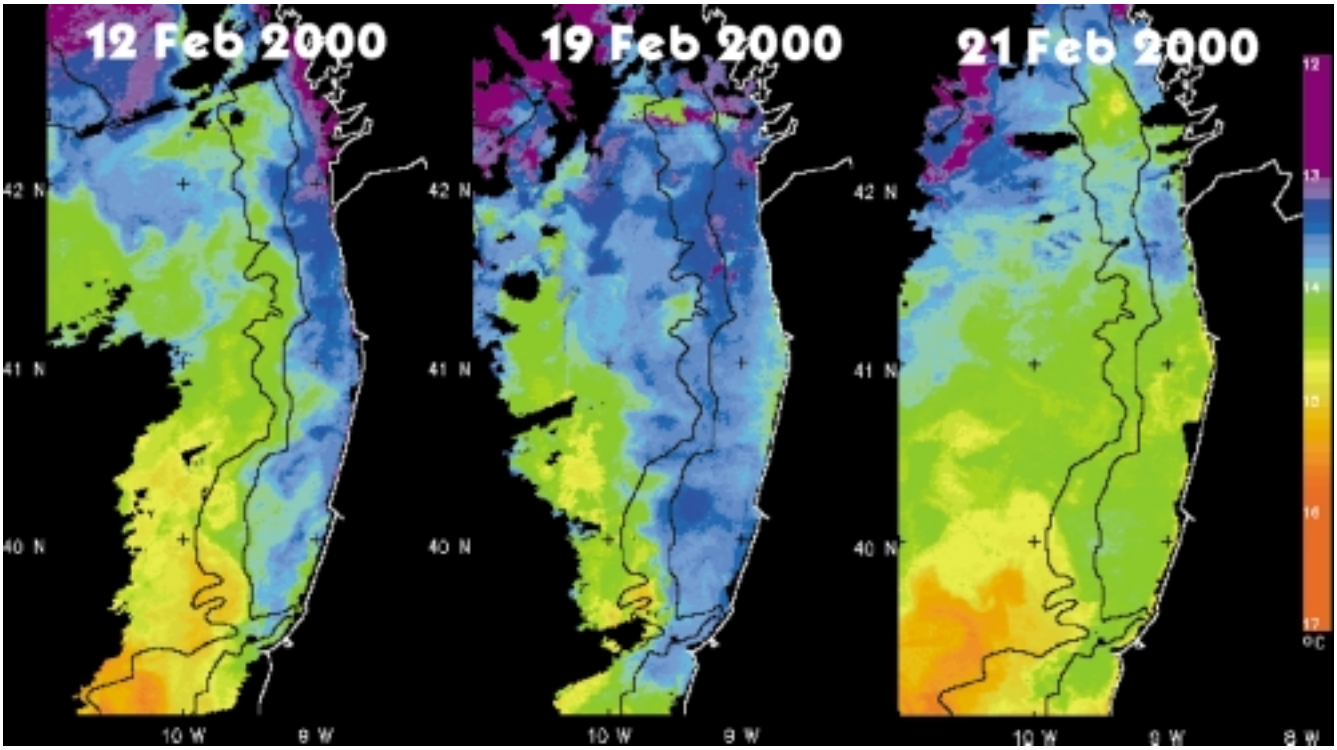
EDITORIAL

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

Welcome to the second issue of the GLOBEC Newsletter of the current year. You will notice that we now have full colour on front and back pages, to accommodate research news that may benefit from it. Through this innovation we intend to increase the scientific content of the Newsletter. As you know this publication is open to research news and scientific articles from any GLOBEC researchers, but please contact us with sufficient time if you plan to submit articles that require full colour, so that we can plan ahead. In the last issue we reported on new GLOBEC national programmes in Portugal and the United Kingdom. We now welcome national activities in Italy and Mexico, a sure sign of the steady growth of our programme. By the time you read this Newsletter we would have activated three of our Foci working groups. These WGs should distil the work of our national and regional programmes towards a GLOBEC synthesis. In the process they are planning a suite of activities that are sure to capture the interest of the GLOBEC community. Please contact the IPO, or the Chairs of the WGs, if you wish to participate in some of these activities. To facilitate this communication we are printing a full membership list of all GLOBEC committees in this Newsletter. It should be useful beyond reflecting the enormous calibre of the scientists backing the programme. You will also note that we have created a new column in the Newsletter, named GLOBEC Science, to disseminate new ideas, review specific topics, and offer advice on statistical issues of common concern. I would like to use this opportunity to invite you to read it, and submit your own articles. Through these selected items, and indeed the full Newsletter, you will notice how GLOBEC is developing. I hope you will find this as exciting at we do at the IPO.



The development of an unusual winter upwelling event off Portugal, during a recent cruise of the GLOBEC Portugal team. See p. 5 for a full story.
Pictures courtesy of Steve Groom, Plymouth Marine Laboratory, UK

GLOBEC IPO - Changes

The IPO in Plymouth continues to develop, and as part of this evolution there are inevitably staff changes. This September sees the departure of Andrea Watson who is returning to college to study web-site design at Plymouth College of Art and Design. Andrea has been Media Co-ordinator for the past three years, and during that time has made great contributions to the development of the IPO. The GLOBEC web-site has been transformed, six issues of the Newsletter have been published, GLOBEC Reports and a GLOBEC leaflet produced, all under Andrea's guidance. In addition she worked closely with Lisa Cronqvist in Stockholm on the efficient publication of the Implementation Plan. Andrea has participated in the IPO meeting at Durham, New Hampshire, the IGBP Congress at Shonan Village, and the recent SC-IGBP meeting at Cuernavaca, Mexico. Through these, and other contacts, the GLOBEC SSC and other members of IGBP have come to know Andrea for her lively, good humoured, and enthusiastic approach. Andrea has been an important part of the IPO, and will be greatly missed. All her many friends in the GLOBEC community will join us in wishing her well in her new life as a student, confident that her studies will still allow time for her love of surfing on the Atlantic beaches of Cornwall.

Roger Harris, Chairman GLOBEC SSC

As soon as we were informed of Andrea's plans the IPO worked hard to ensure that her departure would cause as little disruption as possible. The consolidation of the IPO also required a re-distribution of duties, and thus we decided to appoint an Office Manager instead of a Media Co-ordinator. After some searching we are sure to have found the right person in Charlotte (Lotty) Ireland. Lotty has an HND in Business and Finance from the University of Plymouth, and has been working at the Finance Section of the Plymouth Marine Laboratory for almost two years. During this period she has demonstrated her reliability and effectiveness as an administrator, and is one of the most popular employees at the PML. Lotty is a keen traveller, having spent a year working and travelling in Australia, two summers in the Isles of Scilly and a few wet winters in England in between. I am told that she plays guitar, clarinet and saxophone, which may come useful during meetings of the Scientific Steering Committee; you just never know. As Office Manager Lotty will be your first contact at the IPO, reachable at cji@pml.ac.uk, or at the usual GLOBEC address, globec@pml.ac.uk. On behalf of the GLOBEC community we welcome Lotty on board and wish her good luck.

Manuel Barange, Director GLOBEC IPO

CONTENTS

NEWS FROM THE REGIONAL PROGRAMMES

Report of the Meeting of the GLOBEC/ICES Working Group on Cod and Climate Change

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and Geir Ottersen, University of Oslo, Norway (geir.ottersen@bio.uio.no)

In 1998, the GLOBEC/ICES Working Group on Cod and Climate Change (WGCCC) outlined a 5-year strategic plan that consisted of 7 major objectives:

1. to incorporate environmental information into fisheries management strategies and planning;
2. to examine past events as a means of understanding the links between in the environment and fisheries;
3. to understand the role of zooplankton in determining the variability in cod abundance and production;
4. to undertake comparative studies of life history strategies and interannual variability in growth, distribution, and abundance between cod stocks
5. to understand and predict climate variability and its associated ecosystem response;
6. to ensure that environmental and fisheries data are easily and widely available; and
7. to provide a synthesis of the research information obtained on cod stocks

A number of activities were carried out under this plan including a workshop on the gadoid outburst in the North Sea in March 1999, a theme session on Bio-Physical Modelling at the ICES Annual Science Conference (ASC) in September 1999 and a workshop on the Dynamics of Cod Growth in May 2000. A theme session on Climate-Plankton-Fish Linkages, will be conducted during the 2000 ICES ASC.

A meeting of the WGCCC was held at Dartmouth in Nova Scotia, Canada on May 11-12, 2000, immediately following the workshop on cod growth.

While the WG generally agreed that there had not been enough time to fully digest all of the results and information from the workshop, two proposals were made. First, it was felt that the use of otolith back-to determine of the growth history of cod should be pursued. Historical otolith collections offer great potential to obtain time series of cod growth. Also reductions in the cost per otolith make i feasible to mount a pan-Atlantic study. It is hoped to raise the issue of such a study at the fall EUROcean 2000 Meeting in Hamburg. In addition, the WG decided that a theme session on the growth of gadoids should be proposed for the 2001 Annual Science Conference in Oslo with Drs.Marshall (Norway), Dutil (Canada) and Buckley (USA) as co-convenors. This will allow some of the results from the workshop to be exposed to a wider audience and to broaden the general discussion of growth in gadoid populations.

The WG felt that much new information on cod had appeared since the Cod Symposium held in Reykjavik, Iceland in 1994 and that a new synthesis was warranted. It was decided to attack it on several fronts. First, the WGCCC will continue to assemble cod data, making them available on the web and on a CD. Second, a review will be carried out into possible means of incorporating our present knowledge of cod into the assessment process, such as using Caddy's Traffic Light Approach. Third, a recommendation will be made to ICES at its 2000 ASC to hold a Symposium on Climate Variability and its Effects on North Atlantic Fisheries in Bergen during 2004. Finally, a decision was taken to write a book summarizing all of the information to date on cod with emphasis on comparing different stocks. The WG endorsed this as a multi-year project, and will endeavour to secure such funding during the coming year. M. Heath (UK) has agreed to lead the effort with support from K. Frank (Canada).

Building upon the discussion and recommendations of the Workshop on the Application of Environmental Data in Stock Assessments (Bergen, March 1998), a follow-on workshop to focus upon a case study was proposed by the WGCCC as part of its original 5-year plan. Using the West Greenland/Iceland cod example, models of the circulation would be used to develop transport indices for possible incorporation into fisheries management models. A wide-ranging discussion was held on this proposed workshop. Some WG members noted that there had been several publications on the connection between Icelandic and West Greenland cod and questioned the need for further work on this topic. Others replied that while these studies provided a good qualitative description they are unable to help us predict future states. The aim of the workshop would be to determine if predictions were possible through the development of ocean circulation models and subsequent derivation of a larval transport index. The WG agreed that efforts should be made to involve assessment biologists in the workshop, to ensure the usefulness of such a workshop to management. Larval drift has been hypothesized to be important in areas elsewhere than Iceland/West Greenland and it was suggested that the workshop should be extended to other geographic areas, including, the Gulf of Maine (between Browns and Georges Banks and Georges and the Middle Atlantic Bight), Davis Strait (West Greenland to Labrador) and around the Faroes. This would allow broader discussion on the general transport strategy as well as comparisons between stocks. The WG therefore decided to hold a workshop on larval cod transport processes with emphasis upon the Iceland, West Greenland connection but with examples from other areas where larval transport is considered important. Planning for the workshop will occur during the upcoming year and the meeting scheduled for the spring of 2002.

New SPACC Executive Committee

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

At the onset of the SPACC programme three major planning meetings were held in La Paz (Mexico), Swakopmund (Namibia) and Mexico DF (Mexico), at which point a number of working groups were established (see GLOBEC Report 11). These working groups were given autonomy to generate their own activities, supported by the chairs of the programme, Drs Alheit (Germany) and Hunter (USA). To review the achievements of the programme and evaluate its implementation strategy a small panel of SPACC scientists met in La Jolla, USA, March 2000. Their review was based on the list of activities and programme results, as well as the responses to a questionnaire circulated amongst the chairs of the existing SPACC working groups.

The panel acknowledged that SPACC had been very active in some regions, but that the development of working group activities had been uneven. Major reasons for this were identified as: a) the large geographical area covered by the programme, b) the lack of a formal co-ordinating office (the GLOBEC IPO did not exist at the start of the programme), c) the difficulty in communicating with all SPACC scientists, d) the limited critical mass of the community and e) the insufficient funding stream of the programme.

The panel agreed that the implementation plan and the working group structure SPACC were still relevant, but suggested that, in order to increase focus and ensure maximum use of the available critical mass, future activities should be grouped into a short number of Science Themes. They suggested that pursuing these themes would take the programme into its next implementation phase. The themes were:

a) Theme 1 - Long term Changes in Ecosystems: Retrospective Analysis - including WG2-decadal changes, WG4-paleoecology and WG5-genetics).
b) Theme 2 - Comparative Population Dynamics (including WG3-resource productivity and WG9-Resource availability).
c) Theme 3 - Reproductive Habitat Dynamics (including WG7-Spawning and nursery habitat quality and dynamics, WG8- Spawning habitat dimensions and location and WG6- Daily growth and zooplankton).
d) Theme 4 - Economic Implications of Climate Change (including WG10-Economic Consequences and links to IGBP-GC and Food Systems, and IHDP)

The group also suggested that an Executive Committee should be appointed to spread the load placed on the co-Chairs in the past and to ensure that the four research lines develop in synergy.

At the recent GLOBEC Scientific Steering Committee meeting in Sitges, Spain, May 2000, the SSC approved the recommendations and appointed the following members to the new Executive of SPACC: John Hunter (USA), Jürgen Alheit (Germany), Manuel Barange (IPO, UK), Tim Baumgartner (Mexico), Leonardo Castro (Chile), Dave Checkley (USA), Lorenzo Motos (Spain), Hideaki Nakata (Japan) and Claude Roy (France/ South Africa).

The members were appointed for three years, with a possible extension of their mandate. The present chairs of SPACC, Jürgen Alheit and John Hunter, were asked to continue leading the programme during the next implementation phase. However, it was agreed that a new Chair/ co-Chair should be identified to relieve one of the present co-Chairs at the first rotation of the Executive Committee.

In planning activities, the following meetings were suggested for the immediate future:

1. Long-term Data in Africa (Theme 1). Swakopmund, Namibia, January 2001
2. Long-term Data in the Americas (Theme 1). Lima, Peru, March 2001 (TBC)
3. Use of environmental indices in stock assessment models – 2001 (TBC)
4. Spatial variability in pelagic fish populations (TBD) - Cape Town, South Africa, 2001 (TBC)
5. Economic consequences of pelagic stock fluctuations. TBA

For further information, please contact the GLOBEC IPO, which will act as co-ordinating Office for SPACC until further notice.

New GLOBEC Report Out

Checkley, D.M., Jr, J.R. Hunter, L. Motos, and C. D. van der Lingen (eds.). 2000. Report of a workshop on the use of the Continuous Underway Fish Egg Sampler (CUFES) for mapping spawning habitats of pelagic fish.
GLOBEC Report 14. 66p.

Available from the IPO

The SURVIVAL'2000 cruise: first results

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† With contributions from Alexandra Chicharo (IMAR/Univ. Algarve), Jesús Dubert (Univ. Aveiro), Paulo Gonçalves (IPIMAR/ Univ. Aveiro), Álvaro Peliz (IPIMAR), Pedro Ré (IMAR/Univ. Lisboa), Teresa Rosa (IPIMAR), Antonina dos Santos (IPIMAR)

Fig 1

The main objective of the project "Assessing the impact of hydrodynamical forcing on the survival of small pelagic fish early life stages of western Iberia (SURVIVAL)" (FCT/PRAXIS/P/CTE/11282/1998) is the study of the physical processes (mainly upwelling events during the spawning season) with impact on the dispersal and survival of small pelagic fish (mainly, sardine) eggs and larvae (for more details see GLOBEC International Newsletter, Vol. 6 No.1, 15-17).

The SURVIVAL'2000 cruise took place in March 2000 on board IPIMAR's RV *NORUEGA* with the participation of teams from IPIMAR, IMAR/Univ. Lisboa, IMAR/Univ. Algarve, Univ. Aveiro and Steve Coombs (PML/MBA). The extensive oceanographic survey was conducted off the Western Iberia Peninsula Upwelling System, in two parts different parts: a first sampling box with five transects perpendicular to the coast between Caminha (41.6º N) and Figueira da Foz (41.4º N) and three replications of a small sampling box within the broader sampling area from 23-29 February. Sampling procedures included CTD, Fluorometer and ADCP measurements, plankton

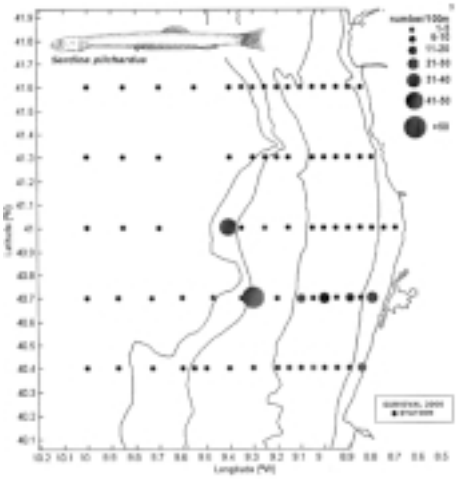

Fig 2a

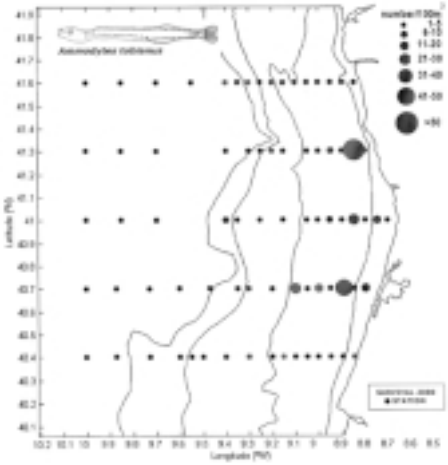

Fig 2b

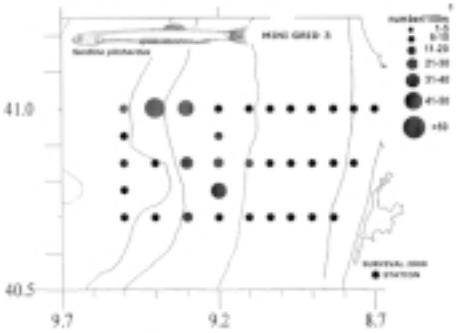

Fig 2c

bongo trawls, and deployment of two currentmeter moorings. A Daily Egg Production Method Experiment (DEPM) for C*alanus helgolandicus* was also performed.

An incidental coastal upwelling event occurred during the cruise as revealed by satellite-derived sea surface temperature (SST) distributions (see front page) and currentmeter records. This situation modified what is supposed to be the typical winter stratification in the area. At surface a lens of colder water spread, in a thin layer of no more than 25 m deep, over the warmer and saltier poleward current waters. As a consequence the typical temperature surface poleward signature vanished in most of the area surveyed . Also interesting is the fact that the salinity field that identifies the plume of river runoff origin, showed unusual high relative values near the coast indicating that has been displaced offshore and detached from the coastline (Fig. 1).

Sardine (*Sardina pilchardus*) (Fig. 2a,c) and blue whiting (*Micromessistius poutassou*) (2d), larvae were more abundant on the shelf break , while sand eel (*Ammodytes tobianus*) larvae were mainly found near the coast (Fig. 2b). Food availability during the cruise was not an limiting factor for the survival of larvae as revealed by preliminary results of microzooplankton abundance and larvae nutritional condition (Fig. 3). The DEPM for C*alanus helgolandicus* was between 1 and 31.5 eggs/female/day.

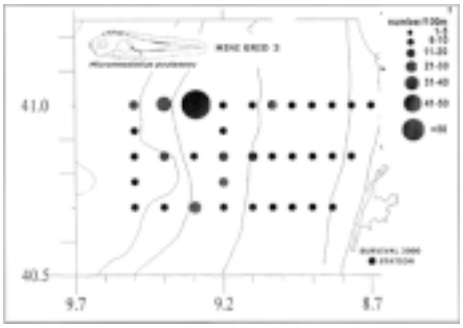

Fig 2d

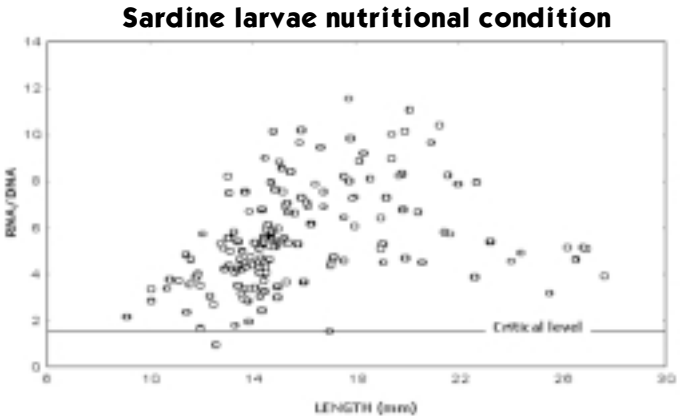

Fig 3

NEWS FROM THE NATIONAL PROGRAMMES

The first Korea-Japan Joint GLOBEC Symposium, Pusan (Korea), 23-25 August 2000

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A Symposium entitled "Long-term variations in the northwestern Pacific ecosystem" was held in Pusan, Korea, 23-25 August 2000. The meeting was co-organised by the Korea and Japanese GLOBEC National Programmes, the Pukyong National University, and the Japanese Society of Fisheries Oceanography. A total of 48 research results (42 oral and 6 poster) were presented in five sessions: Structure and variability in climate and ocean environments and their functioning, Biological processes and ecosystem dynamics, Recruitment and population dynamics of small pelagic fish, Sampling and observation systems and New paradigms in fisheries management.

Participants at the Korea-Japan GLOBEC Symposium

Keynote presentation from Session I was "Circulation and hydrography of the East China Sea (H.-J. Lie, KORDI)". Most presentations reported on large-scale oceanographic research in both time and space, and tried to relate the physical environment and biological productivity.

Session II started with a keynote presentation on, "Data assimilation for marine ecosystem models (E. Hofmann, ODU)", and seven papers followed. Researches on various trophic levels including satellite image and nutrients were presented. Data assimilation techniques showed some promising ways to solve the situation in data limitations, mismatches between scales, and model parameterization.

H. Nakata of Nagasaki Univ. introduced GLOBEC-SPACC activities in the Pacific region as a key note, and ten papers concerning sardine, anchovy, mackerel, saury, jack mackerel, squid, and tuna were presented. Distribution, growth, reproduction, recruitment variability, food availability, and density-dependent effects were discussed in the context of ocean climate change, and the participants shared their interests in co-ordinating for fish population research in Korean and Japanese waters.

Finally, in Session IV and V, tools for long-term monitoring studies and some hot issues in fisheries management of both countries were presented and discussed. D. Checkley (SIO) kindly presented the "Continuous, Underway Fish Egg Sampler "(CUFES).

Through the Symposium scientists from Japan, Korea, and USA realized the need to co-operate in the rescue of fish, fisheries and oceanographic data from the region. It was suggested to repeat this joint Symposium every two years to examine and investigate the relationship between environmental variations and ecosystem responses in the northwestern Pacific region.

The Proceedings with full papers and/or extended abstracts will be published by the University of Tokyo in February 2001. The Organizing and Publication Committee is exploring the possibility of publication in Fisheries Oceanography.

Investigations into the Production of Fish Eggs in the Irish Sea, 2000

Mark Dickey-Collas, Department of Agriculture and Rural Development, Belfast, Northern Ireland
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Fisheries scientists spend most of their time trying to count fish. Being good scientists they are continually driven to improve their methods and the precision of their estimates. With this quest in mind, scientists from four institutes carried out an intensive survey of the plankton of the Irish Sea in the spring of 2000. Their rational was; if you can assess the number of fish eggs produced in a year (Fig 1) and have estimates of the fecundity of mature fish, you could estimate the total biomass of mature fish at that time. This method is called the Annual Egg Production Method (AEP).

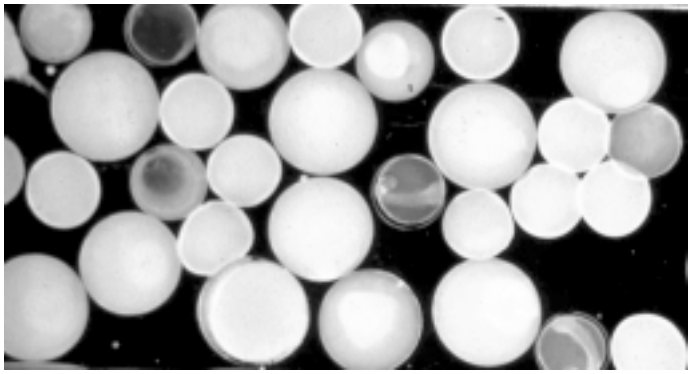

Fig 1. Pelagic fish eggs from the Irish Sea

The four institutes were The Queens University of Belfast, The Marine Institute (Dublin), CEFAS (Lowestoft) and The University of Liverpool (Port Erin Marine Laboratory). The work was primarily funded by the European Commission through DGXIV with additional funding from each respective institute and the Department of Agriculture and Rural Development for Northern Ireland. It was aimed at cod (*Gadus morhua*) and plaice (*Pleuronectes platessa*). The same institutes had already used this method once in 1995 and were now trying to improve the methodologies in 2000 (Armstrong *et al.* in press). The importance of the project was increased with the recent closure of some of the Irish Sea to cod fishing and the implementation of the Irish Sea cod recovery plan, the first attempt by the EU to operate a regional management regime under the Common Fisheries Policy.

But how is this of any relevance to GLOBEC? The surveys in 1995 and in 2000, covered the entire spawning period of cod and plaice in the Irish Sea, i.e. from late January to late May. The surveys used high-speed plankton samplers (Nash *et al*. 1998) to sample the entire water column approximately every 10 nautical miles across the Irish Sea with one survey every 2-3 weeks (Fig 2). In 1995, the samplers were fitted with 280μm nets but in 2000 both 280μm and 60μm nets were on the samplers. Hence over 1000 and 1700 plankton samples were collected in 1995 and 2000 respectively. Corresponding physical data were collected for each sample. In addition nutrient and phytoplankton data were collected over the entire Irish Sea, during the egg production cruises, under funding from the UK NERC Marine Productivity programme.

The plankton samples, along with the physical and chemical data, make up an extensive and comprehensive description of the development of the spring bloom in a temperate coastal sea. Models of zooplankton development in the Irish Sea already exist but have only ever been tested against data from single points and never against data with such combined spatial and temporal resolution. The surveys in 2000, with the use of two nets of different meshes and the collection of microplankton samples, offer a superb opportunity to investigate the population dynamics of the dominant copepods (*Pseudocalanus*, *Temora* and *Acartia*) in relation to the physical processes of the region. In the UK much research effort is spent on the bigger copepods (eg *Calanus*), when many areas, such as the southern North Sea and the Irish Sea, are dominated by the smaller species. These collections can provide a useful insight into ecology of these smaller, more coastal species.

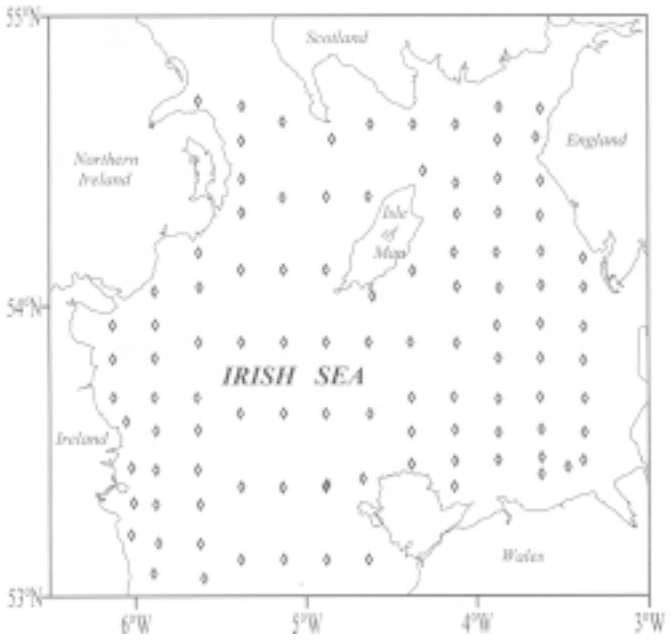

Fig 2. Plankton sampling grid for AEP surveys in the Irish Sea in 2000

For further information about the surveys or the methods, please contact the project co-ordinator Dr Mike Armstrong at the Department of Agriculture and Rural Development (NI) in Belfast.

Armstrong, M.J., Connolly, P., Nash, R.D.M., Pawson, M., Alesworth, E., Coulahan, P.J., Dickey-Collas, M., Milligan, S.P., O'Neill, M., Witthames, P.R. and Woolner, L. (in press). An application of the annual egg production method to estimate the spawning biomass of cod (Gadus morhua L.), plaice (Pleuronectes platessa L.) and sole (Solea solea L.) in the Irish Sea. ICES Journal of Marine Science

Nash, RDM, Dickey-Collas, M & Milligan, SP (1998). Descriptions of the Gulf VII/Pro-Net and MAFF/Guildline unencased high speed plankton samplers. Journal Plankton Research 20:1915-1926

Impact of physical factors on zooplankton and fish dynamics in the Baltic Sea

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After the political changes in Eastern Europe during the 1980s, opportunities and funding for international research co-operation in the Baltic Sea has increased considerably. "Baltic-wide" research projects with participation by all littoral countries were initiated, often funded by the EU (e.g. Baltic Sea System Study – BASYS, see www.io-warnemuende.de/projects/BASYS; Mechanisms influencing long term trends in reproductive success and recruitment of Baltic cod: implication for fisheries management – CORE, see www.ifm.uni-kiel.de/fi/CORE/welcome.htm; Environmental and fisheries influences on fish stock recruitment in the Baltic Sea – STORE, see www.ifm.uni-kiel.de/fi/STORE/welcome.htm). This combined international research effort resulted in a much better understanding of the Baltic Sea ecosystem and also of processes relevant to GLOBEC goals. We are now in a position to formulate stringent hypotheses based on recent findings to investigate the impact of physical factors on zooplankton and fish dynamics in the Baltic Sea according to the Science and Implementation Plans of GLOBEC and we expect the results of GLOBEC research will considerably improve our scientific basis for successful future fisheries and ecosystem management in the Baltic Sea. However, whereas EU funding has been highly successful for "kick-off" projects and the formation of international research teams, GLOBEC research now requires the more stable and secure funding from national agencies.

Long-term trends and regime shifts

Retrospective research is essential as it allows us (i) to disentangle the climate impact from anthropogenic influences on the dynamics of plankton and fish stocks and (ii) to focus and validate subsequent process-oriented research and modelling. The North Atlantic Oscillation (NAO), the strongest climate signal over the North Atlantic, seems to influence physical and biological processes in the Baltic Sea. Historical data on the herring fishery off the Bohuslaen coast, in the Skagerrak, show that there have been 9 periods of large herring catches since the 10th century. The onset of these fishing periods corresponded to times when the winter mildness/severity index of Lamb (1972) exhibited strong downward trends followed by long-lasting negative periods of the NAO (Fig. 1) (Alheit and Hagen 1997). Changes in the state of the NAO influence the three-dimensional circulation in the Baltic Sea and the water mass exchange with the North Sea, and are accompanied by changes in salinity, temperature, oxygen concentration etc., which, in turn, affect marine populations (Alheit et al. 2000, Lehmann et al. 2000).

The decadal dynamics of crustacean zooplankton such as copepods and cladocerans, the main food source of the planktivorous herring and sprat populations but also the principal food supply for early life history stages of gadoids, correlate well with variations in salinity and SST (which can be considered as a proxy for the NAO) (e.g. Alheit et al. 2000, Dippner et al. 2000, Möllmann et al. 2000, Vuorinen et al. 1998). Whereas the exponential growth phase of these copepod populations in spring seems to be regulated by temperature. Their decline later in the year might be controlled by predation (Johansson 1992, Möllmann and Köster 1999, Alheit et al. 2000).

Within the Baltic fish community, dominated by the three species cod, sprat and herring, a shift from a cod- to a sprat-dominated system occurred during the last two decades. This was caused by a declining cod stock, due to recruitment failure and high fishing intensity, resulting in a decrease in predation pressure on sprat which in combination with high reproductive success and relatively low fishing mortalities caused an exceptionally high sprat stock size (ICES 1999). Besides being a major prey species of cod, sprat is, in specific periods, an important predator on cod eggs (Köster and Möllmann 2000a). Thus, a dominance of

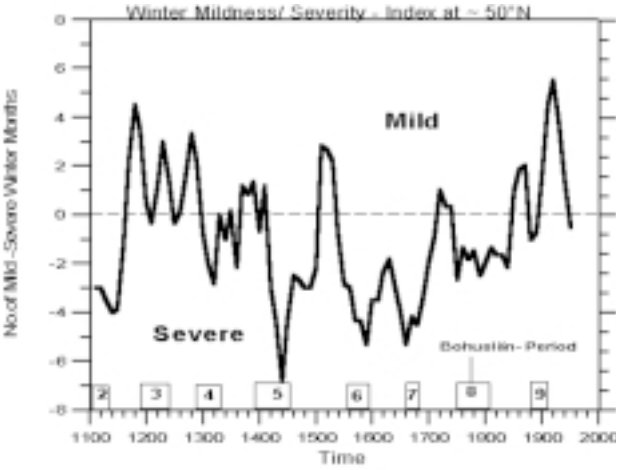

Fig. 1 "Winter mildness/severity index" (Lamb 1972) and Bohuslän periods which correspond to negative peak values. Modified from Alheit and Hagen (1997)

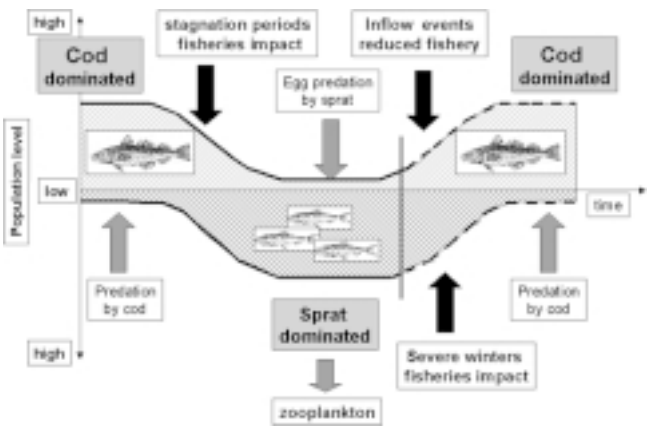

Fig. 2 Conceptual model of regime shifts in upper trophic levels of the Baltic Sea ecosystem, the vertical line marks the situation in 1996.

one of either predator may stabilize a cod-dominated or a sprat-dominated system (Rudstam et al. 1994). Destabilization of the system may be caused either by unfavourable hydrographic conditions for reproduction and subsequent recruitment failure of one of the species, or high mortalities caused by the fishery (Schnack 1997).

Table 1. Coefficients for correlations between early life history stages of cod and sprat in the Baltic Sea (* indicates significant correlation at 0.05 level).

Variable 1	Variable 1	COD	SPRAT
spawning stock biomass	egg production stage 1	0.19	0.66
egg production stage 1	egg production stage 3	0.51	0.82*
egg production stage 3	larval abundance	0.36	0.81*
larval abundance	0-group abundance	0.80*	0.32*

Resolving processes affecting fish stock recruitment

In the last decade substantial effort has been allocated to examine major processes identified to affect the recruitment variability in Baltic cod (Baltic-CORE) and the long-term trends in zooplankton (BASYS). Most recent activities within the Baltic STORE project addressed sprat in particular, as strong interactions between both fish species and specific mesozooplankton species were evidenced. As a result several new time series are available for variables relating to these processes. We used this material to identify critical periods within the recruitment process of cod and sprat by following the success of a year-class during ontogeny from spawner abundance through the egg and larval to the juvenile stage (Köster et al. 1999). This approach proposed by Paulik (1973) examines the entire life history process for critical periods and relationships between successive life stages (Rothschild 2000). To our knowledge there have been few such attempts at following this approach (e.g. walleye pollock in Shelikof Strait, see Kendall et al. 1996; North Sea plaice, see Beverton and Iles 1992), as the amount of multidisciplinary information required is large. In all these aforementioned cases, attempts are still ongoing, as indeed it is in the Baltic, with the major problem in all systems being the lack of availability of time series of key processes and the variety and complexity of processes involved.

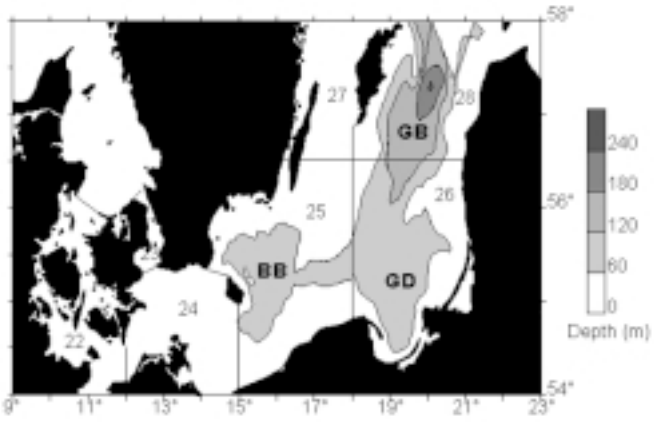

Fig. 3 Major spawning areas of cod and sprat in the Central Baltic (BB: Bornholm Basin; GD: Gdansk Deep; GB: Gotland Basin; numbers: ICES Sub-divisions).

Identification of critical early life stages

Cod and sprat utilize the same deep Baltic basins as spawning areas (Fig. 3), having also largely overlapping spawning times (Bagge et al. 1994, Parmanne et al. 1994). However, they utilize their spawning habitat with an obviously pronounced difference in reproductive success, indicating deviating reproductive strategies or significantly different environmental requirements. This is clearly shown by relationships between production and abundance estimates of various early life stages (Tab. 1). Critical periods for cod recruitment appear to be the late egg to the larval stage. The correlation between the early and late egg stage indicates a substantial variability in egg survival. In contrast, correlations between these life stages are highly significant for sprat, indicating that these stages are less critical for the reproductive success of the clupeid. However, the correlation breaks down from larval to 0-group abundance, while these life stages are highly correlated in cod.

Egg production by the adult stock

A low correlation coefficient between cod spawning stock biomass and the realised daily egg production at peak spawning time, derived from ichthyoplankton surveys, indicates either that the spawning stock biomass is not a reliable measure of egg production or that fertilisation success is highly variable. An extensive analysis of data on sexual maturation, sex ratios and individual fecundity allowed establishment of a time series of potential annual egg production (Köster et al. 2000, Kraus et al. 2000) significantly correlated to the realised production (r = 0.79). For sprat the spawning stock biomass appears to be a better measure of realised egg production, indicating that inter-annual variability in maturation processes, age-dependent sex ratios and individual fecundity is of less importance than in cod.

Survival during the egg stage

Due to low surface salinities, cod eggs in the central Baltic Sea concentrate within and below the permanent halocline, a water body which is characterised by decreasing oxygen concentrations with increasing depths (Wieland and Jarre-Teichmann 1997). The minimum requirement for successful egg fertilisation is 11 PSU (Westin and Nissling 1991). The minimum oxygen concentration for cod egg development is 2 ml/l (Nissling 1994, Wieland et al. 1994) and together these thresholds formed the basis for defining the „reproductive volume“, i.e. the water volume suitable for cod egg development (Plikshs et al. 1993). The reproductive volumes show a pronounced temporal and spatial variability (MacKenzie et al. 2000). Residuals of a linear relationship between late and early egg production are positively correlated with the reproductive volume in the Bornholm Basin, however explaining only 23% of the variance in the residuals. The underlying reason was investigated in laboratory experiments, showing that egg survival is also an increasing function of oxygen concentration above the 2ml/l threshold level (Rohlf 1999). Hence, conditions within the reproductive volume need to be considered when predicting egg survival more precisely (Köster et al. 1999), e.g. integrating the oxygen con-

tent within the reproductive volume increased the explained variance in residuals of the late vs. early egg stage production relationship significantly ($r^2 = 0.45$). In contrast to cod, sprat eggs have a higher buoyancy (Wieland and Zuzarte 1991) and are thus less dramatically exposed to low oxygen concentrations. Furthermore, studies on the impact of clupeid predation on cod and sprat eggs revealed a lower predation pressure on sprat than on cod eggs (Köster and Möllmann 2000a and b), mainly due to a less pronounced vertical overlap between predator and prey.

Survival during the larval stage

Cod larval activity was shown to be negatively affected by low oxygen conditions during incubation (Rohlf 1999). This indicates that a viable hatch-oxygen concentration relationship does not account for the total impact of oxygen conditions on the reproductive success. Larval activity is important for survival since the larvae have to ascend from their hatching depth within and below the halocline to water layers within and below the thermocline, where the best feeding conditions in terms of food supply and light conditions are encountered (Grønkjær and Wieland 1997). A confirmation for this hypothesis was found by biochemical analysis, showing starved larvae to gather predominantly in the halocline (Grønkjær et al. 1997).

In contrast to larger cod larvae, feeding sprat larvae concentrate in near surface water layers (Wieland and Zuzarte 1991, Makarchouk and Hinrichsen 1997). While performing their initial vertical migration from hatching depths, sprat larvae have to pass the intermediate water layer characterised by low temperature originating from winter cooling. Temperature has been shown to have a significant impact on recruiting sprat year-class strength (Grauman and Yula 1989, MacKenzie 1997) and a direct thermal influence on larval survival is likely after severe winter situations. However, the late egg stage production is significantly correlated to larval abundance, indicating, in general, a limited direct impact of temperature. Here we hypothesise a dependence on the availability of suitable zooplankton prey, i.e. especially nauplii and copepodits of Acartia spp. and Temora longicornis, significantly correlated to spring temperatures (Möllmann et al. 2000). Variable prey concentrations may affect nutritional conditions, growth rates and subsequently survival of larvae, resembled in the low correlation between sprat larval and 0-group abundance. However not only a vertical match between larvae and suitable prey, but also a transport to favourable nursery areas may be of importance for larval and early juvenile survival. From studying the flow field within the Bornholm Basin by hydrodynamic modelling and inserting cod larvae as drifters, two contrasting scenarios were identified (Voss et al. 1999, Hinrichsen et al. 2000). Firstly, low wind speed in variable directions result in a retention within the spawning area and secondly, relatively high wind forcing of westerly or easterly direction result in rapid transport towards different shallow coastal environments offering potentially improved feeding conditions (St. John et al. 1995). This dependence of recruitment success on horizontal transport may also be of importance for sprat recruitment. However, this hypothesis is difficult to test without conducting specifically designed studies, as much of the available plankton data has been collected at large temporal and spatial scales, which bear little resemblance to prey abundances and distributions required by larval and early juvenile stages (MacKenzie et al. 1996). Additionally, available studies do not consider at all the quality of the food available (St. John and Lund 1996).

Conclusions

Research activities conducted throughout the last decade designed as contributions to the GLOBEC CCC programme, substantially improved our understanding of processes affecting cod recruitment in the Baltic. Findings were successfully implemented in environmentally sensitive stock recruitment models (Jarre-Teichmann et al. 2000, Köster et al. 2000) and clearly have the potential to improve medium- to long-term projections of fish stock development under different environmental scenarios and fisheries management directives. However, recent results obtained from SPACC related activities demonstrated as well, that pronounced interactions exist between cod and sprat, both acting as predator and prey on different life stages, as well as between planktivorous fish species/life stages and key zooplankton species. In particular, the interaction between zooplankton and fish under variable physical forcing conditions, as well as human impact, e.g. nutrient loading and removal by the fishery, is key in understanding the dynamics of the Baltic Sea ecosystems in upper trophic levels. Hence, allocation of sufficient interdisciplinary research effort according to the GLOBEC Science and Implementation Plans is a prerequisite for the development of future sustainable fisheries and ecosystem management in the Baltic.

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SINAPSI (Seasonal Interannual and Decadal Variability of the Atmosphere, Oceans and Marine Ecosystems)

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SINAPSI is the new Italian contribution to the GLOBEC programme. Over 30 Universities and institutes and 70 scientists are involved in the 3 year project (available from the author). SINAPSI aims to increase our capability to predict climate fluctuations in the atmosphere, ocean and marine ecosystems at the relevant time scales and to define key climatic biogeochemical and physical parameters and key marine areas for monitoring the Mediterranean basin fluctuations in terms of ecosystem response at the seasonal, interannual and decadal time scales. The programme is funded by the Ministero dell'Universita' e della Ricerca Scientifica e Tecnologica (MURST) to the tune of LIt 3,500,000,000, starting this year.

The project will contribute to the analysis of observed climate variability, both at global and regional scales and to the development of global and regional numerical models of the atmosphere, ocean and marine ecosystems. The project aims to stimulate the development and the utilisation of state-of-the-art numerical models of the global atmosphere and ocean for the scientific, academic and operational Italian communities. It concentrates on the global atmosphere-ocean interactions and in particular on the Mediterranean Sea ecosystem dynamics. The Mediterranean is now recognized as a "climatic laboratory" where important interactions between atmosphere, hydrosphere and biosphere occur at high intensity and they can be used as indicators of more general fluctuations and trends. The proposed research is based upon both existing observational data sets and modeling work and the collection of new observations and development of new models in order to be able to better understand and predict the climate fluctuations at seasonal,

interannual and decadal time scales.

The main goals will be achieved through a number of more specific objectives, namely:

1. The understanding and simulation of the seasonal to interannual variability of the atmospheric and coupled ocean-atmosphere systems, through coupled ocean-atmosphere numerical simulations, model developments, diagnostic and theoretical studies. In particular the climate anomalies over the European sector and the Mediterranean area will be investigated;

2. The investigation of the seasonal, interannual and decadal variability of the Mediterranean Sea ecosystem structure through the collection of new observations in key areas of climatic response, the study of existing observational time series, the modeling of the interactions between the atmosphere and the ocean and the numerical modeling of the general circulation variability;

3. The study of the seasonal and interannual variability of primary productivity in the Mediterranean together with the study of benthic, pelagic organism and fish stocks fluctuations through the analysis of existing observational long time series and the modeling of the response of biota to geophysical forcing variability;

4. The study of the paleoclimatic records in the terrestrial and marine ecosystems in order to detect the seasonal/interannual and decadal changes in past climatic regimes and intercompare the conceptual models of the recent and past climate variability.

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Distribution of *Calanus spp.* as determined using a molecular identification system.

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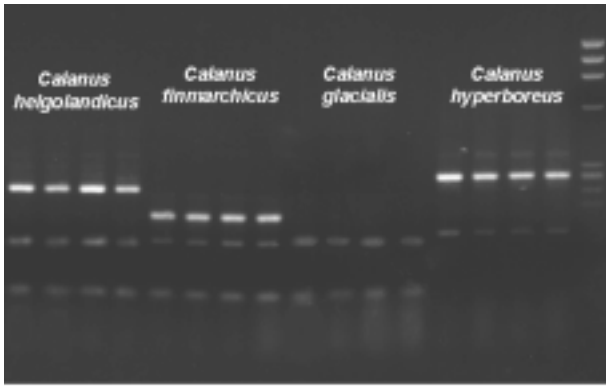
The genus *Calanus* forms a major component of the zooplankton in the North Atlantic in terms of biomass and trophic role. Each species within the genus differs in its life strategy and responds differently to environmental conditions, yet the different species can co-occur and compete in an interspecific manner. To understand how, we need accurately describe their spatial and temporal pattern. To do this, we must have a reliable means of discriminating between the species. Morphologically, the four major North Atlantic species are very similar, with diagnostic features being restricted essentially to minor variations in secondary sex characteristics. This presents a persistent problem for the identification of individuals to species level, with immature animals being the most problematic. For the identification of juvenile stages the geographical location of collection is, at least partially, relied upon to be an indicator of species identity.

Despite this morphological similarity, species of *Calanus* exhibit considerable base sequence divergence within their genomes, and this has been exploited for the development of a molecular method to distinguish between them. Within the mitochondrial genome, the gene encoding the large subunit of ribosomal RNA (the 16S rRNA gene or 16S rDNA) provides an ideal target for such a method since its sequence varies sufficiently to discriminate closely related species, but its intraspecific variation is generally low. Based on this gene we have developed a simple molecular technique to differentiate between the North Atlantic *Calanus* species (*C. helgolandicus*, *C. finmarchicus*, *C. glacialis*, and *C. hyperboreous*) at any developmental stage (Lindeque *et al.*, Marine Biology (1999) 133:91-96). Using the polymerase chain reaction (PCR) we have amplified, cloned and sequenced a section of the mitochondrial 16SrRNA gene, which has in turn allowed us to establish a simple restriction fragment length polymorphism (RFLP) profile to identify each of our four target species. We have developed this system not only to unambiguously identify adult animals, but also to identify any developmental stage (from single eggs to whole adults), and even small isolated body parts (such as a leg or antennule).



Identification of four individuals of each of four species of Calanus using the molecular identification system.

This molecular identification technique has now been applied to a large number of ethanol-fixed animals collected by collaborators during 1997 and 1998, from sites as widespread as Plymouth (UK) and Tromso (Norway). A schematic representation of the distributions is shown in on the

back cover (this issue). The distribution of *Calanus* is fairly reflective of traditional results, but the molecular analysis has clearly indicated extended areas of distribution and co-occurrence when when compared to results from tradition identification systems. Certainly in some of the Norwegian fjords many of the unexpected biological characteristics are now being attributed to misidentification of the species.

The ability to extend identification to all developmental stages facilitates new investigations into the life strategies and co-occurrence of four important *Calanus* species. The system was developed with funding from the NERC thematic programme "Plankton Reactivity in the Marine Environment" and has attracted interest from researchers worldwide. In response, we have secured funding from the new NERC thematic programme "Marine Productivity" (see article by Phil Williamson, GLOBEC Newsletter April 2000, pp 17-18) to expand the species identification system to other copepods for which identification of either the adults or earlier developmental stages is problematic. Current targets include relevant species of *Acartia, Pseudocalanus, Clausocalanus* and *Paracalanus*, and we are collecting (and would welcome) ethanol-preserved examples of the above genera from regions across Europe. Additionally, we would welcome suggestions of other genera whereby an identification solution could be provided by this robust technique.

The IMECOCAL Programme

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A program of ocean monitoring in the southern region of the California Current—off Baja California, MEXICO—has been underway since Autumn, 1997. This program supports major components of the GLOBEC research agenda and is maintained by a consortium of six Mexican institutions. It was initiated with a three-year grant from the Inter-American Institute of Global Change Reserach (IAI) and a five-year grant from the Consejo Nacional de Ciencia y Tecnologia (CONACYT). This financial support has been used to set in place the critical elements of a program that incorporates the Mexican sector of the California Current pelagic ecosystem into an ongoing investigation of the environment and resources. It is modelled after the CalCOFI program (California Cooperative Oceanic Fisheries Investigation) covering the region off southern and central California to the north. Establishing a program of regular observations for the Mexican sector provides the extended coverage needed to match the scales of scientific sampling and analysis to the natural scales of variability in the California Current. It will also provide information relevant to understanding the behavior of transboundary pelagic resources inhabiting both the waters off Mexico and the United States. This program is known as Investigaciones Mexicanas de la Corriente de California (IMECOCAL).

The long-term goal of IMECOCAL is to improve our capability to predict the response of the pelagic ecosystem to regional and global climate change, as well as to the combined effects of harvesting practices by Mexico and the United States. There are five Mexican academic institutions participating in IMECOCAL. These are CICESE (Centro de Investigación Científica y de Educación Superior de Ensenada), UABC (Universidad Autónoma de Baja California, in Ensenada), CICIMAR (Centro Interdisciplinario de Ciencias Marinas, in La Paz), UNAM (Universidad Nacional Autónama de México, in México City), and CIBNOR (Centro de Investigaciones Biológicas del Noroeste, in La Paz). The government agency participating is INP/SEMERNAP (National institute of Fisheries of the Ministry of the Environment, Natural Resources and Fisheries).

The IMECOCAL program has been conducting ocean monitoring cruises every three months with the CICESE research vessel *Francisco de Ulloa* over the sampling grid shown in Fig. 1 since October, 1997. One cruise was carried out on the UNAM research vessel *El Puma*. The IMECOCAL observations are scheduled in collaboration with the CalCOFI program. The IMECOCAL survey design is based on the original CalCOFI Basic Station Plan. The cruises cover a subset of the original CalCOFI grid, with stations spaced 20 nautical miles apart extending a maximum distance of 220 nautical miles offshore on the two long central lines and roughly 120 nautical miles on the other lines. The distance between lines is 40 nautical miles.

CalCOFI surveys consists of quarterly cruises (normally in January, April, July and October) covering the region from the U.S.-Mexican border north to just above Point Conception. This strategy maintains a sampling frequency able to capture the temporal variability critical to describing biophysical response down to interannual-scale climate forcing but compromises knowledge of spatial variability over the system by severely reducing the active area of the sampling grid. Awareness of the importance of multi-decadal variability has been steadily increasing since the 1980s, accompanied by the realization that not only temporal changes in abundance and productivity are important, but

that there are significant latitudinal shifts in the ranges of ecologically and commercially important species. Recognizing the complexity of space-time variability over decadal and longer time scales made it increasingly clear that the reduced CalCOFI sampling design does not adequately describe the fundamental changes in physical and biological structure in which significant spatial variability is embedded within the temporal variability (Hayward, 1996). The IMECOCAL program was initiated to improve our understanding of the overall response of the pelagic ecosystem of the California Current to regional and basin-scale climate change by extending the latitudinal scope of sampling. It also has the practical purpose of tracking ecosystem changes that impact the abundance and productivity of small pelagic fish species off Baja California that are important resources for México.

The IMECOCAL surveys are scheduled to coincide as closely as possible to CalCOFI cruise periods in order to provide an integrated description of the pelagic ecosystem of the California Current. Inclusion of the IMECOCAL results in the annual CalCOFI reports on the state of the California Current has already begun to produce a more complete picture of the ecosystem processes over a large region of the system (e.g., Lynn et al., 1998). The core sampling activities of IMECOCAL cruises include routine CTD casts to 1000 m depth (for detailed temperature and salinity profiles to describe hydrographic structure and circulation). There are also sensors to measure dissolved oxygen and fluoresence profiles to complement the CTD data. Water samples are taken from the surface to 150 m at standard depths, using 5-liter Niskin bottles mounted on the CTD sampling rosette system. The water is used to analyze the concentrations of dissolved oxygen, inorganic nutrients and chlorophyll. At each station, standard oblique bongo tows are made to capture macrozooplancton, including the icthyoplankton (fish eggs and larvae). Vertical Calvet tows are also made at each station for quantitative collection of fish eggs through a depth of 70m. Casts for *in situ* measurements of primary productivity as well as measurements profiling photosynthetic radiation is carried out daily at the mid-day stations. Continuous underway sampling of surface temperature and salinity, as well as continuous ADCP profiling for mapping the currents in the upper 200 meteres is also done.

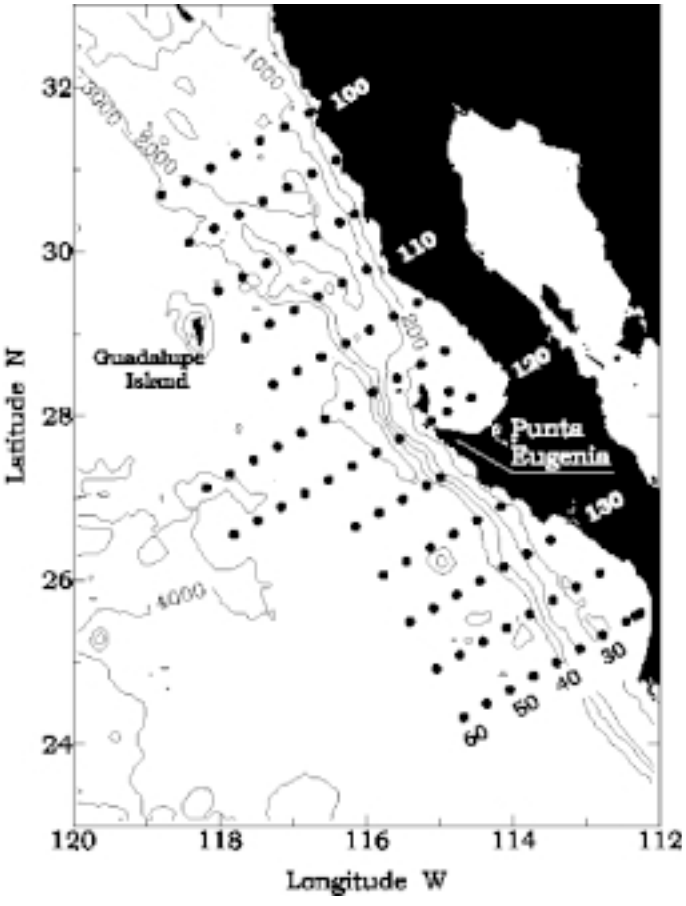

Fig.1 Standard station grid of the IMECOCAL cruises

A CUFES system (Continuous Underway Fish Egg Sampling, Checkley et al., 1997) was installed on the R/V *Francisco de Ulloa* and has been operational since January, 2000. We look forward to contributring to the SPACC program of GLOBEC with improved knowledge of the characteristics of the spawning habitats of small pelagic species of fish populations and enhancing our understanding of space-time changes in distributions, abundances and production of the small pelagic fish populations in relation to environmental variability. Collaboration betwen IMECOCAL and CalCOFI in the employment of the CUFES system is particularly important to understand the response of the transboundary population of the Pacific sardine to climate change and to address the combined effects of harvesting by México and the U.S.

In addition to the monitoring cruises, IMECOCAL maintains sea level pressure gauges at Guadalupe Island (see Fig. 1), about 280 km offshore at 29°N, and at a coastal location at San Quintin (about 31°N). The location of Guadalupe Island provides a unique opportunity to continuously measure the mean flow of the California Current in a way not available at any other place along the west coast of North America. These paired instruments permit us to monitor the sea surface pressure gradient between the island and the coastal stations to provide a measure of the mean flow in the upper ocean (Christensen and Rodriguez, 1979) associated with the California Current . These instruments were purchased with the support of the National Science Foundation of the U.S. under a research grant in collaboration with Scripps Institution of Oceanography. They have been operating since January, 1999, and we would like to maintain them for at least ten years to provide continuous measurements from which to develop a long-term climatology of the flow across the main axis of the California Current in this region.

The IMECOCAL research program also includes the retrospective analyses of available paleoecological records from near coastal sites off southern Baja California to provide a regional historical context of interdecadal to centennial variability as seen of the past 500 to 1500 years to compare to the records off southern California described by Baumgartner et al. (1992).

For more information see http://ecologia.cicese.mx/~imecocal/.

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New Continuous Plankton Recorder (CPR) Survey Data Policy Implemented

14th September 2000

The Sir Alister Hardy Foundation (SAHFOS) maintains and updates the unique Continuous Plankton Recorder database.

Data are held in a relational database containing the plankton abundance data together with time, date and position of sample recorded over 60 years on more than 174,000 samples from the North Atlantic and North Sea. Data are extracted by area co-ordinates and species or taxonomic entities, creating a matrix of plankton abundance values.

SAHFOS's data policy is compliant with the developing data policy for the Global Ocean Observation System (GOOS). The data are freely available, provided that the recipient has signed a 'Data Licence Agreement', available from the SAHFOS Data Manager.

Limited data are currently available on a number of samples in a given area via the SAHFOS web site. It is planned to allow more detailed data searches via the web in the future. Currently all data requests are dealt with by the Data Manager to ensure the integrity of the data. Contact him on e mail sahfos@wpo.nerc.ac.uk WWW: http://www.npm.ac.uk/sahfos

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GLOBEC ACTIVITIES

First Meeting of the GLOBEC Focus 1 Working Group on Retrospective Analyses and Time Series Studies

Ian Perry, Pacific Biological Station, Canada (perryi@pac.dfo-mpo.gc.ca)

The primary goal of the GLOBEC program is to identify the responses of marine ecosystems to global changes. A key driver of global change is the coupled atmosphere-ocean climate system, which experiences variability on seasonal to multi-centennial time scales. One of the principal challenges for GLOBEC is to distinguish marine ecosystem responses to changes in climate from ecosystem responses to changes in direct human activities such as overfishing.

One way to disentangle climate from direct human impacts is to look back in time, to identify marine ecosystem variability in response to climate changes when direct human interventions were weak or non-existent. Another reason to look back in time is to increase the number of observations, i.e. to increase the number of climate cycles to which an ecosystem has responded. For example, during a 10 year program such as GLOBEC, one can expect perhaps one ENSO or NAO event (time scales of about 7 years), but if the observations can be extended decades to centuries into the past, many more low frequency climate cycles can be observed.

This is why the GLOBEC program has a Focus on retrospective and time series studies. The general objective of this Focus is to identify and understand the characteristic, natural, modes of physical forcing and marine ecosystem variability over a range of temporal and spatial scales. The specific Activities and Tasks of this Focus are detailed in the GLOBEC Implementation Plan (IGBP Report 47/GLOBEC Report 13, 1999). The outputs of this Focus will provide geographical and temporal scaling information (e.g. which areas and times are similar), and will provide information and parameter estimates for ecosystem models, detailed process studies, and GLOBEC integrating activities.

Members of the Focus 1 WG in Sitges, Spain. From left to right: T.Baumgartner, N. Ward, A.Bakun, J.Alheit, S. Piontkovoski, B. Planque, K. Drinkwater and I. Perry

The First Meeting

The first meeting of the Working Group for Focus 1 took place 18-19 May, 2000, in Sitges, Spain. In addition to the Working Group members, Dr. Frank Oldfield, Executive Director of the International Project Office for the IGBP program on Past Global Changes (PAGES), also participated. Members of the GLOBEC SSC who participated for at least part of the meeting included R. Harris, M. Barange, E. Gross (SCOR), S. Kim, F. Werner, P. Lehodey, and F. Shillington. The full report of this first meeting is available as a pdf file on the GLOBEC web site.

Since the possible topics of this Focus are broad (ranging from time series statistics to analyses of preserved biological remains and large-scale climate variations), this Working Group was purposefully designed to be small and to act more as a "steering committee" for this Focus. The principal objective of the Working Group is to assist with implementing the activities of this Focus – to identify what topics and activities the IGBP/SCOR/IOC GLOBEC program could conduct to provide "global-added value" to the retrospective and time series studies of the Regional and National GLOBEC programs. For example, do each of these Regional and National programs have similar problems (with respect to techniques, methods, conceptual approaches, etc.) that might be discussed and co-ordinated at a global level? After considerable and lively discussion, several issues and themes emerged with recommendations for further action. These were the development of data inventories, development of collaborative interactions ("Intersection") with other international global change programs; comparisons among different ocean systems; and development of new conceptual approaches to the problem; and creation of new retrospective data sets). There was also discussion of an overarching need to build scientific expertise and capacity.

Inventories

Analyses of historical data on climate states and marine ecosystem responses assumes that these data exist, that they are known to exist, and that they are available for analyses. These three conditions are not always true, however. The GLOBEC program can provide "global-added value" by developing inventories of what marine ecosystem data exist for which areas and time periods, and provide assistance with data archiving. Experience with developing inventories of oceanographic data, however, suggests these can be difficult tasks. Other international efforts have been initiated by the I.O.C with respect to canvassing member nations for information on marine observation programs, and "rescuing" these data (Global Oceanographic Data Archaeology and Rescue – GODAR; see http://ioc.unesco.org/iode/ac-

tivities/data_man/godar.htm). Archiving of data is probably best done by or in collaboration with a formal World Data Centre – this already exists for physical oceanographic data, but does not explicitly include marine biological data (although some of these data are held by the centre for physical oceanography). It is encouraging to note that a World Data Centre has been established for similarly "difficult" paleo data. GLOBEC may need to support development of a World Data Centre for marine biological data as an ultimate goal, but inventories of these data are important steps towards this goal. Additional problems concern what to include in these inventories, for example, what variables, formats, standards, etc., should the individual investigator or National GLOBEC program use for their data so as to be readily compatible with data from other National programs?
Relevant to this topic of Inventories is the problem of how best to support time series collection activities, since it is well known that obtaining institutional and financial support for long-term observational programs is exceedingly difficult. Publishing results from time series and monitoring programs is one of the best methods to provide support and to obtain further funding.
On these two Inventory issues, the Working Group recommended that:

- GLOBEC should establish a Data Management Working Group. This group will develop recommendations on data formats and units, and deal with issues related to accessibility and preservation of GLOBEC data. [This effort is now in progress within the GLOBEC IPO].
- a task team (consisting of Planque, Perry and Bakun) will develop an outline for an overview paper that describes the value of, and the extra information gained from, long-time series data. Collaborations with key participants outside of GLOBEC, and with the CLIVAR Data Working Group, will be sought. The outline is to be discussed at the next meeting of the Working Group.

GLOBEC/PAGES/CLIVAR Intersection

GLOBEC, and Focus 1 in particular, have natural connections with the activities of PAGES (Past Global Changes) and with CLIVAR (Climate Variability and Predicability – part of the World Climate Research Program). The goal of PAGES is to understand the processes involved in environmental and climate change as manifested in the past record, and a goal of CLIVAR is to understand climate variability over a wide spectrum of time scales. These programs intersect with GLOBEC in the problem of understanding how variations in climate have affected marine ecosystems at large spatial and temporal scales. PAGES, in part, is interested in using the marine biological record as an indication of ecosystem responses to global changes. This involves a broadening of proxies and archives beyond fish scales and anoxic basins. GLOBEC can provide PAGES with a fuller understanding of the processes that occur in the water column leading to settling (and preservation) of biological remains on the sea floor. CLIVAR can provide analyses of climate forcing on marine ecosystems for teleconnection studies and for inputs to marine ecosystem models. This includes time scales from seasonal to interannual (observations and models) to decadal and multi-century (which requires strong input from the paleo community as well as ocean model results). The involvement of CLIVAR in this intersection is essential to describe this variability and the climate background within which the marine ecosystem responses occur.

An initial workshop was developed to discuss this GLOBEC/PAGES/CLIVAR Intersection, to explore the interests among the three programs for collaboration, and to build towards a more formal interaction such as has occurred with the PAGES/CLIVAR Intersection. In addition, a specific topic was suggested, which could serve as one of the initial collaborative projects among the three programs. This specific topic concerns developing a history of marine ecosystem changes over the past 2000 years in the Pacific and Atlantic (and possibly Indian and Southern) Oceans. Specific issues considered include

- which of the paleoceanographic sites already being worked on could be included in this broader analysis?
- are there potential new sites that might be included in future coring activities that would be of interest to GLOBEC, PAGES, and CLIVAR?
- what are the long-term possibilities for these collaborative efforts?

This workshop is scheduled for 25-27 September 2000 in Sidney, British Columbia, Canada, and will be reported on in following issues of this newsletter.

Comparative Systems

Three of the four GLOBEC Regional Programs have had activities relating to retrospective analyses (the PICES "Beyond El Niño" symposium; the ICES "Backward-Facing Workshops", and the SPACC - see calendar on backpage) and at least one of these Regional programs has compared systems within its ocean basin (PICES – "Ecosystem Dynamics in the Eastern and Western Gyres of the Subarctic Pacific", Progress in Oceanography 43(2-4), 1999). What is needed, therefore, are comparisons among Regional programs and ocean basins, including the possibility of large-scale atmospheric teleconnections, e.g. between the Pacific and Atlantic. This problem becomes complicated by cascading time scale effects and different focuses among different disciplines, e.g., Andy Bakun pointed out that climatologists tend to look for winter teleconnections, whereas it is the spring-summer period that is important for the biology. Two to three issues should be identified that could form the basis for a workshop(s) among the Regional (and perhaps broader) programs with respect to retrospective comparisons. One suggestion was to look at the climatologies of each ocean basin to determine if there are spatially-coherent time periods of change that might impact upon or be reflected in the Pacific, Atlantic, and the small pelagics (SPACC) regions. The time scales for such coherence among marine ecosystems is crucial, and could range from interannual to El Nino to decadal scales – are these time scales similar throughout the northern (and southern) hemispheres? To develop these ideas, the Working Group recommended:

- A task team (consisting of Perry (PICES CCCC), Drinkwater (ICES CCCWG), Alheit (SPACC) and Ward

(CLIVAR)) is to develop a proposal to compare long-term, large scale ecosystem responses throughout the world's oceans. Particular issues to address include the large-scale fisheries changes that have been observed, when they began, how long they endured, the synchrony between basins and components of the ecosystem (pelagics, demersals) and the probability that they are forced by climate variability. The proposal is to be discussed with ICES and PICES, and tabled at the next FOCUS 1 WG meeting.

New Conceptual Frameworks

Discussions on this topic focussed initially on the need to identify and disseminate the "best available" analytical techniques and approaches, in particular regarding statistics for time series analyses and multiple time series comparisons. Advances in these topics have occurred, but they are often in a literature that is not normally read by marine biologists. Suggestions to overcome these difficulties included a training workshop with a resulting GLOBEC report on "best practices", a paper in the scientific literature, and to "lead by example" in our own publications. The Working Group decided to initially produce an article (or articles) for the GLOBEC newsletter defining the (most common) problems and preferred alternative techniques. The first article in this series, by Dr. Benjamin Planque addressing serial correlation problems, appears in this issue of the Newsletter. Suggestions for topics that would be useful for such a column are welcome, and can be sent to the Working Group Chair (Ian Perry). More profound issues concerning development of new conceptual approaches to the larger problem of non-stationary responses of marine ecosystems to global changes (e.g. that correlations work for awhile, but then fall apart) was recognised as very important but a topic for future consideration.

Capacity Building

Neil Ward presented plans for an International Research Institute for Climate Prediction (IRI) training workshop on Interannual Climate Variability and Pelagic Fisheries, to be held 6-24 November 2000 in Nouméa, New Caledonia. The concept is to explore linkages between climate variability and pelagic fish stocks, and to expose fishery scientists to current climate analysis and prediction techniques. Several members of this GLOBEC Focus 1 Working Group will participate as instructors. This course represents an excellent opportunity to build capacity in climate and fisheries interactions, and the Working Group recommended that GLOBEC support the course. GLOBEC is now a co-sponsor of the program. Further information can be obtained from Neil Ward (nward@iri.ldgo.columbia.edu).

Concluding Remarks

The success of this Working Group for Focus 1 will depend on the interests and participation of the GLOBEC and marine and climate change communities at large, since the members of this Working Group cannot (and should not) conduct this work by themselves. There are natural and strong linkages with Focus 3 (Modelling and Predictive Capabilities) since retrospective studies provide and constrain parameter values in models, and modelling helps with the integration of retrospective and time series data. But the Activities of Focus 1 require the involvement of all those involved in Regional and National GLOBEC activities, since you provide the initial building blocks for the global synthesis of marine ecosystem responses to global changes. We therefore welcome any and all comments and expressions of interest for the activities described in this report, and suggestions for future consideration. In addition, we will be looking for your support for the projects and workshops developed by this Working Group in the year ahead. The next meeting of the Focus 1 Working Group is tentatively scheduled for spring or early summer 2001, most likely in conjunction with the next GLOBEC SSC meeting.

First Meeting of the GLOBEC Focus 3 Working Group on Modelling and Predictive Capabilities

Francisco Werner, University of North Carolina, USA (cisco@email.unc.edu)

The first meeting of the GLOBEC Focus 3 Working Group (F3WG) was held in Chapel Hill, North Carolina (USA) from 9-12 July 2000. A wide range of topics were discussed and a prioritised series of activities was identified for consideration over the next 1-3 years. The following is a brief summary of the results and recommendations of the Chapel Hill meeting.

Additional information material (including the report) is available at the website http://www.unc.edu/~cisco/F3WG.html.

Focus 3 WG from left to right: M. Kishi, L. Botsford, E. Murphy, O. Fiksen, C. Marrase, C. Werner, B. de Young, F. Carlotti, C. Moloney, K. Brander, M. Heath, M. Zhou

The GLOBEC International Implementation Plan (GLOBEC Report 13) identifies four research foci common to GLOBEC programs. These are: Retrospective Analyses and Time Series Studies (Focus 1 WG), Process Studies (Focus 2 WG), Predictive and Modelling Capabilities (Focus 3 WG), and Feedbacks from Changes in Marine Ecosystem Structure (Focus 4 WG). The general objectives of each and the relationship between the Focus Groups are detailed in the Implementation Plan. The objectives addressed by the F3WG and which served to narrow the coming years' activities are:

1. To guide the development of GLOBEC models (biological, physical and coupled) through an assessment of thstrengths and weaknesses of different modelling approaches.
2. To link the different activities in process, retrospective and regional programmes, to better understand and predict the state of marine ecosystems.
3. To facilitate broad synthesis through modelling leading to a global understanding of the response of marine ecosystems to environmental change and harvesting.

Existing Models and Target Species

GLOBEC modelling aims to simulate the variability in populations of fish and zooplankton, evaluate the causes of this variability, and ultimately to develop a predictive capability. While there are a number of models of individual fish and zooplankton taxa, with an increasing number resolving 3-dimensional spatial variability, there are few examples where such models have been successfully coupled to dynamic representations of lower or upper trophic levels. To evaluate the present state of modelling capabilities in these areas, the F3WG identified as a target to consult with the various national programmes, Focus groups and the GLOBEC International Project Office (IPO), and:

- Assemble an inventory of GLOBEC-relevant modelling projects in different nations – building on what national GLOBEC committees are already doing. The inventory should include those efforts working on modelling zooplankton, fish and higher trophic levels.
- Extend the list of the target species in each of the regional and national programmes available in the Implementation Program (GLOBEC Report 13) before the next meeting in 2001.

Temporal and spatial integration issues for marine ecosystem models

The WG reviewed the report from the ICES Study Group (SG) on Spatial and Temporal Integration, Glasgow, 1993 (ICES C.M. 1993/L:9), which considered issues relevant to scaling of process information and data to the scales required for marine ecosystem models. The following sketch, taken from the ICES Study Group on Spatial and Temporal Integration, Glasgow, 1993 (ICES C.M. 1993/L:9), summarises the relationship between observed species composition, state variables in modelling approaches that build from the "bottom-up" with increasing complexity (and numbers of species). The suggested approach is to focus on the target species with links to lower and higher trophic levels by aggregation/sub-gridscale representation rather than including the full complexity of the neighbouring trophic component.

The F3WG recognized that issues of spatial and temporal integration are primarily for consideration in the GLOBEC regional and national programmes. However, issues such as those set out in the ICES SG report should be considered in the formulation of their modelling approaches particularly if data availability is reduced within the neighbouring trophic or physical scales. Of particular interest in the future may be strategic modelling studies explicitly addressing the issue of sensitivity to model spatial resolution.

Size structured models (and measurements) and behaviour

There is already a diversity of well developed age, size or stage structured models of individual taxa available in the research community, some of which can/have been implemented in 3-dimensional hydrodynamic systems, and there is no particular need to strongly stimulate new initiatives in this area. However, although the concepts underpinning the ecosystem size spectrum approach are some 20-25 years old, there have been only a few attempts to implement it in a practical setting. In particular, translation the original time-averaged analytical solution into a set of time-dependent dynamic equations capable of being implemented in spatially resolved schemes, has been difficult. There is a need to encourage mathematicians to address this problem in collaboration with marine modellers.

Similarly, there are a number of recent developments in oceanographic instrumentation that may make the implementation of GLOBEC modelling more achievable than has been the case in the past. In particular, the Optical Particle Counter (OPC) and other particle size detection instruments such as flow-cytometry and multi-frequency acoustics are clearly relevant to the implementation of ecosystem size spectrum models. As a result:

- It is recommended that the F3WG support a workshop on the use of OPC and particle size instrumentation, and in particular on the issues relevant to knitting together size spectra from different instruments in order to span the full range of taxa in the ecosystem.

Behaviour is an important aspect of higher trophic levels and there is a variety of ways of representing behaviour in models. Adaptive (genetic algorithms and dynamic programming) techniques are of particular interest and should be explicitly be addressed in the modelling of marine ecosystems. In relation to GLOBEC, the "problem of animal behaviour" becomes particularly important when one tries to predict advection patterns of zooplankton or fish larvae, and it appears that the vertical distribution of the animals is very important for the predicted advection pattern. In some cases (but not always) it becomes more important to have a good model of animal behaviour than an accurate physical model.

Similarly, encounter rates between predators and prey are often modelled as a function of relative velocity of predators and prey, including turbulence effects. The swimming velocities are typically assumed to be fixed or a constant depending on size. When studied explicitly, the activity level of animals are typically found to be highly variable and influenced by light, food concentration, predator abundance, internal conditions, etc. Our models (and all models including a relative velocity based foraging function) are likely to be very sensitive to the specified activity behaviour of our target species and its predators and (to a lesser degree) prey.

- Position papers will be developed in the next year on key issues to be considered in size-structured models and the incorporation of behaviour. A target outlet will be the GLOBEC Newsletter.

Inter-comparison and Synthesis

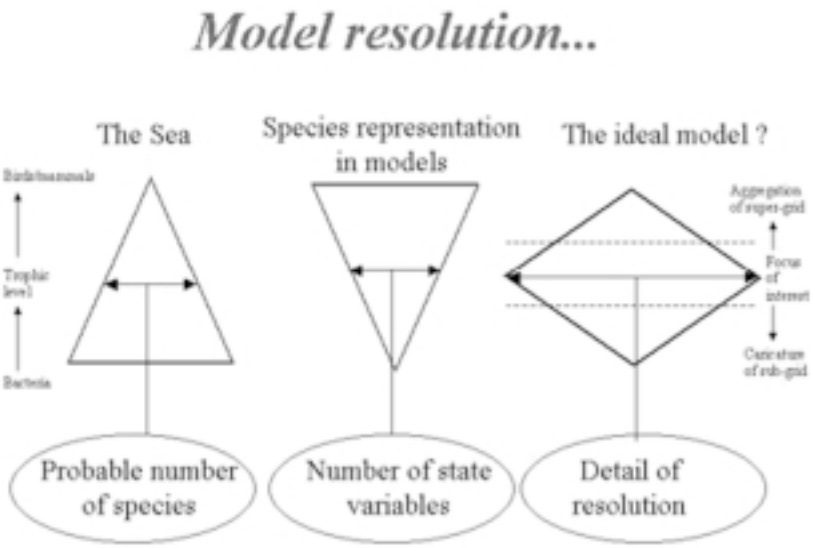
From the particular observation in the ocean, to the ecosystem and its model, through to the basin and the globe there is a need for the inter-comparison of results and ideas and the synthesis of knowledge. The synthesis should ultimately lead to understanding of the problems that have stimulated GLOBEC activity, in particular the explanation of the apparent large-scale synchrony of marine ecosystems to climatic variability. The development of this integration requires the stimulation of inter-comparisons between groups working on common problems. During the next years, the F3WG will consider approaches that integrate components of the ecosystem modelling into larger spatial scale and longer time scale models; serve as a catalyst for the development of inter-comparison of synthesis activities; and where possible, conduct and lead appropriate workshops and meetings.

Three different general levels of interactions will be considered:

(a) inter-calibration exercises with a specific activity in the coming year to convene a workshop or study session on population models of zooplankton;

(b) regional inter-comparisons with a specific activity being to convene a workshop on Eastern Boundary Current Systems and their relation to SPACC (Small Pelagics and Climate Change programmes); and

(c) synthesis activities with a specific activity in the coming year to develop a brief paper addressing the general issues of coupling physics and biology at basin scales and looking at possible applications, e.g., in the Pacific, the North Atlantic and possibly the Southern Ocean



Grand Challenge Questions

The working group discussed the value to GLOBEC of developing a specific "Grand Challenge" question, or series of questions, and what form the question(s) could take. A broad proposal was to follow the question relating to the effects of doubling atmospheric CO_2. The discussion concluded that the generation of a grand challenge would be valuable to F3WG not only because it would focus the development of modelling efforts within GLOBEC, but it would also be valuable for forming a link between the four Focus groups, as well as to other programmes within IGBP and in other international programmes (GODAE, CLIVAR, GAIM). The questions would be addressed not just through numerical models but would necessitate the development of new conceptual approaches. Two questions were identified as a starting point for the preparation of a position paper:

1. *How will marine ecosystems respond to predicted climate change?* This would build on predicted (existing/archived) climate change scenarios and develop a number of approaches to consider how marine ecosystems would respond (with emphasis on zooplankton and food-web changes). Links to other programmes (e.g., PAGES/CLIVAR), and the Focus 1 Working Group would enable consideration of the historical basis for changes.
2. *How do marine ecosystems respond to rapid (< 100 yr) climate change?* This is a more focused version of Question 1. With mounting evidence for rapid rates of climate, how quickly will we see changes in marine ecosystems? Are we expecting evolutionary changes, dynamic changes within one system model or shifts between two models systems? This would be valuable for examining the potential changes and shifts in marine living resources.

Closing remarks

Achieving the objectives set in the first meeting of the F3WG will not be simple. However, through collaboration with the GLOBEC IPO, the other Foci Groups, and the existing IGPB programs, as well as GOOS, GODAE, CLIVAR, etc., we hope to stimulate discussion and provide concrete recommendations that will benefit the various ongoing GLOBEC and related programmes. The GLOBEC Newsletter will be used as a means of information and update on the status of our activities.

News from the GLOBEC SSC

Roger Harris, Chairman GLOBEC SSC, Plymouth Marine Laboratory, UK (r.harris@pml.ac.uk)

The fifth meeting of the GLOBEC Scientific Steering Committee was held on the Mediterranean coast of Spain, in Sitges near Barcelona, from 15-17 May 2000.

This was the first meeting since the publication of the GLOBEC Implementation Plan (GLOBEC Report 13), as well as being the first SSC meeting to be held under the auspices of the fully established GLOBEC IPO in Plymouth. For both reasons the Sitges meeting marked a new level of activity within GLOBEC, with a strong focus on implementation.

Some particular highlights from the discussion, and resultant agreed actions, include additions to the newly re-launched web-site, plans for a GLOBEC Brochure, agreement to produce a GLOBEC Special Report on the current status of the National Programmes, and the approval of the Data Policy. All of the former items coming under the responsibilities of the IPO.

Plans for the three newly established Working Groups, for Foci 1,2, and 3, were considered and approved (see pages 16-20 in this Newsletter for reports on Focus 1 and 3). Attention was given to activating Focus 4 initially though contribution to the emerging IGBP "Food Systems" initiative. It was agreed that work on typology issues would begin through a joint effort between the SSC and IPO, possibly in collaboration with LOICZ.

GLOBEC SSC, left to right: F. Shillington, E. Hofmann, N. Pinardi, P. Lehodey, S. Piontkovski, R. Sanchez, G. Ottersen, F. Carlotti, I. Perry, C. Marrase, F. Werner, J. Alheit, R. Harris, T. Baumgartner, S. Kim, S. Poulet

Initial ideas for a second GLOBEC Open Science Meeting were discussed, and agreement was given to co-sponsoring an ICES/GLOBEC/PICES Zooplankton Ecology Symposium. Framework Activities will be advanced by an Optical Plankton Counter users workshop to be held in 2001.

A list of the Agenda Topics is given below, and the full Minutes of the Sitges Scientific Steering Committee Meeting are available on the GLOBEC web-site (http://www.globec.org) For those without easy Internet access, copies of the Minutes are available on request by mail from the Plymouth IPO.

- Executive Officer Report
- Report on established GLOBEC Working Groups
- Strategy for Implementing Focus 4
- Strategy for implementing Framework activities
- Regional Programmes
- Strategy for implementing Integrating activity 9.0
- National Programmes
- Report of the IGBP SC
- Relations with GOOS LMR
- Future of Ocean Biogeochemistry
- IGBP Open Science Conference
- The budget and prioritising the calendar of meetings

The SSC discussions in Sitges initiated an impressive range of implementation activities, which are a testimony to the vitality of the GLOBEC programme, and which will provide the international community with many practical opportunities to participate in the future development of GLOBEC research.

The IGBP-IHDP-WCRP Global Environmental Change and Food Systems Project: a GLOBEC perspective

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

The question of how Global Environmental Change (GEC) will affect our ability to meet the food demands of a rapidly expanding human population is an issue of global importance. The world's population has been swelling at a rate of approximately 80 million people per year, mostly in regions where food is already at a premium. Until recently the economy of the world assumed that natural 'goods and services', such as fertile soil, fresh water and natural resources were cheap or free of charge. Many scientists and policy makers now believe that we are near the sustainable yield thresholds for many of the earth's resources. The marine environment is no exception. In 1883 Thomas Huxley stated that all great fisheries were inexhaustible. Barely a hundred years later the FAO reports that over 60% of all worlds' fisheries are overexploited or exploited at full capacity. FAO projects that the per capita fish yield is likely to level of or decrease in the next few decades. Thus, if the marine environment is to remain a crucial protein source for the human race, alternative means of boosting food production need to be found.

While population growth is driving the need for more food, Climate Change is adding uncalled for pressure to marine and land-based resources world-wide. For example, about 75% of the world's coral reefs monitored by the Global Coral Reef Alliance are showing signs of bleaching due to increases in seawater temperature. Bleaching leads to death, and with coral reefs providing over 25% of the fish catch in developing regions the prospect is worrisome. With such concerns in mind a growing aquaculture industry is being promoted to sustain world fish supplies, but unless ecologically sound practices are enforced the aquaculture industry may actually be a contributing factor to the collapse of oceanic fisheries. For example, many intensive aquaculture systems use 2-5 times more fish protein in the form of fish meal, to feed the farmed species, than is supplied by the farmed product. As most fish meal is produced from pelagic species in upwelling areas, such practices effectively transfer high volume, low price fish resources from developing regions to support low volume, high price fish products in developed countries, hardly solving the problem they tried to address.

At a meeting at the ICSU headquarters in Paris, France, in March 2000, the three major international research programmes on Climate Change, the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme (IHDP) and the World Climate Research Programme (WCRP), concluded that a major international effort was needed to address these issues. The major thrust of the new project will be to estimate the impacts of Global Environmental Change on food production, availability and accessibility across biophysical and socio-economic systems from regional to global scales, and to analyse the effectiveness of adaptive strategies to reduce societal vulnerability. The combined effort of the three programmes is essential, as the required science depends on strong links between biophysical and socio-economic sciences in both project design and implementation. A planning team was appointed to guide the planning phase, and a planning meeting of about 25 people was held at the University of Reading, UK, in July 2000. The project will address three fundamental questions, in search of policy-relevant or institutional contributions to address the project's objectives:

1. How does GEC additionally affect food provision and vulnerability in different regions and among different social groups?
2. How might different societies and different categories of producers adapt their food systems to cope with *both* GEC *and* changing demands?
3. What would be the environmental and socio-economic consequences of adaptations to these changes?

The GEC and Food Systems initiative has direct links to GLOBEC. The consequences of maintaining or increasing

current fish exploitation patterns are relevant to our Focus 2 (Process Studies) drives towards understanding and quantifying the responses of marine ecosystems to fishing. They are also relevant to our Focus 3 (Predictive and Modelling Capabilities) efforts to develop prognostic models of long-term changes in zooplankton and fish stocks. These consequences culminate in the objectives of our Focus 4 (Feedback from Changes in Marine Ecosystem Structure), particularly in reference to our work on earth system impacts from changes in marine ecosystems. For example, GECFS is likely to develop scenarios of future adaptations to increase food supply regionally and globally. Some of these scenarios may be determined in close co-operation with GLOBEC's marine ecosystem typologies, thus adding to the value of both initiatives. The links with some of our regional programmes may be more obvious, like the relevance of the Small Pelagic fish and Climate Change Programme (SPACC) 4th theme ('Economic implications of climate change') activities.

GEC and Food Systems is still in the planning stage, and in the next few months several meetings will be held to develop a scientific programme that can be effectively implemented. A final project proposal will be unveiled at the IGBP Open Science Conference in Amsterdam, July 2001. The IPO will continue to monitor the development of GEC and Food Systems, and will inform the community through this Newsletter. For more information, please contact the IPO.

GLOBEC SCIENCE

A column for scientific notes of relevance to the GLOBEC community

At the first meeting of the GLOBEC Focus 1 working group, held in Sitges, Spain, it was agreed that the GLOBEC community would appreciate some advice on specific analytical or statistical techniques relevant to our research objectives. The creation of a scientific column in the GLOBEC Newsletter, the official source of communication between GLOBEC researchers, was suggested. To kick off the series, Dr Benjamin Planque agreed to write a review on common pitfalls in retrospective analysis studies. Any reader of this Newsletter is invited to submit a contribution to this column, including responses to previously published columns. Contributions will not be formally reviewed but they will be circulated to the Chairpersons of our Foci working groups prior to publication to ensure consistency and relevance to the activities of GLOBEC's working groups. Contributions on any technical, analytical, statistical or modelling aspects of GLOBEC relevance should be send to Dr Manuel Barange, editor of the Newsletter. There will be no specific calls for submission, so just send them when they are ready. Remember that the column can be a perfect sounding board for new ideas, or a platform for early publication, so use it to your benefit as well as the benefit of the GLOBEC community. We all look forward to your contributions, and thank Benjamin for getting the ball rolling.
The Editor

Retrospective analysis, pitfalls and solutions – serial correlation

Benjamin Planque, IFREMER, Nantes, France (benjamin.planque@ifremer.fr)

Ecological time series rarely resemble statistical *noise*, but instead often display patterns such as cycles, trend, or persistence which can generate serial correlation. The comparison of time-series (in particular in correlation type analyses) requires adapted techniques to take serial correlation into account. These techniques have been tested on ecological time series and are now available in statistical packages. They should become part of the basic statistical toolbox for retrospective analysis.

The analysis of time series has provided an extremely valuable tool for the study of biotic and abiotic interactions in natural ecological systems. A plethora of examples can be extracted from the literature, the best known probably being the hare / lynx relationship in North America. In marine ecology, time-series have also been used to generate new ecological hypotheses or to test existing ones.

Contrary to experimental studies, which can be designed to fit the criteria requested for subsequent statistical analysis, the collection of time-series data is constrained in such a way that these criteria cannot always be met. One such criterion is the assumption of statistical independence between samples. A time series of independent observations can typically be represented by white noise, a signal in which variance is similar at all time scales. Ecological and environmental time series rarely resemble white noise. This is fortunate because it implies that the series is structured in such a way that it can be used to better understand the system under study and possibly to predict its future behaviour. On the other hand, it is problematic for statistical analyses which require independence between samples, such as correlation analysis.

The antagonism between ecologically meaningful structures in time series and the consequent violation of the statistical assumption of independence between samples is present in nearly all ecological time-series. However it is often unrecognised by the authors or the reviewers of papers which make their way to publication in the field of marine ecology. The purpose of this letter is to discuss the particular

problem of serial autocorrelation, and to present some of the techniques for dealing with it.

The autocorrelation in a time series can be measured as the correlation of the series with itself for a specific lag. Measuring autocorrelation for several lags produces the autocorrelation function (ACF). When the values of the autocorrelation function for lag 1 and above are significantly different from zero the data in the series are not statistically independent and some correction has to be made prior to statistical testing. There are two categories of techniques available to do so. The first one is to transform the original data so that the resulting time-series is not autocorrelated. The second one is to evaluate the true number of statistically independent observations in the series. (I will only deal here with the case of positive autocorrelation, most common in environmental and ecological time-series.)

The first technique is often referred to as pre-whitening (since the resulting series resembles white noise). Techniques for pre-whitening can include the removal of trends or cycles, the first-order differencing of the original series, or a combination of these. The advantage of such techniques is that they allow standard statistical testing to be performed with little or no loss in the number of degrees of freedom (df). The drawback is that they concentrate on short term fluctuations in the ecological signal. These are often more *noisy*, which reduces the power of statistical testing. In addition, long-term fluctuations or cycles which may have great ecological significance are *removed* by the pre-whitening process. In consequence, pre-whitening techniques should be used when the process under study is occuring *a priori* at a high frequency.

The alternative category of methods involves the re-estimation of the number of degrees of freedom. Several equations have been proposed for foing so. For example, the equation proposed by Chelton (1984) and by Pyper and Peterman (1988):

$$\frac{1}{N^*} = \frac{1}{N} + \frac{2}{N}\sum_j r_{xx}(j) r_{yy}(j)$$

where N^* is the number of independent joint observations on the time-series X and Y, N is the sample size and $r_{xx}(j)$ and $r_{yy}(j)$ are the autocorrelation of X and Y at lag j. Estimators of r are obtained using the Box-Jenkins' equation (Box and Jenkins 1976), modified by Chatfield (1996):

$$r_{xx}(j) = \frac{N}{N-j} \cdot \frac{\sum_{t=1}^{N-j} (X_t - \bar{X})(X_{t+j} - \bar{X})}{\sum_{t=1}^{N} (X_t - \bar{X})^2}$$

where $\bar{X}$ is the overall mean. Such methods are relatively robust, unlesss the original time-series are too short, which renders difficult any accurate estimation of the autocorrelation function. The advantage of such techniques is that the original series remain unaltered, so that medium or long-term signals that may be part of the ecological process under study are not removed. However, as for pre-whitening techniques, correcting the number of df reduces the statistical power of the test, which can lead to inconclusive analyses. Trends, cycles and persistence do not have the same statistical properties and it is sometimes wise to combine the two types of techniques to remove the bias of the statistical test due to dependence between data.

The correct use of such techniques should help in identifying statistically robust relationships. It should also provide more detailed empirical information on the temporal scales at which the processes underlying these relationships do occur.

This letter was inspired by some discussions that took place during the Globec Focus 1 WG meeting in May 2000. Some sections have been inspired by the reading of chapter 11 in Bakun (Patterns in the Ocean. Ocean processes and marine population dynamics., 323 pp., California Sea grant college system, La Jolla, 1996) and the introduction chapter of Legendre and Legendre 1998 (Numerical ecology., 853 pp., Elsevier, Amsterdam, 1998)

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ICES- Cod and Climate Change

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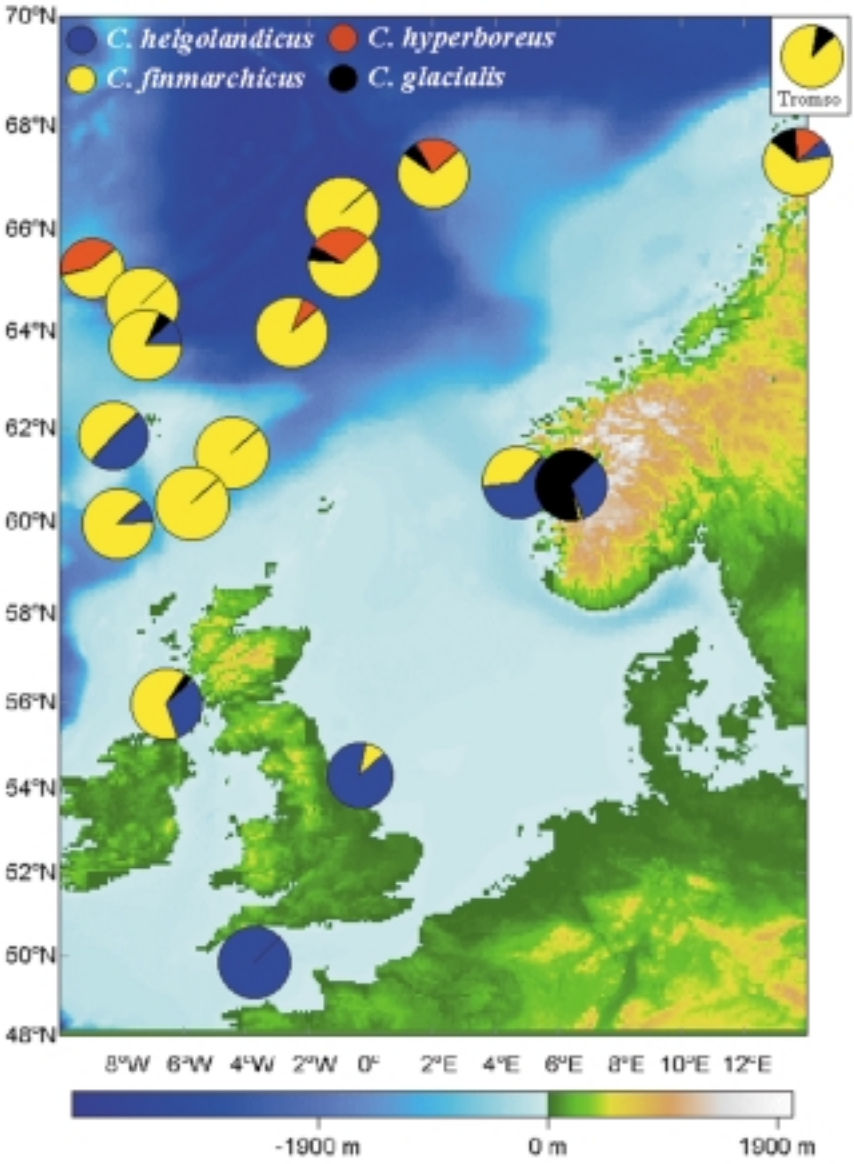

Distribution of four species of Calanus, as identified using a molecular identification system suitable for any life stage. (see article by G. Smerdon and P. Lindeque, p.12)

GLOBEC CALENDAR

2000

11-13 September: GLOBEC Focus 2 WG, Roscoff, France
25-27 September: GLOBEC/PAGES/ CLIVAR Intersection Meeting, Sidney, Canada
5- 6 October: GLOBEC Executive Committee meeting, Plymouth, UK
10-13 October: SCOR General Meeting, Washington, USA
11-13 October: US GLOBEC SSC Meeting, Woods Hole, USA
16-20 October: SPACC-ENVIFISH and SPACC-VIBES Annual meetings
Cape Town, South Africa
20-28 October: **PICES Annual Science Conference GLOBEC Session**
Hakodate, Hokkaido, Japan
6th-24th November: GLOBEC/IRI Workshop on Interannual Climate Variability and Pelagic Fisheries
Nouméa, Nouvelle Calédonie
20-22 November : IGBP-GEC and Food Systems. Focus 1.
Stockholm, Sweden

2001

January: **GLOBEC-China Workshop on sampling and observational systems**
TBA, China
20-28th February: 15th SC-IGBP meeting, Chang Mai, Thailand
March: GLOBEC Steering Committee Meeting, TBA
March: SPACC meeting on long term data in the Americas, Lima, Peru
10-13 July: **IGBP Science Conference**
Amsterdam, The Netherlands
21-28 October: **IAPSO/GLOBEC Symposium**, Mar del Plata, Argentina
28- 30 November: 1st Symposium GLOBEC-Spain, Cadiz, Spain

GLOBEC INTERNATIONAL

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