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Report of the Working Group on Zooplankton Ecology (WGZE)

5–8 April 2004
Hamburg, Germany

International Council for the Exploration of the Sea

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Executive summary

The Working Group on Zooplankton (WGZE) had a convivial and constructive meeting, hosted by Dr Wulf Greve in the German Centre for Marine Biodiversity, Hamburg, Germany. There were 20 WG members at the meeting representing nine ICES countries. Several others not able to attend (including representations from two other ICES countries) sent written submissions or presentations to contribute.

Main points summary

ToR f. Review and consider new technologies for identification and enumeration of plankton species

The SAHFOS CPR team has published a very useful new atlas on the plankton zoogeography in the North Atlantic and North Sea.

New and improved acoustic and optical sensors and deployment platforms for plankton sampling (e.g., VPR, ZOOVIS, SIPPER, LIDAR, OPC/LOPC) are becoming common and improving rapidly. Improved computer memory and processors, allied to scanning and visualization techniques are helping to automate some aspects of taxonomic sampling and sample processing (e.g., ZOOSCAN, SIPPER, FLOWCAM). Also, molecular techniques are most likely to result in the most significant advances in the way zooplankton and their characteristics are sampled, studied and identified (e.g., ZOOGENE, COMZ). However, in most nations there is often a critical shortage of plankton taxonomists to work on samples and who can train the image analysis systems or select known species for sequencing. The biodiversity of the entire holoplankton in global ocean ecosystems is estimated at only something <10,000 species. It is considered an achievable aim to describe and genetically catalogue this entire holoplankton biodiversity. New horizons would open for understanding in marine systematics, evolution, biogeography and ecology.

Archival sample collections more accessible and valuable as image analysis techniques improve. Quickly done "rough", but increasingly effective, analyses allows targeted "full species" analysis, so making plankton sample analysis simultaneously more immediate, effective, broader based and better focussed.

- To introduce and promote this technology WGZE propose generating a list of available open source software for automatic identification of plankton to be included on the ICES WGZE web pages.
  The WG listed some known plankton gear intercomparison with, optical, and acoustic methods (Appendix 4). Many such studies are not worked up, published, and available. WGZE suggest this may be worth a collected volume of papers on intercomparison and evaluations to produce recommendations for gear uses.
  Updates for the Zooplankton Methodology Manual, (a 2nd Edition?); with new gear descriptions, new length/width to biomass data and many other methodological advances etc, will soon be required.
- WGZE propose lists references and algorithms that enable determinations of biomass from individual length or width measurements of zooplankton.
- WGZE propose that ICES WGZE web site could act as a message board to communicate advances and updates and to collate these data and make them available.
- WGZE propose that ICES WGZE web site act as a focus for a "Virtual Network of taxonomic experts" to work alongside Fiches sheet developments to improve availability and delivery of taxonomic expertise.

WGZE discussed ideas for creating a European Monitoring Network (for zooplankton) to aid the ocean science community. There are several similar terrestrial programs and some marine (e.g.,, HABWATCH). The idea is to generate and organise a network of scientifically supervised lay people, to make plankton collections and observations at many sites along the coastlines.

Suggested Theme Session for 2006 ICES Annual Science Conference;
"Methods and comparisons of plankton field sampling and analysis, particularly use of image acquisition and analysis technology."

Helgoland Roads Zooplankton Colloquium, on the Occasion of the 30th Anniversary of the Time-Series
This was arranged as an additional session so the WGZE members could participate along with many others who were there to celebrate this very considerable achievement. A series of talks were given on;

1. Zooplankton monitoring in the ICES area (Mr Steve Hay),
2. Biodiversity dynamics as environmental indicators (Dr. Michael Tuerkay),
3. Monitoring of the marine environment in Germany (Dr. Hartmut Nies),
4. Monitoring the North Sea since 1873 at Helgoland Roads (Prof. Dr. Friedrich Buchholz) and
5. Thirty Years of Helgoland Roads zooplankton: from observation to prognosis (Dr. Wulf Greve).

The afternoon of useful talks and discussion was followed by a relaxed evening together for more talking.

ToR a. Update the annual ICES plankton Status Report, including extending the time-series with new sites, phytoplankton series, and advances in monitoring technology

Improvements are made to the ICES Plankton Status Report this year. Updated site data is contributed and new CPR information prepared and donated by SAHFOS. This introduced broad scale North Atlantic data and sectored overviews, provide background and context for regional detail. New Canadian data is included with further improvements of anomaly plots of data allowing better trend observation and comparison. Prospects are good for future developments and research efforts are beginning to use the data, in syntheses and collaborations between monitoring effort, so adding value to each and all. This encourages the WGZE in this service to the marine science community.

- WGZE proposed that WGZE, WGPE and WGHABD members attending the next ASC, should meet for an hour or two to explore ways to collaborate in the Plankton Status Report.
- WGZE propose a Workshop, open to the WGZE, WGPE, WGHABD and other groups, to harmonize the Plankton Status Report and define key species and parameters that should be included in future editions, as well as to consider analysis - regional trends, climatic indices, correlation with fisheries trends, etc.

Additional suggested data should include particularly the phytoplankton data, or chlorophyll as proxy, and simple physical parameters such as SST and salinity (also broadly available from hydrographic databases). Also lists of species and key species / relative seasonal abundances, local diversity etc. All would increase the data's usefulness. WGZE see growing recognition of the importance of macroplankton, particularly gelatinous species, and of invertebrate predator fields, their dynamics and influence in marine ecosystems generally.
The availability of further data sets depends on goodwill but also on the ICES Plankton Status Report being seen to be useful, WGZE opinion is *that ICES needs to expend greater effort on consolidating, managing and making available biological data on phyto and zooplankton. The SG on Marine Integrated Data also recognised these deficiencies and was calling too for better online access to such data from ICES web site.*
The WGZE is dismayed that an existing long-term time series of data from the Irish Sea, collected from the Isle of Man, is due to end soon since the laboratory at Port Erin is to be closed.

ToR b. Consider future developments and collaborative approaches in time-series measurements and interpretation

The International Symposium on Zooplankton Production (Gijon 2003) revealed an increasing number of long-term data sets and researchers interested in variability, trends, cycles and comparative ecology of plankton systems. Calls were made for the emphasis and support required to enable funding and resources for such research.
PICES colleagues propose a SCOR Working Group for global-scale comparison of zooplankton time series. If successful, work will start early in 2005 for three years. The PICES group approached the ICES WGZE aiming for collaboration to enrich the proposal and to include WGZE on the SCOR WG.
CIESM: This council has a Round Table on the "Harmonization of zooplankton time series" during the 37th CIESM (Barcelona, 7-11 June 2004). Aims to launch a new project named "Mediterranean Zooplankton Time Series", among the objectives is analysis of historical and new time series of the Mediterranean zooplankton, the harmonization of sampling, etc. WGZE member will try to attend.
Delphine Bonnet gave a brief talk about an interesting current project to look at latitudinal variability in *Calanus helgolandicus* biology. This very relevant study has gathered collaborators from 22 sites for comparison throughout Europe and the Mediterranean where *Calanus* abundance time series, cruise data and process studies exist, and the group seeks others to extend the latitudinal range.

- WGZE suggests that ICES should play a lead role to maintain at least a database of metadata for the North Atlantic (and the Mediterranean – in moves to collaboration/globalisation). The metadata inventory of the Plankton Status Report, ICES held HELCOM data and ancillary data serve as examples and a good starting point. Links must also be established with other data centres holding plankton data.
- WGZE recommends that ICES improves its existing and unimpressive web site to advertise actions and products more boldly with links to plankton data held at monitoring institutes and marine data centres.

- Valuable archive plankton samples and specimen collections should be discovered and made available for new analysis. Again, a collection of metadata describing archive collections would highlight their existence. Samples are often partially analysed e.g., for fish eggs and larvae and associated with environmental and other data. Image analysis now makes analysis of such collections far more practical.
- The Census of Marine Life initiative was mentioned as also interested in archived data and sample collections and could perhaps provide support and funds for sample rescue projects.
- WGZE strongly recommends that ICES calls for reference species collections, supported when possible by genetic sequencing, becomes a formal part of plankton analysis for monitoring and survey work.

ToR h. Start preparations to summarise status and trends of zooplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000-2004, and any trends over recent decades in these communities; for input to the Regional Ecosystem Study Group for the North Sea in 2006

WGZE is tasked to describe states and changes between 2000 and 2004 in the North Sea plankton ecosystem (e.g., seasonal cycles, community changes). We need to get data and information for the North Sea from fixed stations or cruises plus monitoring and process studies. Aim first to list the marine institutes around the North Sea then ask what plankton data they hold for the period. To find relevant cruises, consult the ROSCOP cruise programs database at ICES. For example, the Cod Eggs survey in February/March 2003 generated many North Sea samples.

WGZE know of at least the following relevant data sets:

- CPR North Sea transect data
- Stonehaven Monitoring Station
- Dove Monitoring Station
- Plymouth L4 Monitoring Station
- Monitoring in Shetland underway 2003-2004
- Other likely data held in Oslo and Bergen

- WGZE propose a virtual zooplankton workshop on the North Sea, hosted on ICES website, as the focus and holding centre for data, analysis and ideas. This allows all to contribute, not just North Sea countries in the WG group, and brings other experts in to the plan. Most useful if the site were available for the 2005 WGZE meeting to work then on data for the 2006 North Sea Status Report.

WGZE noted that reference to status and trends prior to 2000 will be essential. Attention is called to the German government project SYNCON (Synthesis and New Conception for North Sea Research) quite recently (1998-2000) produced a comprehensive study of many aspects of the North Sea Ecology. The North Sea Flex program and results are also important historically.

To give flavour to the exercise, Michel Harvey from Canada described the monitoring program on the east cost of Canada and efforts to produce AZMP descriptions and indices of changes. The Helgoland time series has also shown evidence of status changes: • Changes were noted in species reproductive season, with abundance peaks occurring earlier (shift from summer to spring peak). • Two years absence of the appendicularian *Fritellaria* but the hydromedusan *Obelia* was present. This may be correlated to the observed composition changes of food stocks.

WGZE noted again that OSPAR and EU WFD have not included zooplankton status measures in their recommendations for monitoring. The ecosystem role of zooplankton, mediating phyto and fish production, modulating nutrient fluxes, etc. makes the "oversight" seem short-sighted to say the least, especially given that these and many other policy drivers are calling loudly for ecosystem approaches.

ToR c. Review impacts of climate change on plankton communities using biological indicators, with special consideration of fisheries

There is evidence that plankton dynamics are linked to recruitment in some fish stocks, but there is considerable scepticism in the WGZE and we feel the science community generally about the derivation and use of indices and indicators. The WGZE realises that it is tasked with the development of indices that are relevant and useful for fisheries management. Also, WGZE realises that generating indices requires exploring multiple factors and associations, so requires multivariate techniques or multi-parameter models to produce simple, repeatable indices. It is very possible however, that such results may be wrongly interpreted or applied, when all the known and unknown variability is reduced to single figure indices.

An important example of observed climate change impacts on the plankton community affecting fish (herring) recruitment from the Norwegian Sea was presented. For a Norwegian time series from 1995 to 2003 correlations were identified between NAO and the lagged biomass of plankton in May of the following year. These data can be used in fisheries management of herring (assessment of present stock size; and particularly in projection of stock size). It seems that

overwintering areas of herring change according to temperature distribution. After overwintering, the herring migrates to the coast to spawn. The growing larvae feed successively on the developmental stages of *Calanus finmarchicus* (eggs, nauplii, copepodites). A herring condition index closely follows the zooplankton biomass (December) in all years of the time-series, and the centre of gravity of the herring population abundance shifted between the coast and offshore regions over time. The derived information make prognosis possible and is now being used in prediction of growth of herring stocks.

Another example given was the correlation of *Noctiluca* abundance with temperature (Heyen, Fock & Greve 1998), obtained by a partially automated statistical analysis of the Helgoland time series. This emphasised the importance of temperature and possibilities for forecasting.

"What results of zooplankton research are useful for managers of ecosystem resources?" was raised for discussion. One issue is the timing and match/mismatch theory relevant for predator-prey relationships. A presented example was *Ammodytes marinus*, predicting next years landing from previous year's landings, temperature and copepod nauplii abundance 14 days after hatching (Mainik, Lange & Greve 1999).
The influence of jellyfish abundance and NAO on the success of herring recruitment through predation and food competition effects on larvae in the North Sea was discussed in the light of recent work. There is still much to learn about invertebrate predators, including jellies, and their effects on ecosystem functioning, also on socioeconomic activities such as fisheries, aquaculture and tourism. The EU EUROGEL project will help to address these problems. There was further discussion of the importance and role of jellies, points including their role as food for certain fish and the nature of predation on and among the jellyfish.

- The proposal with WGZE support, by colleagues in PICES (North Pacific Marine Science Organization), for a SCOR working group on "Global Comparisons of Zooplankton Time Series" makes serious attempts at a global synthesis more feasible. The WGZE asks ICES to strongly support this plan. There are already observed synchronies and patterns in global fisheries data, The SCOR WG will attempt to find these in plankton data.

It was pointed out that there is still no particular zooplankton index developed so far, but that a major task for the WGZE is to try to shift the view of fisheries people. Their view must recognise that many aspects of plankton dynamics mediate fish recruitment success, rather than only the success of fish larvae as predators. The question remains largely unresolved of, how and how much of phytoplankton production – new or regenerated, one way or another – flows into fish production?; yet this is central to an ecosystem perspective of fisheries. Also important are links through the benthos. If much phyto production falls straight to the seabed, then how will benthic production increase? If so, then meroplankton will feed back this biomass to the water column, to grow, die and return to the benthos as survivors, food or detritus. These pathways are hardly studied or understood as yet, but important for understanding fisheries productivity in ecosystems and in interpreting scenarios of climate change, regime shifts and fisheries harvesting strategies.

ToR d. Review publications and outputs from the ICES/PICES/GLOBEC Symposium (Gijon, May 2003) and the implications for plankton research

The 3rd International Zooplankton Production Symposium on: *"The role of zooplankton in global ecosystem dynamics: Comparative studies from the world oceans"* was co-sponsored by ICES, PICES and GLOBEC (Global Ocean Ecosystem Dynamics Project). The symposium gathered 333 participants from 38 countries and held three half-day workshops, 8 scientific sessions and a public exhibition, with 136 oral presentations and 16 invited talks and with 243 posters exhibited.

Long-term data sets drew the attentions of researchers interested in variability, trends, cycles and comparative ecology of plankton systems. There is growing recognition of the essential role that zooplankton play in regional and global biogeochemical fluxes and cycles, mediating the transport and the balance of particulate and dissolved matter in the system. New approaches to zooplankton modeling were discussed. Two sessions were devoted to technical innovations in study of zooplankton with high temporal and spatial resolution.

It was expressed during the symposium that zooplankton monitoring would do much to reveal the quality status of the ecosystem, natural large-scale variability and regime shifts. The European Water Quality Directive of December 2000 was welcomed as an initiative to oblige the EU coastal nations to carry out continuous and standardised monitoring and reporting of status in coastal and transitional waters. It was noted that zooplankton do not appear as a monitoring target. *It was strongly suggested that means should be found to include zooplankton monitoring in the EU water directive at the same level as phytoplankton and benthic monitoring.*

- The importance of this symposium was remarked as a firm step toward close cooperation between ICES, PICES and GLOBEC and all agreed that we should endeavor to expand into other research areas in the future. At the end, our colleagues from Japan announced that they will initiate negotiations for the organization of the next International Zooplankton Production Symposium in Japan. In fact, our Japanese colleagues have very recently announced that they are prepared to host the 4th International Zooplankton Production Symposium in Hiroshima at the beginning of June,

2007 (see letter in Annex 5). A formal letter and active support from ICES, PICES and GLOBEC would be very appreciated and helpful.

A selection of the best Gijon symposium papers will be published in a volume of the ICES Journal of Marine Science in June 2004 as Vol. 61, No 4.

ToR g. Review the state of the art of enzymatic activity methods to estimate plankton secondary production

Work and theory on "Zooplankton growth and physiology" was reviewed by Bob Campbell. He concluded that enzyme measurements show correlation with actual rates, but are not necessarily true. There is apparent evidence of underlying homeostasis, which could explain why different methods give roughly similar results. Enzyme measurements are not so useful in biogeochemistry. Growth indices are not specific, have no units and depend on a correlation approach, while moulting indices are correlated with secondary production. So, are enzyme proxies useful? The answer seems to be sometimes and with caveats.

However, even if results may be problematic they have shown interesting insights and indications of physiological activity. There is a need for more laboratory studies. Lutz Postel, more confident of the meaning in his results, then presented some positive results gained through the methods Santiago Hernandez Leon's group brought to his laboratory in Warnemünde, he stressed potential problems when using protein as scaling factor.. Delphine Bonnet then briefly presented Lidia Yebra Mora's complex of AARS enzyme work done with Santiago in the Canaries and at Plymouth Marine Laboratory.

A number of WGZE members and others in these research areas, have strongly agreed the need to set up and participate in a workshop on Enzyme Activity Measurements and Assays in Marine Science. This aims to consolidate past/present efforts and to bring expertise to bear on solving problems and understanding practice and theory in such measurements, and to develop future approaches.

- A review is needed of the state of the art of enzymatic activity methods, and other biochemical approaches, used to estimate rates of zooplankton production and activity. WGZE propose that ICES sponsor this workshop where both traditional and state-of-the-art methods may be tested thoroughly under controlled conditions, in order to assess, compare, and intercalibrate the many different methods.

ToR e. Review of achievements of the ICES Zooplankton Taxonomic Workshop (CM 2003/C:14.)

Alistair Lindley reported on the ICES Workshop on Zooplankton Taxonomy hosted by the Sir Alister Hardy Foundation of Ocean Science (SAHFOS) in Plymouth, in June 2003:
Presentations and practical sessions were balanced during the workshop and a short report of the workshop including the agenda can be found on the website www.ices.dk/reports/occ/2003/wkzt03.pdf.

The WGZE pointed out the need to revise the ICES identification leaflets. These leaflets represent prime taxonomic literature and the web-based version of the sheets should make it possible to update them more quickly and employ more advanced presentation techniques. Harry Dooley, put excellent effort into digitising the sheets, but the WGZE and ICES has to decide what to do in the future. In discussion about possible co-operation to improve the use and dissemination of results, co-operation had been proposed with ETI (Expert centre for taxonomic identification). The WGZE proposed to keep in touch with ETI but to be cautious in making agreements that may compromise the free availability of taxonomic information.

To support A. Lindley in the challenge to update and supplement the ICES identification leaflets, it was recommended that an informal subcommittee be formed to deal with the issues. Luis Valdez and S. Hay volunteered to help. The group discussed experts who might be willing to contribute to the ICES leaflets.

Concerning the ITIS (Integrated Taxonomic Identification System) species coding, the group agreed that we should support ICES in updating the species names, synonyms and codes. *It is suggested that an amount of COML funding (already in ICES?) should be made available to support implementation of ITIS coding.* Todd O'Brien volunteered to act as a contact person with ITIS. The WGZE appreciated the benefits of a standard coding system, especially as an opportunity to get taxonomists from all over the world to agree together (!!!) and to have a common focus for nomenclature and taxonomic revisions. No alternative to ITIS as a global taxonomic coding system is currently available. Practically ITIS not only needs a good support system, it also needs to generate an expert user-base and to be updated easily and quickly. A more distributed system should be a positive advantage. WGZE has members also serving on SGMID so fruitful discussions were held on plankton databases where a strong need for integration exists.

- The recent COML meeting was mentioned. Held in New Hampshire and attended by several WGZE colleagues. This group is currently preparing a proposal to COML and the Sloan Foundation for a global Census of Marine Zooplankton (CMarZ) project aiming for taxonomic descriptions, including genetic sequences, of all existing holoplankton species. The WGZE recommends that ICES declare support for this initiative.
- It is proposed that the ICES WGZE will meet in Lisboa, Portugal 4–7 April in 2005.

1 Opening of the meeting

Those attending were:
Steve Hay, Wulf Greve, Luis Valdés, Astthor Gislason, Eilif Gaard, Sophie Pitois, Peter Wiebe, Michel Harvey, Mark Benfield, Todd O'Brien, Webjørn Melle, Sigi Schiel, Rabea Diekmann, Rob Campbell, Claudia Halsband-Lenk, Alistair Lindley, Delphine Bonnet, Philippe Grosjean, Devarajen Vaitilingon, Lutz Postel

Apologies for inability to attend were given by:
Erica Head, Doug Sameoto, Pat Kremer, Sigrun Jonasdottir, Maria Emília Cunha, M^{y} Luz Fernandes and Xabier Irigoien, most of whom submitted presentations or written comment on the ToRs for presentation and consideration through the Chair.

The meeting opened with some words of encouragement from the chair, a round of introductions and a welcome and comments on the meetings housekeeping arrangements from our kind host Dr Wulf Greve. The chair then pointed out that the Colloquium Annex 3 was scheduled for the afternoon, that a couple of people would not arrive until then and that the agenda had been arranged to accommodate these and to place ToR topics in an amenable order to be addressed by the group. The proceedings then began with an outline of the agenda and its adoption for the group's consideration.

2 Adoption of the agenda

The amended agenda for the WGZE meeting (Annex 2) followed the terms of reference adopted as resolutions by the ICES 2003 Annual Science Conference and Statutory Meeting and was adopted as follows. The WGZE will report to ACME and to the Oceanography Committee at the 2004 Annual Science Conference. The terms of reference for this meeting are to:

ToR a. Update the annual ICES plankton Status Report, including extending the time-series with new sites, phytoplankton series, and advances in monitoring technology. lead – Luis Valdes; Rapporteur – Steve Hay

ToR b. Consider future developments and collaborative approaches in time-series measurements and interpretation. lead - Steve Hay; Rapporteur – Luis Valdes

ToR c. Review impacts of climate change on plankton communities using biological indicators, with special consideration of fisheries. lead – Webjørn Melle; Rapporteur – Claudia Halsband-Lenk

ToR d. Review publications and outputs from the ICES/PICES/GLOBEC Symposium (Gijon, May 2003) and the implications for plankton research. lead – Luis Valdes; Rapporteur – Peter Wiebe

ToR e. Review of achievements of the ICES Zooplankton Taxonomic Workshop (CM 2003/C:14). lead - Alistair Lindley; Rapporteur – Rabea Diekmann

ToR f. Review and consider new technologies for identification and enumeration of plankton species. lead – Peter Wiebe; Rapporteur – Todd O'Brien

ToR g. Review the state of the art of enzymatic activity methods to estimate plankton secondary production. lead - Rob Campbell; Rapporteur – Delphine Bonnet

ToR h. Start preparations to summarise status and trends of zooplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000-2004, and any trends over recent decades in these communities; for input to the Regional Ecosystem Study Group for the North Sea in 2006. lead – Wulf Greve; Rapporteur – Sophie Pitois

3 ToR f. Review and consider new technologies for identification and enumeration of plankton species

(Lead: Peter Wiebe; Rapporteur: Todd O'Brien)

The session started with an announcement by Alistair Lindley of SAHFOS that an updated CPR atlas was now available. This new atlas contains revised zooplankton and phytoplankton abundance distributions as sampled by the CPR program from 1958 to 1999. This atlas also incorporates newly adopted numerical procedures and display features developed since the first (1970's) CPR atlas.

The session proceeded with a review presented by Peter Wiebe, of new technologies for the identification and enumeration of plankton species. For field plankton sampling, the continued development of electronics (e.g., miniaturization of components, ultra high storage capacity, low power components, longer battery life, and higher telemetry rates) is rapidly bringing increasingly capable technologies into play for plankton sampling and processing. New and improved acoustic and optical sensors (both particle detecting/sizing and image forming) along with cable based (towed or profiling) and autonomous (AUV/gliders) platforms are becoming common and improving rapidly. In the laboratory, improved scanning and visualization techniques are helping to automate some aspects of taxonomic sample processing and identification as discussed in more detail below.

Of the new technologies that are beginning to be used in plankton work, molecular techniques are most likely to result in the most significant changes in the way zooplankton are sampled and identified. The rapidly developing technology of DNA species identification is now being used by projects such as ZooGene, GLOBEC and others. These techniques allow species distinctions for morphologically indistinguishable species and developmental stages, and the identification of species metapopulations and of subpopulations of cryptic species. Current technologies being developed, with highly geared development efforts, for human security and rapid identification purposes may soon become available for plankton sampling and ID applications.

The point was made that unlike benthic biodiversity or that in some terrestrial ecosystems, the biodiversity of the entire holoplankton in global ocean ecosystems is estimated at only something <10,000 species. It is considered an achievable aim to describe and genetically catalogue this holoplankton biodiversity. The goal of creating a comprehensive inventory of zooplankton species in the oceans will require revision and creation of morphological information fundamental to taxonomic descriptions. This must be accompanied by unique identifying genetic sequence, or sequences and be associated with other essential information on environmental conditions and constraints related to species distribution and abundance. Such an achievement would open many new horizons for understanding in marine systematics, evolution, biogeography and ecology. There is a growing background of theory on biodiversity in ecology, and a growing concern at the loss of biodiversity on the planet. The growing need and feasibility of a world wide zooplankton species diversity census was emphasized as the starting point and stimulus to enable the rapidly advancing molecular tools (DNA chips etc) to be applied in new plankton sampling technology.

Mark Benfield continued with a presentation and discussion on the Visual Plankton Recorder (VPR), the ZOOVIS optical plankton system, and the application of LIDAR in coastal plankton studies. Mark provided an example of the power of acquiring coupled image and acoustic data to study the distribution and abundance, and behaviour of euphausiids in Knight Inlet. The imaging system enabled the identification of the species within a strong acoustic scattering layer that showed diel migration. In addition, with knowledge of the water column currents, the orientation of the euphausiids could be determined. In this case, they were swimming horizontally and oriented into the flow. The prototype ZOOVIS is now being modified to increase its performance and reduce the cost of construction.

Steve Hay, in Xavier Irigoien's absence, summarized AZTI's development of new plankton counting techniques. Xavier's group has developed the "Plankton visual analyser" or PVA software for zooplankton image analysis. The software is designed to work with an image scanned at 600 to 1200 dpi. Prior to scanning, it was recommended that the plankton be stained red. The software includes a neural net identifier that must be trained. Contact Guillermo Boyra or Xabier Irigoien at AZTI (www.azti.es) to obtain a free copy of the software. Following discussion raised the points that some workers had found standard scanners only good for large species and many ended up producing fuzzy images, as they often get vibration problems. The subject of holographic approaches was raised and the work of Dr John Watson at Aberdeen University, Scotland, on the EU HOLOMAR project which proved the concept. He is following up through further collaborative ventures with smaller and more useful designs.

Philippe Grosjean presented new in-lab software and optical methods available for processing plankton samples for Gabriel Gorsky's ZooScan system. This system can be used for automatic and semi-automatic identification of zooplankton. The system generates and analyses high resolution net zooplankton and micronekton scanned images (7500x17000 pixels for each picture). Although the hardware will be a commercial product, the software for this system will be free and could be adapted for others systems. Philippe emphasised that the real challenge is in using machine

learning to create robust identification systems. Problems often arise because of the morphological variability within taxonomic groups and from errors made by experts in setting up training data sets. Most machine learning systems are designed for, and rely on, fixed and exactly known groups with no errors in training sets. Philippe presented a comparison of 15 various methods for doing the automatic identification, showing that all have precision in the range 50% - 70%. He described a new, fast and computationally efficient approach known as discriminant vector forest (dvf), with which possible accuracies are in the 80% range.

The abilities and limitations of these new images analysis technologies and methods were discussed. In summary, many of these techniques, which are good now, will continue to be refined as image-resolutions, software and hardware improve. There are a growing number of groups working to achieve and improve these techniques across a range of disciplines. Clearly however, with each new application, ground truth and expert human review and verification were, are and will be necessary. These new tools are best used as an aid to the scientists and technical support personnel that process the samples and should **not** be viewed as a replacement for them. In most nations there is often a critical shortage of plankton taxonomists who can train these image analysis systems. As the techniques improve they render archival samples even more accessible and valuable. The ability to quickly do "rough" analyses also helps and allows the conduct of limited and targeted "full species" analysis, so making plankton sample analysis simultaneously more effective, broader and better focussed.

To introduce and promote the availability of this technology a recommendation was that the WGZE generates a list of open source software available for automatic identification of plankton to be included on the ICES WGZE web pages with appropriate references.

It was also suggested that WGZE needs to make a list of available references and algorithms that enable the determination of biomass from individual length or width measurements of zooplankton. It was asked if it was possible to use ICES Web site to collect the biometrics of plankton.

It was considered that it might be time to update the Zooplankton Methodology Manual, (a 2nd Edition?); with new gear descriptions, new length/width to biomass data and many other methodological advances etc. Again it was suggested that the ICES WGZE website could act as a message and post board for the plankton research community to communicate advances and updates.

It was also proposed that the ICES WGZE website could act as a focus for a "Virtual Network of Taxonomic Experts" which could work to improve the availability and delivery of taxonomic expertise.

Also a possible Theme Session was suggested for the 2006 ICES Annual Meeting in Aberdeen, Scotland on the "Methods and comparisons of plankton field sampling techniques, particularly use of image acquisition and analysis technology."

Webjorn Melle introduced development of a new "macrozooplankton net" at IMR Bergen. Current plankton sampling tends to often ignore the macro-zooplankton, focusing on either the larger fish or the micro- and meso-zooplankton. This new net, towed at 2 to 3 knots, is designed to sample this often ignored portion of the community. The new macro-zooplankton trawl net has a 6 m x 6 m mouth opening, with a 40 meter length, and has multiple cod-ends that allow for discrete depth sampling. Comparisons between plankton trawl and fish trawl have been made for catches of the euphausiid, *Meganyctiphanes norvegica*. There does not seem to be any avoidance of the plankton trawl or the fish trawl, but the plankton trawl caught far more of the smaller, juvenile, first generation stages of *M. norvegica.* This lead to the conclusion that 60% of the biomass of this key species was not captured / estimated by standard gear. Thus, the biomass of euphausiids has been grossly underestimated by previous surveys. Webjorn also noted that samples were taken to enable comparisons between the plankton trawl, the $1m^2$ MOCNESS and the WP2.

The working group generated a listing of known intercomparison work with plankton gear, optical, and acoustic methods (Annex 4). Many of these studies are not worked up, unpublished, and unavailable. It was suggested that this may be worth a volume of collected papers on intercomparison of zooplankton sampling equipment and how to evaluate all of the data to work out recommendations for gear to use under particular circumstances.

In the discussion that concluded the session, Wulf Greve talked about his ideas for creating a European Monitoring Network (for zooplankton). There are similar terrestrial programs; Wulf wants to bring these scientific approaches to the aid of the ocean science community. That is, to generate and organise a network of lay people, scientifically supervised, to make plankton collections at many sites along the European coastlines. He envisions these individuals sampling weekly and providing reports in the same way that terrestrial scientists have developed reporting systems for bird populations or for meteorological observations. He asked for suggestions and/or how other similar projects got the public interested. Rob Campbell said there is a NOAA red-tide watch programme on the US East Coast that does a similar thing. Peter Wiebe gave the example of "Pond Watch" on Cape Cod (Massachusetts, USA) that deploys citizens to collect samples that are used to characterise the status of estuarine ponds in the area and identify eutrophication problems.

Helgoland Roads Zooplankton Colloquium, **on the Occasion of the 30th Anniversary of the Time-Series (Annex 3)**

This was arranged as an additional session so the WGZE members could participate along with many others who were there to celebrate this very considerable achievement. A series of talks were given on;

1) Zooplankton monitoring in the ICES area (Mr Steve Hay),
2) Biodiversity dynamics as environmental indicators (Dr. Michael Tuerkay),
3) Monitoring of the marine environment in Germany (Dr. Hartmut Nies),
4) Monitoring the North Sea since 1873 at Helgoland Roads (Prof. Dr. Friedrich Buchholz) and
5) Thirty Years of Helgoland Roads zooplankton: from observation to prognosis (Dr. Wulf Greve).

The afternoon of useful talks and discussion was followed by a relaxed evening together for more talking.

4 ToR a. Update the annual ICES plankton Status Report, including extending the time-series with new sites, phytoplankton series, and advances in monitoring technology

(Lead: Luis Valdes; Rapporteur: Steve Hay)

Discussion opened with consideration of improvements to the existing Status Report. It was noted that as the report grows so does the task of compiling it. Luis Valdes was congratulated for his editorship and others offered to assist. To keep the task feasible, changes need to be planned and introduced sequentially over the next years. The first noted improvement is the addition of updated CPR information prepared and donated by SAHFOS, which has introduced broad scale North Atlantic data and sectored overviews, and so provides background and context for regional detail at contributing sites. This very welcome addition was reinforced by the confirmation by Michel Harvey and Erica Head of the addition of new data from Canada, so our thanks go to all at SAHFOS (particularly Anthony Richardson) and the Canadian team who generate these data. Some broad trends are noted, with declining copepod abundance in the eastern Atlantic areas, while no such trend is evident in the west. SAHFOS' phytoplankton data shows increases in the eastern Atlantic and perhaps also in the west. Recent papers based on CPR and other data have done much to contribute to debate on ocean climate change and regime shifts (see SAHFOS website for details).

Further improvements are incorporated this year through the efforts of Todd O'Brien. He presented some anomaly plots from sample data, which were discussed and all agreed they will allow much better appreciation of data trends Todd volounteered his assistance to Luis in adding these plots to the Plankton Status Report. We noted however that with a diverse array of sampling gear and frequencies across the data, also the nature and measures of species or biomass data vary across sites, so some care should be taken in interpreting any comparisons. Discussion concluded that it is important to coordinate efforts within the different ICES WGs dealing with plankton communities. It was proposed that the members of the WGZE, WGPE and WGHABD attending the next ASC should meet together for a half day to explore ways to collaborate in the Plankton Status Report. Also mentioned was the need to convene a specific Workshop open to the WGZE, WGPE, WGHABD and other relevant groups, to harmonize the Plankton Status Report and define key species and key parameters that should be included in future editions, as well as consider analysis - regional trends, climatic indices, correlation with fisheries trends, etc.

The question was also raised as to whether proper recognition is given to the macroplankton, particularly gelatinous species, which are not caught identifiably in the CPR. It was agreed that gelatinous forms are poorly sampled by conventional samplers, that video and acoustic gears will help and that these groups must be a focus if we are to comprehend invertebrate predator fields and their dynamics and influence in marine ecosystems. The historical emphasis on commercial fish larvae has distorted the present understanding of foodwebs and species inter-dependencies. There followed some discussion of environmental, top-down and bottom-up driving forces in influencing plankton dynamics, community structures and productivity cycles. It was agreed that the Status Report is a good starting point for the integrated studies needed to understand forms and functions in diverse plankton communities and foodwebs and their geographic and temporal variations.

There was further discussion of how the data should be presented; for example seasonal or annual descriptions - the consensus was for annual. There was also discussion of additional data, particularly the addition of phytoplankton data, or chlorophyll proxy phyto-biomass data, and simple physical parameters such as SST and salinity. The merits of inclusion of such data were appreciated as they build towards what is required for an ecosystem approach and comparisons, but logistically there are problems. Chlorophyll and other data contributions mean more cost/effort for donors to subscribe their data, which is a serious problem for contributors. It is appreciated that the WG on Phytoplankton Ecology, hopefully in collaboration with the WG on harmful Algal Bloom Dynamics are working towards a collection of phytoplankton monitoring data in the ICES area. The WGZE felt that we should wait to see what they come up with before making attempts to merge the data. Meanwhile, where the Plankton Status Report could be enhanced with Chlorophyll data etc it

should be so. There was resistance to provision of physics, as this would greatly increase the work in presenting data. It was noted that SST and salinity data are available from global databases so could be derived for separate meta-analysis and provided at the scale of CPR data contributions rather than for individual areas. Consensus agreed that the Plankton Status Report is a moving target and the WGZE will aim to expand and improve it as often as possible.

There was discussion of the availability of further data sets. Highlighted was the possibility of further data from the Baltic (discuss with ICES data managers who hold HELCOM data set), data from Portugal, (Emelia to contact) France (Philippe to contact) and from the Barents Sea (since 1980s) and southern Norway (Webjorn to investigate). There was a consensus opinion that ICES needs to expend greater effort on consolidating, managing and making available biological data on phyto and zooplankton. Todd O'Brien has had some contact and agreement to help facilitate this effort within ICES and it is noted that the SG on Marine Integrated Data also recognised these deficiencies and was calling for better online access to such data from ICES web site.

The Working Group noted with dismay that an existing long-term time series of data from the Irish Sea, collected from the Isle of Man, is due to end since the laboratory at Port Erin is to be closed. WGZE consider that this is a very unfortunate and untimely move since there is such an increasing need and global effort to maintain and establish new time series observations and to consolidate these into broader syntheses across many monitoring sites. Long term series are extremely rare and historically undervalued. In these times of recognised changes in climate, fisheries and anthropogenic effects, they are now increasingly considered very valuable data sets, which really should be treated as national and international assets. The chair's and others' correspondence with the authorities responsible for the time series has as yet, not elicited much hope for its rescue. WGZE also noted that no great effort seemed to have gone into promulgating these Irish Sea plankton data, which might partially explain the lack of recognition of its worth by the broader science community. The Plankton Status Report would welcome and benefit from access to the metadata and summary data sets and might help to promote the data set's value.

In conclusion it was agreed that the 2002-3 Plankton Status Report is improved significantly and that prospects are good for future developments in enhancing existing data. Also the group is encouraged by beginning research efforts which utilise the data, promote syntheses, bring collaborations between contributing monitoring efforts and added value to each.

5 ToR b. Consider future developments and collaborative approaches in time-series measurements and interpretation

(Lead: Steve Hay; Rapporteur: Luis Valdes)

The Chair introduced this ToR by attesting that the data collation effort is growing worldwide. There is a growing trend towards large databases or data centres collecting plankton biology data. The recent International Symposium on Zooplankton Production revealed an increasing number of long-term data sets and of researchers interested in variability, trends, cycles and comparative ecology of plankton systems. As consequence, there is a present need to describe and achieve quality standards in sampling and sample analyses. He also noted that already some of the data sets are large enough for effective overview and synthesis. Indeed some such efforts are underway. (see later, eg: SCOR WG proposal and latitudinal comparison of Calanus biology) These efforts should take account of advances in statistical techniques and employ a wide collaboration, including too other environmental and biological data sets and skills in data analyses, interpretation and biophysical modelling.

The need of harmonization of procedures, results and analyses in zooplankton monitoring programmes is recognized by the members and scientific committees of the largest marine Councils:

- **ICES**: In 2003 the ICES WGZE originated a proposal (Plankton Time Series Observations – PLATO) submitted to the EU-VI FP for financial support as a network of excellence. In 2004 the group of Helgoland lead a proposal submitted to the ESF (European Science Foundation) to fund a workshop at European scale to discuss these topics and consider options for harmonization of sampling procedures in plankton, analyses, etc.
- **CIESM**: This Council has programmed a Round Table on the "Harmonization of zooplankton time series" during the 37th CIESM (Barcelona, 7-11 June 2004) with the goal to launch a new project named "Mediterranean Zooplankton Time Series", which include among its objectives the retrospective analysis of historical and new time series of the Mediterranean zooplankton, the harmonization of sampling, sample treatment and data analysis, etc.
- **PICES**: Our colleagues are proposing a SCOR Working Group to do a global-scale comparison of zooplankton time series. They consider that such analysis must be an international cooperative effort and the objectives include the identification of a set of consolidated and representative "long zooplankton time series". The SCOR Working Group, if

the proposal is successful, will start the work on early 2005 and would continue for three years. The PICES group has approached the chair of the ICES WGZE regarding our collaboration to enrich the proposal and include our participation on the SCOR Working Group.

The ICES WGZE discussed these opportunities and we fully agree that we should play a proactive role. One member of this group will attend the Round Table on the "Harmonization of zooplankton time series" during the 37th CIESM where we can contribute with our experience in preparing the Plankton Status Report and to offer them our collaboration for future activities within CIESM.

Regarding the PICES proposal to create a SCOR Working Group on "Global Comparisons of Zooplankton Time Series", the chairman of the ICES WGZE will take a lead role to maintain relationships with our colleagues in PICES and cover some gaps that we observed in the objectives, data sets as well as propose some ICES WGZE experts that could enrich the original proposal. We also consider it is very important to ICES that a number of important data sets from the North Atlantic be considered as representative "long zooplankton time series" for future reference studies (see later).

The second part of the discussion continued by stating that the collective value of data sets is greater than its dispersed value and that an accessible world data bank for time series is strongly needed. The members of this group consider that ICES should play a lead role to maintain at least a metadata database for the North Atlantic and the Mediterranean. The metadata inventory of the time series contained in the Plankton Status Report, including ancillary data, serve as an example to know where data samples and data are preserved and available to other scientist in the present and future. This will also enable identification of gaps in spatial coverage, so additional partners in these regions can be found. If possible the WGZE suggests that ICES should try to find staff and time to collect and collate available plankton survey and monitoring data. The metadata and data sets in the Plankton Status Report and HELCOM data should make a good starting point for this, and links could be established with other data centres holding plankton data to obtain at least the metadata sets from them. In essence the WGZE calls for ICES to provide more efforts in supporting and developing biological databases in addition to those on fish stocks. Also WGZE has noticed that there is very poor awareness in the research community of where plankton data is held available. The WGZE recommends ICES improve the existing web site to advertise boldly and include links to plankton data held at monitoring institutes (given for example in the metadata in the Status Report) and at data centres such as ICES, NODC, BODC, OBIS etc.

The ICES WGZE also wants to remark the existence of an important number of under-exploited archive plankton sample collections, many of which are at risk of disappearing. Much has already been lost, largely as formaldehyde became more widely known as a health hazard and safety rules required special facilities for sample storage in many countries. However many collection still exist. All these archive samples and specimen collections should be discovered and made available for new analysis. Again, a collection of metadata describing such archive collections would be a good starting point to highlight their existence. If appropriate storage space, eg old railway tunnels or mines, could be found, then perhaps central storage and sample curation facilities would be a practical solution. These collections form a valuable resource that does not involve expensive ship/sea-time to collect, often they have partial analyses such as fish eggs and larvae already analysed and /or much associated environmental and other data. Image analysis techniques now available make the analysis of such collections a far more practical proposition. It was mentioned that the Census of Marine Life project is also interested in archived data and sample collections and could perhaps provide support and funds for sample rescue projects.

The WGZE also noted that with modern advances in molecular biology, biochemical analyses and genetics, it should be recognised that archive and ongoing collections may prove useful resources for further studies. As material needs to be specially preserved for genetics work, in 100% ethanol or DNA later and such, then those involved in running plankton monitoring programmes with trained taxonomic analysts, are uniquely placed to collect and provide specimen material for genetic sequencing. Some such collections are in place but more such efforts are needed urgently. Such sequencing greatly aids studies of taxonomic and evolutionary relationships and zoogeography, confirms identifications and may show up cryptic species or other interesting information. The WGZE would recommend therefore that reference species collections, supported where possible by sequencing efforts, become a formal part of plankton analysis projects for monitoring and survey work.

6 ToR h. Start preparations to summarise status and trends of zooplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000-2004, and any trends over recent decades in these communities; for input to the Regional Ecosystem Study Group for the North Sea in 2006

(Lead: Wulf Greve; Rapporteur, Sophie Pitois)

Wulf Greve opened the discussion by pointing out that in Hamburg the German government project SYNCON (Synthesis and New Conception for North Sea Research) had quite recently (1998-2000) produced a comprehensive study of many aspects of the North Sea Ecology. These 9 reports include ones on Phyto and zooplankton and are available as .pdf files on the Internet and as books. Wulf also pointed to the Flex data from the mid seventies, which focus on North Sea plankton in relation to Spring production, the study deployed 10 ships and reports and papers are available, though the data may not all be available by now. While much of the data will not be from 2000-2004, these and other data and analyses must form the background necessary to understand more recent studies and give them context.

As an example of regional plankton study, Michel Harvey from Canada described the monitoring program on the east cost of Canada. This has 6 fixed stations with sampling every 2 weeks: AZMP (Atlantic Zone Monitoring Program). A yearly report on the state of the Ocean at each given station is produced. Fixed stations were sampled from 1994 to 2003 with field surveys between 1999 and 2003. The presentation focussed on Anticosti Gyre station in the gulf of St Laurence, where measures include:

1) zooplankton biomass, abundance, species composition and a univariate zooplankton index.
2) survey of zooplankton biomass
3) mackerel eggs survey

This study is an example of zooplankton community structure and changes over time. All results are available from http://www.meds-sdmm.dfo.mpo.gc.ca.

The discussion then moved back to the case of the North Sea for which similar changes in zooplankton community composition have been noted, including some in the period 2000–004.
For examples, from the Helgoland time series there have been seen:

- Changes in species reproductive season, with abundance peaks occurring earlier (shift from summer to spring peak).
- Two years absence of the appendicularian *Fritellaria* but the hydromedusan *Obelia* was present. This may be correlated to the observed composition changes of food stocks.

WGZE need to be able to describe the changes that occurred between 2000 and 2004 in the North Sea ecosystem (i.e. seasonal cycles, community changes). To achieve this we need to get data and information available for the North Sea, such data could come from fixed stations or cruises and we know at least of the following:

- CPR North Sea transects data
- Stonehaven Monitoring Station
- Dove Monitoring Station
- Plymouth L4 Monitoring Station
- Monitoring in Shetland underway 2003-2004

There may be data in Oslo (contact perhaps Stein Kaartvedt Biological institute, University of Oslo.)
Also see monitoring data held by Institute of Marine Research, Biological St. Areudal – Flødevigen (Webjorn Melle to investigate)

The possible availability of other datasets will be investigated intersessionally and a case should be made about the importance of including zooplankton in monitoring programs, that may be restricted to study of phytoplankton or study of

only larval fish and fish eggs, which are also plankton. . It is worth considering every dataset from every cruises from the North Sea, samples could be located and their condition assessed (This could be done by consultation of the ROSCOP database for cruise programs, accessible via ICES web site). For example, the Cod Eggs survey which was performed in February/March 2003 and generated a large amount of samples from most of the North Sea. It was also proposed that a list of the marine institutes around the North Sea could be prepared and they should be then asked what plankton data they hold for the period. It was again noted that OSPAR have not included measures of zooplankton status in their recommendations for monitoring. Given the role of zooplankton in mediating phyto and fish production, and modulating nutrient fluxes, this seems short-sighted to say the least, especially given that other policy drivers call for an ecosystem approach.

There was some discussion about the proposal for a virtual zooplankton workshop on the North Sea. This emphasised the importance of the WGZE together making the effort to pool data so that anyone from the group could access and contribute to the analysis of these, in preparation for the 2006 status report. There were however some reservations concerning making data from some studies and monitoring sites so publicly available. The decision of course must rest with owners of original datasets, but it is possible to restrict access by password to registered-user access for web or DB held data. There is a need to generate general and key species lists, seasonality information, distinctive community and population features, measures of the range of variability over the period and area and retrospective analysis. We agreed that the ICES WGZE web site should be made more dynamic and could easily provide the focus and a holding centre for accumulated data, analysis and ideas for all in the group to contribute. It would be very useful if such a site were available for the 2005 WGZE meeting to access data to work on during the meeting.

7 ToR c. Review impacts of climate change on plankton communities using biological indicators, with special consideration of fisheries

(Lead: Webjørn Melle; Rapporteur: Claudia Halsband-Lenk)

The session opened with a further presentation by Michel Harvey. He showed first a figure of a CIL temperature index showing a significant cold period in the 1990's in the Gulf of St. Laurence, Canada. He continued with a presentation entitled "Annual state of the zooplankton at the AZMP (Atlantic Zone Monitoring Program) fixed stations: looking for a multivariate index". With the help of PRIMER MDS plots, strong seasonal patterns of zooplankton abundance are shown, including the contribution of various taxa/stage groups to that seasonal cycle. Some interannual variability was seen and it was tested in simulations to find whether the index changed and how it increased or decreased when parameters such as abundance, timing etc. varied. The index was then related to environmental factors. In conclusion, this tool promises some potential to analyse multivariate patterns in time-series, but needs to be assessed with longer (>4 years) time series in future. Peter Wiebe showed a similar MDS approach for the Gulf of Maine from a current Master's thesis in his lab.

Webjørn Melle continued the session with a short consideration of the ToR, noting particularly that there is now plenty of evidence that plankton dynamics are linked to recruitment, but there is considerable scepticism about the derivation and use of indices and indicators. He then gave a presentation giving an example of climate change impacts on the plankton community which in turn affect fish (herring) recruitment from the Norwegian Sea. In the study area, the temperature distribution at 50 m depth was dramatically different in the years 2002 and 2003, the former characterized by a high NAO index, while the latter showed a low NAO. The high NAO in 2002 resulted in low temperatures due to a reduced inflow of warmer Atlantic water, combined with high zooplankton biomass, in a large part of the eastern area in that year. In 2003, low temperature distribution was more patchy, but less widespread with accordingly lower plankton biomass in those cold spots.

The Norwegian team have been able to classify sampling stations in relation to physical water mass origins, Arctic, Atlantic and coastal. For a time series from 1995 to 2003 correlations were identified between NAO and the biomass of plankton in the May of the following year. There was some discussion of the lags observed in such correlation of biological cycles and NAO signals. These data can be used in fisheries management of herring (assessment of present stock size; and particularly in projection of stock size). It seems that overwintering areas of herring change according to temperature distribution. After overwintering, the herring migrates to the coast to spawn. The growing larvae feed successively on the developmental stages of *Calanus finmarchicus* (eggs, nauplii, copepodites). A herring condition index closely follows the zooplankton biomass (December) in all years of the time-series, and the centre of gravity of the herring population abundance shifted between the coast and offshore regions over time. The derived information make prognosis possible and is now being used in prediction of growth of herring stocks.

Introduction of oceanographic gliders was suggested equipped with different sensors (ADCP, fluorometer, etc.) to investigate such oceanic areas to get more regular data coverage and possibly even biological information, e.g., on *Calanus*

from acoustic backscatter patterns. Webjørn responded to an enquiry about indications of top-down control of Calanus by herring. He thought that for species up to the small pelagic fish in the system, control is mainly bottom-up. This is confirmed by analyses of the CPR data for the North Sea system.

The likelihood that jellyfish abundance influences the success of herring recruitment, through predation on larvae and food competition in the North Sea, was discussed in the light of recent work. The question was posed; "why do jellyfish like *Aurelia* become dominantly abundant in the first place?" This was answered by Rabea Diekmann who pointed out that direct predation pressure of jellyfish on fish eggs and larvae has been recorded in the Baltic Sea. Evidence for top-down control of fish by jellyfish predation has been discussed previously. Data on polyp survival were mentioned which indicate that variability in Aurelia abundance may be due to a mix of temperature patterns and predation pressure and other factors probably play a role in abundance patterns as well. There is still much to learn about invertebrate predators, including jellies, and their effects on ecosystem functioning and socioeconomic activities such as fisheries, aquaculture and tourism. There was further discussion of the importance and role of jellies, points including their role as food for certain fish and the nature of predation on them. Sigi Schiel suggests that effort to put data on *Aurelia*, herring and *Calanus* together for the North Sea should be made.

Wulf Greve presents another example for the correlation of *Noctiluca* abundance with temperature from his paper with co-authors in Climate Research (Heyen, Fock and Greve 1998), obtained by a partially automated statistical analysis of the Helgoland time series. This emphasised the importance of temperature and possibilities for forecasting. Rabea Diekmann asked whether experience exists in WGZE with multivariate statistical methods that go beyond PRIMER, namely RDA and CCA techniques that are commonly used in benthic studies, but so far not applied in plankton investigations. The advances of these techniques versus the ease of use and availability of PRIMER were discussed. The chair accepted that the WGZE should emphasise the development of indices that are relevant and useful for fisheries management. Also, generating such indices certainly requires exploring multiple factors and associations and therefore needs multivariate techniques or multi parameter models to produce simple, repeatable indices. It should be remembered that, however easy or hard indices may be to produce it is very likely that they will be hard or impossible to interpret and understand. Therefore caution in acceptance and interpretation of "simple" indices is important and ambiguities in their interpretation should be avoided.

After a break, the group discussed the proposal by Ian Perry *et al*. for a SCOR working group on "Global Comparisons of Zooplankton Time Series", attempts at a global synthesis. The chair opened a discussion on inputs to be sent to the initiators. This was in order to complement their list of time-series with the available data collections from WGZE and to provide some constructive criticism to their approach.

There was some concern that the development of the draft proposal manuscript as an outcome of the Gijon symposium, has been prepared without any real-time consultation with members of the WGZE, but WGZE felt a strong need to support and participate in this proposal. (*The chair later learned by correspondence that there had not been time for such prolonged consultations*) The collective value of data sets is greater than their dispersed value and an accessible world data bank for marine biological time series is strongly needed. The proposed time-series data sets have some gaps, which could be filled. So suggested supplements to Table 1 of the proposal (Representative long time series):

Barents Sea	→ ?
Gulf of St. Laurent (E Canada)	→ Michel Harvey
Norwegian Sea	→ Webjørn Melle
Baltic Sea	→ Rabea Diekmann(Christian Möllmann?)/Lutz Postel
Iberian Peninsula	→ Luis Valdes
Adriatic (Trieste)	→ Serena Fonda
Wedell Sea	→ Sigi Schiel

In the WGZE discussion there was a feeling that inclusion of only > 10 year time series might loose considerable available information on seasonal cycles and species-specific life history information, much of this is available from time series less than 10 years old. The question of why such shorter-term data is excluded is raised but not really answered in the proposal. Changes in the timing and extent of seasonal cycles for key species or groups must be critical to an evaluation and any links with ocean climate variations. Even if decadal changes cannot be compared at least seasonality and interannual variability could be compared between regions and with earlier times where long TS exist.
For an assessment on a North-South Scale (in addition to the intended West-East = Pacific-Atlantic comparison), the European time series from mid-latitudes like from Gijon are of particular importance to get the whole picture and should be included.

There were concerns that some assumptions that are made in chapter 2 of the proposal (Why zooplankton?), in particular that " most zooplankton population changes can be attributed to environmental factors", these we think are not well founded, rather they are a hypothesis to consider.

The restriction to only relative abundance rather than including absolute numbers caused some debate. Although relative values are more easily compared, since they rule out for example trophic interactions, the significance of changes in absolute numbers may be important to consider.

There was some criticism that no product, in terms of an interpretation of the global synthesis, is suggested in the proposal (i.e., what does it all mean?). If patterns are found, they have to be explained and interpreted. This in turn would mean that there would be a need for considerable ancillary data to be collated to allow meaningful interpretation of observed patterns.
The WGZE propose some further experts that could enrich the original proposal. Suggestions for members/associate members in the SCOR working group (list chapter 5 of proposal) include:

Roger Harris (ICES + GLOBEC, time series Plymouth)
Gregory Beaugrand? (still associated with SAHFOS)
Wulf Greve (one of the longest time series in the ICES area)
Astthor Gislason (Icelandic time series)
Luis Valdes (time series Gijon)
Todd O'Brien (biological data expert)

It was noted that, Associated members need to be assured of external funding of travel.

The question, "what results of zooplankton research are useful for managers of ecosystem resources?" was raised for discussion. Wulf Greve mentioned one issue that certainly should be, that is the timing and match/mismatch theory relevant for predator-prey relationships. He presents an example for *Ammodytes marinus*, predicting next years landing from previous year's landings, temperature and copepod nauplii abundance 14 days after hatching (Mainik, Lange & Greve 1999). It was pointed out that there is still no particular zooplankton index developed so far, but that it is a major task for the WGZE to try to shift the view of fisheries people. Their view must recognise that many aspects of plankton dynamics mediate fish recruitment success, rather than only the success of fish larvae as predators. The question, how and how much of phytoplankton production – new or regenerated, one way or another – flows into fish production?, remains largely unsolved, yet is central to an ecosystem perspective of fisheries. Also important are links through benthos, if much phyto production falls straight to the seabed, will benthic production increase? If so, then meroplankton will feed back biomass to the water column, to grow, die and return to the benthos as survivors, food or detritus. These pathways are hardly studied or understood as yet, but important for understanding fisheries in ecosystems and interpreting known scenarios of climate change, regime shifts and fisheries harvesting strategies.

Delphine Bonnet gave a brief talk about an interesting current project to look at latitudinal variability in *Calanus helgolandicus* biology. Very relevant to ToR b, this study has gathered collaborators from 22 sites for comparison throughout Europe and the Mediterranean where *Calanus* abundance time series, cruise data and process studies exist, and seeks others to extend the latitudinal range. The species is a key biomass component in many of the areas studied and although much is known of its northern congener *C. finmarchicus*, equivalent understanding of *C helgolandicus* is lacking. It has been shown (CPR) that the zoogeographic ranges of these Calanus species have changed relative to each other and to other members of the plankton over the past 40 years. These changes are ongoing and for example have had demonstrable effects on the ecology of the North Sea. These changes have also been linked to ocean climate change and regime shifts, thus such inter-regional comparison is important to understanding of underlying biology and the consequences of ecosystem change.

The question of different gears and their relative sampling efficiencies arose again. This long ongoing technical debate still challenges us and the analysis of data from the WGZE seagoing workshop raised some of these issues again. Lutz Postel and Peter Wiebe had earlier asked the WG participants to assess a list of plankton taxa and to group them in combination categories of motility (slow and fast) and size (small, medium and large) according their experience. The categories were defined to help assess the fishing capacities of different zooplankton nets (MOC 180, MN 200, WP-2 200, RMT 333). Statistics were presented on which net caught these size and motility groups and in what relative quantity, taking into account net opening and mesh size. The results were presented and compared to the earlier evaluation of Hein Rune Skjoldal and Lutz Postel's group in Warnemünde. The results showed highest agreement in the category size+motility (44% of all taxa), but only 11% in the size category alone. In 39% of the taxa agreement was found in the motility category while in 6% of the taxa no agreement was found in any category. Peter Wiebe indicates that the relative data do not assess the efficiency of a net since total numbers are not given and large taxa occur in smaller quantities than small ones. The consistency of the data from a given net over several deployments would be an interesting point. Another source of error in these data may come from sub-sampling procedures that occur after sampling and represent the database for the analysis. A paper recommended by WGZE that indicates parameters for plankton net design is Clutter (1968).

8 ToR d. Review publications and outputs from the ICES/PICES/GLOBEC Symposium (Gijon, May 2003) and the implications for plankton research

(Lead: Luis Valdes; Rapporteur: Peter Wiebe)

Luis Valdes opened the session by giving a brief report about the symposium and the subsequent progress towards the production of a symposium publication volume.
The 3rd International Zooplankton Production Symposium convened with the title: *"The role of zooplankton in global ecosystem dynamics: Comparative studies from the world oceans"*. It was co-sponsored by the International Council for the Exploration of the Sea (ICES), North Pacific Marine Science Organization (PICES) and Global Ocean Ecosystem Dynamics Project (GLOBEC). The symposium was held in 20–23 May 2003, at the Congress Center in Gijón (Spain), gathering 333 participants from 38 countries from around the world.

The full programme of the Symposium included three half-day workshops, 8 scientific sessions (Table 1) and a public exhibition on the world of plankton. Scientific sessions accommodated a total of 136 oral presentations and 16 invited talks (2 invited talks per session). Sessions 1, 2, 3, 7 and 8 were full-day sessions, sessions 4, 5 and 6 were half-day sessions and in parallel to the oral presentations, 243 posters were exhibited during the Symposium.

Table 1: Scientific sessions and Workshops programmed in the 3rd. IZPS

SI:	Physical variability and zooplankton population dynamics
S2:	Role of zooplankton in biogeochemical cycles
S3:	Climate influences: What are long-term zooplankton data sets telling us?
S4:	New approaches to zooplankton modeling (morning session)
S5:	Progress in molecular biology
S6:	Application of new technologies
S7:	Comparative life histories and life cycles of zooplankton populations within and between North Pacific and North Atlantic
S8:	Microzooplankton in the marine pelagial: Recent advances from molecules to ecosystems
Workshop 1: Gelatinous zooplankton and fish: Predators, prey, or nuisance.	
Workshop 2: Meso- and bathypelagic zooplankton study: Current status and future aspects.	
Workshop 3: Climate variability, zooplankton abundance and distribution: comparative opportunities from the world's oceans.	

The major objectives of the Symposium were more than fulfilled and the exchange of views, ideas, and data by planktologists from around the world has stimulated and facilitated development of new research directions and ideas.

The symposium revealed a number of long-term data sets and of researchers interested in variability, trends, cycles and comparative ecology of plankton systems (Symposium sessions 1, 3, 7 and Workshops 1 and 3). The needed of harmonization of procedures, results and analyses was discussed in the light of the Plankton Status Report produced annually by the ICES WGZE. It was also stated that the collective value of data sets is greater than its dispersed value and that an accessible world data bank for time series is strongly needed. The demonstrated relationships between plankton variability and climate variability indicate that plankton time series sampling and analyses are needed. This is particularly true if we are fully to understand variability in fish stocks and fisheries. Such time series information should be incorporated within the basic conceptual approaches and quantitative models of biological oceanography.

New approaches to zooplankton modeling were discussed in session 4. Innovative applications of models that advance our understanding of zooplankton population dynamics and the role of zooplankton in biogeochemical cycles were presented. Models cover the full range of processes and scales: coupled bio-physical models, models of the populations dynamics of zooplankton species or taxa, biogeochemical models, individual based models, and predator-prey models, and it was demonstrated that modeling is an especially powerful tool because it allows one to conduct novel experiments and to test hypotheses that are otherwise too expensive or too difficult to conduct *in situ*.

Small-scale turbulence and ecosystem levels were treated in sessions 1 and 8. It was shown that small-scale turbulence affects a range of zooplankters and processes. There are bottom-up effects that should increase the net production of the system as well as top-down effects that should move biomass into the heterotrophic compartments. Small-scale turbulence also affects sedimentation to some degree. All these effects on biological activities and community structure modify the quantity and/or quality of particulate matter and therefore have consequences for biogeochemical fluxes.

Biogeochemical fluxes and cycles were treated in session 2, where nice examples of the importance of zooplankton mediating the transport and the balance of particulate and dissolved matter in the system were presented. It was shown that the degree of coupling of zooplankton and producers gives rise to regional and seasonal variations in the abundances of

producer stocks, nutrient utilization and recycling efficiencies, and elemental export ratios. Hence, there is a growing recognition of the essential role that zooplankton play in regional and global biogeochemical cycles.
Two sessions were devoted to present technical innovations to study zooplankton (sessions 5 and 6). Recent technical developments on automatic methods (session 5) to count and measure zooplankton at real time are now able to provide 3-D data from the physical environment and biota with high temporal resolution. However the trade-off between gaining spatial and temporal resolution and losing details on species and life-stage information has hampered a breakthrough in new methods. Progress in molecular biology (session 6) can help to solve this bottleneck, as genetics systems promise to be more popular, cheap and easier to apply for identification of species. But molecular biology is also revealed as a powerful tool to understanding zooplankton diversity, dynamics and production and field studies presented at this symposium demonstrate practical applications that have yielded new insights into the role of zooplankton in ocean ecosystems.

During the discussions on zooplankton time series and monitoring in environmental programmes it was mentioned the minor role of zooplankton monitoring in the European Water Quality Directive of December 2000. This EU Directive was welcomed as an initiative to oblige the EU coastal nations on continuous and standardised monitoring and reporting of state of life in coastal and transitional waters, but it was noted that zooplankton do not appear as a target community. It was expressed during the symposium that zooplankton monitoring would do much to reveal the quality status of the ecosystem, natural large-scale variability and regime shifts. It was strongly suggested that means should be found to include zooplankton monitoring in the EU water directive at the same level as phytoplankton and benthic monitoring.

It was remarked the importance of this symposium as a firm step toward close cooperation between ICES, PICES and GLOBEC and all agreed that we should endeavor to expand to other research areas in the future. At the end, our colleagues from Japan announced that they will initiate negotiations for the organization of the next International Zooplankton Production Symposium in Japan. In fact, our Japanese colleagues have very recently announced that they are prepared to host the 4th International Zooplankton Production Symposium in Hiroshima at the beginning of June, 2007 (see letter in Annex 5). A formal support from ICES, PICES and GLOBEC will be very appreciated and helpful.

A selection of the best symposium papers will be published in a volume of the ICES Journal of Marine Science in June 2004 as Vol 61, No 4. At the time of this report being presented to the WGZE, the proofs of each article were being corrected. The table of contents of this volume is included in Annex 6. Of the 42 manuscripts submitted for publication, 28 will appear in the volume.

In an important sense the Symposium did not conclude with the closing ceremony, but it is still alive for debates and collaborations. Examples are, on the collaborative approaches in time-series measurements and its interpretation (e.g., Tor b in this meeting) and on the future directions on marine plankton research.

9 ToR g. Review the state of the art of enzymatic activity methods to estimate plankton secondary production

(Lead: Rob Campbell; Rapporteur: Delphine Bonnet)

This session opened with an introduction to the background of a call for a workshop around this subject from the chair, and proceeded with a talk from Rob Campbell on "Zooplankton growth and physiology". The main points are summarised here.

Zooplankton growth has always been considered as a "problem measurement", so can enzyme proxies be used as a solution? They are fast, specific, cheap and they do not induce artefact during the incubation.
Enzymes work as follows;
$S + E \leftrightarrow ES \leftrightarrow E + P$ (where S: Substrate, E: Enzyme, ES: Substrate-Enzyme complex, P: Product)

One can measure release of the enzyme, loss of substrate or the fabrication of products and measure the enzyme at each level of the reaction. The most common method in which enzyme activity is measured is in the ETS (Electron Transport Chain). Production of NADH is measured in protein metabolism studies and for growth measurements some growth proxies can be monitored. Those components are either involved in growth process (RNA:DNA, AARS's: AminoAcyl-tRNA Synthetase, etc.) or in moult (enzymes used by copepods to leave their exuvia: release of free chitobiase).

Rob showed a few examples of enzyme activity measured in *N. plumchrus*: ETS: respiration, GDH activity and protein activity. However, there are some problems in using enzyme proxies:

1) There is little theoretical underpinning
   Example given of mitochondrial respiration: are the different steps of the Krebs cycle limited? The idea of a rate-limiting step in electron transfer sites is not really believed anymore. Protein metabolism has the same problem.

2) Assays are not carried out in *in vivo* conditions

When the samples are homogenised for analysis (measurement of enzyme in solution), the membranes are disrupted and the sample condition is exacerbated by the detergent applied. The reaction is optimised for pH, substrate is offered in excess and there are some cell-free homogenates. So then what do we measure?

V max is a proxy for enzyme activity (unitless)

Enzyme measurements are proxies, there are problems in application and are these correlate with temperature and biomass. Enzyme measurements are state and time specific, they should at least be separated by species. Also, calibrations are temporally dependent and such measurements are also integrating measures, which obscures true appreciation of variance. Yet they "sort of work", and as evidence, Rob showed an example of respiration rate correlated with Enzyme Activity.

Thus in conclusion enzyme measurements show correlation with actual rates, but are not necessarily true. There is apparent evidence of underlying homeostasis, which could explain why different methods give roughly similar results. Enzyme measurements are not so useful biogeochemically.

Growth indices are not specific, have no units and depend on a correlation approach and moulting indices are correlated with secondary production. So, are enzyme proxies useful? The answer seems to be sometimes and with (many) caveats. They measure response by individuals in particular cases and circumstances. It must be remembered that these measures are not predictive and are at best semi-quantitative providing relatively little "added value". Rob justified his conclusions, by saying that the literature reviews on growth rate (Huntley & Lopez, Hirst & Lampitt, Hirst & Bunker, etc.) did not use any references to enzymatic studies.

However, even if results may be problematic they have shown interesting insights and indications of physiological activity. There is a need for more laboratory studies to enable more complex experiments and analyses to understand the complexity of what is being measured. In situ studies on individual organisms would provide much insight and there should be studies linking various disciplines such as genomics and proteomics to enzyme function and behaviour in varying environments. There is also a large and growing literature on metabolic control theory. Rob concluded by saying that he would really like to participate in a workshop on Enzyme Activity Measurements and Assays in Marine Science. There is a need to consolidate past/present efforts and to bring expertise to bear on solving problems and understanding practice and theory in such measurements, then to develop future approaches.

Lutz Postel then presented some results of the method Santiago Hernandez Leon´s group has brought to his laboratory in Warnemünde. He stressed potential methodological problems when using protein as scaling factor.

Lutz described potentials and limitations of enzymatic methods in comparison to classical approaches to study zooplankton production, i.e. incubation methods. The data basis produced by the latter techniques is remarkable. This resulted in the formulation of temperature and body size dependent models in order to calculate specific production rates. He illustrated the advantage of allometric model approach by Banse and Mosher (1980) in contrast to the temperature approaches of Huntley and Lopez (1992).

From his results in the Baltic Sea he underlined that enzymatic activities follow the allometric relationship. Therefore, comparisons of relative results of enzymatic activity (e.g., the amount substrate consumption per time interval) with P/B ratios by the Banse and Mosher (1980) according to $P/B = 0{,}64 \text{ body mass}^{-0.37}$ ±2% may produce realistic specific production rates.

Nevertheless, various sources of variability originated by the methods are possible. For example, protein is often used as a scaling factor. But there are different protein assays in use. Some of them determine the soluble fraction only and may interfere with substances for example with lipids. Meanwhile there are some improvements of the Lowry method available and there are methods which are more suitable for plankton studies. A brief review is in Postel *et al*. (2000). Finally he underlined the need for a workshop to test and to discuss the potentials and limitations of enzymatic approaches.

Postel, L. Fock, H. and Hagen, W. 2000. Biomass and abundance. pp. 83–192. In: ICES Zooplankton Methodology Manual. Ed. by R. Harris, H.R. Skjoldal, J.Lenz, P. Wiebe and M. Huntley. Academic Press, San Diego, San Francisco, New York, Boston, London, Sydney, Tokyo: 684pp.

Delphine Bonnet then briefly presented Lidia Yebra Mora's AARS work at Plymouth Marine Laboratory. She has measured growth in *Daphnia* with the AARS's method along with Santiago Hernadez Leon and she observed correlation between the physical structures in the Canaries Islands (e.g., eddies) and zooplankton growth (*Scolecithrix danae*). She now has work in progress studying *Calanus* and *Pseudocalanus* in the deep Atlantic and UK coastal waters, also in rearing experiments, finding good correlation between growth and AARS's activity in *Pseudocalanus elongatus*.

Conclusions:

- A review is needed of the state of the art of enzymatic activity methods used to estimate zooplankton production and activity (Rob Campbell will contact others in the research community and may write this review).
- Rob Campbell will contact Santiago and collaborate on a "draft-resolution" to submit to ICES to obtain sponsorship for the Workshop on Enzyme Activities aiming for this to be held next year.
- The ICES Zooplankton Methodology Manual requires update and review in this as in other areas.

10 ToR e. Review of achievements of the ICES Zooplankton Taxonomic Workshop (CM 2003/C:14).

(Lead: Alistair Lindley; Rapporteur: Rabea Diekmann)

Alistair Lindley reported on the ICES Workshop on Zooplankton Taxonomy hosted by the Sir Alister Hardy Foundation of Ocean Science (SAHFOS) in Plymouth, in June 2003:

Presentations and practical sessions were balanced during the workshop. The taxonomist Dr. Geoff Boxhall gave two very important opening presentations about: 1) copepod morphology and general characteristics of developmental stages, and 2) the classification of copepods with an emphasis on non-calanoids. On the second day A. Lindley presented the taxonomy and identification of some small calanoid species. It was noted that some ICES identification leaflets need urgent revision and the present gaps need to be filled by new sheets. One of the most important issues identified by the group was the preparation of a new identification leaflet for *Clausocalanus*, which was offered to be done by two participants of the workshop, Emília Cunha and Astrid Cornils. However, there is currently an urgent need to make additionally the corresponding revisions for the copepod genus *Pseudocalanus*.

At the same day the Woods Hole Silhouette Digitiser was presented by Nancy Copley and the group tried out the available software. In general, image recognition programs are supposed to have great potential for application to many studies of interest to the WGZE, like it was discussed on the first day of the 2004 meeting, in ToR f.

At the third day a very important talk was given by Richard Kirby who gave an account on genetic techniques, in particular to methods developed for DNA-analysis on formalin preserved material. First attempts had been performed for *Ammodytes* species, and the results looked very promising. The development of this new method will be probably very meaningful for the WGZE, in that rare but formalin-preserved zooplankton material can be re-analysed with genetic techniques.

In summary, the workshop got a very positive feedback from participants and S. Hay congratulated A. Lindley for its successful realisation. Steve mentioned the extraordinary importance of getting taxonomists together in order to get feedback from experts as, e.g., Geoff Boxhall. However, more prepared labelled specimens should be available during future workshops in order to improve the output of the practical sessions. Additionally the workshop was nearly entirely on crustacean plankton, as other groups are unfortunately less worked on. The next workshop should, thus, concentrate also on gelatinous plankton. A proposal for a follow-up workshop is currently in preparation within Marbef and it will be probably held in Portugal. A substantial handout produced during the workshop, including, e.g., all given presentations, was distributed among participants. Most WGZE members announced strong interest in this handout and A. Lindley promised to send copies on demand to the working group members and the general availability of this handout was also discussed.

A short report of the workshop including the agenda can be found on the website www.ices.dk/reports/occ/2003/wkzt03.pdf.

Following the report by A. Lindley, the chair initiated a small discussion picking up again the need to revise the ICES identification leaflets. These leaflets represent prime taxonomic literature and the web-based version of the sheets should make it possible to update them more quickly and employ more advanced presentation techniques. Harry Dooley, who is about to retire, had put much effort into digitising the sheets, but the WGZE and ICES has to decide where to go in the future. A discussion started about possible co-operation to improve the use and distribution of the leaflets. A. Lindley mentioned that co-operation had been proposed with ETI (Expert centre for taxonomic identification) for identification literature. Unfortunately ETI charges for their products and has a very wide biodiversity remit. It was argued that the WGZE is concerned mainly about the biodiversity of zooplankton. So far, ETI released a CD about plankton in the North Sea without including copepods. Furthermore, the ETI software is from the some points of view not very useful for practical work at the microscope. The WGZE proposed to keep in touch with ETI but to be cautious in making agreements that may compromise the free availability of such taxonomic information.

In order to support A. Lindley in the challenge to update and supplement the ICES identification leaflets, it was recommended that a subcommittee be formed to deal with the issues. Luis Valdez and S. Hay volunteered to help. The group discussed names of experts who might be willing to contribute to the ICES leaflets. For example the WG was reminded that B.W. Frost (School of Oceanography, Washington) had fairly recently revised the genus *Pseudocalanus*. And may be persuaded to use his paper to develop a new sheet.

Concerning the ITIS (Integrated Taxonomic Identification System) species coding, the group agreed that we should support ICES in updating the codes, species names and synonyms. P. Wiebe mentioned that no person is available at this years meeting to make real comments on this. Todd O'Brien suggested that an amount of CmarZ funding in ICES should be

made available to support ITIS coding implementation. He volunteered to act as a contact person with ITIS. An alternative to ITIS as a global taxonomic coding system is currently not available and problems can be solved given the will and some resources. The centralised structure of ITIS is actually problematic as a monolith tends to be slow and less flexible. The global plankton community not only needs a good current system, it also needs this to be updated easily and quickly. A more distributed system would be a positive advantage. The WGZE appreciated the benefits of a standard coding system, especially as an opportunity to get taxonomists from all over the world to agree together (???) and to have a common focus for nomenclature and taxonomic revisions..

11 Any other business

The week before, P. Wiebe had attended a SGMID meeting about integrated data management within ICES and he outlined the results. Structure and policies of database management in ICES were presented during the meeting. Similar to ITIS, ICES databases are a centralised system and it was recommended that databases should be more distributed in the future. A recommendation was made to review the progress within ICES database management, e.g., on getting access to and integrate the HELCOM data from the Baltic Sea. In summary, available databases should be directly linked and missing datasets need to be added, also very important for the WGZE (e.g., the set-up of the annual ICES Plankton Status Report). As an example, integrated data systems are already available, like that at the BODC. These could be used by ICES. Additionally, many different suggestions were made during the SGMID meeting for the technical solution of data integration that may improve the current database problems. Consequently this WG proposes a theme session on marine integrated data during the ASC 2005. The WGZE encouraged T. O'Brien to make a presentation as he is the one with the closest expertise within data management from the attending working group members.

WG members Wiebe, Schiel, Hay and Melle briefly mentioned the recent COML meeting held in New Hampshire and chaired by Anne Bucklin, which they and many others from around the world had attended. That group is currently preparing a proposal to the Sloan Foundation for a global Census of marine Zooplankton (CmarZ) project that will aim to complete taxonomic descriptions of all plankton in the worlds oceans and seas. A draft of the proposal is already available to meeting participants. P. Wiebe presented the main points from the CmarZ Science plan. To fulfil the plans money has to be raised from national agencies through project submissions. One important issue will be the distribution of questionnaires on zooplankton collections to identify where important zooplankton collections are stored and to include personal collections. The project will furthermore install a network of taxonomic experts, with a special emphasis on genetic sequencing, which is very important to make final identification of species and of cryptic species possible. The report of the meeting will be submitted to the Sloan Foundation at the end of April and the final proposal is scheduled for July.

12 Next meeting

The final decision where the next year meeting of the WGZE will be held, was not made during the meeting as Maria Emilia Cunha, who had previously and generously offered to host the WGZE in 2005, was not present. However, in M.E. Cunha has since confirmed her kind offer and the **WGZE will meet in Lisboa, Portugal 4th – 7th of April in 2005.** Michel Harvey of Canada has also offered to host the working group, and some preliminary plans were made for meeting in 2006 in Quebec at the IML or in Montreal.

13 Resolutions and suggested Terms of Reference for 2005

The working group agreed upon some resolutions that should be forwarded to the OCC and the ICES Council:

►ICES should sponsor a workshop on enzymatic, other biochemical and molecular methods to measure rate processes in zooplankton.

Workshop Justification (see also report text and theme session proposal)
We propose that ICES sponsor a workshop, to be organised by a sub-group of WGZE members with others, where both traditional and state-of-the-art methods may be tested thoroughly under controlled conditions, in order to assess, compare, and intercalibrate the many different methods. Enzyme activities and concentrations have long been used as proxies for vital rates of marine zooplankton (e.g., respiration, excretion and growth) and recent work has focused on developing new proxies that give more representative rate measurements. Recent advances in the understanding of biochemistry and animal physiology suggest that many of the assumptions of those methods are not valid and that the rates measured by these techniques do not necessarily represent *in situ* rates in a quantitative way. There is a growing and current need for measurements of zooplankton vital rates. New techniques must be developed that provide more mechanistic and direct measurements.

►ICES data managers should take responsibility for providing and maintaining a web based "virtual" workshop to further the collaborative comparison and analyses of plankton time series and other zooplankton data in the North Sea areas.

Justification for Enhanced ICES Web Site
There is a strong feeling that an improved website at ICES in terms of appearance and functionality would greatly benefit ICES and the WGZE and other WGs. Currently the web site is essentially static and hard to navigate. By providing space and facility in webspace on the server, WG members could easily contribute data, references and updates along with other resources to further their work and that of others in ICES such as the Plankton Status Report and REGNS Status Report preparations. A password protected project space is easy to set up and fairly secure. This would allow much wider participation, sharing of data and analyses, skills and knowledge transfer and great convenience for a low cost overhead. With the drive towards ecosystem approaches and particularly the REGNS demands, WGZE badly needs such a facility.

The essentially volounteer efforts of WG members could be much more effectively harnessed to the tasks ICES wishes to see done. Other pressing WGZE calls for such interactive web use are to create a virtual taxonomic expertise facility to promote this critical skills base. Also, the existing ICES Fiches Plankton ID sheets are much out of date and now in electronic form. Development and enhancement of this valuable ICES resource would also be greatly assisted by available interactive web based resources.

►ICES should sponsor a further taxonomic workshop and further efforts to advance the Fiches plankton ID sheets and other taxonomic manuals, to encourage the training and retention of plankton taxonomic skills (the next workshop is proposed to be held in 2006).

Justification for support for next ICES Taxonomic workshop
The WGZE has held a number of workshops over its time in existence, 1 seagoing gear comparison, 2 experimental methods workshops and 2 successful Workshops on Zooplankton Taxonomy. WGZE hopes that ICES recognises the expanding need for retaining and disseminating these taxonomic skills and knowledge in this previously faded but resurgent and increasingly critical area of marine science. Plans will be made intersessionally and reviewed at the 2005 WGZE meeting.

►ICES practical support and sponsorship should be stated and provided to the 4th international Zooplankton Production Symposium, to be held in Japan in 2007.

Justification for support

The success of the three Zooplankton Production Symposia held so far has been very considerable and growing. The collaboration of ICES, PICES and GLOBEC hold great promise for greater success, particularly with the suggested emphases and agenda of the next proposed symposium. It is evident from the Japanese proposal (WGZE report Annex 5), that the organisation of the science and the event are in very capable and experienced hands. This has become a major event with a significant effect on the direction and effectiveness of plankton research worldwide. In supporting these symposia ICES gains influence and considerable prestige and opportunities for extending collaborations and participation in the global efforts to advance and integrate plankton biology.

Proposed theme sessions for the ASC 2005 were extensively discussed. The group aimed at interdisciplinary approaches and especially a link toward relevant topics for fisheries biology.

►The WGZE wishes to co-sponsor with the SGMID and WGMDM in proposing a joint theme session

"theme session on marine integrated data"

Justification

Data management techniques and the building of integrated databases are a progressive and vital area for any prospect of facilitating and achieving an ecosystem perspective, synthesis attempts and joined up science generally. Zooplankton studies are just beginning to be integrated into major international databases including those of ICES and WGZE hopes to do all we can to encourage and support these initiatives. The group is calling for ICES to do more in this area and members are actively working to advance this, with the ICES Plankton Status Report and previous work on determining metadata description etc. This theme session would be an opportunity to bring those managing databases together with contributors and users to make progress together.

For theme sessions for the ASC in 2005, the following propositions were made by the WGZE itself:

►"**Ecosystem forecasting and operational oceanography as tools for marine scientists and resource managers, current status and methods."**

Justification

Zooplankton ecology and monitoring are central to furthering models and understanding of marine ecology generally. Operational Oceanography and the development of forecasting (and hindcasting) tools depend as much on the physical-biological models and conceptual tools as they depend on consistent, high quality sample and data collection. Sampling and survey plans and designs are in turn dependant on good theory and models. There are current and practical developments incorporating plankton and environmental data over a range of time and spatial scales into fisheries forecasting and management. Integration of all the skills and approaches required needs a continuous, constructive dialogue and practical interactions to be maintained between disciplines. The theme session proposed would enhance and review this dialog between marine scientists and should lead to practical suggestions and outcomes relevant to the aims and practical requirements of marine resource managers. Hopefully this may also provide a forum for individuals involved in the policy and practise of marine resource management to give input into the processes they depend on so much for advice and tools.

►"**The application of enzymatic, and other biochemical and molecular methods to measure ecological rate processes in zooplankton populations."**

Justification

We have already proposed (see case above) that ICES sponsor a workshop, to be organised by a sub-group of WGZE members with others, where both traditional and state-of-the-art methods may be tested thoroughly under controlled conditions, in order to assess, compare, and inter-calibrate the many different methods. This is an exciting and fast moving area of marine science and it will be very helpful if a theme session could bring together the often very independent researchers working in this area. There is certainly considerable work that could be presented and the rapid developments in theory and practice should ensure good and constructive debate and a useful foundation for the setting up of workshops and other scientific collaborations.

►There is also a call to WGZE from the WGCCC for a jointly sponsored **Workshop on Impact of Zooplankton on Cod Abundance and Production (2005)**, under discussion.

The Chair of WGZE has been contacted by the joint chairs of ICES/GLOBEC Cod and Climate Change WG, who have started to plan for future workshops. The first planned workshop is on "Impact of Zooplankton on Cod Abundance and Production" briefly described below. WGCCC felt that such a workshop would benefit greatly by being arranged in co-operation with WGZE. The WGZE also reciprocate this and would wish to work together with WGCCC to make this workshop a success.

Proposed, **Workshop on Impact of Zooplankton on Cod Abundance and Production (2005)**
Relations between temporal and spatial dynamics of zooplankton and early stages of cod will be examined. Issues to be addressed include:

How the timing of zooplankton production and spatial dynamics of nauplii relates to the spawning and distributions patterns of early stages of cod, and ultimately cod recruitment.

Links between later stages of cod and zooplankton will be addressed, and how the importance of *Calanus finmarchicus* relative to other zooplankton species varies spatially as the prey for cod.

A combination of statistical data analyses, process studies and a variety of modelling approaches will be applied. The workshop will build on the results of the US and UK GLOBEC studies, Norwegians studies and recent CCC activities including the 2002 Transport Workshop and the 2003 Theme Session on Transport of Cod Eggs and Larvae as well as output from the ICES 2003 Zooplankton Symposium.

Relation to strategic goals The workshop is focused directly towards Goal 2 in the new Strategic Plan, while also contributing towards Goals 3, 4 and 5.

Suggested co-operation
ICES Working Group on Zooplankton Ecology (WGZE) and with the PICES/ICES proposed workshop on Evidence for and Impacts of Large-Scale Long-Term Variability in Zooplankton Populations.

Also a possible Theme Session was suggested for the **2006** ICES Annual Meeting in Aberdeen, Scotland on the **"Methods and comparisons of plankton field sampling techniques, particularly use of image acquisition and analysis technology."**

13.1 WGZE Terms of Reference for 2005

After discussion on future TORs, more were put forward than were possible in one meeting. This then evolved into the following suggestions which cover review of plankton research and methods as well as maintaining and developing collaborative approaches and the useful products of the WGZE, particularly the ICES Plankton Status Report.

The **ICES Working Group on Zooplankton Ecology [**WGZE] (Chair: Steve Hay, UK) proposes to meet in Lisboa, Portugal, from 4–7 April 2005 to review:

a) Update of the annual plankton status report. It is planned to extend it to new sites and include concurrent hydrographic data, phytoplankton series and advances in monitoring technologies.

b) Future development and collaborative approaches in plankton time series measurements and interpretation, including collaboration with global synthesis attempts and regional comparisons.

c) Comparison of geographic and seasonal patterns across the range of plankton monitoring sites in the ICES area with emphasis on key species; approaches and preparation for North Sea ecosystem assessment (REGNS).

d) Consider multivariate statistical methods and other models as means to evaluate and assess zooplankton population and community dynamics in relation to environmental factors, ocean climate changes and fisheries assessment.

e) Review preparations and progress towards

   i) a workshop on enzymatic and other biochemical and molecular methods to measure or assess rate processes in zooplankton.

   ii) the 4th international zooplankton production symposium to be held in Japan 2007.

iii) a "virtual" workshop to further the collaborative comparison and analyses of plankton time series and other zooplankton data in the North Sea areas.

iv) A further taxonomic workshop to advance the Fiches plankton ID sheets, also to encourage the training and retention of plankton taxonomic skills. This should focus to a large extent on gelatinous plankton taxonomy.

v) a workshop to be held during the 2004 ASC to coordinate the conjunction of the zooplankton and phytoplankton activities to the ICES Plankton Status Report.

f) Review and consider the role of meroplankton in pelagic shelf seas ecosystems and their contribution to productivity in these areas.

g) Review progress with ICES data management of biological information.

Supporting Information

Priority:	The activities of this group are a basic element of the Oceanography Committee, fundamental to understanding the relation between the physical, chemical environment and Living Marine Resources in an ecosystem context. Reflecting the central role of zooplankton in marine ecology, the group members bring a wide range of experienced expertise and enthusiasm to bear on questions central to ICES concerns. Thus the work of this group must be considered of very high priority.
Scientific Justification:	Action Plan nos. ( ) a) This is a repeating task established by the Working Group in 2000 to monitor the plankton abundance in the ICES area. The material presented under this item updates and expands the annual Summary Plankton Status Report in the ICES area. Reported results are significant observations and trends based on a wide range of time series sampling programmes. Efforts are in hand to expand the report, to include phytoplankton and elementary physics and to facilitate comparative analyses. b) The time series contained in the Plankton Status Report is preserved and available to ICES and others in the present and future. The sample and data collation effort is growing, alongside expanding national and international demands for monitoring data. There are moves and projects proposing global syntheses, regional ecosystem assessments and autecological studies of key species across latitudinal ranges. These projects, syntheses and global collaborations must be enabled and supported. c. The Plankton Status report is core to preparation of North Sea ecosystem assessment (REGNS). This subset of the extensive data required must be sensibly aggregated with and assessed in relation to other data on physics, chemistry, phytoplankton and predator fields, including fish and invertebrates. This is an extensive data collation and expert analysis effort which the WGZE wishes to contribute fully towards. d. The present need to describe and achieve quality standards in sampling and sample analyses requires; that overview and synthesis should take account of advances in statistical techniques and should employ as wide collaboration and skills base in data analyses and interpretation as is possible. It is particularly hard to link plankton into fisheries assessment without a good statistical and biophysical modelling approach. e) The WGZE has a good practical history of sponsoring and running workshops and the Zooplankton Production Symposium. A range of these is projected, some in train already, others just proposed. The organisation and review of these is essential to successful collaboration with other sponsors and to their future success. Each outlined in this ToR either is or has historically been a fruitful endeavour for the WGZE and ICES generally. f) A regularly raised area of ignorance in marine ecology is the role of meroplankton in pelagic ecosystems, particularly in shelf seas. These are almost exclusively the recruiting larvae of benthic invertebrates upon which much depends including fisheries and aquaculture, and significant changes in meroplankton communities have been demonstrated, not least for the North Sea. New techniques and ideas need to be applied to promote research in this area, our discussion aims to stimulate this process. g) Progress with ICES data management of biological information needs to be reviewed and ongoing consultations discussed. The WGZE has already contributed much, such as guidelines on metadata. This ToR makes time for ongoing considerations and review of collaborations and

	developments, including quality control, between WGZE and others such as the WGMDM, SGMID and the WGSM.
Relation to Strategic Plan:	This working group's efforts embrace the scientific objective of understanding the physical, chemical, and biological functioning of marine ecosystems. The group facilitates discussion, collaboration and practical exchange of ideas and information needed for perspective and synthesis on one hand and enhancement of specific skills and methods on the other, across ICES groups and with other organisations.
Resource Requirements:	The Working Groups programme encompasses the ongoing work of all its members, however, there is an increasing need for specific support from ICES staff in the areas of data management advice and further website development to facilitate future developments and collaborative initiatives.
Participants:	The group has a enthusiastic core membership, and is successfully making efforts to attract broader participation both across ICES nations and across relevant skills.
Secretariat Facilities:	Web site maintenance to highlight contact details and activities and publish outputs for the WGZE needs more effort, to focus practical interaction between WGZE members themselves and with the wider research community.
Financial:	None specified apart from the annual WGZE and Plankton Status Report's reproduction costs and perhaps more time and effort from secretariat support staff.
Linkages to Advisory Committees:	The Group reports to ACME, mainly for the provision of scientific information on Ecosystems and welcomes input from other committees
Linkages to Other Committees or Groups	Links with the WGMDM, WGRP, WGPE and WGHABD are established and contact is maintained. The input to REGNS is an ongoing effort. The Plankton Status Report is of interest and practical use to a range of interested groups within ICES and PICES, and other national and international research groups and agencies. Increasingly marine research, marine management and even marine institutes are re-aligning to take an ecosystem view, these linked and collaborative approaches between many working and study groups must be encouraged.
Linkages to Other Organisations:	IGBP, SCOR, ESF, COML, PICES, GOOS and GLOBEC and others have research activities meetings etc., of interest and relevant to the activities of the WGZE. Contacts and references are maintained through networking and collaborative activities.

14 Annexes

Annex 1 List of participants – ICES Working Group on Zooplankton Ecology

Name	Address	E-mail
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Annex 2 WGZE Agenda and programme – Hamburg 2004

Monday 5 April
Introductions, Announcements and Housekeeping.
ToR f. Review and consider new technologies for identification and enumeration of plankton species.
Helgoland Roads Zooplankton Colloquium, on the Occasion of the 30th Anniversary of the Time-Series – Additional Session

Tuesday 6 April
ToR a. Update the annual ICES plankton Status Report, including extending the time-series with new sites, phytoplankton series, and advances in monitoring technology.
ToR b. Consider future developments and collaborative approaches in time-series measurements and interpretation.
ToR h. Start preparations to summarise status and trends of zooplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000-2004, and any trends over recent decades in these communities; for input to the Regional Ecosystem Study Group for the North Sea in 2006.

Wednesday 7 April
ToR c. Review impacts of climate change on plankton communities using biological indicators, with special consideration of fisheries.
ToR d. Review publications and outputs from the ICES/PICES/GLOBEC Symposium (Gijon, May 2003) and the implications for plankton research.
ToR g. Review the state of the art of enzymatic activity methods to estimate plankton secondary production.

Thursday 8 April
ToR e. Review of achievements of the ICES Zooplankton Taxonomic Workshop (CM 2003/C:14).
AOB – including consideration of ToR for 2005, suggestions for future Theme Sessions, workshops etc

Annex 3 Colloquium Programme

senckenberg
forschungsinstitut und naturmuseum

Helgoland Roads Zooplankton Colloquium
at the Occasion of the 30th Anniversary of the Time-Series

Schedule
Hamburg, Notkestraße 85, DESY Building 3 (Ex-BAH) 5.4.04 15:00 – 17:30 hrs

1) Mr. Steve Hay, FRS Marine Laboratory, Aberdeen
ICES WG Zooplankton Ecology
1*5:00 hrs. Zooplankton monitoring in the ICES area*

2) Dr. Michael Tuerkay Forschungsinstitut und Naturmuseum Senckenberg, Frankfurt:
15:20 hrs. Biodiversity dynamics as environmental indicators

3) Dr. Hartmut Nies, Bundesamt für Seeschifffahrt und Hydrographie, Hamburg:
15:40 hrs. Monitoring of the marine environment in German

16:00 hrs. Tee and Coffee Break

4) Professor Dr. Friedrich Buchholz, Biologische Anstalt Helgoland im AWI, Helgoland:
16:30 hrs. Monitoring the North Sea since 1873 at Helgoland Roads

5) Dr. Wulf Greve, Deutsches Zentrum für marine Biodiversitätsforschung (FIS) und Bundesamt für Seeschifffahrt und Hydrographie, Hamburg:
16:50 hrs. ***30*** **Years HELGOLAND ROADS ZOOPLANKTON:**
from observation to prognosis
17:10 hrs. Discussion

6) *18:00 hrs.* Get-together with the ICES Working Group Zooplankton Ecology

Annex 4 Noted gear trials and comparisons

1) Intercomparison of zooplankton (net) sampling systems: results from the ICES/GLOBC sea-going workshop in Storfjorden, Norway (June 1993), Hein Rune Skjoldal, Peter H. Wiebe, Lutz Postel, Tor Knutsen, Stein Kaartvedt, and Doug Sameoto.
2) Intercomparison of 1-m^2 BIONESS, a 75 cm-diameter ring net, and a Laser OPC in the Gulf of Saint Lawrence in spring 2001. Michel Harvey, and Alex Herman
3) Intercomparisons of concurrent video plankton recorder and 1-m^2 MOCNESS estimates of zooplankton abundance in Wilkinson Basin Gulf of Maine. Benfield, M., E. Hartfiled, P. H. Wiebe, A Lavery, C. Greene, and N. Copley.
4) Intercomparison of high volume pumping system and the 1-m2 MOCNESS. T. Durbin, J. Runge.
5) Intercomparison of LOPC and a 25 cm diameter ring net with 0.73 um mesh in Gulf of Saint Lawrence. A. Herman.
6) Intercomparison of a video plankton recorder and bongo nets in surveys on the Northwest Atlantic Continental shelf. S. Gallager and others.
7) Additional work known to exist but not available in press are:
   AWI - samples from acoustics and multinet? Antarctic polar front.
   AWI - Antarctic bongo RMT, multinet comparison, Sigi Schiel.
   Baltic sea intercomparison of samplers in the 70's ???
   Knight Inlet BIONESS OPC Bongo Nets and camera and acoustic/multibeam/ADCP, Mark Benfield and others
   Straight of Georgia OPC and closing ring net comparison plus laboratory calibration (nearly finished manuscript, Rob Campbell
   BIO group pump system comparison with ring nets and OPC casts (Doug Sameoto)
   OPC acoustics and nets in lakes comparison, ? Sprouls

   BioMoc, multi-net 6m2 IKMT (1000µm) towed in same locations in North Sea (Rabea Deikman)
   Comparison of macro-zooplankton trawl with Mocness, WP2 and fish trawl. (Webjorn Melle)
   Video Plankton Recorder and ring net comparison in the Arctic. (Ashjian)
   Continuous comparison between 150 and 500µm oblique towed ring net (CalCOFFI), Apstein net. (Wulf Greve)
   Comparison of CPR and ARIES in Irminger Sea. Also in Northern North Sea, ARIES multidepth sampling with comparison of EK500 multi-frequency acoustics, 600 and 1200KHz ADCP and OPC. (Steve Hay)
   USF - Sipper data comparison with HRS data. (???)
   CPR and WP2 comparison (Finnish Inst of Marine Research)-. (J. Flinkmann)
   VPR and net comparison. (Sell)
   Bottle data and 63µm mesh ~50 cm diameter ring net (vertical haul) Bay of Biscay 2000 and 2001. Net data available and possibly bottle data too. (Francois Carlotti, Delphine Bonnet)

Annex 5 Proposal for the,

ICES, PICES, GLOBEC 4th International Zooplankton Production Symposium

The 3rd International Zooplankton Production Symposium, held 20–23 May 2003 in Gijon, Spain, was the most successful one in the series so far (the first Symposium was in 1961, in Charlottenlund, Denmark, and the 2nd one – in 1994, in Plymouth, UK). Some 333 delegates from 38 countries from six continents attended the meeting. The Symposium provided a great opportunity for many zooplankton ecologists to present their own research topics, exchange experiences and data, obtain new ideas, and of course warm friendship.

As all the previous symposia were held in Europe and there were large time gaps (9-31 years) between meetings, it is highly recommended that the next Symposium be held outside Europe and within a much shorter time. Over the Extravaganza Dinner table of the last symposium, Japanese delegates received an informal request for the organization of the next Zooplankton Production Symposium in Japan. Since then, I have discussed this issue with my colleagues and explored the options and availability of conference centers, hotels, manpower, etc., and now we are very happy to announce that we are prepared to host the 4th International Zooplankton Production Symposium in Japan, in 2007. We, Japanese zooplanktologists, will do the best for the organization of the Symposium. In order for the Symposium to be really international, support from the international organizations and programs such as ICES, PICES and GLOBEC is essential, like in the previous symposium. The attached plan is still primitive and much has to be done until circulating the first official announcement of the Symposium (i.e. first circular).

Here, I would like to ask the officers of ICES and GLOBEC for the agreement to co-sponsor the 4th International Zooplankton Production Symposium. I have already received the formal agreement from PICES (Dr. Alexander Bychkov). To forward this plan, I also would like to ask for recommending delegates to work as symposium conveners.

Draft Outline Plan of the
ICES, PICES, GLOBEC - 4th International Zooplankton Production Symposium

Time:	End of May and beginning of June, 2007 (4–5 days).
Venue:	International Conference Center, Hiroshima, Japan.
International sponsors:	ICES, PICES and GLOBEC
Local sponsors:	The Plankton Society of Japan
	The Japanese Society of Fisheries Oceanography
Symposium conveners:	**Delegates from ICES, PISCES and GLOBEC (to be determined)**
	and Dr. Shin-ichi Uye (Professor, Hiroshima University)
Scientific steering committee:	**Delegates from various countries (to be determined)**
Local organizing committee:	Dr. Shin-ichi Uye, Chief (Professor, Hiroshima University)
	Dr. Hideaki Nakata (Professor, Nagasaki University)
	Dr. Shuhei Nishida (Professor, the University of Tokyo)
	Dr. Michio Kishi (Professor, Hokkaido University)
Scientific foci:	**Human and climate forcing of zooplankton populations (tentative)**
Programme	
Monday:	**workshops, reception**
Tuesday:	**opening, oral and poster sessions**
Wednesday:	**oral and poster sessions**
Thursday:	**oral and poster sessions, excursion, conference dinner**
Friday:	**oral and poster sessions, closing**

Annex 6 The list of papers to be published in the 3rd Symposium Edition of the ICES Journal of Marine Science

3rd International Zooplankton Production Symposium: *"The role of zooplankton in global ecosystem dynamics: Comparative studies from the world oceans"*

Proceedings of a Symposium held in Gijón, Spain, May 20-23, 2003
Guest Editors: L Valdes, R. P. Harris, T.Ikeda, S.McKinnell, and W.Peterson

Contents

Introduction
L Valdes, R.P.Harris, T.Ikeda, S.McKinnell and W.Peterson

Climate variability, zooplankton abundance and distribution – comparative opportunities from the world's oceans

Identifying Global Synchronies in Zooplankton Populations: Issues and Opportunities
R I Perry and H Batchelder

Climate influences: What are the long-term zooplankton data sets telling us?

A nine year increasing trend in mesozooplankton biomass at the Hawaii Ocean Time Series Station ALOHA
C C Sheridan and M Landry

Interannual abundance patterns of copepods during an ENSO events in Icy Strait, southeastern Alaska
W Park, M Sturdevant, J Orsi, A Wertheimer, E Fergusson, W Heard and T Shirley

Zooplankton volume trends off Peru between 1964 and 2002
P Ayón, S Purca and R Guevara-Carrasco

Seven copepod species considered as indicators of water mass influences and changes
D Bonnet and C Frid

Zooplankton variablility and climatic anomalies from 1994-2001 in the Balearic Sea (Western Mediterranean)
M L Fernandez de Puelles, V Joaquin and L Vicente

Microzooplankton in the marine pelagial : Recent advances from molecules to ecosystems

Microzooplankton production in the oceans
M R Landry and A Calbet

Application of new technologies

Comparison of biomass and size-spectra derived from Optical Plankton Counter data and net samples. Application to the assessment of mesoplankton distribution in the NW and N Iberian shelf

E Nogueira, G. Gonzalez-Nuevo, A.Bode, M.Varela, X.A.G.Moran, L.Valdez

Enumeration, measurement and identification of net zooplankton samples using the ZOOSCAN digital imaging system
P Grosjean, M Picheral, C Warembourg and G Gorsky

Role of zooplankton in biogeochemical cycles

Mesozooplankton size-fractionated metabolism and feeding off NW Spain during autumn: implications of a poleward current
J A Isla and R Anadón

Metabolism and chemical composition of mesopelagic ostracods in the western North Pacific Ocean
H Kaeriyama and T Ikeda

Effects of food concentration and diet on CDOM accumulation and fluorescent composition during grazing experiments with the copepod, *Calanus finmarchicus*
J Urban-Rich, J T McCarty and M Shailer
Radiotracer determination of the diet of calanoid copepod nauplii and copepodites in a temperate estuary
K Finlay and J C Roff
Taxonomic versus trophic structure of mesozooplankton: a seasonal study of species succession and stable carbon and nitrogen isotopes in a coastal upwelling ecosystem
A Bode and M T Alvarez-Ossorio
Carbon cycling through the pelagic food web in the northern Humboldt Current off Chile (23°S)
H E González, R Giesecke, C A Vargas, M Pavez, J Iriarte, P Santibáñez, L Castro, R Escribano and F Pagès
Composition and temporal distribution of cirripede larvae in Southampton Water, England, with particular reference to the secondary production of *Elminius modestus*
E Muxagata, J A Williams and M Sheader

New approaches to zooplankton modelling

A Modeling Study of the Influence of Environment and Food supply of Environment and Food Supply on Survival of *Crassostrea gigas* Larvae
E E Hofmann, E N Powell, E A Bochenek and J M Klinck
Langrangian Modeling Studies of Antarctic Krill (*Euphausia superba*) Swarm Formation
E Hofmann, A G E Haskell, J M Klinck and C M Lascara

Physical variability and zooplankton population dynamics

Population structure of the copepods *Centropages typicus* and *Temora* stylifera in different environmental conditions
I Di Capua and M G Mazzocchi

Vertical and seasonal distribution of eight *Clausocalanus* species (Copepoda: Calanoida) in oligotrophic waters
À Peralba and M G Mazzocchi

Hydrographical chacteristics and zooplankton distribution in the Mallorca Channel (Western Mediterranean): Spring 2001
M L Fernandez de Puelles, J Valencia, J Jansa and A.Morillas

Spatial Patterns of Mesozooplankton Distribution in the Southwestern Atlantic Ocean (31-41°S): Relationship with the Hydrographic Conditions
M Marrari, M D Viñas, P Martos and D.Hernandez

***Sagitta friderici* Ritter-Zahony (Chaetognatha) from South Atlantic waters. Abundance, population structure and life-cycle**
M C Daponte, F L Capitanio, D E Nahabedian, M D Viñas and R M Negri

A comparative study of *Calanus finmarchicus* mortality patterns in five localitites in the North Atlantic
M Ohman, K Eiane, E G Durbin, J A Runge and H-J Hirche
Comparative life histories and life cycles of zooplankton populations within and between the North Pacific and North Atlantic

Comparative ecology of overwintering *Calanus finmarchicus* in the northern North Atlantic, and implications for life cycle patterns
M Heath, P R Boyle, A Gislason, W S C Gurney, S J Hay, E J H Head, S Holmes, A Ingvarsdottir, S H Jonasdottir, P Lindeque, R T Pollard, J Rasmussen, K Richards, K Richardson, G Smerdon and D Spiers

Life strategies of calanoid congeners in two different climate regimes: a comparison
C Halsband-Lenk, F Carlotti and W Greve

Life cycle strategies of Northern krill, *Meganyctiphanes norvegica*, for regulating growth, moult- and reproductive activity in various environments. The case of fjord populations.
J Cuzin-Roudy, G A Tarling and J-O Strömberg

Annex 7 **ICES plankton status report 2003–2004**

Zooplankton monitoring results in the ICES area, Summary Status Report 2002/2003

Prepared by the ICES Working Group on Zooplankton Ecology

Editor: Luis Valdés
Numerical analysis and Figures: Luis Valdés, Todd O'Brien, Anthony Richardson and Angel L. Urrutia

Data provided by: David Mountain, Doug Sameoto, Michel Harvey, Astthor Gislason, Alistair Lindley, Anthony Richardson, Eilif Gaard, Webjorn Melle, Lutz Postel, Steve Hay, Wulf Greve, Roger Harris, Delphine Bonnet, Angel L. Urrutia, Luis Valdés and M. Teresa Alvarez-Ossorio

Contents:

1. Background

The ICES strategic plan recognised the ICES role in making scientific information accessible to the public in addition to the fisheries and environmental assessment groups. Thus, during the 1999 Annual Science Conference a general request was made from ICES to the Oceanography Committee Working Groups to develop data products and summaries that could be provided on a routine basis to the ICES community via the ICES web site. The Working Group on Zooplankton Ecology (WGZE) consider as a priority action to produce a summary report on zooplankton activities in the ICES area based on the time series obtained in the national monitoring programmes.

This is the fourth summary on zooplankton monitoring results in the ICES area. This issue starts a new series that includes also collections on phytoplankton data in some locations coincident with the zooplankton sampling sites. The final goal will be the production, in the near future, of a unique Plankton Status Report with environmental variables.

Additionally we also improve this year report with two new series on the Canadian coastal waters (Anticosti Gyre and Gaspé Current), the presentation of annual means of zooplankton abundance in terms of anomalies and the inclusion of a general overview of SST, phytoplankton colour index and copepod abundance for the entire North Atlantic provided by SAHFOS, which serves to discuss the regional description of the time series results from the monitoring programmes and to put the data on a basin scale context.

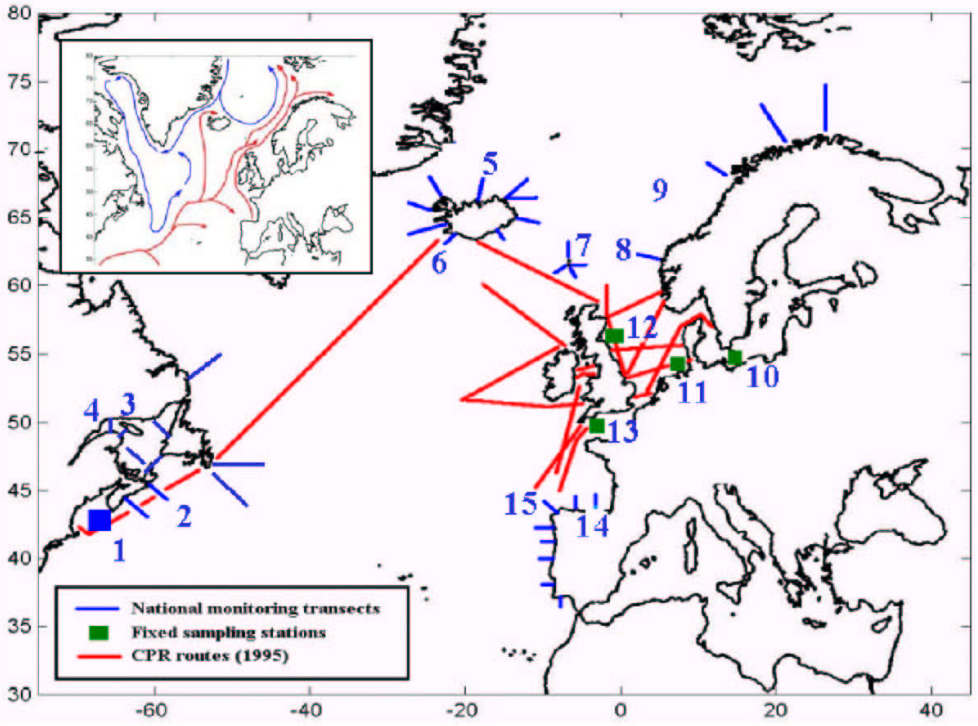
2. Regional coverage

The information collated by the ICES WGZE on, zooplankton sampling programmes in the ICES area include 5 fixed stations and 35 standard sections (approx. 250 sampling stations) distributed on the continental margins of both America and Europe and covering from the temperate latitudes south of Portugal to the colder regions north of Norway and Canada. In addition, there are several fixed CPR routes that cover coastal and oceanic waters in the Atlantic. The sampling networks and the collections used in this report are shown in Figure 1.

As shown in the time series collections presented here, zooplankton abundance is very variable between years. Temperature can have a large influence on the community structure and production of zooplankton and can cause large seasonal, annual and decadal changes in zooplankton population size and species distribution. Other factors that explain biogeographical differences in species distribution, in plankton abundance and in biological processes are the extent of exposure to sun light, the timing of the spring bloom, the length of the season of water column stratification, etc. It was for these reasons that data sets included in this report are presented by affinities in temperature and biogeographical areas, which correspond to regional seas or basins and discussed under this biogeographical scheme.

The main characteristic of the zooplankton monitoring programmes is the temporal resolution of observations. Zooplankton is also sampled with a variety of nets, over a variety of temporal and spatial scales, so a comprehensive interpretation of the data sets requires information on metadata to describe the content, quality, and other data characteristics (sampling gear, mesh size, depth, sampling site, dates, ancillary data, person responsible for the data, etc.) are included in Section 6. These metadata will help a reader locate and understand the data presented in this document.

Data are presented in biomass (Canada, Icelandic-Norwegian basin) or abundance (Baltic Sea, North Sea, English Channel, Bay of Biscay and Iberian coast), with only one data set expressed as abundance in number of organism per sample (CPR), and another expressed in plankton volume (Georges Bank). Abundance and biomass are structural variables that allow for an easy comparison.



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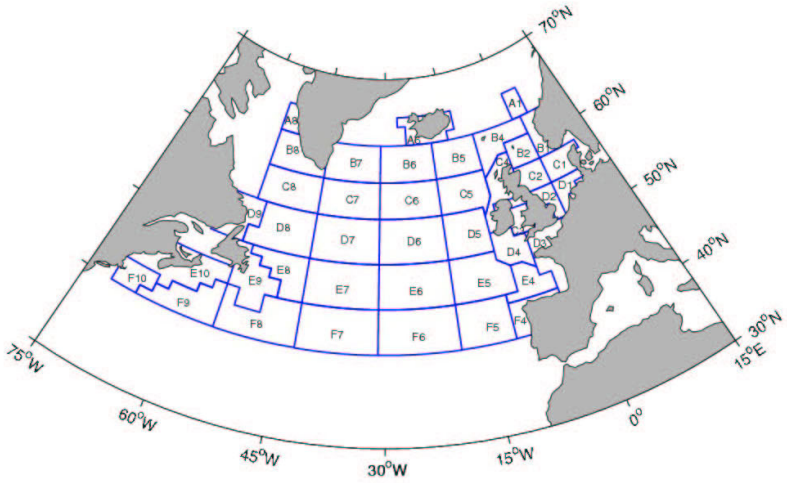

B

Figure 1: **A:** Zooplankton sampling network in the ICES area (only sampling programmes reported in the WGZE); numbers make reference to the collections used in this report. Map in the upper left corner represents the schematic general circulation of the North Atlantic. **B:** Map of CPR standard areas in the North Atlantic.

3. Regional descriptions

Western Atlantic

Area 1: Georges Bank

The Northeast Fisheries Science Center conducts two types of zooplankton monitoring programmes, operated by the Laboratory in Narraganset. The first is CPR transects across the Gulf of Maine and across the shelf from New York City towards Bermuda. Currently some of the recent data from this programme are being reviewed.

The second type of monitoring is by Bongo net (333 µm mesh) samples collected four to six times per year over the shelf region. A number of possible indices could be provided. Data presented here, show the plankton displacement volume on Georges Bank in the early spring and early autumn (Fig. 2). The increase in plankton volume on Georges Bank in the spring of 2003 appears due in large part to an increase in the amount of phytoplankton in the samples.

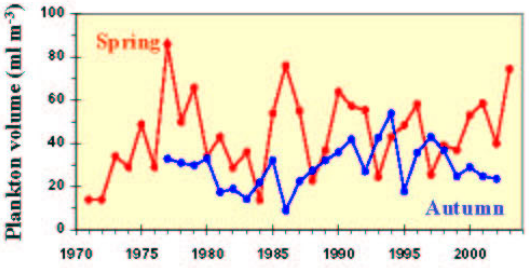

Figure 2: Plankton displacement volume on Georges Bank in the early Spring and early Autumn

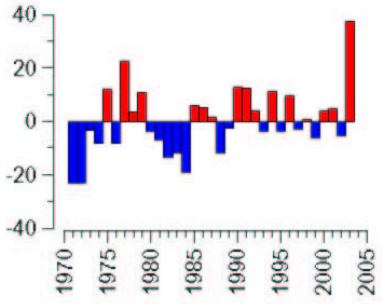

Figure 3: Annual mean biomass deviations from the long-term mean (x = 37.2 ml/m^3) of all biomass values.

Figure 3 shows that with the exception of the a very high value in 2003, the time series is quite stable with mean displacement volumes around 40 ml/m^3.

Area 2: Emerald Basin (West Atlantic, Scotian Shelf)

Zooplankton are sampled twice a year (spring-summer and fall-winter) with a variety of nets and optical instruments, the main sampling net being a 0.75 m diameter ring net mounted with a 200 µm mesh. Sampling is carried out on a number of stations on a series of transects that run perpendicular to the coast of Nova Scotia across the Scotian Shelf. The most frequently sampled station is in Emerald Basin, a deep basin approximately in the center of the shelf. These data are used to monitor long-term changes in the levels of zooplankton species abundance. A stock status report on the state of the phytoplankton and zooplankton in Canadian Atlantic waters is prepared every year. This report is also published on the web at http://www.dfo-mpo.gc.ca/csas/Csas/English/Status/general.htm.

It is believed that the size of the autumn population of *Calanus finmarchicus* in Emerald Basin is a good indicator of the size of the population on the Scotian Shelf during the previous spring and summer (Sameoto and Herman, 1990). The *C. finmarchicus* population declined between 1995 and 1997 to reach the historical low levels of 1984. During 1998 and 1999 the population had recovered reaching maximum levels in autumn of 1999 but again populations declined to a low in 2002. In spring 2003 values are close or a bit above the mean of the time series. *C. finmarchicus* accounts for a significant portion of total zooplankton, which shows the same general pattern in abundance (Fig. 4). The temperature anomaly at 50 m in June and the numbers of *C. finmarchicus* appeared to be related, showing that, as the temperature increased, there was generally an increase in the size of the *C. finmarchicus* population.

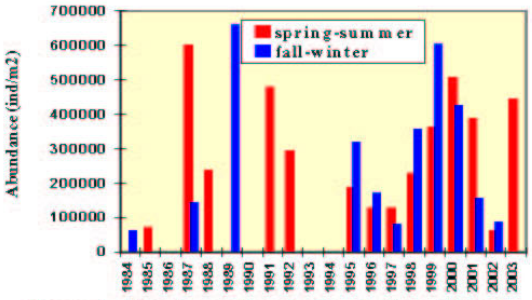

Figure. 4: Abundance of zooplankton in Emerald Basin (1984-2003)

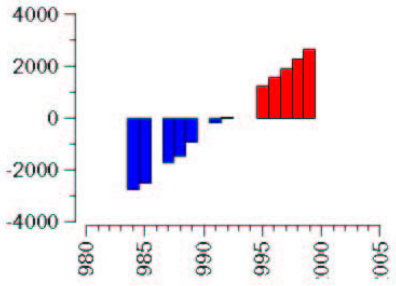

Figure 5: Annual mean abundance deviations from the long-term mean ($x = 33724\ ind/m^2$) of all abundance values.

A slightly increasing trend in abundance is noted when annual means are calculated for the period 1984-2000 (Fig. 5), however this could be an statistic artefact due to the gaps in the data in some seasons.

Areas 3 and 4: Gaspé Current and Anticosti Gyre (St. Lawrence Estuary)

The Atlantic Zone Monitoring Programme (AZMP) was implemented in 1998 with the aim of collecting and analysing the biological, chemical and physical field data that are necessary to (1) characterize and understand the causes of oceanic variability at the seasonal, interannual and decadal scales, (2) provide multidisciplinary data sets that can be used to establish relationships among the biological, chemical and physical variables, and (3) provide adequate data to support the sound development of ocean activities. The key element of the AZMP sampling strategy is the oceanographic sampling at fixed stations and along sections. The fixed stations are occupied about every two weeks, conditions permitting, and the sections are sampled from one to three times during the year. The location of the regular sections are shown in Figure 1.

Data presented in the present status report correspond to two sampling stations at Gaspé Current and Anticosti Gyre, both at the St. Lawrence Estuary. In 2002 the overall biomass of zooplankton observed in the Anticosti Gyre was comparable with what we observed in 1999, 2000 and 2001, while the overall zooplankton biomass in the Gaspé Current was slightly higher that in 2001 and 2000. However the total abundance was generally consistent with previous observations (Fig. 6). The zooplankton biomasses observed in 2002 along the all sections for both seasons was comparable with observations made in 2001 and 2000 (Drinkwater and Pepin, 2003).

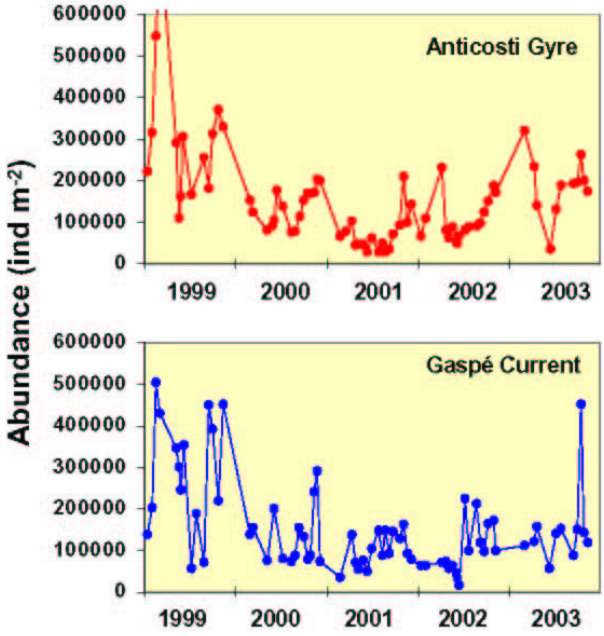

Figure.6: Abundance of zooplankton in St. Lawrence Estuary

Icelandic-Norwegian basin

Areas 5 and 6: Siglunes (North Iceland) and Selvogsbanki (South Iceland)

The Icelandic monitoring programme for zooplankton consists of a series of transects perpendicular to the coastline. Sampling of the transects to the north and east of Iceland was started in the 1960s. Additional section lines to the south and west were added in the 1970s. There are now about 90 stations in total. Zooplankton investigations are carried out at these stations every year in May-June. Long-term changes in zooplankton biomass at Siglunes transect from the north of Iceland and at Selvogsbanki from the south are shown in Figure 7. At Siglunes the values are averages from 8 stations, while on Selvogsbanki the values represent averages from 5 stations.

At the Selvogsbanki transect the zooplankton biomass showed a peak during the early 80's while a low was observed during the late 80's. Peaks were also observed around 1995 and 2000-2001. The time period between the zooplankton peaks on the Selvogsbanki transect has been 5-10 years.

North of Iceland (Siglunes transect) the high values of zooplankton in the beginning of the series dropped drastically with the onset of the Great Salinity Anomaly of the 1960s. Since then zooplankton biomass has varied with highs at approximately 7-10 years intervals. The highest and lowest values differ by a factor of about 24. The last peak in zooplankton biomass occurred around 2000.

The zooplankton biomass north of Iceland is influenced by the inflow of warm Atlantic Water to the area. Thus, in warm years, when the flow of Atlantic Water onto the northern shelf is high, the zooplankton biomass is almost two times higher than in cold years, when this inflow is not as evident (Astthorsson and Gislason 1998, Astthorsson and Vilhjalmsson 2002). The reason for this may be the better feeding conditions of the zooplankton due to increased primary production in warm years, advection of zooplankton with the Atlantic Water from the south, and faster temperature dependent growth of the zooplankton in warm years. During both 2000 and 2001, when the biomass of zooplankton north of Iceland was particularly high, the inflow of warm Atlantic water onto the northern shelf was also high. South of Iceland the links between climate and zooplankton biomass are not as evident as north of Iceland. Most likely the variability off the south and west coasts is related to the timing and magnitude of the primary productivity on the banks which in turn are influenced by the freshwater efflux from rivers and wind force and direction.

Comparison with other data from the northern North Atlantic shows that observed zooplankton biomass in spring is descriptive of the mean copepod biomass in that year. Recent research also shows that the variation of zooplankton biomass in the Icelandic area is in tune with long term variability of zooplankton abundance over a much larger area, i.e. in the northern North Atlantic in general (Astthorsson and Gislason 1995) as shown in section 4 of the present Status Report..

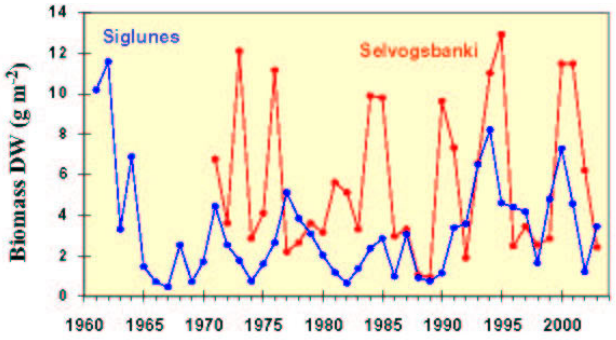

Figure 7: Year to year variability of zooplankton biomass at Siglunes and Selvogsbanki.

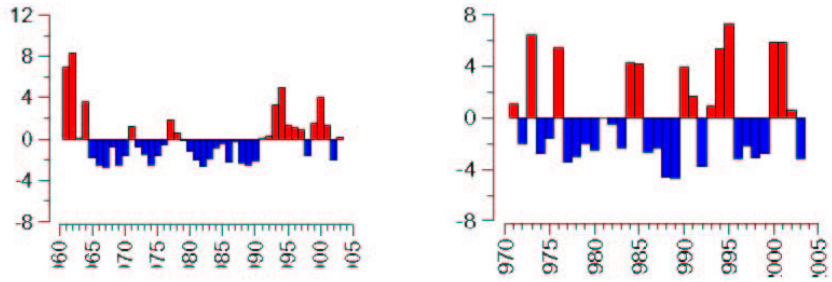

Figure 8: Annual mean biomass deviations from the long-term mean of all biomass values at Siglunes (left graph, $x = 3.3\ g/m^2$) and Selvogsbanki (right graph, $x = 5.7\ g/m^2$).

Figure 8 do not shows any significant trend in the time series of annual means, but the differences in yearly annual means are typically higher in the southern transect of Selvogsbanki (right) than that northern transect of Siglunes (left).

Area 7: Faroe Islands

The Faroese Fisheries Laboratory operates 4 standard sections radiating northwards, eastwards, southwards and south-westwards from the Faroes. These sections are sampled 4 times per year: in February, May, June/July, and November.

The northwards section, from the Faroes into the southern part of the Norwegian Sea (which is presented here), contains 14 stations with a distance of 10 nautical miles between each station. The southernmost end of the section is on the Faroe shelf, and in most years contains essentially neritic zooplankton, mixed with variable abundance of oceanic zooplankton. The abundance of oceanic zooplankton (mainly *Calanus finmarchicus*) on the shelf is highly variable between years. From the slope and northwards, the southernmost part of the section covers warm Atlantic Water (AW), while the northernmost part of the section covers cold East Atlantic Current Water (EICW).

Figure 9 and 10 shows the average zooplankton biomass in the upper 50 m in these two water masses in the oceanic part of the section in May 1990-2003. This usually is close to phytoplankton spring bloom. *C. finmarchicus* is the dominant species in both water masses. With the exception of 1993, the biomass was clearly higher in the cold water mass in the northern part of the section than in the warmer southern part. The reason is a higher abundance of overwintered *C. finmarchicus* (CV and adults) combined with presence of *Calanus hyperboreus* in the northern part. In the Atlantic water, much fewer large individuals are present, but higher numbers of small (recruit) stages in May. Since the reproduction starts earlier in the southern part of the section, the total numbers of *C. finmarchicus* are higher on average in the Atlantic water than in the East Icelandic Current Water, despite the lower biomass (Gaard, 1996, 1999).

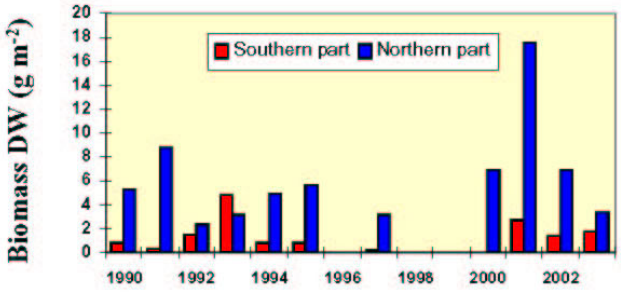

Figure 9:. Zooplankton biomass at 0-50 m depth in Atlantic Water (southern part) (left) and the East Icelandic Current Water (northern part) (right) on section North in May 1990-2003. No data from 1996, 1998, 1999 and 2000 south.

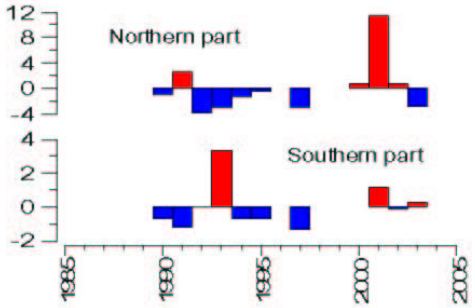

Figure 10: Annual mean biomass deviations from the long-term mean of all biomass values from the Northern (x = 6.2 g/m^2) and Southern (x = 1.5 g/m^2) areas.

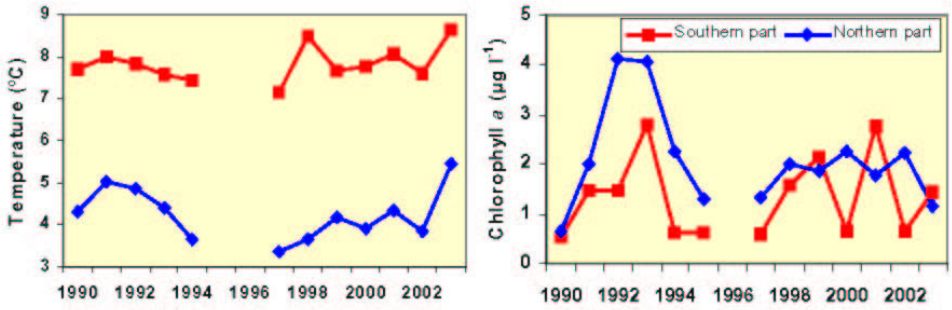

Figure 11. Temperature (left) and chlorophyll *a* (right) concentrations at 0-50 m depth on section North, May 1990-2003. The chl. *a* values for 2003 are preliminary.

Apparently the temperature difference is a main reason for the general difference in timing of reproduction between the two water masses. Phytoplankton abundance cannot explain the difference, since the chlorophyll *a* concentration in most years are higher in the cold EICW than in the warmer AW (Fig. 11, right). A likely main reason for the relatively early reproduction in the cold EICW in 2003 (compared to the previous years in the time series) is that the water was unusually warm. The average temperature in the upper 50 m in this water mass was 5.5°C which is 1.5°C higher than in 2002 and was the highest temperature recorded in the time series in this water mass (Fig. 11, left). Furthermore the front between the two water masses had a quite northern position in 2003. While the general difference in timing of *C. finmarchicus* reproduction in the two water masses seem to be mainly an effect of temperature differences, interannual variability seems to be a combined effect of temperature and phytoplankton abundance.

Area 8 and 9: Svinøy and the Norwegian Sea

Four fixed transects are sampled within the "IMR Monitoring Programme": 2 transects into the Norwegian Sea [the Svinøy transect (15 stations) and the Gimsøy transect (10 stations)] and 2 transects in the Barents Sea [the Fugløya-Bjørnøya transect (7 stations) and the Vardø-North transect (8 stations)]. Transects are sampled at various frequencies: the Norwegian Sea transects 4-10 times/yr and the Barents Sea transects 3-5 times/yr. Additionally the Norwegian Sea is surveyed in May and July-August, both surveys ca. 50-100 stations. Data are stored at the HELIX database at IMR. Periodic reports are made annually to the Ministry of Fisheries and to the IMR´s "Havets Miljø" (Annual Report on Marine Environment).

The development of zooplankton biomass in spring at the Svinøy transect showed very small variations among years in the period 1997-2001 (Fig. 12), and the maximum biomass in early summer varied from 8 to 9.3 g DW m^{-2}. In 2002, the biomass as an average for all stations was 11.32 g DW m^{-2} (April 28-30) higher than previous years. The maximum biomasses were 11.8 and 111 g DW m^{-2} as an average for the eastern and western part, respectively. In 2003 the highest biomasses were observed in the second part of April, 12.6 g DW m^{-2} in the eastern part, and 11.3 g DW m^{-2} in the western part, i.e. almost similar to the previous year.

Due to the still reduced coverage of the Svinøy transect (4 and 5 times in 2001 and 2002, respectively) no firm conclusions can be made with previous years with regard to the zooplankton development.

Figure 12b shows the zooplankton biomasses in the Norwegian Sea 1994-2002 based upon the July-August surveys. The biomasses varied from 5.1 (1998) to 10.8 g DW m-2 (1994), the biomasses in 1998 being the lowest observed during this period. The average for the whole period is about 7.15 g DW m^{-2}. The survey last year took place somewhat further east and north than previous years, and the average biomass was the lowest observed since the monitoring started; ca. 4 g DW m^{-2}. A reduced number of stations and a minor change in the geographical area investigated make the basis for comparison with previous years uncertain.

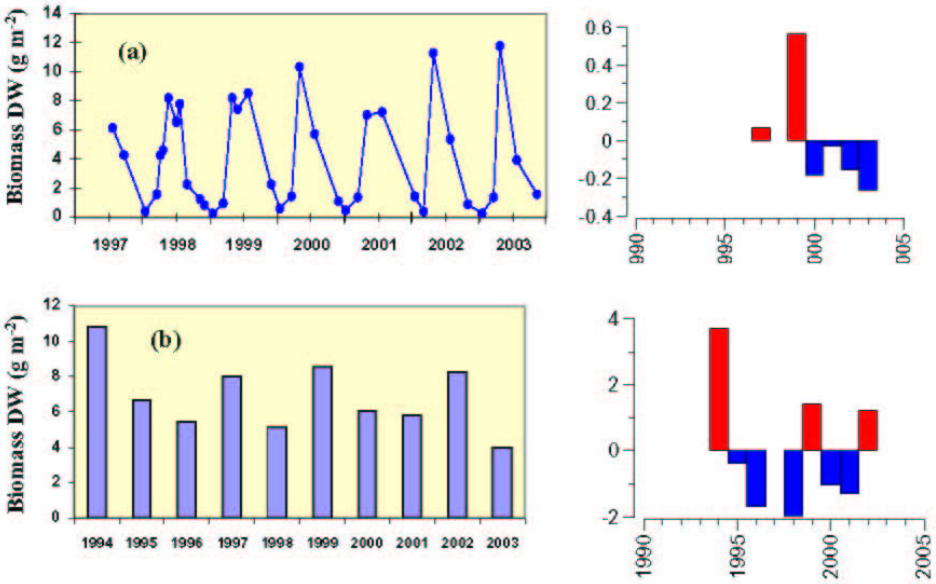

Figure 12: Left: Zooplankton biomass at Svinøy transect (a) and Norwegian Sea (b).

Right Figure: Annual mean biomass deviations from the long-term mean of all biomass values at Svinøy transect (top plot, $x = 4.1\ g/m^2$) and Norwegian Sea (bottom plot, $x = 7.1\ g/m^2$).

Baltic Sea

Area 10: Arkona Basin (Germany)

The Baltic Sea Monitoring Programme (BMP) consists of 24 international stations. The stations cover the different sub-areas of the Baltic Sea from the south-westerly Mecklenburg Bay to the north-easterly Gulf of Finland. Each station is sampled at least 4 times a year, but laboratories of all Baltic States contribute to the BMP increasing the amount and the frequency of data. Data are stored at HELCOM (Helsinki Commission) and will be stored at ICES in the future. Periodic Assessment Reports are prepared every 5 years by contributions of all HELCOM member states (http//www.helcom.fi; HELCOM, 1996).

For purposes of illustration, one station (54°55`N, 13°30'E) has been chosen from the data base (Fig. 13). This station is sampled from the surface down to 25 m or to the depth of the seasonal thermocline (30 m). The total series covers the period from 1973 to the present. In some years the sampling coverage is quite poor (e.g. 1995 and 1996). Variations in the range 10000-50000 ind m^{-3} are typically observed during the seasonal cycle in the western Baltic Sea. Peaks of

plankton observed in spring 1983, 1988, 1995, 1998, 2000 and 2002 were because of mass developments of rotifers, which often happened after mild winters. In spite of these peaks, the cladoceran *Bosmina coregonii* is the dominant species during summer when water temperature reaches 16 °C (HELCOM, 1996). Although no statistical trend is observed, 4 of the 6 spring peaks mentioned above occurred during the last 8 years.

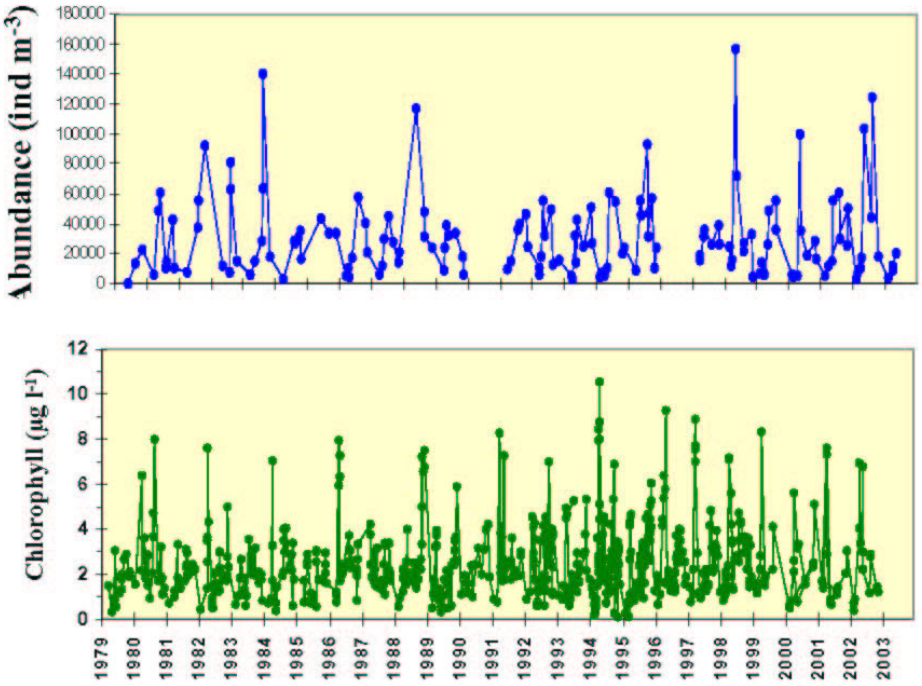

Figure 13: Zooplankton and phytoplankton abundance at Arkona Basin (Baltic Sea) in 1999-2003

Chlorophyll concentration at Arkona Basin show high values all year round with seasonal spring blooms over 6 µg l^{-1} and over 2 µg l^{-1} most of the year (Fig. 13). However it is noted a decreasing trend since 1994 when maximum values reach 11 µg l^{-1}.

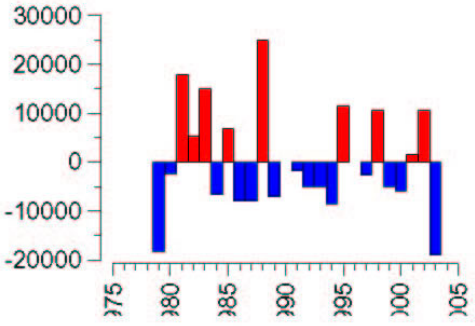

Figure 14: Annual mean abundance deviations from the long-term mean ($x = 30237$ *ind/m*^{3}) of all abundance values.

Figure 14 shows that with the exception of the low values in 1979 and 2003 and the high values of abundance in 1989, the time series is quite stable in annual mean abundances and no trends are noted.

North Sea and English Channel

Area 11: Helgoland (SE, North Sea)

Since 1975 every Monday, Wednesday and Friday two oblique plankton net samples (150 µm, 500 µm) have been collected at the station Helgoland Roads (54°11′18"N, 7°54′E), Helgoland being the only offshore island of the North Sea. Almost 400 taxonomic entities of holoplankton and meroplankton (benthic-and fish-larvae) are counted. Time-series were started within the Biologische Anstalt Helgoland and have been continued after the institutional re-organisation in a co-operation of the German Centre for marine Biodiversity, the Federal Maritime and Hydrographic Agency and the Biologische Anstalt Helgoland.

The purpose of the program is the documentation of plankton population dynamics for the recognition of regularities and variances in the abundance distribution. This will allow plankton prognoses in season, dimension and finally abundance, and for the detection of biodiversity changes possibly caused by external forcing. Examples of results using several analytical techniques, types of information extracted from the data and models on prognosis for zooplankton dynamics on several time-scales can be found in Greve (1994), Greve *et al.* (1998) and Heyen *et al.* (1998).

Small copepods represents a significant fraction of the total zooplankton in Helgoland. Seasonal cycles and year to year variability of small copepods can be observed in Figure 15. The ~30-year time series 1975-2003 shows two periods (Fig. 15 right). A first period 1975-1990 when the copepods shown an increasing trend; since then (1991-2003), the population has been oscillating quite regular with averages values of abundances around the half of the first period (4293 vs. 2441 ind m^{-3} in the first and second periods respectively).

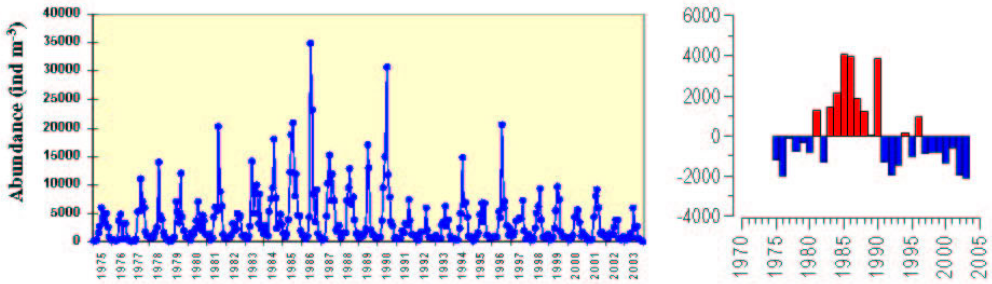

Figure 15: Left: Small copepods abundance at Helgoland. Right: Annual mean abundance deviations from the long-term mean ($x = 3462\ ind/m^3$) of all abundance values.

Area 12: Stonehaven (Scotland, NW North Sea)

The Stonehaven sampling site is located at 56°57.80′N 002°06.20′W, approximately 5 km offshore from Stonehaven which is a fishing harbour 28 km to the south of Aberdeen. The water depth at the site is 50 m. Sampling for hydrographic parameters, concentrations of inorganic chemical nutrients and the abundance of phytoplankton and zooplankton species has been carried out on a weekly basis off Stonehaven since January 1997. The objective of the programme is to establish a monitoring base for assessing the status of the Scottish coastal

waters ecosystem, and the responses to climate change. Comparison of the results with archive regional data on temperature, salinity and nutrients and phytoplankton biomass, indicates that the site off Stonehaven provides a reasonable index of the state of the coastal waters. The biological data illustrate the consistencies and variability in seasonal succession of plankton species and their abundance. It is evident that there are significant differences among seasons and years.

The water column at the sampling site remains well mixed throughout much of the year, except when in late summer and autumn when surface heating and settled weather often cause temporary thermoclines to appear. The seasonal minimum temperature generally occurs in the last week of February/first week of March. Water movement is generally southerly with quite strong tidal currents. In the late summer and through autumn of most years, water with a high Atlantic Ocean content passes down the Scottish East Coast. These events are particularly observable in the salinity signal. For example 1997 showed a strong salinity increase in the late summer whereas 1998 showed very little. These influxes often bring oceanic species in: for example the chaetognath *Sagitta serratodentata* and the siphonophore *Muggiea atlantica* are indicators of this oceanic influence.

The seasonal pattern of plankton production is clearly evident in these data, as is the variability among years in its extent. Nutrient data also show strong seasonal cycles but again there is interesting inter-annual variability evident. This is also seen in the variations observed in the phytoplankton and chlorophyll data (Fig. 16). Large differences can be seen between years in the observed biomass of many common species of zooplankton, with a general increase from 1997–2000 (Fig. 16) but a lower observed abundance overall in 2001 and 2002. In 2003 zooplankton peaks again with the second hihgest values of the time series.

The time series, although short, is at a fairly high observational frequency, this allows insight into the seasonal dynamics and succession of species throughout the annual cycle. This provides an excellent background against which to carry out process studies, modelling and comparisons with other sites. Data also provide assessment of the extent of local variability and allow consideration of the local effects of broader patterns of ocean climate change.

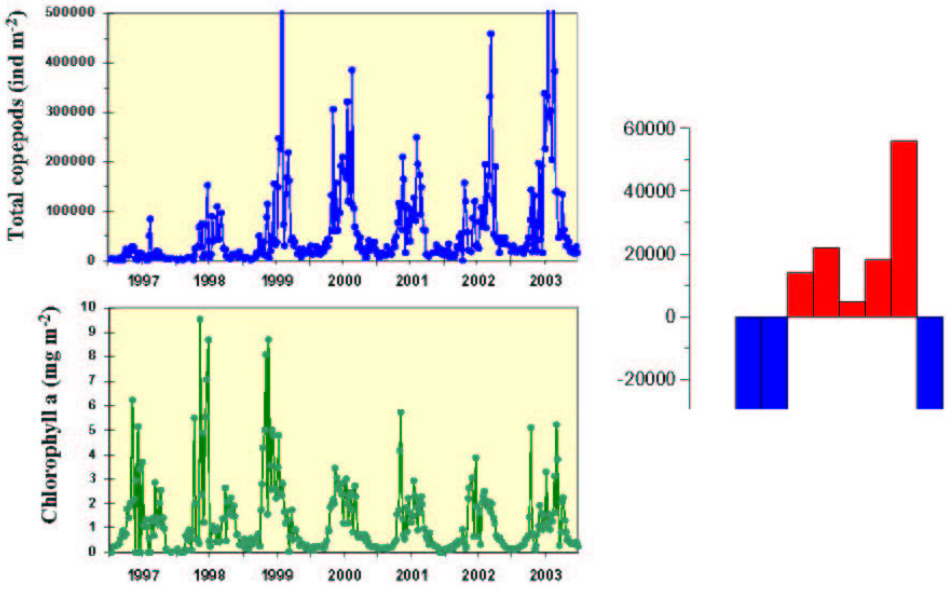

Figure 16: Weekly abundance of copepods and chlorophyll at Stonehaven (left) and Annual mean abundance deviations from the long-term mean ($x = 56497$ *ind/m²*) of all abundance values (right).

Zoop

Several zooplankton species are of particular interest in that they show wide variations in their abundance. For example the important common copepod genus *Calanus* is represented by two species off Stonehaven. Firstly and most abundantly in the spring and summer is *C. finmarchicus*, an important species in that the large spring influx and production provides food for fish larvae in spring. However, its congener *C. helgolandicus*, a more southern species and generally most abundant in summer and autumn, has increasingly shown evidence of increased productivity and extended survival through the winter months. This is most likely a reflection of changes in the physical environment through the last few months of the year, with faster or slower cooling of the sea affecting the strongly temperature-dependent physiology of these small plankton. Interannual variability in over-winter survival is likely to affect the population dynamics for a number of species, and may "kick start" the production cycle when it begins in spring each year. Such dynamics may have for example, considerable implications for larval survival and recruitment to fish populations as well as consequences for assessments of the effects of local eutrophication pressures on the coastal marine ecosystems of eastern Scotland.

Data are regularly processes in the FRS MLA database and some of these data are displayed on the MLA web site (http://www.marlab.ac.uk/Montoring/Stonehaven/Stoneframe.html) and published in periodic reports (e.g. Heath *et al*., 1999).

Area 13: Plymouth (English Channel)

Zooplankton is collected weekly at station L4 (04°13'W, 50°15'N) about 15 miles SW of Plymouth in the English Channel. The station is about 50m deep and influenced by seasonally stratified and transitional mixed-stratified waters (Pingree and Griffiths, 1978). Organisms are collected with a 200 µm WP2 net towed vertically from 50 m to the surface. Samples are split for count and identification to genera or species level under a dissecting microscope. The L4 data are publicly available through a data CD (on demand) and a web site (recently updated): www.pml.ac.uk/L4. L4 station was created in 1988 to monitor zooplankton population dynamics but numerous parameters have since been added: nutrients, bacteria and viruses, hydrographical parameters, suspended matter for satellite data calibration, phytoplankton, *Calanus helgolandicus* egg production, etc. This monitoring station is currently funded by the PML Core Research Programme.

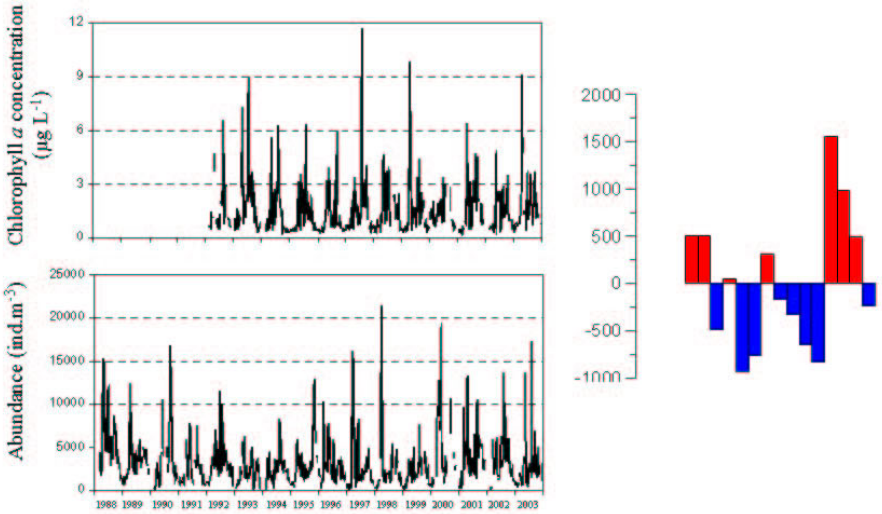

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Figure 17: Left: Weekly chlorophyll *a* concentration and zooplankton abundance at Station L4 (Plymouth) and Right: Annual mean abundance deviations from the long-term mean ($x = 3027$ *ind/m*^{3}) of all abundance values.

Weekly zooplankton abundance as well as Chlorophyll *a* concentration at L4 shows clear seasonal cycles (Fig. 17). Peaks of high zooplankton abundance and Chlorophyll *a* concentration are regularly observed in spring and late summer-beginning of autumn.

A slight decreasing trend in total zooplankton abundance can be noticed over the whole time series. However this trend is not significant and is mainly due to the high zooplankton abundance in 1988 (not represented in Fig. 17). Maximum yearly abundances were observed in 1988 due to high densities of decapoda, cladocera, fish larvae, *Oikopleura* spp. and hydromedusae and in 2000 with peaks of polychaeta larvae and copepods (e.g. *Temora longicornis* and *Oithona similis*). Especially low abundances were observed in 1993, 1994 and 1999. Total zooplankton abundance was high in 2000 whereas the lowest yearly chlorophyll *a* concentration over the whole time series was observed the same year.

Bay of Biscay and Iberian coast

Area 14: Santander (Southern Bay of Biscay)

Four transects are monitored in the ICES area off the Spanish coast. This involves an extensive physical, chemical and biological monthly sampling series at each site, with special attention to the sampling and analysis of hydrographical parameters, nutrients, chlorophyll *a*, and phytoplankton and zooplankton species. Data are regularly entered in the IEO databases, and hydrographic and nutrients data are also available in the ICES database. Depending on the transect, the time series extend from 1988 (A Coruña and Vigo), 1991 (Santander) and 1994 (Asturias) to the present.

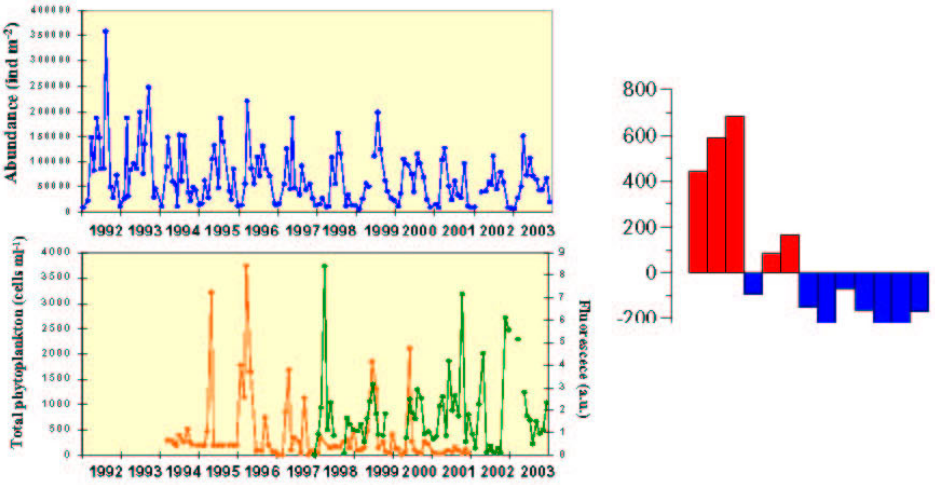

Figure 18: Left: Monthly zooplankton abundance (upper panel) and phytoplanton cells (orange line, left scale) and fluorescence in arbitrary units (green line, right scale) in a neritic station off Santander. Right: Annual mean abundance deviations from the long-term mean ($x = 1397$ *ind/m*^{2}) of all abundance values.

Long-term changes of zooplankton abundance at Santander show a slight decreasing trend (Fig. 18). The result is in opposition to the upward trend showed by the water column stratification index (Lavin *et al.*, 1998). This relationship between zooplankton and environmental conditions highlight the importance of the longer duration that the water column remains stratified could have in limiting the interchange of nutrients from deeper to surface waters and consequently limiting the growth of phytoplankton and zooplankton (Valdés and Moral, 1998). A similar relationship between an increasing trend in the water column stratification and a decline of zooplankton biomass was reported by Roemmich and McGowan (1995) at the Californian coast (CalCOFI series).

Area 15: A Coruña (NW Iberian Peninsula)

In the coastal and neritic regions off Galicia (NW Spain) the classical pattern of seasonal stratification of the water column in temperate regions is masked by upwelling events from May to September. These upwelling events provide zooplankton populations with favourable conditions for development in the summer months, the opposite of what occurs in other temperate seas in this season of the year. Nevertheless, upwelling is highly variable in intensity and frequency, and shows a substantial year-to-year variability.

Zooplankton values in A Coruña (Fig. 19) differ to that in Santander (Fig. 18): zooplankton abundance is higher in A Coruña and the time series does not show any trend. Both characteristics are partly due to the influence of the seasonal upwelling, which prevents the water column from properly stratifying, reinforces the input of nutrients to the photic layer, enhances the growth of phytoplankton populations and therefore enhances the growth of zooplankton populations. [Note that the time series shown in Figure 15 is composed of two curves, one for the zooplankton >250 µm, and the other for zooplankton >200 µm].

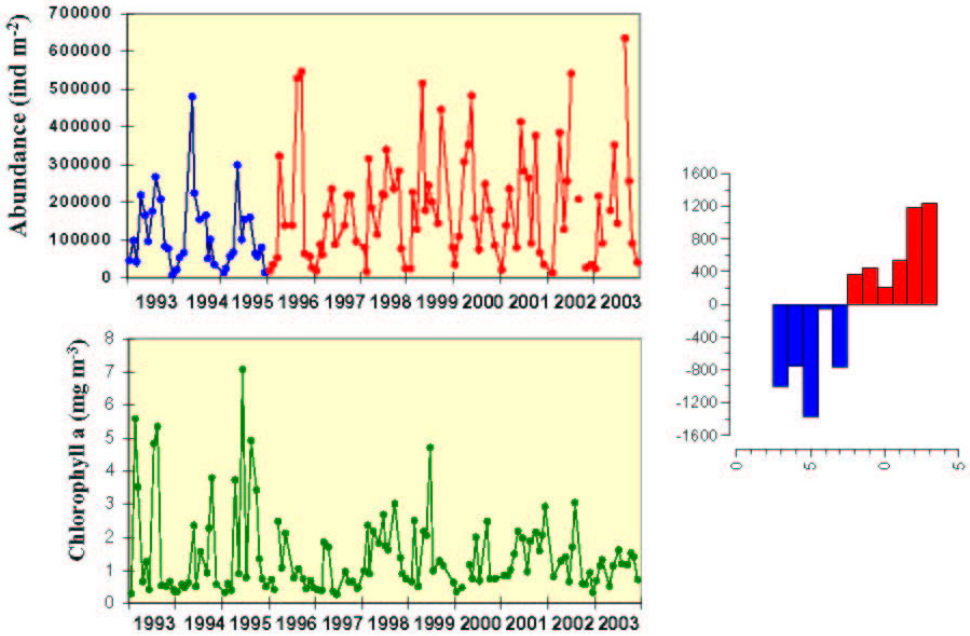

Figure 19: Left: Monthly zooplankton abundance (upper panel) and chlorophyll in a neritic station off A Coruñar. Right: Annual mean abundance deviations from the long-term mean (x = 2922 *ind/m*^{2}) of all abundance values.

4. Discussion: A general overview of the North Atlantic

The time series of total copepod abundance (numbers.m^{-3}) from 1946-2002 in CPR standard areas throughout the North Atlantic (see Figure 1 for map) is shown in Figure 20. Annual means were calculated according to Colebrook (1975). This method excludes years in which data from fewer than eight months were available. The dashed line represents the long-term mean in each standard area. The most striking feature of the time series is a general long-term decline in total copepod abundance east of Iceland, although some areas shown no trend (e.g. northern North Sea). In the western North Atlantic total copepod abundance has remained relatively unchanged since 1946. Highest copepod abundance is in the eastern North Atlantic, and particularly in the southeastern North Sea. The most recent data for the Continuous Plankton Recorder is from the year 2002: data for 2003 will only be available toward the end of 2004. It is clear that the year 2002 is broadly consistent with this trend, with lower than usual copepod abundance throughout most of the standard areas, particularly in the southeast. Many of the areas in the Northeast Atlantic show slightly higher than usual copepod abundance in 2002. These results are coherent with the time series showed in the regional description.

Figure 21 shows the long-term inter-annual values from 1946-2002 of Phytoplankton Colour in CPR standard areas in the North Atlantic. Phytoplankton Colour is the degree of greenness of the CPR silk. It includes the chloroplasts of unbroken and broken cells, as well as small, unarmoured flagellates, which tend to disintegrate on contact with formalin. Phytoplankton Colour is a good index of total chlorophyll (Hays and Lindley, 1994) and is closely related to biomass estimates from satellite (Batten et al., 2003). There has been a large increase in Phytoplankton Colour since the late 1980s in most regions (particularly the northeast Atlantic and the Newfoundland shelf). From the late 1940s to the late 1980s, high biomass was restricted to spring and autumn when diatoms dominate (data not shown). Since the late 1980s, however, the biomass has increased throughout the seasonal cycle. Biomass generally dropped in 2002, but was still generally higher than the long-term mean. In other parts of the North Atlantic, high increases in biomass were seen off the Newfoundland Shelf (with an increase in winter blooms), the Scotian Shelf and the Labrador Sea. In the northern North Atlantic and in the sub-polar gyre, phytoplankton biomass has generally declined over the last two decades, but has shown an increase since 1998.

Figure 22 shows the long-term inter-annual values of Sea Surface Temperature (SST) from 1946 to 2002 in CPR standard areas in the North Atlantic. Temperature shows an overall increase since the early seventies for the whole North Atlantic as indicated by the pronounced positive anomalies. On the other hand, a decreasing trend in SST from the early fifties until the early seventies can be observed particularly in the southern part of the central North Atlantic. This decreasing signal in SST is less relevant in the North Sea where temperatures during this period show no clear trend. This general pattern corresponds well to the division proposed by Beaugrand (2003) on the basis of both SST and scalar wind. Beaugrand (2003) suggested that the north-east Atlantic can be divided into three hydroclimatic regions. The first division approximately north and south of a line of 53°N and in the region north of about 53°N, two other regions were be defined on the basis of their long-term monthly changes in SST. The subarctic gyre and the North Sea. Both regions have been characterized by an increasing trend in wind intensity, which is highly correlated positively with monthly NAO indices, especially in spring and autumn. In the subarctic gyre south of Iceland, phytoplankton biomass has decreased while in the North Sea phytoplankton biomass has increased (Fig 21, Beaugrand 2003). This tends to suggest that temperature is an important factor that limits phytoplankton biomass south of Iceland. However, it could also be argued that if we follow a top-down hypothesis instead of an hydrographically driven ecosystem, the decrease in zooplankton abundance in the North Atlantic could be realizing the predatory pressure over the phytoplankton and trigger an increase in their biomass and hence could be the reason explaining the increase in the CPR colour index.

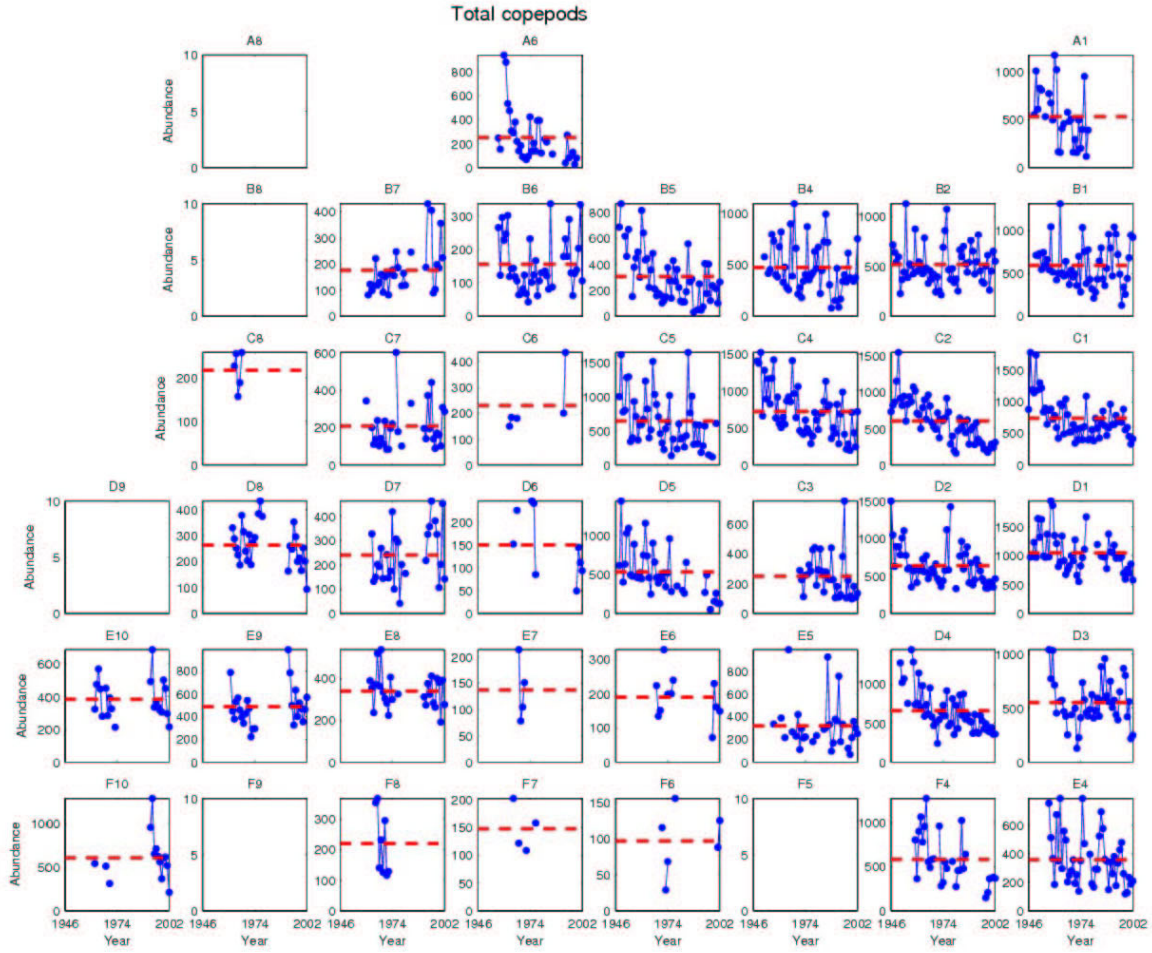

Figure 20: Time series from 1946-2002 of the total copepod abudannce in CPR standard areas in the North Atlantic (see Fig. 1 for map).

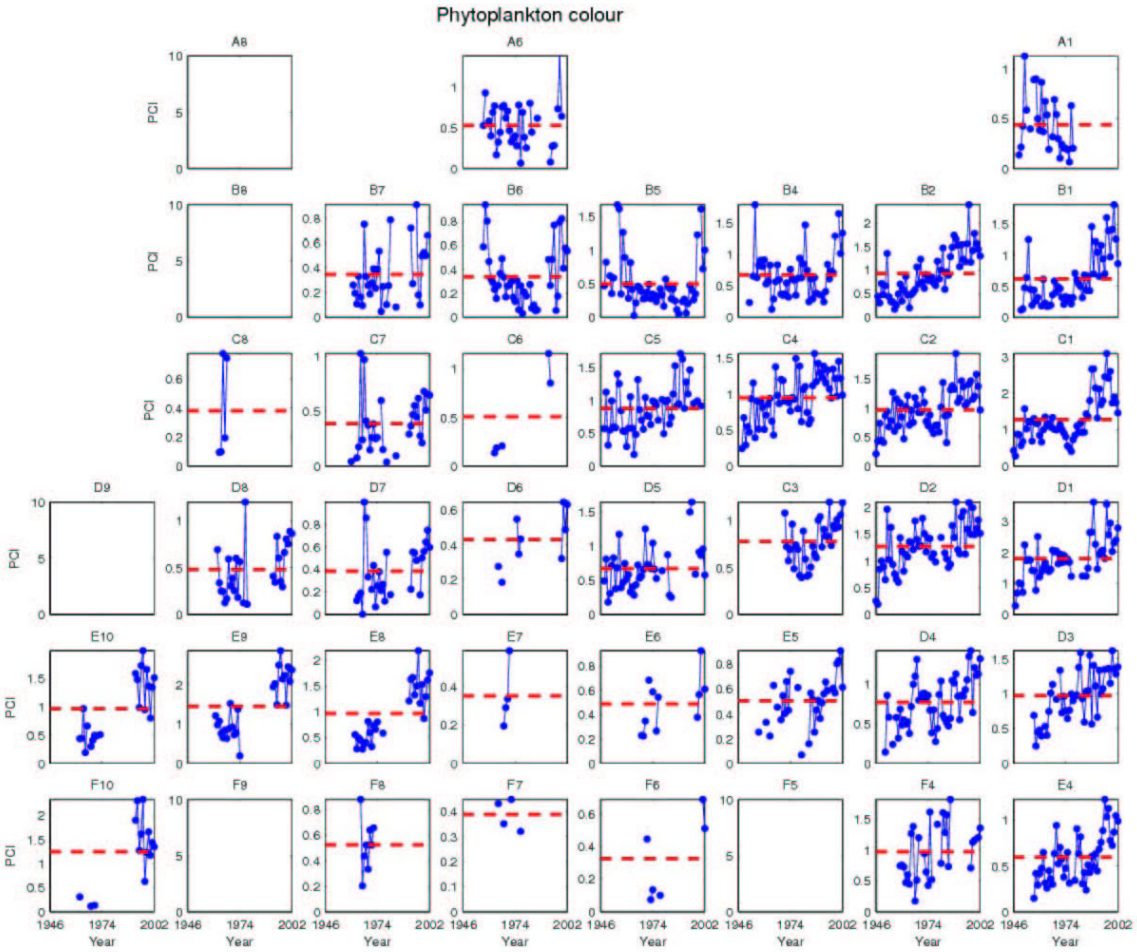

Figure 21: Time series from 1946-2002 of the Phytoplankton Colour Index in CPR standard areas in the North Atlantic (see Fig. 1 for map).

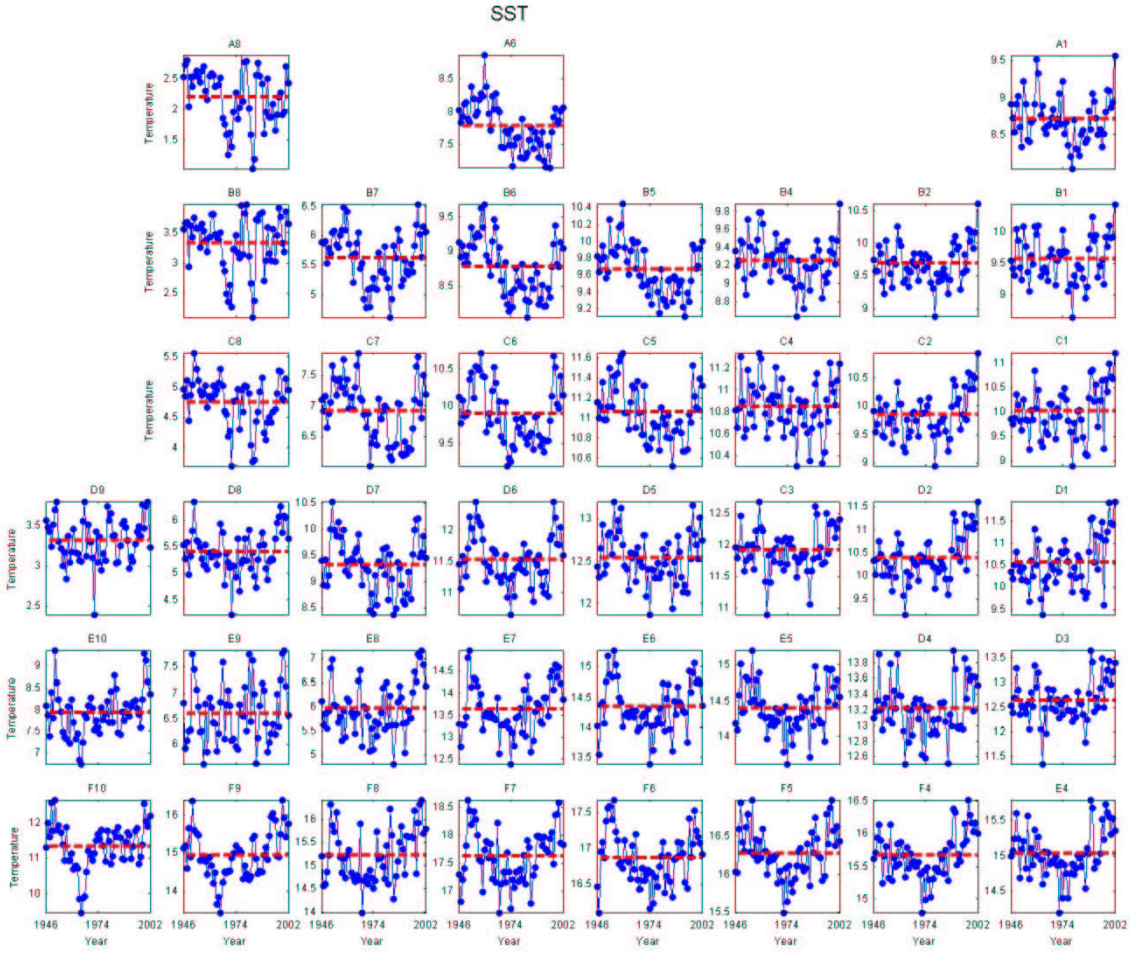

Figure 22: Time series from 1946-2002 of the Sea Surface Temperature in CPR standard areas in the North Atlantic (see Fig. 1 for map).

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6. Characteristics of the collections used (Table of Metadata)

Country	USA (1)	CANADA (2)	CANADA (3)	CANADA (4)
Monitoring programme	NFSC, Narragansetr, RI	Scotian Shelf	AZMP	AZMP
Sampling location	Georges Bank	Emerald Basin	Gaspé Current	Anticosti Gyre
Latitude (N)		43° 57' N	49° 24' N	49° 72' N
Longitude (E-W)		62° 57' W	66° 20' W	66° 25' W
Station Depth (m)		265	265	265
Period of data available	1971-ongoing	1984-ongoing	1999-on going	1999-on going
Frequency (number of cruises/yr)	4-6 per year	random	Every two weeks with some gaps	Every two weeks with some gaps
Gear/diam (cm)	Bongo net	Ring/ 75	Ring/75	Ring/75
Mesh (µm)	333	250	202*	202*
Depth of sampling (m)		0-265	Bottom-surface	Bottom-surface
Ancillary data		hydrography, nutrients, fluorescence, PAR		
Contact person	David G. Mountain	Doug Sameoto	Michael Harvey	Michael Harvey
Email address	dmountai@whsun1.wh.whoi.edu	sameotod@mar.dfo-mpo.gc.ca	HarveyM@dfo-mpo.gc.ca	HarveyM@dfo-mpo.gc.ca
Location of data		bio/chem database BIO	meds	meds
Observations (*)			* the mesh of the net used in 1999 wa a 158 µm	* the mesh of the net used in 1999 wa a 158 µm

Country	ICELAND (5)	ICELAND (6)	FAROE (7)	NORWAY (8)	NORWAY (9)
Monitoring programme	MRI-Iceland	MRI-Iceland	FFI-Faroe Islands	IMR-Bergen	IMR-Bergen
Sampling location	Siglunes-transect	Selvogsbanki-transect	Faroe Shelf	Svinøy transect Norway	Norwegian Sea
Latitude (N)	*	*	62°20 N to 64° 30' N	*	*
Longitude (E-W)	*	*	6° 05' W	*	*
Station Depth (m)	*	*	*	*	*
Period of data available	1961-ongoing	1971-ongoing	1989-ongoing	1993 -onging	1994-ongoing
Frequency (number of cruises/yr)	Yearly (1 May-June)	Yearly (1 May-June)	Yearly (late May)	6-10	July-August surveys
Gear/diam (cm)	1971-91: Hensen; 92-pres:WP-2	1971-91: Hensen; 92-pres:WP-2	1990-1991 Hensen 1992-present WP2	WP-2 (56)	WP-2 (56)
Mesh (µm)	200	200	200	200	200
Depth of sampling (m)	0-50	0-50	0-50	0-150	0-150
Ancillary data	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll
Contact person	Astthor Gislason	Astthor Gislason	Eilif Gaard	Bj. Ellertsen	Bj. Ellertsen
Email address	astthor@hafro.is	astthor@hafro.is	eilifg@frs.fo	bjornar.ellertsen@imr.no	bjornar.ellertsen@imr.no
Location of data	database MRI	database MRI	FFL	Helix database, IMR	Helix database, IMR
Observations (*)	Transect of 8 stns from 66°16'N, 18°50'W (bottom depth: 80m) - 68°00'N, 18°50'W (bottom depth: 1045m)	Transect of 5 stns from 63°41'N, 20°41'W (bottom depth: 46m) - 63°00'N, 21°28'W (bottom depth: 1004m)	Transect with bottom depth from 50 to100 m	Transect of 15 stns from 62°22'N, 5°12'E (bottom depth: 160m) - 64°40'N, 0°00'W (bottom depth: 2695m)	Large areas of the Norwegian Sea are surveyed evrey year. Bottom depth varies between stations

Country	GERMANY (10)	GERMANY (11)	UK (12)	UK (13)
Monitoring programme	IOW	BSH and DZMB	FRS-MLA	L4-PML/UK
Sampling location	Arkona Basin, Baltic Sea	Helgoland	Stonehaven, Aberdeen	Plymouth
Latitude (N)	54° 55'N	54° 11.18N	56° 57.80' N	50° 15' N
Longitude (E-W)	13° 30'E	7° 54E	02° 06.80' W	4° 13' W
Station Depth (m)	48		50	50
Period of data available	1973-ongoing	1975-ongoing	1997 - ongoing	1988 - 1997*
Frequency (number of cruises/yr)	Seasonally (4)	Monday, Wednesday and Friday	Weekly (52)	Weekly (~40)
Gear/diam (cm)	WP-2	Hydrobios and Calcofi	Bongo/40	WP2
Mesh (µm)	100	150 and 500	200	200
Depth of sampling (m)			47	50
Ancillary data		hydrography, nutrients, chlorophyll, pigments (recently)	hydrography, nutrients, chlorophyll	hydrography, CNH, chlorophyll, Calanus egg Prod.
Contact person	Lutz Postel	Wulf Greve	Steve Hay	Roger Harris/X. Irigoien
Email address	lutz.postel@io-warnemuende.de	wgreve@meeresforschung.de	haysj@marlab.ac.uk	rph@ccms.ac.uk
Location of data	German Ocean Data Centre, IOW		SERAD, FRS MLA	PML/CCMS
Observations (*)				Later samples in process

Country	UK	SPAIN (14)	SPAIN (15)
Monitoring programme	Continuous Plankton Recorder	IEO-SPAIN	IEO-SPAIN
Sampling location	North Atlatic	Santander	La Coruña
Latitude (N)		43° 34.4' N	43° 25.3' N
Longitude (E-W)		3° 47.0' W	8° 26.2' W
Station Depth (m)	*	110	77
Period of data available	1946-ongoing	1991-ongoing	1990-ongoing
Frequency (number of cruises/yr)	approx 12, some missing mon/yrs	Monthly (12)	Monthly (12)
Gear/diam (cm)	CPR, aperture 1.24 cm x 1.24 cm	Juday 50	Juday 50
Mesh (µm)	280	250	1971-96: 250; 96-pres: 200
Depth of sampling (m)	7-10	50	50
Ancillary data	Temperature, colour index	hydrography, nutrients, chlorophyll, phyto. cells.	hydrography, nutrients, chlorophyll, phyto. cells.
Contact person	Chris Reid	Luis Valdés	Maite Alvarez-Ossorio
Email address	pcre@wpo.nerc.ac.uk	luis.valdes@gi.ieo.es	maite.alvarez@co.ieo.es
Location of data	SAHFOS database	Database SIRENO IEO	Database SIRENO IEO
Observations (*)	Data correspond to several CPR routes and are presented here as the CPR standard areas of the NA		