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

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Contents

1 Executive summary

The ICES Working Group on Zooplankton Ecology [WGZE] met at the INIAP/IPIMAR, Fisheries Research Institute, Lisbon, Portugal, 4–7 April 2005.

ToR a) Update of the annual ICES plankton status report – advances in monitoring technologies.

The fifth ICES Plankton Status Report (PSR) of time-series was contributed and prepared by WGZE, this year for an ICES Cooperative Research Report. Meta-analysis allowed inter-comparison of variability. Improvements were discussed with examples of other data useful for incorporation. WGZE considered methods, harmonization of units, metrics and availability of guidelines for new studies. Unfortunately WG Phytoplankton Ecology has not produced an equivalent or much support for the ICES PSR. WGZE is eager to extend metadata on all plankton monitoring sites and time-series in ICES areas and to expand exemplary datasets and interpretive analyses.

New technology is developing very fast and brings benefits but also new problems. New applications and sampling are now possible. Using stereomicroscopes and identification keys, taxonomy is slow, labour intensive and highly-trained specialists are increasingly rare. Advances in image acquisition and analysis and machine learning, from trained taxonomists, allow analysis of digitized plankton images to support, ease and speed-up the work and yield extensive new size spectrum data. Digital imaging technologies and video plankton recorders work quite well for macro-plankton. For meso-plankton there are major limitations in volume sampled and with data handling of high resolution images. Analysis of digital images provides an opportunity for methods homogenization if a common framework is agreed. Free software, with source code distributed and editable by all (Open Source License), is a good basis to develop such a common framework. Note the GLOBEC/ SPACC workshop, San Sebastian 1–3 November 2005, "Image analysis to count and identify zooplankton" (http://www.sciviews.org/zooimage/index.php).

WGZE invited Dr Gabby Gorsky, as visiting representative, to present information on CIESM efforts "Toward a Concerted Action for Zooplankton Studies in the Mediterranean", and a CIESM meeting on "Harmonisation of Zooplankton Time-series" to which Dr Luis Valdes of WGZE had been invited. G. Gorsky emphasised the great need for coordinated and cooperative approaches to plankton monitoring and time-series, to create an expert network and to harmonise methods. CIESM are trying to build bridges to ICES, CoML, GOOS, IMBER and EU programs. WGZE is keen to extend its relationships with CIESM. A joint WGZE and CIESM plankton groups meeting was suggested, perhaps about 2007 in concert with or soon after the Fourth Zooplankton Symposium. G. Gorsky offered to host the next WGZE meeting.

ToR b) Future development and collaborative approaches in plankton time-series.

Time-series data must be gathered and used to create synthesis by linking data centres and holders. The Plankton Status Report, HELCOM and other data serve as a good start. WGZE is linked to a new SCOR Working Group on Global Comparisons of Zooplankton Time-series. Their goal is global analysis of zooplankton decadal variability (i.e., to do for zooplankton what SCOR WG98 did for small-pelagic fishes), aiming to investigate zooplankton as the link between physics and fish. Zooplankton sampling is simple, inter-comparable and fishery-independent. Time scales of zooplankton population responses (~1 year or less) track climate forcing at inter-annual/decadal time scales. Long zooplankton time-series are now available and initial results are exciting. **The SCOR WG125 wishes another one or two Atlantic region members, and would greatly welcome ICES sponsorship of this. WGZE contributes to the SCOR WG with data and expertise and Luis Valdes, expert in southern temperate Atlantic and Mediterranean plankton, has volunteered as a further associate member of**

the SCOR WG. WGZE appreciate the suggestion from SCOR WG for another ICES-sponsored Norwegian Sea/North Atlantic associate member, Webjorn Melle was suggested but his participation will depend on ICES-sponsorship and some funding support for travel and subsistence.

Zooplankton and ichthyoplankton activities of the GEF Baltic Sea Regional Project were presented and discussed. A new CPR line is set up, between Gdynia and Karlskrona in Sweden. The possible closing down of the Portugal CPR route raised concern; Portuguese funds will end in December 2006. There is concern about recurrent closing down of various zooplankton monitoring sites over the years. It is extremely important to maintain this sampling. Time-series monitoring is often low key and inexpensive relative to short term studies and adds value as background to dynamic and reactive research studies. Also it provides validation data for modelling, especially if results are considered with and integral to other regional monitoring efforts. WGZE noted again and with some despair that zooplankton monitoring is not included in regulations or many European monitoring activities, e.g., EU-Water Framework Directive, OSPAR, etc. It is hoped that newly developing EU Strategy Documents might refer to zooplankton more effectively. Zooplankton has been the primary research area that has demonstrated regime shifts and climate change in shelf seas and at basin scales. It is **the** link between primary/benthic production and fisheries. Funding often depends on regulatory requirements for data.

ToR c) Comparison of geographic and seasonal patterns ---.

The WGZE Plankton Status Report is an active output that can be used for ecosystem status assessment. Discussion noted various trends and changes, particularly in the North Sea and the North Atlantic. These include changes in biomass, community structure, zoogeography and phenology. Examples noted zooplankton decreases in CPR areas of the North Sea and that spring production has shifted to earlier. Helgoland data also illustrate shifting length of production season, spring moves back but with little shift in the end of season. These shifts influence often temperature dependant fish recruitment patterns. Match/ mismatch between species seasonal cycles and/or distributions are particularly important. Species disappearances and timing changes are important for ecology including fish production and fisheries management. For integrated managements of marine environments and resources, as per EU strategies, a prime development area is the use of integrated operational models, yielding easily understood output to aid decision-making. Two approaches are GIS multilayer developments and, particularly in relation to plankton, the development of phenological models similar to many used for terrestrial ecosystems. Phenology is relatively easy, but often qualitative. Going quantitative could enable prediction of trophic timings, dependencies and interactions. Examples were discussed in relation to climate scenarios, regime shifts and ecology in the North Sea, Baltic and around Iceland and the Faeroes.

ToR d) Consider multivariate statistical methods and other models as means to evaluate and assess -

Multivariate techniques are almost essential to the process of analysing complex hydro-biological data. An overview of some techniques and ideas was given and discussed, along with other relevant issues, e.g., spatial autocorrelation, advection, software and packages etc., with a series of examples and collection of appropriate references, see Annex 3. Multivariate approaches and models are powerful, often able to yield easy-to-understand analyses and indices for examining spatio-temporal variation in complex community structure. To be used and interpreted with caution, with expert assistance and review sought by inexperienced or inexpert users, it is important to give ecological meaning to any relationships.

WGZE proposed a practical workshop in the use of multivariate statistics to field plankton studies, organised by SAHFOS at the MBA facility in Plymouth, to be discussed further before formal proposal. Re-analysis of older data sets would certainly be fruitful and relatively easy, using modern computing techniques. Many had or knew of useful "old" data but such retrospective analyses are often not "sexy" enough for funding. More must be done to conserve, preserve and make digitally available this sea of old data. Policymakers must pursue this issue more vigorously.

ToR e) Review preparations and progress towards:
i) a workshop on enzymatic and other biochemical and molecular methods---.

Santiago Hernandez Leon with several interested parties is preparing for a lab and field workshop series in the sub-tropical Canaries. WGZE think this is a practical, useful and timely development in a rapidly advancing field. Wider use and deployment of biochemical approaches holds prospects for assessing rates and processes in the lab and in the field alongside biomass and abundance assessments. Practical examples in a wide literature are many but techniques lack general acceptance and have problems of application, calibration and interpretation. Authoritative guidance needs to be agreed and published.

Many techniques (diapause and hormonal behaviour controls, kairomones, enzymes, lipids, stable isotopes, and molecular /genetic approaches) were discussed, including Swier Oosterhuis' interesting presentation on their chitobiase method. WGZE considered other sites and venues for further workshops in the Arctic Labrador region and Southern North Sea. Modellers need good functional relationships and often experimental data covers unreal gradients/ranges or is too sparse for good fitting. A good task for these workshops would be to review and update the Zooplankton Methodology Manual sections. Wider calls for parties interested in the workshops should be made, advertising at the ASC perhaps. A Theme Session at the 2007 Symposium on "Molecular and Biochemical Approaches in Studies of Pelagic Ecology" was proposed to raise/focus interest among the dispersed proponents of marine biochemistry.

ii) the 4th International Zooplankton Production Symposium ---.

Luis Valdes is the ICES representative and Steve Hay is also a member on the Committee of the ICES/ PICES/ GLOBEC Fourth International Zooplankton Production Symposium. (Japan 28 May to 1 June 2007 in Hiroshima). The symposium is announced on PISCES and ICES web pages. **WGZE felt that the ICES page needs some work to be made more demonstrative**. Backers and steering committee have good international representation. ICES have agreed to support the symposium with DKK 10,000. The announced Theme for the symposium is: ***Human and Climate Forcing on Zooplankton Populations.*** One day is for workshops, four lecture and posters days, and one free afternoon. Symposium papers are to be published as agreed in the *ICES Journal of Marine Science*. For the BASIN workshop, the IOC SCOR WG on Global Zooplankton, the Mediterranean Group and many others, the symposium will be a good venue to present summaries. WGZE suggest an expert in paleoclimatology/paleoceanography, such as Prof. W.F. Ruddiman, might be invited to give a keynote speech with a broad perspective. In Japan the focus is likely to be strong on the Pacific but there should be good representation from Atlantic research centers. Various themes were suggested; species diversity comparisons, use of biochemical methods, descriptions of time-series, seasonality and phenology, and indices of ecosystem status and function. WGZE should work on these ideas and communicate to Luis Valdes and WGZE next year.

iii) a "virtual" workshop to further the collaborative comparison and analyses ---.

Web presence is seen by many as a big problem for ICES. Development is not up to speed, but we assume and hope that effort is being made. When ICES could not support this initiative, Todd O'Brien has done so instead, with a website to service WGZE (http://www.wgze.net). He deserves our and ICES thanks and support in this. Another example of the benefit ICES receives from the enthusiasm of scientists involved. A major reason for this originally proposed WGZE and ICES-run website was to provide support for the process of collating/analysing data for REGNS. An example of such collaboration is the trans-latitudinal study of *Calanus helgolandicus* ecology (Bonnet *et al.*, 2005). ICES should develop ways to credit authors and data providers so that they learn to trust such a system.

iv) a further taxonomic workshop to advance the Fiches plankton ID sheets --.

ICES Fiche Plankton Identification sheets are now available on the ICES website and can be ordered on CD or downloaded as PDF files. ***The website is hard to navigate to get to the online downloadable pdf files and should be improved.*** Alister Lindley at SAHFOS is the present editor and there are some developments. He has a very hard job to get rapidly diminishing experts to prepare sheets for free. There is very poor funding for such taxonomy and little time or tolerance for this work. Previous and successful taxonomic workshops have been held (two sponsored by ICES/WGZE and one by CMarZ in Japan. Baltic research teams have also a history of practical workshops. WGZE agreed that another is needed with focus on gelatinous and macroplankton. WGZE calls for another ICES-sponsored Zooplankton Taxonomic Workshop to be held again at SAFHOS/MBA in 2006, they have facilities and expertise.

Outwith ICES, the EU MARBEF Network project, ETI biodiversity work and increasing appreciation of the "hidden" taxonomy talents in Russia and the eastern European countries were all noted. World Association of Copepodologists (WAC) do good work in disseminating knowledge and training (workshop in Tunisia in 2005 very rapidly oversubscribed). A Census of Marine Life – Census of Marine Zooplankton (CMarZ) initiative seeks to describe holozooplankton globally and to tie traditional morphological approaches and molecular genetics (ZooGene and species barcoding). A growing number use molecular genetics to support and enhance taxonomic and ecological studies. Examples were discussed in relation to enabling ecosystem approaches. Use of taxonomic centres in Poland and elsewhere reflects economic arguments but mainly a lack of taxonomic expertise in many western EU countries and the US. There are quality assurance issues and more is needed to enhance taxonomy training. Dissemination and revision of literature, manuals, etc., for taxonomic identification is required before experts become extinct.

v) discussion to be held during the 2004 ASC and intersessionally to co-ordinate the conjunction of the zooplankton and phytoplankton monitoring reports ---.

The Chair had been unable to attend the 2004 ASC as it seems so did most of the working group of phytoplankton ecology. WG HABD has expressed support for status reports and earlier provided some names of phytoplankton monitoring contacts. Oceanography Committee (OCC) discussion suggested disbanding or merging WGPE, possibly with WGZE. Resisted by Luis Valdes at the OCC meeting, and WGZE support him in this. ICES WGPE/ WGHABD, and WGZE cover an enormous subject range of species and areas. It is too complex to manage all together and one annual meeting could not cover the ground. It is increasingly important to develop cohesive, ecosystem approaches through status reports. It is important to get phytoplankton into the PSR alongside summary physics and nutrient data. There should at least be an extensive collection of metadata, including contacts, to encourage further efforts at synthesis and collaborative analysis. WGZE have a standardised approach and PSR format, it is possible to expand with an accepted format and a dedicated collection/ description/ submission of phytoplankton data.

ToR f) Review and consider the role of meroplankton ---.

Meroplankton may often represent over 70% of all meso-zooplankton abundance, though whether on average this is correct was debated. However in shelf seas, where meroplankton often dominate and which carry about 95% of the fish yield, there the meroplankton have high importance to regional and species productivity in terms of biomass, growth, spatial distribution and seasonality. WGZE agreed that meroplankton is not well studied either by the zooplankton or the benthic ecologists. Some examples of spatial and temporal distributions of meroplankton were presented and discussed from three different regions, namely Gulf of Gdansk (Poland), Stonehaven (North Sea) and the Portuguese coast. Meroplankton species communities change greatly between regions, since they reflect the benthic system which is much more diverse than the plankton. Some meroplankton species are quite sensitive to temperature changes and are therefore good candidates as indicator species for climate change. This sensitivity may cause change in time of spawning, rather than magnitude of the effect. Meroplankton is of interest especially in terms of recruitment and importance to fisheries (mainly for the eggs and larvae of fish and larvae of commercial decapoda and mollusca). Other ICES groups have considered these topics, namely WGRP, BEWG and SGCRAB. Species identification is the most important problem preventing meroplankton study but advances in taxonomy and genetics will improve the situation.

ToR g) Review progress with ICES Data Management ---.

This subject raised both recurring interest and frustration in discussion and a strong feeling among those present that the complexity of plankton communities, sampling strategies and differing analytical approaches is confounding the use of ICES data formats with too much detail. While there was agreement that this reflects the reality of the data, often this requires too much effort by the data providers to reformat their data to provide to ICES. Demands will inhibit data provision and exchange, may put many off making the effort to recast their data format and result in lost data. More general approaches are more flexible and simply gather the data in whatever form, leaving the provider free to contribute without great effort on formatting. Central data deposition is good for physics and chemistry, but hard for biology and not necessarily productive as often errors may be propagated very fast and data misinterpreted.

Greater emphasis on metadata collection and advertisement would catalogue more and encourage contact and collaboration between data holders. ICES has a good data model as an example to follow. Issues of data ownership and publication rights are still live issues with many scientists, which inhibit data exchange, collaborative analyses and submissions to data centres. This is particularly so for biologists who may have spent years of laborious specialist work generating the sample analysis from even a single set of samples. WGZE suggest a start with metadata collection of complex biological data; Plankton Status Report/ HELCOM data as examples. ICES should encourage synthesis workers to approach data holders to collaborate in their efforts and analysis; this aids data verification and widens collaborative approaches. Note also that much data is still in paper or computer record formats, funding is poor to impossible for data retrieval or backward looking efforts. Many others are attempting central data storage.

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Contacts between WGZE, WGRP, and WGCCC, have resulted in an ICES/GLOBEC "Workshop on the Impact of Zooplankton on Cod Abundance and Production [WKIZC]" held at ICES Headquarters in Copenhagen, 7–9 June 2005. This meeting is of considerable interest and expected to be productive.

A series of Terms of Reference were proposed for the WGZE meeting next year.

It is proposed to hold the next (2006) meeting of the ICES Working Group on Zooplankton Ecology in Villefranche, France during the week 27–31 March, kindly hosted by Dr Gabriel Gorsky of the Observatoire Océanologique.

2 Opening of the meeting

The ICES Working Group on Zooplankton Ecology [WGZE] (Chair: Steve Hay, UK) had a convivial and constructive meeting, at the invitation of Dr Maria Emília Cunha and hosted by Dr Maria Manuel Angélico and colleagues in the INIAP/IPIMAR, Fisheries Research Institute, Lisboa, Portugal. The meeting began 1200h on 4 April ending 1200h on 7 April 2005. There were 22 attendees at the meeting represented 14 ICES Member Countries. Seven members not able to attend (including representations from three other ICES Member Countries) sent written submissions or presentations to contribute. We also welcomed three new participants from the Baltic Seas Regional Project at our WGZE meeting.

The meeting opened with some words of encouragement from the Chair, a round of introductions and a welcome and comments on the housekeeping arrangements from our hosts. The agenda for the WGZE meeting (Annex 2) addressed the Terms of Reference set out as resolutions by the ICES 2004 Annual Science Conference and Statutory Meeting and was adopted and discussed as follows. WGZE will report to ACME and to the Oceanography Committee at the 2005 Annual Science Conference. The terms of reference for this meeting were:

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

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

ToR 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).

ToR 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.

ToR 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) discussion to be held during the 2004 ASC and inter-sessionally to co-ordinate the conjunction of the zooplankton and phytoplankton monitoring reports into the ICES Plankton Status Report.

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

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

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3 Discussion - ToR a) Update of the annual ICES Plankton Status Report. It is planned to extend it to new sites and include concurrent hydrographic data, phytoplankton series and advances in monitoring technologies

Discussion opened with consideration of improvements to the existing Status Report. This is a central contribution from our WG to ICES and the science community and is our fifth summary on zooplankton monitoring results in the ICES area. This issue also includes phytoplankton data in some locations coincident with the zooplankton sampling. This year's report is also improved with five new data series (Baltic Sea - 3 Barents Sea - 2). Thus 18 collections this year, increased from 10 in the first report. Additionally, SAHFOS has contributed a general overview of SST, phytoplankton colour index and copepod abundance for the entire North Atlantic which gives context for the regional time-series results and puts the data in a basin scale context. Surface temperature is also provided in 4 of the 18 collections with the objective of extending this parameter to all the data sets in the near future. A number of WG members had sent in data to present and contribute although unable to attend the meeting. Examples include data on the Atlantic Zone Monitoring Program on the Scotian Shelf of Canada.

The Status Report has reached a complexity level that merits citable publication. Presently the Plankton Status Report is an Annex to the WGZE report and an ICES web product. As such it cannot be easily cited, or recognised as an official ICES publication. The ICES Publications Committee invited us to publish the report as an *ICES Cooperative Research Report*, approved in the ICES resolution 1C05/2004 of the Publications Committee. The WG agreed that this format is a good medium for annual publication of the Status Report. This promotes the work of ICES Expert's Groups, in an ICES product more accessible to scientific community.

During the annual meeting of the OCC at the last ASC (Vigo, 2004) it was suggested we discuss the harmonization of units (m^2 and m^3) and metrics (abundance, biomass) used in the Zooplankton Status Report. Regarding the metrics, data are presented in biomass (Icelandic-Norwegian basin) or abundance (Canada, 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) (Table 1).

Abundance and biomass are variables that allow for easy comparison, so we do not consider this is a decisive factor affecting the utility of the summary results presented in the status report. The main reasons for use of either are linked to the sampling programmes. For time-series based on restricted monthly or weekly sampling where identified species counts are made, then abundance is a better expression than biomass. Biomass is a measure used mostly in sampling programmes based in large surveys, when hundreds of samples are obtained and where microscope counts are unrealistic and usually uneconomic; however, new automated techniques may soon alter this situation). The point was also made that the Status Report is intended as a summary comparison and "taster" for the data. Individuals or groups interested in compiling or working on aspects of these data have access through the metadata to the originators and data owners. WGZE is interested in working towards an overview and comparative analysis and our latest report does move to provide such comparisons.

Table 1: Comparison of sampling collections: Frequency and units.

DATA SET	SAMPLING FREQUENCY	UNITS
Georges Bank	Spring-Fall	Disp. Volume ml/m^3
Emerald Basin (Scotian Shelf)	Spring-Fall	Abund. Ind/m^2
Gaspé Current (St. Lawrence Estuary)	Monthly	Abund. Ind/m^2
Anticosti Gyre (St. Lawrence Estuary)	Monthly	Abund. Ind/m^2
Siglunes (North Iceland)	Yearly	Biom. DW gr/m^2
Selvogsbanki (South Iceland)	Yearly	Biom. DW gr/m^2
Faroe Islands	Yearly	Biom. DW gr/m^2
Svinoy (Norwegian Sea)	Quarterly	Biom. DW gr/m^2
Norwegian Sea	Yearly	Biom. DW gr/m^2
Arkona Basin (Germany, Baltic Sea)	Monthly	Abund. Ind/m^3
Helgoland (Germany, SE North Sea)	Monthly	Abund. Ind/m^3
Stonehaven (Scotland, NW North Sea)	Monthly	Abund. Ind/m^2
Plymouth (English Channel)	Monthly	Abund. Ind/m^3
Santander (Southern Bay of Biscay)	Monthly	Abund. Ind/m^2
La Coruña (NW Iberian Peninsula)	Monthly	Abund. Ind/m^2
North Atlantic (SAHFOS)	Monthly	Abund. Per sample (~3 m^3)

Many collections express their results in numbers/m^3 (density) but others use numbers/m^2 below sea surface (standing stock), where possible we have converted m^3 into m^2. Why m^2 or m^3? Density is generally highly variable with depth, choosing /m^2 avoids variability in organism numbers and distribution due to physics or migrations in a depth varying water column. This conversion is unnecessary when the sampling integrates the organisms in the water column, which is mostly the case. Also, when the sampled water column is constant then conversion from depth averaged m^3 to m^2 is a direct multiple of the sampling depth, without any changes in proportions. This discussion concluded that questions on the measures and units are not trivial but we have to accept that both are valid and consistent approaches. The WG noted too that SAHFOS CPR team do not routinely use either m^3 or m^2, but a unit of sampling assumed as equivalent to abundance per 3 m^3. This is driven by their consistent historical methodology, which in fact means their data are a little difficult to compare with other collections but remain internally consistent.

Plankton sampling mesh size really is very important when comparing abundances or biomass between different data sets. We recognise this, but also see that established monitoring programmes will not change the continuity of their time-series by changing mesh sizes simply because there may be a preferred standard. In the course of discussion, it was put forward that difficulties in the inter-comparisons of data sets are often avoided when trends are compared. From a statistical point of view, trends are likely to be more important that methodological details. Work by Todd O'Brien also compared data sets by dividing the yearly mean anomaly values against the anomaly-mean itself, this yields a normalized unit free reference of relative variability. It also means that the variability of different time-series can be inter-compared without being affected by metrics, units or sampling gears. These re-analyses will be incorporated to the Status Report as a means to integrate patterns in all the data within a single plot.

The discussion continued on the inclusion of key hydrographic data in future status report edition. There was a general agreement on the importance and relevance of these data and considered details such as the depth at which the temperature or any other parameter should be measured/given. It was accepted that, at this stage in the report's evolution, the surface temperature and (if possible) the temperature at the maximum sampling depth will be enough to deal with in the short term. Our SAHFOS member noted that SAHFOS sent a general overview of the North Atlantic including temperature data. This year a new section will be added to the Report's discussion in which the abiotic parameter temperature is that which explains most of the variance of the plankton anomalies. This part of the discussion ended with a comment on the inclusion of the general climate indices such as the NAO index, which will be reconsidered in the next meeting.

The backbone of the status report is the time-series of abundance/biomass, but the WG believe that other material can be usefully incorporated and presented in a more informal way (e.g., boxes with key or exemplary information). This would to some extent avoid the difficulties imposed by attempts at standardisation and could highlight interesting information and observations. It was noted that whereas key species may often be the dominants or indicators, even the lowest abundance perceived is an important reference point for new species occurring in an area.

Examples of good improvements could be:

- The inclusion of a table with the ten top species at sites where this information is available (perhaps both the ten top species for a year and the ten top species over all time-series);
- The time-series of selected key species (e.g., warming indicators such as *Temora stylifera*);
- Indications of unusual events (e.g., *Penilia avirostris* records in 2004 in Helgoland, blooms of gelatinous species, etc.);
- Shifts in patterns (e.g., meroplankton appearance in Helgoland, length of seasons, new species, disappearance of others);
- Introduction of alien species (e.g., *Cercopagis pengoi* in the Baltic Sea).

There was discussion of the inclusion of chlorophyll and phytoplankton data. The WG Phytoplankton Ecology has not really managed to produce an equivalent output, or good support for the ICES Plankton Status Report. This is seen as unfortunate. WGZE is still eager to extend the metadata on all plankton monitoring sites and series and to expand the exemplary datasets to include at least chlorophyll. While we have managed to gather some phytoplankton data into the current Status Report this issue will remain a discussion item until better resolved. Although we have included some such data interpretation of the zooplankton time-series is compromised due to this broader lack of phytoplankton data. There are also still a number of ICES countries that have plankton time-series but do not provide data for the report; WGZE would encourage their participation.

Discussion moved to advances in monitoring technologies, Xabier Irigoien presented an introduction to the GLOBEC/ SPACC workshop on "Image analysis to count and identify zooplankton" (ZooImage), to be held at San Sebastian, 1–3 November 2005, organized by Xabier Irigoien, Philippe Grosjean and Angel Lopez Urrutia.

The WG noted that while zooplankton samples are traditionally collected with plankton nets and analyzed by taxonomists using a stereomicroscopes and identification keys, this work is slow, labour intensive and requires highly-specialized, well-trained and increasingly rare people. With the current and progressing advances in image acquisition and analysis and machine learning, the analysis of digitized plankton images can now support, ease and speed-up the work of these taxonomists. Xabier demonstrated how the image analysed data look (using his own software PVA (download free at http://www.azti.es). Comparison between microscope counts and image analysis look very similar. Accuracy of digital software image sample analysis is up to about 80% when compared with plankton experts working traditionally. Automation allows things that microscopy logistics make hard to do otherwise (e.g., egg size distributions) and image analysis software can be either bought from proprietary sources or as share/ freeware downloads (e.g., Image Tools - http://ddsdx.uthscsa.edu/dig/itdesc.html)

These approaches are not free of criticism. In fact there remain some severe constraints. Examples mentioned (1) sea and sample turbidity are limitations on this technique, (2) particle coincidence in images can also confound the system, (3) coincidence in the shapes of different species, of copepods for instance, diminishes the resolution of species recognition (4) there is a strong dependence on clean (detritus is problematic) and well contrasting images (staining helps) and expert training of the "intelligent" software by (available?) taxonomists. Nevertheless, by using image analysis, abundance and sizes (including many varied measurement types), with various degrees of taxonomic resolution, can be easily monitored with cheap and fast systems that do not destroy the sample. Results also allow for easy comparison with other data sets. The planned workshop at San Sebastian from 1–3 November 2005 is a very welcome and necessary attempt to; (1) expand these methods within a wider community, (2) evaluate the quality of these technologies and (3) create a network of experts. Although this is a GLOBEC workshop, the ICES WGZE strongly supports this initiative and will appreciate the main results and conclusions being reported to the group at its 2006 meeting.

Philippe Grosjean sent some thoughts to be presented through the Chair about the Free Tools to analyze zooplankton which will be a major part of the workshop topics. P. Grosjean noted that in a context where various zooplankton series are collected and analyzed together, like in the ICES WGZE, one needs common tools and methods to analyze samples, but, most importantly, to homogenize measurements. The analysis of digital images of zooplankton brings an opportunity for such a homogenization, if everybody agrees on a common framework. Free software, with source code distributed and editable by all (Open Source License), is a good basis to develop such a common framework. The recently created Laboratory of Numerical Ecology of Aquatic Systems (Mons-Hainaut University, Belgium) is willing to develop and promote such free tools. Other examples are FLR (Fishery Libraries in R, see http://www.commit-fish.info/flr), PASTECS (Package for the Analysis of Space-Time Ecological Series, see http://www.sciviews.org/pastecs), and SciViews-R (a Graphical User Interface on top of R, aiming to ease its use by biologists, see http://www.sciviews.org/SciViews-R) that P. Grosjean's group co-develops with other partners (LOV, CEFAS, AZTI, …).

Similarly, together with Xabier Irigoien and Angel Lopez-Urrutia, they would like to jointly initiate a common framework for the analysis of digital images of zooplankton, using free tools. The starting point of this common framework will be the "ZooImage" workshop that in San Sebastian. (see also the web site http://www.sciviews.org/zooimage/index.php) P. Grosjean asked that interested people contact him by email on the question of developing such free tools (Philippe.Grosjean@umh.ac.be).

P. Grosjean presented his idea of what the main points of that framework will be:

- Should be done exclusively with free (and if possible, open source) software, like ImageJ and R;
- Should work on any kind of computer (PC under Windows or Linux, Mac OS X, Unixes);
- Should be able to import and work with images of different origin (Zooscan, of course, but also FlowCam, digitals pictures taken with a binocular + digital camera,… and possible with tools like VPR, Sipper, etc., if there is an opportunity and interest to extend the software to such systems);
- Should be freely distributed through the internet;
- Learning should be facilitated thanks to courses / training sessions like during the ZooImage workshop;

- Should provide a simple and easy GUI (Graphical User Interface) for most users;
- Should provide advanced tools for statisticians/programmers in order to allow customization;
- Everybody in the scientific community should be able to freely contribute to its development, but a core team will be responsible of its maintenance;
- The first working version will be available just before the ZooImage workshop, beginning of November.

P. Grosjean also noted that, together with BioTOM who manufacture the Zooscan, the development team will take care of bidirectional compatibility. It should be noted the Zooscan uses many optimized (but very expensive) pieces of software, which make it much faster to process very large images that the free tools will be able to. Indeed, the framework will be built more as a support to the Zooscan system, providing support with additional tools, not as a concurrent product. We expect to achieve the same complementarities with other commercial systems like the FlowCam in the future. We expect also to develop compatibilities with the high-resolution zooplankton image database that Phil Culverhouse is willing to develop.

The Group discussed newly developing digital imaging technologies and the use of video plankton recorders. It was noted that the techniques work quite well for macro plankton. Where nets for example may miss small patches of species such as euphausiids or jellyfish, video, measuring in situ can be better. However for mesoplankton there are major limitations in volume sampled and with data handling of high resolution images. For microplankton/phytoplankton flow cytometers and combination devices such as “Flowcam” can be very effective. A lot of the new technology is now coming very fast and brings new sampling problems. It is also recognised however that our old net systems still have many problems such as such as variable size fractionation by meshes used, clogging by phytoplankton, they may destroy fragile species and manual microscopy is very laborious and expensive. Digital imaging allows automated analyses and ease in revisiting/checking where strange results are found. There are new possibilities in that digital images can be made and sent to a place that does the analyses and sends back the results. Wider application and sampling may be possible with sampling work in coastal regions done by trained but inexpert volunteers with a central lab doing the sample processing. Pond Watch in the south eastern USA is example of the use of volunteers to get very useful monitoring data from coastal regions.

After a coffee break the WG restarted with a talk by Gabby Gorsky, invited by WGZE as visiting representative of CIESM, based at Laboratoire d’Oceanographie, Villefranche sur Mer, France. He had co-chaired a CIESM round table meeting in June 2004 in Barcelona on the Harmonisation of Zooplankton Time-series, which Luis Valdes of ICES WGZE attended at their invitation. G. Gorsky emphasised the need for coordinated and cooperative approaches to plankton monitoring and time-series. His presentation to WGZE was about CIESM efforts “Toward A Concerted Action For Zooplankton Studies In The Mediterranean”. G. Gorsky is leading a Zooplankton Indicator Project with the themes;

1) past and present status of zooplankton;
2) improving expertise in taxonomy;
3) identification of global change impact on the Mediterranean;
4) data treatment and management;
5) relationships with fisheries.

His project is trying to build bridges to ICES CoML, GOOS, IMBER and EU programs. He stated that the present emphasis is on harmonization of sampling, sample treatment and data analysis. A key activity is building a metadatabase of sites and sampling. There are a number of good time-series in the Mediterranean including some CPR data. There are northern species that do occur in the Mediterranean so there are direct links with plankton ecology in the north-east Atlantic and shelf seas. A good example of possible output is the recent paper by Delphine Bonnet and many others (data from 18 laboratories and 26 sampling stations) on *An overview of Calanus helgolandicus ecology in European waters.* It was noted by WGZE that such collaborations should be actively pursued by plankton ecologists and encouraged by ICES and other such organisations. The sea and the weather cross borders at will, so does the need for research ideas and funding. The idea was suggested of having a joint meeting like for ICES/PICES with the CIESM plankton group. It was pointed out that some time is needed to develop this and because things politically complex, it might not happen very soon. The thought was that perhaps about 2007 for holding a joint meeting, perhaps in concert with or soon after the zooplankton symposium. Alternatively Gorsky suggested he and the Mediterranean group might host a meeting, not necessarily sponsored by ICES. He offered to host the next WGZE meeting in his institute, which would enable Mediterranean, scientists' some options for meeting with WGZE members.

G. Gorsky is involved in the French financed ZOOPNEC pilot study with 7 laboratories involved in the NW Mediterranean. They are holding a workshop in October to create a network of experts and work to harmonise methods. They are striving to apply new techniques, conduct retrospective analyses of time-series and surveys, implement databanks, improve availability of information and encourage outreach efforts. The group want to fill out the entire MEDAR/Medatlas database for the Mediterranean. The study will involve instrument intercalibration and new collection techniques such as improved nets and the Zooscan system (now a commercial system and this image technology may be the most efficient way to deal with many samples in the future). The Zooscan Image Analysis yields about 30 different measures. Comparing the slope of size spectra with diversity measures gives parallel patterns throughout the year. There is general concern about the lack of taxonomic expertise in Europe. He remarked that there are still a number of taxonomists in eastern Mediterranean areas, which WGZE is aware is also true in the north eastern European countries.

G. Gorsky's group are concentrating on looking for indicator species rather than biomass or abundance. An example is rare Acartia species, with assemblages positively correlated to NAO spring bloom relationship; negative relationship to summer blooming. The disappearance of a once common larvacean species from the Mediterranean was mentioned, indicating changes in inflow from the Atlantic. His group has also had problems bringing together quality data from zooplankton time-series and cruises.

Luis mentioned that the copepod *Temora stylifera* is showing a biogeographical shift, moving north. Peter Wiebe also mentioned that there is a *Temora* species doing the same thing in the NW Atlantic. Steve Hay has noticed new species appearing at his Stonehaven monitoring site in the north eastern North Sea and that CPR has shown such trends in the area. Astthor has found new species of fish in Icelandic waters, but they have not yet really been looking for new zooplankton because of limitations in their sample analysis methods. Eilif Gaard noted that *Calanus hyperboreus* has disappeared from their samples at Faeroe. He also said that north of the Faeroe Islands the reproduction of *Calanus* has historically started later in cold water, but is now changed and starting earlier with a change in the cold water regime of 1 to 2 degrees. Another point raised was that the timing and intensity of the spring bloom and other events may have altered, even if new species have not been seen plankton production and species survival could be affected. The group felt that the more of this kind of information that is illustrated and presented the better and the Plankton Status Report is a good forum to present such things.

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

WGZE suggested last year 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. It was emphasised that time-series must be gathered together and used to create synthesis and to make the data more widely available.

G. Gorsky described the work in CIESM to facilitate analysis of historical and new time-series of the Mediterranean phytoplankton and zooplankton, and the harmonization of sampling, with the aim to bring together a synthesis of environmental and plankton data.

Continuing from last years meeting discussion, Todd O'Brien presented information on the newly established SCOR Working Group 125, "Global Comparisons of Zooplankton Time-series", Chaired by D. Mackas (Canada) and H. Verheye (South Africa). The goal of this WG: A global analysis of zooplankton decadal variability (i.e., to do for zooplankton what SCOR WG98 did for small-pelagic fishes). This idea grew out of a session (organized by Ian Perry and Hal Batchelder) at the 2003 International Zooplankton Production Symposium in Gijon.

In summary the SCOR WG Terms of Reference are:

- Form a globally representative set of "long zooplankton time-series".
- Facilitate transfer of data sets to a secure electronic archive.
- Develop, test, and share protocols for data summarization & statistical analysis.
- Compare zooplankton time-series using a suite of numerical methods. Examine:
- Correlation structure (time scale and spatial pattern);
- Synchronies in timing of major fluctuations;
- Likely causal mechanisms and consequences;
- Sensitivity and specificity of the data-analysis tools;
- Develop priorities and recommendations for:
    - Future monitoring efforts;
    - Additional processing of existing sample archives.

One major aim is to investigate zooplankton as the key link between "physics" and "fish". It was noted that zooplankton sampling methods are relatively simple, inter-comparable and fishery-independent. Time scales of zooplankton population response (~1 year or less) gives good tracking of climate forcing at inter-annual/decadal time scales. Long zooplankton time-series are now available from several different parts of the ocean and there are recent improvements in tools for data analysis & data exchange/management.

A range of data is available across many sites, mostly net tows (various mesh sizes), though some hydro-acoustics & optical measures. These yield total biomass (most locations), Community abundance/composition (~20% so far but increasing, varying coverage & resolution), seasonal timing of life cycles in relation to environments (phenology – available for a few mid-high latitude sites), biochemistry (genetics/ condition).

Data analyses includes many within-region analyses recently completed or underway. A range of statistical analysis methods are applicable, such as raw time-series, anomalies from local seasonal climatology, multivariate ordination & classification, CuSum and other indicators of trends & transitions. Typical findings are large decadal variability in biomass (3–5x), larger decadal variability in community composition/ species ratios (10–50x), significant correlations with climate and fishery indices ($|r| \sim 0.3–0.8$), meridional and zonal shifts in boundaries and shifts in seasonal timing at multiple trophic levels (~1 month or more). The next steps are global comparisons of these regional time-series looking at amplitude of variability, time scales of variability (interval and steepness), composition and sequencing of alternative system states and synchrony. Initial results are exciting.

Deliverables for the SCOR WG;

- Compilation & comparative analysis of 6–10 long zooplankton time-series (Symposium & peer-reviewed publication, 2007–2008);
- A data-analysis "tool-box" (available online in 2006?).

Priorities and recommendations for future sampling and data-archaeology (2006–2007?).

Also probable:

- Improved knowledge of how & why marine ecosystems respond to climate;
- Improved buy-in and access to a global zooplankton database;
- More efficient sampling and sample-processing;
- Raise profile, credibility & management applications of "ecosystem approach".

The next step will be global comparisons of the regional time-series. The WG will not produce a complete global zooplankton database (or set of inter-operable regional databases) on a SCOR WG budget but will motivate others to work toward this goal. A potential data-base framework is now in development by US NMFS (run by Todd O'Brien - Copepod). Todd O'Brien is a member of the SCOR WG and will learn from the techniques used in the WG and provide feedback to WGZE. **The SCOR WG wishes another one or two Atlantic regions members, and would greatly welcome ICES sponsorship of this. WGZE contributes to the SCOR WG with data and expertise and Luis Valdes, Expert in southern temperate Atlantic and Mediterranean plankton, has volounteered as a further associate member of the SCOR WG. WGZE appreciate the suggestion from SCOR WG for another ICES sponsored Norwegian Sea/North Atlantic associate member, Webjorn Melle was suggested but his participation will depend on ICES sponsorship and some funding support for travel and subsistence.** WGZE agreed that it should also contribute to the SCOR WG by starting analyses of "own" data (reported in the Status Report) and then coordinate with SCOR findings for other regions and consider SCOR WG methods.

Piotr Margoński introduced the group to the zooplankton and ichthyoplankton activities of the Sea Fisheries Institute, Gdynia, Poland (BSRP), a lead laboratory within the GEF Baltic Sea Regional Project. Activities on zooplankton and ichthyoplankton comprise: Intercalibration of sampling and analytical methods, zooplankton taxonomy training, procurement of necessary monitoring equipment, to increase participation and contribution to the ICES Working Group on Zooplankton Ecology (WGZE), and establish contacts and cooperation with other Baltic Sea research projects studying the role of zooplankton (e.g., GLOBEC-Germany), and to propose zooplankton indicators for ecosystem based management of the Baltic Sea. A range of different approaches to produce plankton indicators was presented, showing the long history of ecosystem approach to management within the Baltic scientific community. A new CPR line between Gdynia and Karlskrona in Sweden with a finer mesh size (nylon 100 µm) and battery driven sampling in periods representing 5–10 nautical miles has been established.

Margoński's introduction was followed by a discussion of standardisation of sampling methods. It was argued that standardisation of sampling methods is not easy because this is linked to ongoing long-term time-series. The group noted that mesh size and taxonomy is critical with respect to standardisation. It was suggested that WGZE should adopt the "Baltic" methods (workshops and "ring tests") of intercalibration of taxonomic skills and expertise, presenting this as an ICES initiative from WGZE. It was noted again and with some despair that zooplankton is not included in many European monitoring activities, e.g., EU Water Framework Directive, OSPAR etc. It is hoped that newly developing EU Strategy Documents might begin to refer to zooplankton more effectively. In previous years WGZE has repeatedly noted and argued against this gap in regulatory consideration which encompasses nutrients/ phytoplankton/ eutrophication, then benthos/ habitats and impact assessments and then fisheries/ birds and mammals, but requires no zooplankton status assessment. This is extraordinary given that zooplankton has been the primary research focus in recent times that has demonstrated regime shifts and climate change in shelf seas and at basin scales. Zooplankton is **the** link between primary production, benthic production and fisheries production in normal, eutrophic, oligotrophic, exploited or polluted waters. Zooplankton is also easily and relatively inexpensively measured and there is a long, though often fragmentary, history of zooplankton monitoring as the ICES Plankton Status Report shows very well. An ecosystem approach in policy should also be promoted.

The possible closing down of the Portugal CPR route was raised as an example point of concern, amidst general concern about the recurrent closing down of various zooplankton monitoring sites over the years and the consequent disruption of valuable time-series. Another obvious example was the stopping and restart of the CPR route off the eastern Canadian seaboard with the unfortunate gap timed with a fisheries collapse. Carlos Mendes gave a short presentation which illustrated the insights that this west Iberian Peninsula CPR route had already given. Portuguese waters are important in several respects, both regional and global. They are at the northernmost limit of the eastern Atlantic upwelling System, they partially incorporate the eastern edge of the Azores Front/Current System, and they are the main route for the dispersion of Mediterranean water into the Atlantic. Finally, they are an important area for the poleward transport of properties due to the Slope Current, the Iberian poleward flow.

Being the southernmost area of ICES, this route's data contribution enlarges the latitudinal range of CPR sampling and greatly enhances coastal station monitoring studies and other science projects in the region. As plankton biogeographic changes associated with climate change become more and more evident, the assessment of the marine area off the west Iberian Peninsula assumes an increasing ecological importance locally, but also in ICES regional and global terms.

Plankton samples have been collected monthly off the West Iberian Peninsula since 1958 with the Continuous Plankton Recorder (CPR) constituting the longest zooplankton time-series available off the Iberian coast. This invaluable data set for monitoring plankton has been interrupted several times, whenever the budgets of the CPR survey program ran out. Since January 2002 some funds from Portugal allow the maintenance of Iberian route, but those funds will end in December 2006. It is extremely important to maintain this sampling in order to preserve a long-term time-series allowing the assessment of possible changes in plankton communities and abundances and to aid understanding of these changes on the North Atlantic basin scale.

The point was made that such time-series monitoring is often low key and inexpensive relative to many more "dynamic" but short term studies. However it is also true that such monitoring adds very much value as background to dynamic and reactive research studies and provides valuable validation data for modelling studies. This is especially true when results are considered alongside and integral to wider and other regional monitoring efforts around the world. WGZE agreed that this topic should perhaps be raised in an article published in a scientific magazine to bring the issue to wider attention. Zooplankton monitoring has suffered in the past from a lack of science-political advocacy, mainly since it has often been perceived and presented as incidental to pollution, eutrophication or fisheries concerns. However, climate change and concerns about its consequences has begun to change hearts and minds, although not yet the science policy and regulatory frameworks which tend to ensure funding. Also, even though hi-tech advances are now beginning to enable zooplankton to be sampled at resolutions approaching those of physics and chemistry, there remains a need to ensure that these support rather than supplant data collection in long term monitoring of zooplankton. Consistency is essential to the value and statistical interpretation of these time-series.

It was noted that the ICES WGZE is well placed to provide advice on why and how to monitor zooplankton. It was remarked that the Zooplankton Methodology Manual has now been widely accepted as a very useful publication, although parts of it could do with some revision by now. The group also agreed that WGZE should set out recommendations on what the sampling program of any new monitoring sites should be, to be included in a ToR for next year. It was suggested that the group should begin by reviewing the work being done on analysis of zooplankton monitoring data and ecosystem indicators by the SCOR working group "Global Comparisons of zooplankton time-series" and the GEF Baltic Sea Regional Project. Based on this review and other considerations then recommendations for future monitoring sampling programs could be given.

5 Discussion - ToR 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)

The Chair opened with remarks about the purpose of this session, noting that ICES looking for active outputs and products that can be used across disciplines and used for ecosystem status assessment and to inform management decision making. Discussion then noted that phytoplankton and zooplankton data from the CPR in the North Atlantic has demonstrated changes in biomass, community structure and zoogeography and phenology. For example zooplankton has decreased in CPR areas D1 and D2 of the North Sea and spring production has shifted to earlier in the year. The data W. Greve showed illustrated that length of the production season is another shifting parameter as spring moves back while there is little shift in the end of season timing. The influence of these shifts in biomass, spring production and community structure, has been observed in various fish larvae with spawning ranges from early to late. The spring shift in spawning of fish larvae is determined by temperature in the preceding winter. Cold winter causes late spawning and warm winter causes earlier spawning. For the common and important *Oikopleura dioica* the eight week seasonal duration observed in 1975 has extended to almost 12 weeks in 2003. It had been mentioned in previous discussion that *O. dioica* had disappeared from the northwestern Mediterranean. These events are important for fish production and management of the fisheries, and ICES is looking for active products that can be used across disciplines for ecosystem management. Also noted was the fact that the composition of the plankton is changing. *Fritillaria* has almost disappeared from the Baltic, and in the Helgoland time-series it was completely missing for two years. So appearance/ disappearance can be intermittent and is almost certainly linked to environmental change. Thus it is just as important an event to report as is new species coming into a region.

The sea is no longer just about fisheries, W. Greve further discussed a new initiative of a commission, including people from backgrounds in fisheries, tourism, environment etc… to consider and design new approaches to managing the sea, using an integrated approach in agreement with stated EU strategies. Such a commission would aim to provide good management advice in the form of models that can be understood. These models would be able to make predictions of fish stock increases and decreases, eutrophication, sea level rises (coastal engineering), by looking at phenology for each species. Phenology is relatively easy, but qualitative in nature. Going quantitative might be a next step to enable prediction of trophic timings, dependencies and interactions.

There is also a need to produce operational models that reduce complexity caused by the high number of species, yet still provide useful information for management of ecosystem status. This would have to be an iterative process, i.e., model building modified by data verification followed by improved model building. Such models and their output/ performance could be made publicly available so that different users could go their own ways to improve the models. Asked for illustrations of useful models, W. Greve mentioned a niche model that he has been using, he said that his modelling work fits the data nicely but he is not sure about its applicability. The group agreed that several models use NPZ and other formulations that have not evolved much in recent years. The problems arise in part due to increases in complexity that affect analytical tractability but often simply result from a lack of real demographic plankton data required for validating and specifying quantitative parameters and functional relationships. There are great advances in progress in 3D hydrodynamic models and these are being used at various scales and linked to both mass balance models such as ERSEM and to Individual Based Models and particle tracking models that reflect real behaviours. These are exciting developments which will yield new insights, but only if we can provide the science to validate and parameterise the models, while addressing the need to reduce dimensions to tractable, meaningful and consistent analyses, models and indices with practical uses. There is also a need to regularise the collection of the data needed to parameterise operational approaches.

Slides illustrating work done in the North Sea using the CPR data were shown (Beaugrand *et al.*, 2003, Nature, 426, 661–664). These illustrated the following changes: increase of the mean number of species per association of zooplankton leading to changes in biodiversity, regime shifts, increase of warm-temperate water species etc... Changes in plankton that result in match-mismatch between prey and fish and indicating that temperature increases is not favorable for fish larvae (i.e., reduction in recruitment). This is a good example of why we should take an ecosystem approach. Attention was drawn to recent work on a time-series of scyphomedusan by-catch from ICES North Sea juvenile gadoid surveys in the seventies and eighties. This has demonstrated strong correlative links between variations in jellyfish species abundances and the climate indices such as the NAO, different in sign for different North Sea regions and also linked to historical variability in fish recruitment.

From the Baltic area, Christian Möllmann presented some data from 1975 to 2005; The Baltic has a two-layers system, BSI index showed a regime shift at end of the 1980s reflecting warmer temperature and lower salinities in the 1990's, while the North Sea influx to the Baltic Sea determines salinities. Abundance of cod declined in the 90s while sprat increased (due to the decline from cod’s predatory pressure) and herring shows a gradual decline in spawning stock biomass despite an overall abundance which remained rather stable. *Acartia*, *Pseudocalanus*, and *Temora* are key species of copepod in the region and are food for fish larvae. *Pseudocalanus* was dominant in the late 80's (this was good for cod), then declined in the 90's while *Acartia* and *Temora* increased. Christian showed that it is such anomalies in plankton abundances that influence fish recruitment and explained that low salinity has a negative effect on O2 and the survival of cod eggs. Thus the low salinities of the 90s combined with fewer *Pseudocalanus* to negatively affect cod recruitment during that period. Herring also feeds on *Pseudocalanus* and so it decreased as well. Sprat feeds on cod eggs and *Pseudocalanus* and as a result can inhibit herring. Besides this, the very high level of fishing on cod in the 90's prevented the stock from recovering. The key is in the idea of a reproductive water volume at intermediate depth that enables cod recruitment. This volume has nearly disappeared in the Baltic because of reduced inflows from the North Sea. Christian concluded that SST and climate change do not influence fish recruitment directly in this region but rather do so via zooplankton, salinity and O_2 concentrations.

Astthor Gislason then presented some Icelandic data on spatial and long term variability in plankton monitoring around Iceland. Nine lines of stations (total c90) are sampled in May/June for hydrography, nutrients, phyto and zooplankton (WP2 net, 50 m to surface). Primary production tends to be high in places where currents meet. Annual primary production is higher in the South, where temperature ranges between 6 to 12 C, than in the North (1 to 7 C), higher on-shelf than off-shelf, higher in the North West and South East frontal areas; its value decreases eastward in the north. From 1960 to 1995 time-series the mean primary production tends to divide into periods where salinity >34.5 and those where < 34.5. PP is higher in high salinity waters than in lower salinity this reflects differences in stratification. Variability is most evident in total zooplankton from two transects, with north and south of Iceland showing major highs and lows.

The seas north of Iceland can undergo major changes in temperature and salinity. The correlation between NAO and salinity is not very good, representing high inflows of Atlantic water, until local wind conditions are taken into account. Mean primary productivity during spring in the North Shelf is higher in Atlantic water than Artic water, reflecting more favourable mixing conditions in Atlantic water (i.e., moderate mixing and nutrient renewal) than in Artic water (i.e., limited mixing). Total zooplankton biomass is very similar in Atlantic and Artic waters, the tendency is for higher zooplankton biomass during warm years, this may be related to faster temperature dependent growth of zooplankton or advection of zooplankton with the Atlantic water from the south.

Egg production of the key species *Calanus finmarchicus* for the period 1996–2002 is most often highest during May and June with more than 80 and up to 150 eggs/female/day. Factors found to affect egg production rates are prosome length, chlorophyll *a* and temperature; regression analysis showed the highest correlation between egg production and chlorophyll *a*, some correlation with prosome length and none with temperature. Luis Valdes pointed out that there seemed to be a curvelinear relationship to temperature that is not reflected in a linear model. In conclusion, the factors affecting secondary production of *Calanus finmarchicus* are mainly primary production which influences reproductive maturity of organisms, maternal size and thus individual production. Temperature, advection and predation also play a part.

There has been a distribution shift for some species. In the case of fish, Icelandic blue whiting catches have increased in Atlantic waters from 1995 to 2004 whereas it's been more variable in the Faeroe waters, and whiting has moved from south Iceland to north during the period 1995–2004. Haddock and to an extent cod also showed northwards movement with higher abundance in 2004 (warm year) compared to 1995 (cold year). Monkfish has spread around Iceland in the same period of time.

In the case of *Calanus finmarchicus* for the period 1960–2004, this species has declined everywhere but in particular in the North and East of Iceland, while *Calanus hyperboreus* has been increasing since the mid-1980s in the East region. *Oithona* has also increased all around Iceland. In general the proportion of arctic species has increased north of Iceland while abundances of other species have decreased.

After Astthor's presentation the discussion returned to the issue of REGNS and the need to make a real effort in providing and pooling more of our data. Sophie Pitois will enquire about time-series in CEFAS, in particular DOVE time-series samples that are in the process of being analysed. WGZE need to gather as much data as possible since the REGNS Workshop in May 2005 will begin the process of collating data for the region. The Norwegians will contribute some data mainly phytoplankton, SAHFOS will contribute North Sea time-series from CPR routes. This year they have launched their WinCPR gridded database of plankton abundance in the North Sea compiled from monthly sampling by the Continuous Plankton Recorder (CPR) survey. The available data covers the years 1948 to 1997. German GLOBEC data on the North Sea should also be available. The data that is in the Plankton Status Report is already available to ICES and more detail can be obtained from those managing data for the North Sea stations. WGZE will work further to compile and contribute these data for REGNS.

6 Discussion - ToR 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

Multivariate techniques are almost essential to the process of analysing data from monitoring and complex hydro biological studies, which usually produce multi-dimensional data that is hard to visualise and analyse. Rabea Diekmann, had agreed to consider this topic prior to the WGZE meeting but was unfortunately unable to attend. We are grateful that she did do some homework for the WG and attached in annex 3 is a short list summarizing a few examples of multivariate statistical techniques used in zooplankton community analyses. She did not find time to include examples of GAMs and GLMs. The list is contains examples and is obviously not complete as there are more techniques and many more examples in the literature. However it may be a useful starting point for those interested in these statistical techniques.

Peter Wiebe opened the discussion by presenting a summary on methods for analysing multivariate data in community ecology, based on the textbook "Analysis of Ecological Communities" by Bruce McCune, James B Grace, and Dean L. Urban. published in 2002 by MjM Software Design.

The process of "data reduction" is very important in the analysis process. It has two basic parts: 1) summarizing a large number of observations into a few numbers and 2) expressing many interrelated response variables in a more compact way. Data reduction may be done either by classifying a large number of variables into a smaller set of classes (Categorization/Classification), or by the creation of a synthetic continuous variable (Ordination). Thus data reduction will produce either categorical variables or quantitative ones.

Categorical variables are qualitative variables that have no inherent rank or measure (e.g., trophic position: herbivores, omnivores, carnivores). Ordinal variables on the other hand, may be either measured or ranked.

Multivariate data sets may include many objects each with many measurable attributes or variables. The objects and attributes will vary according to type of study. Thus, in community analysis the objects may be, e.g., survey stations or community type, whereas the attributes may be species or environmental factors. Other types of studies include: Niche-space analysis, Behavioural analysis, Taxonomic analysis and Functional or Guild analysis.

The Data Matrix is the rectangular arrangement of the data systematically organized into a matrix in which each row represents the values of all attributes (of a subset of attributes) for one object and each column represents values of one attribute for each object (of a subset of objects). It may analysed among objects (i.e., among sample units, the Q route) or among attributes (i.e., among species, the R route). Choice of Q or R route usually determines choice of analytical method.

At the end of his brief overview Peter Wiebe gave an example of how multivariate statistical analysis was employed to reveal temporal and spatial patterns of copepod abundance in nearshore waters of the western Gulf of Maine (Christopher Manning's Masters Project at the University of New Hampshire under the supervision of Professor Ann Bucklin). The sampling took place monthly from April to November along a cross-shelf transect extending from coast (60–110 m depth). The zooplankton was sampled with vertically stratified Mocness tows. The sampled data included zooplankton species counts, CTD, fluorescence, chlorophyll, nutrients and phytoplankton, i.e., data that all the members of the group could identify with. Four species made up >80% of all copepods sampled. There was a significant difference in species composition between depths on most sampling occasions. The data were divided based on if they were collected above or below the pycnocline and Multi-Dimensional Scaling (MDS) was used to illustrate temporal variation in community structure. The results of the MDS plots showed that the community changed most significantly over the temporal scale (seasonally), while the effects of depth and station groups were not all that important. To conclude, the multivariate approach proved to be a very powerful tool to yield an easy-to-understand index for the temporal variation in plankton community structure.

Sigrún Jónasdóttir then made a brief presentation on the principles behind path analysis as an extension of multiple regression. This aims at providing an estimate of the strength of causal connections between sets of variables, thus enabling the investigator to exclude from the regression analysis the variables that are not important, and only include important ones. The core idea behind path analysis is that the investigator tries to build a realistic model before carrying out the analysis.

Xavier Irigoien gave a short talk on a project in the Bay of Biscay, where multivariate statistics are used to model relationships between mesoscale hydrographic structures and zooplankton distributions. The project seeks to integrate different methodologies in sampling (e.g., CPR, vertical tows with conventional nets). The objectives are threefold: 1) data compilation and sample analysis, 2) statistical description and predictive modelling (using GAM/GLM-GIS to make predictive habitat distribution maps), and 3) use of the model outputs in studies of climate change, fisheries and plankton production. The study is ongoing and data are still being collected. Xavier showed some examples of field and model outputs. As to model development, it is important to give ecological meaning to the relationships and so make the models more robust. Alternative statistical approaches should also be assessed. There are several other issues relevant to the development of appropriate models, e.g., spatial autocorrelation, advection.

There was some discussion on software and PRIMER was mentioned. This has a wide range of univariate, multivariate and graphical routines for species/samples abundance/ biomass analyses using matrices. The data may come from monitoring, community ecology or environmental impact studies with associated physical and chemical data. Developed through a spin out company from Plymouth Marine Laboratory http://www.primer-e.com/), PRIMER was noted as a tool commonly employed in marine ecological work. The use of the R software for carrying out multivariate statistical analysis was considered. In this context it was noted that there is a learning curve to using the more complex commercial packages which are expensive. With using R directly this curve is steep, although there are Windows front-end products to R available on the Web, one relatively inexpensive example is called "Brodgar". A free demo version can be downloaded from http://www.brodgar.com. Much other statistical software can be obtained free from the web an example noted was “Distance” survey design software from the CREEM project at St Andrew’s University, http://www.ruwpa.st-and.ac.uk/distance/.

Christian Möllmann proposed that a workshop in the use of multivariate statistics to field plankton studies should be held. The proposal was well received by the group, and it was decided to put the proposal forward as a formal ToR. Further the word "practical" should be emphasised in the ToR statement. WGZE felt that the course should be designed for and on the premises of the biologists and address real data provided by those attending. It was also said that the temporal and spatial time-series data that group members were providing for the

Plankton Status Report could serve as input for such a workshop. It was noted that such a workshop could probably be organised by SAHFOS in Plymouth.

Peter Wiebe described an interesting study, carried out several years ago, seeking to explain the distribution of euphausiid species in warm and cold water core rings in the Atlantic (Slope water, northern and southern Sargasso Sea). The study showed that there was a difference in species composition between the rings, but no explanatory variable was found to explain this, other than latitude. Latitude, however, is not very useful in this context, and Peter felt that modern multivariate techniques might be able to resolve this. Luis Valdes pointed out that in a study like this autocorrelation might be a problem, for instance temperature tends to be related to latitude. The re-analysis of older data sets could almost certainly be a fruitful exercise since modern techniques and computing power make this feasible and relatively easy if the data are available. It was felt that many scientists are likely to have such old data sets in their files, but it was noted that such retrospective analyses is often not "sexy" enough for funding. Examples were discussed and many were positive that they had or knew of useful "old" data. One example is the re-digitisation of a time-series of annual, summer scyphomedusan abundance in the North Sea, data held by FRS in Aberdeen (Steve Hay). This has been recently reanalysed by Chris Lynam at St Andrew's University and resulted in several new and interesting papers linking the jellyfish abundances and distribution with climate indices and fish recruitment success in different North Sea areas. More must be done to conserve, preserve and make digitally available this sea of old data. Many such calls are made but as yet funding is very sparse, this issue must be pursued more vigorously by the policymakers.

7 Discussion - ToR e) Review preparations and progress towards:

7.1 A workshop on enzymatic and other biochemical and molecular methods to measure or assess rate processes in zooplankton

The proposed workshop on enzymatic and other biochemical and molecular methods to measure the rate process in zooplankton was originally proposed by S. Hernandez -Leon, with good input in 2004 from Rob Campbell and declared interest from a number of practitioners and supporters such as Lutz Postel and Lidia Yebra Mora. The Chair opened with the point that this workshop plan had been a long time in preparation with relatively little progress. Frustratingly the idea is sound and this should be a practical, useful and timely development in a rapidly advancing field. The wider use and deployment of such biochemical approaches holds real prospects for assessing rates and processes in lab experiments and more significantly in the field alongside biomass and species abundance assessments. There are practical examples in the literature but the techniques suffer from a lack of general acceptance and there are known problems of application, calibration and interpretation. There needs to be authoritative guidance agreed and published. Some progress has been made; Santiago Hernandez Leon is planning to hold a workshop in the Canaries and has begun to organize it. People at this working group meeting had little expertise in these subjects, but there is still considerable interest in seeing this move forward.

Luis Valdes had an email from Santiago. He plans to have two workshops one in the lab and one on field work. At least Germany, Netherlands, UK, Norway, US and France have people interested in this topic. Erica Head in Canada is also interested in this topic, and had suggested to the Chair that Research ship "Hudson" could perhaps be able to act as a venue for a seagoing workshop since they may have sufficient berths/ space aboard on some cruises. There was interest in the idea of making a comparison with the sub tropical Canaries site with a cold sub arctic site and even to cover the range perhaps a temperate site in the North Sea, perhaps based at Helgoland which has facilities and Rob Campbell may be able to organise this.

It was suggested that diapause and hormonal control of behaviours is another issue that can be addressed biochemically. Also lipids, stable isotopes, and molecular approaches were raised as associated biochemical approaches to ecological assessments of species condition, behaviour and food web interactions. The point was made that it would be a good task for these workshops to review and update the appropriate parts of the Zooplankton Methodology Manual. Various names of researchers in ICES countries who are interested in biochemical developments in marine ecology were mentioned. W. Greve added some names and said that he wants to see quantifiable relationships produced of temperature with the biochemical processes controlling life history cycles. It was raised in discussion that modellers often have a hard time getting functional relationships out of laboratory data. Usually the experimental data do not cover a broad enough range to properly derive and describe functional relationships. Else, the experimental conditions at the extremes do not reflect reality across the environmental gradients and ranges species actually experience.

Swier Oosterhuis had sent a PowerPoint presentation on their chitobiase method to the Chair to present. Chitin biochemistry in crustacea such as the ubiquitous copepods results in enzyme release into the water when these dominant species moult. Work on the Marsdiep series in 1998 showed highs and lows of chitobiase in the seawater. Also presented were extensive experiments done to validate and apply the technique. Increase in body weight versus free chitobiase enzyme produced into incubation water illustrated that this technique can measure/ estimate growth. Degradation by bacteria of the enzyme takes about 20 hours - quite quickly and so measurement reflects recent events. For studies on *Temora longicornis*, *Pseudocalanus elongatus* and *Calanus finmarchicus* strong relationship were found. Some work was conducted on surveys in the Faeroe/Shetland channel in July 1999 and in Loch Etive in May 2001. Low versus high ratios of estimated Production/ Biomass showed ratios were low in the channel but high in Loch Etive. Plumes and blooms examined for evidence of crustacean production in the southern North Sea and secondary production estimated with chitobiase fitted the overall picture of productivity in the system. Vertical profiles of estimated secondary production at the Frisian Front in North Sea were also shown to vary temporally.

Discussion of these interesting results raised some questions. For example, it was questioned whether a large biomass growing slowly produces the same amount of chitobiase as a small biomass growing rapidly. It was suggested that what is also needed is a biochemical indicator of predation on the secondary producers, which would extend the application to consider more complete food webs and address issues of bottom up vs top down control, density dependence in species growth and productivity etc. It was also suggested that there may be fish or other predation that may contribute to the chitobiase in water column. The authors will be targeting future work to see how far this technique might be advanced and they are keen to see the method deployed more widely.

It was felt by the WG that the workshop idea needs to be pushed to conclusion. Bob Campbell was reluctant last year to take a lead as Santiago Hernandez Leon has proposed the workshop to the WG and has begun planning for the open coastal warm waters workshop in October 2006. It was decided to review the situation next year once more and hope that more concrete progress will have been made. Meanwhile a wider call for interested parties should be made. Perhaps some advertising at the ASC might be in order. It was proposed that a Theme Session at the 2006 ASC on "Molecular and Biochemical Approaches in Studies of Pelagic Ecology" could be a good idea and would raise/focus interest among the dispersed proponents of such studies and expertise.

7.2 Discussion - ToR e) Review preparations and progress towards: The 4th international zooplankton production symposium to be held in Japan 2007.

Luis Valdes is the ICES representative on the Committee for the ICES/ PICES/ GLOBEC International Zooplankton Production Symposium in Japan 28 May to 1 June. Hiroshima, Japan. Steve Hay is also a member of this committee. The symposium is announced on PISCES and ICES web pages, though **WGZE felt that the ICES page needs some work and to be made more demonstrative**. Backers and steering committee have been named with good international representation. ICES have agreed to support symposium with 10000Dkr. The announced Theme for the symposium is: ***Human and Climate Forcing on Zooplankton Populations.*** One day will be used for workshops, with 4 days of lectures and posters and one free afternoon. Symposium papers should be published in ICES journal of Marine Science. This has been discussed with ICES and WGZE has strongly endorsed a resolution to that effect (Annex 7). There followed some discussion of human and climate forcing on zooplankton communities. Climate forcing is being discussed a lot and is addressed through several major international and many national initiatives. For WGZE questions were asked as to whether this can yet be modeled effectively at scales ranging from global to basin and local areas, given current data and understanding of planktonic ecosystem constituents and their function in the seas? Much work is in progress and it was felt that we live in interesting times and have a contribution to make through WGZE and the initiatives and outputs we have and may achieve.

Luis Valdes pointed out that for endeavours such as the BASIN workshop, the IOC SCOR Global Zooplankton Comparisons WG, the Mediterranean Group lead by Gorsky and many others, the symposium in Japan will be a good time to present summaries of these initiatives.

It was restated that WGZE need to take the Plankton Status Report beyond what it has been doing. Again, species distributions shifting to the north or south and changes in community diversity and seasonality are important to monitor and study in relation to other ecosystem components and trends. For the spring and summer species the seasons may be getting longer, while for winter species seasons get shorter. The shifts and changes are likely to be good for some species and not for others in any given region. One of the strengths of time-series is comparison of inter-annual effects. Short time-series may often be sampled or updated monthly and will not accurately record the shifts in seasonal change. The WG feel the need for shorter time intervals in monitoring if seasonal plankton dynamics are being considered. WGZE also considered that there should be greater effort to research techniques to find phenological trends in the seas and oceans for key species indicators. Fish larvae show this trendy behaviour very nicely - based on temperature it appears possible to predict when the abundance of some fish larvae will peak. It was suggested that an expert in paleoclimatology; paleoceanography such as Prof. W.F. Ruddiman, might be invited to give a keynote speech with a broader perspective.

The symposium in 2007 may be a good place for the SCOR WG to present comparisons of climate variability effects, e.g., PDO and NAO and their links to zooplankton dynamics. It was suggested that since the meeting is in Japan the focus is likely to be stronger on the Pacific. Hopefully there will be good representation of science from the Atlantic research centers. Local monitoring of the inshore waters is being more and more strongly driven by new policy mandates, so we need to pull together the data sets and generate some contribution based on the Status Report from this working group. The issue of lack of required zooplankton monitoring in OSPAR was raised again and the need to define just what should be measured. The feeling was that at least what is presented in the ICES Plankton Status Report should be required. Some felt that there should be reference to species lists. However, it was argued that this was too complicated for OSPAR, though comparison of species diversity lists might be a good topic for Japan. Another theme suggested for the Symposium in Japan was the use of enzymatic methods to study growth. W. Greve agreed to consider producing a suggestion on the theme of Descriptions of Time-series and Phenology; Luis Valdes and Webjorn Melle agreed to consider Indices of Ecosystem Status and Function; and Steve Hay will consider the Use of Biochemical Methods in Marine Ecology. These ideas should be worked on between WGZE meetings and communicated to Luis Valdes as the ICES representative on the Symposium Steering Committee and to the WGZE meeting next year.

7.3 Discussion - ToR e) Review preparations and progress towards: A "virtual" workshop to further the collaborative comparison and analyses of plankton time-series and other zooplankton data in the North Sea areas.

This was considered something of a hot potato item as web presence is seen by many as a considerable problem for ICES. Web development is not up to speed, but we assume that effort to fix this is being made, although there is not much sign of this. After the WGZE meeting it became apparent that ICES could indeed not support this initiative, so Todd O'Brien has done so and has started up a website to service WGZE (http://www.wgze.net). He deserves our and ICES thanks and support in this. Another example of the benefit ICES receives from the natural enthusiasm of the scientists involved. A major reason for this originally proposed and ICES-run website was to provide support for the process of making and analysing available data for REGNS. It was pointed out that such initiatives involving much dispersed collaborations depends on there being a willing editor to organise and moderate the website (such as in the case of the previously mentioned trans-latitudinal study of *Calanus helgolandicus* ecology). ICES should also develop means to the credit authors and data providers so that they learn to trust such a system.

There was again discussion and concern that the ICES data framework developing for biological data seems to be very complex and prescriptive in fields and data. This may put many off making the effort to recast their data into another format from their own and again result in lost data. There are strong arguments for currently proprietary data sets to be assembled for use in collaborative frameworks, virtual or otherwise, or indeed to be made public. The issues of data ownership and particularly publication rights are still live issues with many scientists, which inhibit data exchange, collaborative analyses and submissions to data centres. This is particularly so for biologists who may have spent years of laborious specialist work generating the sample analysis from even a single set of samples.

7.4 Discussion - ToR e) Review preparations and progress towards: 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.

The ICES Fiche Plankton Identification sheets are now available on the ICES web site and can be ordered on CD or downloaded as PDF files. ***The web site is hard to navigate to get to the online downloadable pdf files and should be improved.*** Alister Lindley at SAHFOS is the present editor for the ICES Plankton sheets. Although there are some developments he has a very hard job to get a rapidly diminishing band of experts to prepare these sheets essentially for free. There is generally very poor funding for such taxonomic work and little time or tolerance for such unpaid "academic" work when it falls outside modern prescriptive job descriptions and institutional deadlines. Therefore essentially this work has stopped developing. However there are other developments outwith ICES, the EU MARBEF Network project, ETI biodiversity work at the University of Amsterdam, increasing appreciation in the west of the "hidden" talents in taxonomy in Russia and the eastern European countries. Also a Census of Marine Life – Census of Marine Zooplankton (CMarZ) initiative is now started which seeks to describe holozooplankton globally and to tie traditional morphological descriptive approaches and molecular genetics (ZooGene and species barcoding). The literature and experience of WG members and their colleagues sees a growing number of studies using molecular genetics to support and enhance taxonomic and ecological studies.

A particular example is work on the ecology of decapod crustacean larvae carried out at IPI-MAR in Portugal, also work on decapod larvae recruitment is going on in FRS in Aberdeen and both projects are linked to studies of adult biology and seasonality. The main reasons the larvae of benthic organisms are seldom studied is the difficulty of identifying these to species, a great shortage of taxonomic skills and the expensive and laborious nature of the sample analysis. Techniques such as real time PCR and DNA chips are holding out great promise that this bottleneck may be about to disappear. When (not if) all this technical advance develops to routine use, then the huge range of possibilities for plankton/ benthos studies and production/ recruitment to juvenile and adult populations will become a real prospect at a species level. This hopefully will cause the benthic ecologists to look up more and plankton ecologists to look down. Either way or both is good and enables a truly ecosystem approach to become more realistic.

Previous and successful taxonomic workshops have been held (two sponsored by ICES/ WGZE and one by CMarZ in Japan. Research teams around the Baltic have also had a good history of practical workshops. WGZE agreed that another is needed and there is good reason to focus on gelatinous plankton and macroplankton generally. It was mentioned that some workers had sent samples to several labs to cross compare results. Inter-calibration may be a key issue to focus on, with genetics essential for the intercalibration as the species assignment is then incontrovertible, with identification of cryptic species also probable. There is great need to get as many plankton species as possible properly sequenced. WGZE calls for another ICES-sponsored Zooplankton Taxonomic Workshop to be held in 2006. SAFHOS in Plymouth held the last of these and are keen to hold another. They have the facilities and resident expertise.

The point was made that for projects in labs where taxonomic skill is expensive and/or weak, extensive use is now made of the commercial sample analyses being carried out at sorting centres in Poland, Russia or elsewhere, where there are taxonomists and the training and literature survive. This is now a fairly longstanding situation with positive and negative aspects. There is an underlying question as to the quality control (accuracy and consistency) applied to the taxonomic analyses and some present had experience of problems in this regard. However it is good that the skills are being retained and practiced and presumably there is ongoing training for technicians and taxonomists working on these samples. It would be interesting to see just how these are achieved at these sorting centres. It was noted that taxonomic training was more extensive in some countries compared to others. At least Germany, Holland and Japan are increasing emphasis on this training of a new generation of taxonomists.

Societies such as the World Association of Copepodologists (WAC) are doing very good work in disseminating taxonomic knowledge and training (workshop in Tunisia in 2005 was very rapidly oversubscribed). While there have been many calls, there is a persistent lack of available funding to train taxonomist or conduct the work, probably as this often is not considered research per se. Thus it is increasingly difficult logistically to supply expertise where the holders are often found to have died, retired or be otherwise rare. Professional taxonomists are not necessarily the best teachers, so what is also required is revision and dissemination of the literature and development of manuals and resources for taxonomic identification. Efforts such as the two volume book South Atlantic Plankton, Edited by Demetrio Boltovskoy 1999 (Backhuys Publishers, ISBN 90-5782-035-8), Martin Angel and Kasia Blachowiak-Samolyk for their ostracoda web site - http://ocean.iopan.gda.pl/ostracoda/, The user-friendly guide to coastal planktonic ciliates at http://www.liv.ac.uk/ciliate/ and CDs etc developed by ETI are all very much to be congratulated on their efforts in this regard and others should be encouraged to produce or contribute to regional manuals for plankton species identification and summary distribution/ life cycle descriptions perhaps including meristic data on lengths: weight, carbon, nitrogen etc. The bibliographies of experts are themselves a very valuable resource and a reflection of many years experience in a highly dispersed and highly specialised literature.

7.5 Discussion - ToR e) Review preparations and progress towards: Discussion to be held during the 2004 ASC and intersessionally to co-ordinate the conjunction of the zooplankton and phytoplankton monitoring reports into the ICES Plankton Status Report

The Chair had been unable to follow this up as he had been unable to attend the 2004 ASC as it seems so did most of the working group of phytoplankton ecology. Discussion by the Oceanographic Committee had suggested disbanding the WGPE or merging with another WG, possibly WGZE. This was resisted by Luis Valdes at the Oceanography committee meeting and the WG support him in this. The ICES WGPE and WGZE between them cover an enormous range of subjects, species and areas and it would be simply too complex to manage all together and a single annual meeting could not possibly cover the ground in a few days.

The Chair admitted that after his representations of some time ago to the WGPE had been ignored he had put only a little effort in to chasing these up. There also seems to have been no contact or initiative from the WG Phytoplankton Ecology, who still seem to be following their plans alone. At WGZE instigation some years ago an extended joint meeting was held in Bergen between WGZE and WGPE. Although some interesting points were raised no constructive progress in collaborative and joined up thinking had emerged. The WGHABD Chair had however expressed support for zooplankton and phytoplankton status report joining up and had earlier provided some names of phytoplankton monitoring contacts, mostly though with only harmful species data.

It is increasingly important to develop a cohesive, ecosystem approach to such status reports and WGZE still thinks it important to get phytoplankton into the status report alongside summary physics and perhaps nutrient data. At the very least there should be an extensive collection of the sampling metadata, going beyond what is presented and including contacts, to encourage further efforts at synthesis and collaborative analysis. The WGZE members Luis Valdes and Todd O'Brien aided by Ángel López Urrutia and some others have put in a great deal of work to collating the data sent to them to produce the Status Report. There is also considerable worry that to extend this to include extensive other data would make the production of the report too difficult and time consuming. Given that we have standardised the approach and format of the Status Report, it would only really be possible to expand with an acceptance of the format and a dedicated collection/ description/ submission of phytoplankton data by the phytoplankton people themselves. So for the moment we will where possible include data on chlorophyll as depth integrated or surface values. WGZE call on all those who submit their data to our group for the Plankton Status Report to include temperature and salinity in the mixed layer and from bottom, wherever these data are available.

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

S. Jónasdóttir introduced this ToR starting with defining the three main keywords of the ToR, meroplankton, shelf seas and productivity. She pointed out that meroplankton are considered often to represent over 70% of all meso-zooplankton in terms of abundance, a number that was debated somewhat as to whether it is correct even as an average. However in the shelf seas, where meroplankton often do dominate and which carry about 95% of the fish yield, there meroplankton have high importance to regional and species productivity in terms of biomass, growth, spatial distribution and seasonality. Meroplankton according to the definition in the ICES Zooplankton Manual includes fish larvae but in the present discussion meroplankton was considered only as larvae stages of benthic organisms.

There is a general agreement that meroplankton is not well studied either by the zooplankton or the benthic ecologists. Some examples of spatial and temporal distributions of meroplankton were presented and discussed from three different regions, namely Gulf of Gdansk (Poland), Stonehaven (North Sea) and the Portuguese coast. The conclusion was that meroplankton species composition and abundance vary greatly in space and time. The pattern of occurrence often appears as huge peaks of abundance of one or a few species for a short period of the year (days- a few weeks). Therefore they are susceptible to being missed during sampling cruises. Meroplankton species communities, since they reflect the benthic system which is much more diverse than the plankton, change greatly between regions.

It was pointed out that some meroplankton species are quite sensitive to temperature changes and are therefore good candidates as indicator species for climate change. This caused some discussion as the sensitivity may cause change in time of spawning, rather than magnitude of the effect. Either way this sensitivity has potential to be used to track environmental changes. Meroplankton have been considered as of interest especially in terms of recruitment and their importance to fisheries (mainly for the eggs and larvae of fish). These topics have been considered by other ICES groups, namely WGRP, BEWG and SGCRAB. It was recognised that the most important problem preventing meroplankton study is problem of identification. Everyone agreed on the great difficulty in identification of many meroplankton genera to a species level and expertise is rare within ICES community. However, there is progress and for example a new illustrated key for identification of decapod larvae for European seas has been recently published that will allow their identification to genus and species level (dos Santos and González-Gordillo 2004 J. Mar. Biol. Ass. U.K. 84: 205-227). Additionally, in a few years time, developments in genetics, such as the barcode program and genetic chips, will allow easy identification of meroplankton and consequently will allow a more useful focus on this group. Links between plankton and benthos will become much more amenable to investigation.

9 Discussion - ToR g) Review progress with ICES data management of biological information

This topic was quite briefly discussed, although throughout prior discussions the area had received some debate. There is a strong feeling among those present that the complexity of plankton communities, the range of sampling strategies and differing levels of analytical approaches to samples is confounding the data formats with too much detail. If ICES want to produce a format to cover all these complexities and then expect all the data providers to wade through and verify all that detail then they are often not going to raise much enthusiasm among a world of very busy investigators. It is one thing to attempt to set a standard, many will be grateful for the guidance, but making data calls too prescriptive will result in fewer responses. Sampling and species data are much more complex than physics and chemistry as ICES data managers know; also they are used for a much wider range of investigations. More and more the approach from many large data centres seems simply to gather the data as it is collected and presented by the originator, without extensive translation and reformatting. The consensus of our WG is for ICES to follow that model rather than being prescriptive. These data will have many, many uses and interpretations so why not leave it to the data user rather than the originator to format all he gathers into a style that suits their particular analyses. Data users might even do so into a format the data centre prefers, positive feedback! So long as the meta-data is well described and the data itself intact, understandable and available, then investigators time will not be “wasted” in reformatting. This is so unless they are assembling mixed data, attempting synthesis or background, then it is part of such investigator's tasks. It was considered that an emphasis on metadata collection and advertisement would catalogue more of what is available and encourage contact and collaboration between data holders where there is difficulty or reluctance to provide data to central repositories.

10 Any other business

Following on from previous years' discussions and contacts between WGZE with WGRP and WGCCC, an ICES/GLOBEC "Workshop on the Impact of Zooplankton on Cod Abundance and Production [WKIZC]" is to be held at ICES Headquarters in Copenhagen on 7–9 June 2005. This meeting is of considerable interest and expected to be a productive exercise. The WKIZC continues the strong links between WGZE and groups studying fish recruitment and biology. These had contributed to the popular Theme Sessions O and J at the 2004 ASC.

The WKIZC is being organised by Øyvind Fiksen, Jeff Runge, and Christian Möllmann, and Christian being at our WGZE meeting, he gave the group a short presentation on the plans and agenda. The group considered that he and his colleagues had done a good job and that we look forward to the outcomes. Some WGZE participants intended to be part of the WKIZC proceedings in June, or had colleagues planning to attend.

11 Resolutions and terms of reference proposed for 2006

11.1 Next Meeting (2006)

It is proposed to hold the next (2006) meeting of the ICES Working Group on Zooplankton Ecology in Villefranche, France during the week 27–31 March, kindly hosted by Dr Gabriel Gorsky of the Observatoire Océanologique.

11.2 WGZE Terms of Reference proposed for 2006

1. Update the ICES Plankton Status Report; consider progress towards consolidation, interpretation and appropriate statistical methods.
2. Assess and improve WGZE contribution to REGNS and North Sea Ecosystem Status assessment.
3. Plan and prepare for additional analyses and products utilising the Plankton Status Report Time-series.
4. Plan and consider agenda for a joint meeting with CIESM plankton scientists.
5. Review the causation and impacts of introduced or disappearing plankton species, particularly from regions in the ICES and CIESM areas.
6. Consider and consolidate the use of web site and virtual resources for support of WGZE endeavours.
7. Review achievements, progress and prospects for;
    - i.) Workshop on the Impact of Zooplankton on Cod Abundance and Production [WKIZC].
    - ii.) Workshop on enzymatic and other biochemical and molecular methods to measure rate process in zooplankton.
    - iii.) SCOR Working Group, Global Comparisons of Zooplankton Time-series.

iv.) ICES/ PICES/ GLOBEC International Zooplankton Production Symposium in Japan 2007.

v.) GLOBEC/ SPACC workshop "Image analysis to count and identify zooplankton" (ZooImage), San Sebastian 2005.

vi.) A taxonomic workshop to advance the Fiches plankton ID sheets, also to encourage the training and retention of plankton taxonomic skills.

vii.) Plans and progress in relevant national and international projects relating to plankton studies (e.g., MARBEF, BASIN and others).

viii.) Data management issues at ICES and elsewhere.

11.3 Theme Session Proposals for 2006 ASC

The ICES Working Group on Zooplankton Ecology proposes two theme sessions for the 2006 ICES Annual Science Conference:

Biogeographical changes in zooplankton communities; consequences for marine ecosystems. Conveners - Luis Valdes and Peter Wiebe

and **What zooplankton are fish really eating? Species and diets, availability and dependency.** Conveners – Xabier Irigoien and Christian Mollman

11.4 Other Resolutions

WGZE propose that the ICES Publication Committee formally resolve and commit to publishing the proceedings of the 4th ICES/PICES/ GLOBEC Symposium on Zooplankton Production in the ICES Journal of Marine Science as a special edition.

The working group held a vote to propose a replacement for the outgoing Chair.

Dr Ástþór Gíslason of the Marine Research Institute, Reykjavík, Iceland was proposed, and unanimously voted for as new Chair by the group. He has kindly agreed to chair the Working Group through the next term.

The SCOR WG also wishes another Atlantic member, and would greatly welcome ICES sponsorship of one. WGZE contributes to the SCOR WG with data and expertise. WGZE appreciate the suggestion from SCOR WG for an ICES sponsored North Atlantic associate member, Webjorn Melle was suggested but will depend on ICES sponsorship of travel and subsistence funding.

It is suggested that a practical workshop in the use and application of multivariate statistics to plankton studies should be held. Such a workshop could probably be organised by SAHFOS at the MBA facility in Plymouth, UK. It is felt that this should be discussed further with the Statisticians before making a formal proposal.

Annex 1: List of participants

22 attended from 13 countries plus 7 *others submitted verbal/written contributions from 3 other countries. We also welcomed 3 † new participants from the Baltic Seas Regional Project at our WGZE meeting.

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Annex 2: WGZE Lisbon 2005 Meeting Agenda

Monday 4 April

12:00 Introductions, Announcements and Housekeeping.

12:30 Lunch

13:30 **ToR e)** Lead - Steve Hay; Review preparations and progress towards;

i) a workshop on enzymatic and other biochemical and molecular methods to measure or assess rate processes in zooplankton. (Santiago Hernández-León, / Rob Campbell if available or by submission)

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

(Luis Valdés / Steve Hay)

15:30 Coffee Break

15:45

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

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. (SAHFOS)

v) discussion to be held during the 2004 ASC and intersessionally to co-ordinate the conjunction of the zooplankton and phytoplankton monitoring reports into the ICES Plankton Status Report. - Steve Hay / Luis Valdes

Tuesday 5 April

Morning- **ToR 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. lead – Luis Valdes; rapporteur – Lutz Postel

Afternoon - **ToR 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). lead – Wulf Greve; rapporteur – Sophie Pitois

Wednesday 6 April

09:00 **ToR b)** Future development and collaborative approaches in plankton time-series measurements and interpretation, including collaboration with global synthesis attempts and regional comparisons. Lead – Todd O'Brien; Rapporteur – Webjørn Melle

10:30 Coffee Break

11:00 **ToR g)** Review progress with ICES data management of biological information.

Lead –Todd O'Brien; Rapporteur – Xabier Irigoien

12:30 Lunch

13:30 **ToR 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. lead – Peter Wiebe; rapporteur – Astthor Gislasson

15:00 Coffee break

15:30 **ToR f)** Review and consider the role of meroplankton in pelagic shelf seas ecosystems and their contribution to productivity in these areas. lead – Sigrún Jónasdóttir; rapporteur – Antonina Santos

Thursday 7 April

09:00

AOB – including;

1. Election of Chair for 2006-2008
2. Consideration of Terms of Reference for 2006,
3. Suggestions for future ASC Theme Sessions, workshops etc
4. Completion of Rapporteur reports

12:00 - FINISH

Annex 3: Some Examples of Multivariate Approaches

Multivariate statistical techniques used in zooplankton ecology, especially for community analyses: Examples of recent methodical approaches.

MULTIVARIATE TECHNIQUES	APPLICATION	PUBLICATION
Canonical Correspondence Analysis (CCA)	Relationship between the zooplankton fauna of the Zeeschelde estuary and different environmental factors (e.g., Sal, T, NH4+, Chla)	Tackx *et al.* (2004)
Canonical Correspondence Analysis (CCA)	Exploratory tool to assess the important environmental variables influencing spatial patterns of ichthyoplankton and pelagic fish and squids at Georges Bank	Garrison *et al.* (2002)
Canonical Correspondence Analysis (CCA)	Relationship between copepod species sampled at a shelf in northern Norway and environmental variables – temporal and spatial variations	Halvorsen and Tande (1999)
Canonical Correspondence Analysis (CCA)	Analysing the response of zooplankton species in the northern Baltic to hydrographic parameters using time-series data	Viitasalo *et al.* (1995)
Canonical Correspondence Analysis (CCA)	Relationship between the copepod community (resolving species and life stages) in the central Barents Sea and spatial (latitude, depth), temporal (month) and hydrographic factors (Sal, □t)	Pedersen *et al.* (1995)
Canonical Correspondence Analysis (CCA) – partial ordination	Relating meroplankton species densities of the French-Belgian coast with environmental variables and geographic locations using the latter matrices alternatively as covariables – taking into account the spatial components in species distribution	Belgrano *et al.* (1995a) (1995b)
Centred PCA (based on covariance matrix)	Determination of seasonal and diel patterns of diversity of calanoid copepods; examination of the spatial variation of the diversity of calanoids at diel and seasonal scales	Beaugrand *et al.* (2001)
Cluster Analysis: Hierarchical agglomerative clustering	North coast of Spain: Classifying copepod life stages into size classes with similar vertical distributions and movements	Fernandez de Puelles (1996)
Cluster Analysis: Hierarchical agglomerative clustering	Identification of homogeneous periods and stations in the lower St. Lawrence estuary concerning copepod species assemblages	Plourde *et al.* (2002)
Cluster Analysis: Hierarchical agglomerative clustering	Zooplankton of the Antarctic: Classifying samples into groups with similar communtiy composition/ species with similar distribution patterns using cluster analysis coupled with UPGMA (based on Bray-Curtis similarity matrix)	Chiba *et al.* (2001)
Cluster analysis: Hierarchical complete linkage method	Clustering geographic regions of similar copepod diversity using CPR data – mapping indicator assemblages in the North Atlantic and adjacent seas and determine typical species associations	Beaugrand *et al.* (2002)
Clustering (Hierarchical agglomerative clustering) on recalculated data from the first two eigenvectors and principal components of a PCA	Analysis of an ecosystem regime shift in the North Sea: Classify temporal periods of similar zooplankton composition (CPR data using calanoid copepod biomass and diversity) by previously decreasing the influence of episodic events or high-frequency variability	Beaugrand (2004)
Correspondence Analysis (CA)	Mediterranean salt marshes: Obtaining a quantitative disturbance measurement derived from the score of the second principal dimension and the Euklidean distance from values of disturbed and stable conditions on the first factorial plane of a CA – relationship with different diversity measures	Quintana (2002)
Discriminant analysis (DCA)	Separation of environmental variables (e.g., Sal, T, Chla, POC) according to previously defined temporal or spatial groups based on copepod species assemblages	Plourde *et al.* (2002)
Non-metric MDS Analysis	Zooplankton of the Antarctic: Ordination of samples into groups with similar communtiy composition/ of	Chiba *et al.* (2001)

	species with similar distribution patterns (verification of cluster analysis based on the same similarity matrix)	
Non-metric MDS Analysis	Identification of the spatial structure of mesozooplankton species in the Labrador Sea	Head *et al.* (2003)
Principal Coordinate analysis (PcoA)	Identification of homogeneous periods and stations in the lower St. Lawrence estuary concerning copepod species assemblages supported by the results of the hierarchical agglomerative clustering model – calculating the spearman correlation between principal axes and species abundances to identify the species that contribute most to the formation of each seasonal or spatial group.	Plourde *et al.* (2002)
RDA on Hellinger transformed data	Investigation of fish and cephalopod early life stages at seamounts: Vertical and horizontal structuring of species assemblages in relation to topographic and hydrographic features	Diekmann *et al.* (submitted)
Standardised Principal Component Analysis (PCA; based on correlation matrix)	Identification of major long-term monthly changes in calanoid copepod diversity in CPR-data (principal components) and localisation of the region of maximal variability (mapping of elements of eigenvectors)	Beaugrand (2003)
Standardised Principal Component Analysis (PCA; based on correlation matrix)	Analysis of an ecosystem regime shift in the North Sea using CPR-data of calanoid copepods (biomass and species diversity) – seasonal and yearly variations	Beaugrand (2004)
Standardised Principal Component Analysis (PCA; based on correlation matrix)	Investigation of the effect of food availability and quality (as calanoid copepod biomass, mean size and abundance of selected taxa) on cod recruitment in the North Sea: Examination of long-term monthly changes in the plankton ecosystem by PCA and relationship of the first PC to cod recruitment (and further sub-analyses)	Beaugrand *et al.* (2003)
Three-mode PCA (multiregressive model of the PCA for a 3-way table)	Parallel investigation of the temporal (17 years/ 12 months) and spatial structure (20 locations) in CPR plankton data (abundances of 11 selected species)	Beaugrand, Ibañez, Reid (2000)

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Annex 4: Proposed Terms of Reference 2005

The **Working Group on Zooplankton Ecology** [WGZE] (Chair: A. Gislason*), Iceland) will meet in Villefrache, France from 27–31 March 2006 to:

a) Update the ICES Plankton Status Report; consider progress towards consolidation, interpretation with appropriate statistical methods and recommended monitoring standards.

b) Assess and improve WGZE contribution to REGNS and North Sea Ecosystem Status assessment and other data synthesis efforts.

c) Plan and prepare for additional analyses and products utilising the Plankton Status Report Time-series.

d) Plan and consider an agenda for a joint meeting with CIESM plankton scientists.

e) Review the causation and impacts of introduced or disappearing plankton species, particularly from regions in the ICES and CIESM areas.

f) Consider and consolidate the use of web site and virtual resources for support of WGZE endeavours.

g) Review achievements, progress and prospects for;

i.) Workshop on the Impact of Zooplankton on Cod Abundance and Production [WKIZC].

ii.) Workshop on enzymatic and other biochemical and molecular methods to measure rate process in zooplankton.

iii.) SCOR Working Group, Global Comparisons of Zooplankton Time-series.

iv.) ICES/ PICES/GLOBEC International Zooplankton Production Symposium in Japan 2007.

v.) GLOBEC/ SPACC workshop "Image analysis to count and identify zooplankton" (ZooImage), San Sebastian 2005.

vi.) A taxonomic workshop to advance the Fiches plankton ID sheets, also to encourage the training and retention of plankton taxonomic skills.

vii.) Plans and progress in relevant national and international projects relating to plankton studies (e.g., MARBEF, BASIN and others).

viii.) Data management issues at ICES and elsewhere.

Supporting Information

Priority:	The activities of this group are a basic element of the Oceanography Committee, funda-mental to understanding the relation between the physical, chemical environment and living marine resources in an ecosystem context. Reflecting the central role of zoo-plankton 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 and central to ecosystem approaches.
Scientific Justification and relation to Action Plan:	Action Plan No: 1.2 - 1.13; 2.2, 2.9, 2.10; 3.2,3.3,3.15; 4.2,4.10, 4.11,4.14, 4.15; 5.2 – 5.5, 5.9, 5.10, 5.13 – 5.17; 6.1; 8.1,8.2, 8.4 **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 and setting monitoring standards and recommrndations.

	b) Several data sets included in the Plankton Status Report are 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 and one which WGZE wishes to contribute to. **c)**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 grow-ing, alongside expanding national and international demands for monitoring data. There are studies and projects attempting 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. 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 good statistical and biophysical modelling approaches. **d)** ICES must recognise as WGZE does, that the broader interests of an expanding EU requires better efforts at integration and collaboration in research. So too there is a movement towards broader and more global syntheses and comparisons in the research community, particularly being driven by the process and implications of climate change for marine ecology generally. WGZE members are keen to forge links with their fellow plnkton scientists in CIESM as there is much to be learned and gained through exchange and collaboration. **e)** Appearance of new species or disappearance of established species has been noted in a variety of regions. There is a need to gather examples and examine how they may be related to changes in their environment and what the consequences might be for plankton communities and regional ecology. **f)** Given that ICES has proved unable to operate a web “virtual” worksite for our WG, WGZE has set up a site thanks to the enthusiasm of one member. This welcome initiative we need to foster and capitalise on, therefore we need to review to develop the application of this approach to our endeavours. **g)** This ToR relates to a range of workshops and initiatives which our working group is involved with. WGZE has to review these regarding progress and implications for ICES and the research community generally. These initiatives are the main means by which we keep our work relevant, communicate and implement our ideas and formulate future contributions and efforts. This initiative and feedback process is vital to ICES future. Through WGZE ICES has a good practical history of sponsoring and running workshops and the Zooplankton Production Symposium. Within ICES and generally, data management of biological information needs to be reviewed and ongoing efforts and consultations discussed.
Resource Requirements:	Resource required to undertake the activities of this group is negligible. However, ICES must be committed to provide some sponsorship and support for workshops and the 4th Zooplankton Symposium
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 The Group is normally attended by some 20-25 members and guests
Secretariat Facilities:	None beyond communication support
Financial:	Beyond the 10,000DK support for the Symposium in 2007 and publication costs for the Plankton Status Report, no other current financial implications
Linkages To Advisory Committees:	The Group reports to the Oceanographic Committee and ACME (information also relevant to some ACFM and ACE aims) Mainly WGZE provides scientific information on plankton and ecosystems and welcomes input from other committees , working/ study groups etc
Linkages To other Committees or Groups:	Any and all working and study groups interested in marine ecosytem monitoring and assessments, modelling and/or plankton studies, including fish and shellfish life histories and recruitment studies.
Linkages to other Organisations:	Links with the WGMDM, WGRP, WGCCC, WGPE and WGHABD are intended and some contact is maintained. ICES could perhaps help more in fostering greater cross group contact and activities. The WGZE 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, PICES, CIESM, GOOS and GLOBEC with 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. IGBP, SCOR, ESF, COML/ CMarZ, and others have research activities meetings etc., of interest and relevant to the activities of WGZE. Contacts are maintained through networking and collaborative activities.
Secretariat Marginal Cost Share:	ICES:

Annex 5: Theme Session proposals, ASC 2006

1) The **Working Group Zooplankton Ecology** [WGZE] propose that a Theme Session at the ICES 2006 Annual Science Conference should be

Biogeographical changes in zooplankton communities; consequences for marine ecosystems. Theme Session conveners - Luis Valdes and Peter Wiebe

Supporting Information

Priority:	These subjects are considered to have a very high priority.
Scientific Justification and relation to Action Plan:	Action Plan No: 1.2 – 1.9; 2.2, 2.10; 4.2, 4.10, 4.14; 5.9, 5.10, 5.16 To a large extent our current assessments of the ecosystem effects of climate change have been most effectively demonstrated by reference to to the observed spatial and temporal changes in abundance, distribution and phenology of plankton communities and key species. Ecosystem regime shifts and links with fisheries harvests, recruitment etc have been demonstrated over a range of scales, from basin scales in the Atlantic and Pacific oceans down to different responses noted for different regions of the North Sea. It is likely that any ecosytem approaches to fisheries management, marine protected areas, habitats and biodiversity conservation or integrated coastal zone management will be assisted by reference to information on marine plankton.
Resource Requirements:	Secretarial support
Participants:	It is expected that responses to a call for contributions will reflect the wide interest and active research current in this subject area.
Secretariat Facilities:	None
Financial:	No financial implications
Linkages To Advisory Committees:	ACME, ACFM, ACE
Linkages To other Committees or Groups:	Many
Linkages to other Organisations:	CIESM, GLOBEC, SCOR, GOOS, CoML/CMarz, EU and national programmes
Secretariat Marginal Cost Share:	ICES:

2) The **Working Group Zooplankton Ecology** [WGZE] propose that a Theme Session at the ICES 2006 Annual Science Conference should be

What zooplankton are fish really eating? Species and diets, availability and dependency. WGZE Conveners: Xabier Irigoien and Christian Möllman

Supporting Information

Priority:	These subjects are considered to have a very high priority.
Scientific Justification and relation to Action Plan:	Action Plan No: 1.2, 1.3, 1.12, An ecosystem approach to fisheries and marine environmental management requires understanding of the trophic links in the ecosystem. Despite very many studies and a wide literature, difficult problems remain associated with estimating the transfer of secondary production to fish (or other) predators. This suggested theme topic is aimed to encourage some resolution or at least a concensus approach to decribing the food species of plankton eating fish throughout their life cycles.
Resource Requirements:	Secretarial support
Participants:	It is expected that responses to a call for contributions will reflect the wide interest and

	active research current in this subject area.
Secretariat Facilities:	None
Financial:	No financial implications
Linkages To Advisory Committees:	ACME, ACFM, ACE
Linkages To other Committees or Groups:	Many, including especially WGRP and WGEEF
Linkages to other Organisations:	CIESM, GLOBEC, EU
Secretariat Marginal Cost Share:	ICES:

Annex 6: ICES Plankton Status Report 2003/2004

ICES Cooperative Research Report

Rapport des Recherches Collectives

No. 276

August 2005

Zooplankton monitoring results in the ICES area: Summary Status Report 2003/2004

Prepared by the ICES Working Group on Zooplankton Ecology

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

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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 website. The Working Group on Zooplankton Ecology (WGZE) considers it 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. The WGZE has edited such an annual report since 2000.

This is the fifth summary on zooplankton monitoring results in the ICES area. Phytoplankton and temperature data for some locations corresponding to the zooplankton sampling sites are also included in this report. The final goal will be the production, in the near future, of a Plankton Status Report with environmental variables.

In addition we have improved this year's report with several new series on the Barents and Baltic Seas, 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 also places the data in a basin scale context.

The work in preparing this report is based on contributions from members of the ICES Working Group on Zooplankton Ecology (WGZE) and from colleagues in ICES Member Countries, who are leading zooplankton time-series programmes. In addition to the editors, the following people have contributed or provided comments on the contents:

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2 Regional coverage

The information collated by the ICES WGZE are derived from zooplankton sampling programmes in the ICES area which include 5 fixed stations and 35 standard sections (approx. 350 sampling stations) distributed on the continental margins of both America and Europe and covering an area from the temperate latitudes south of Portugal to the colder regions north of Norway, Iceland, 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 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 (latitude), 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 are 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 and 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.). These metadata can be found in Section 6 and will help a reader to locate and understand the data presented in this document.

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

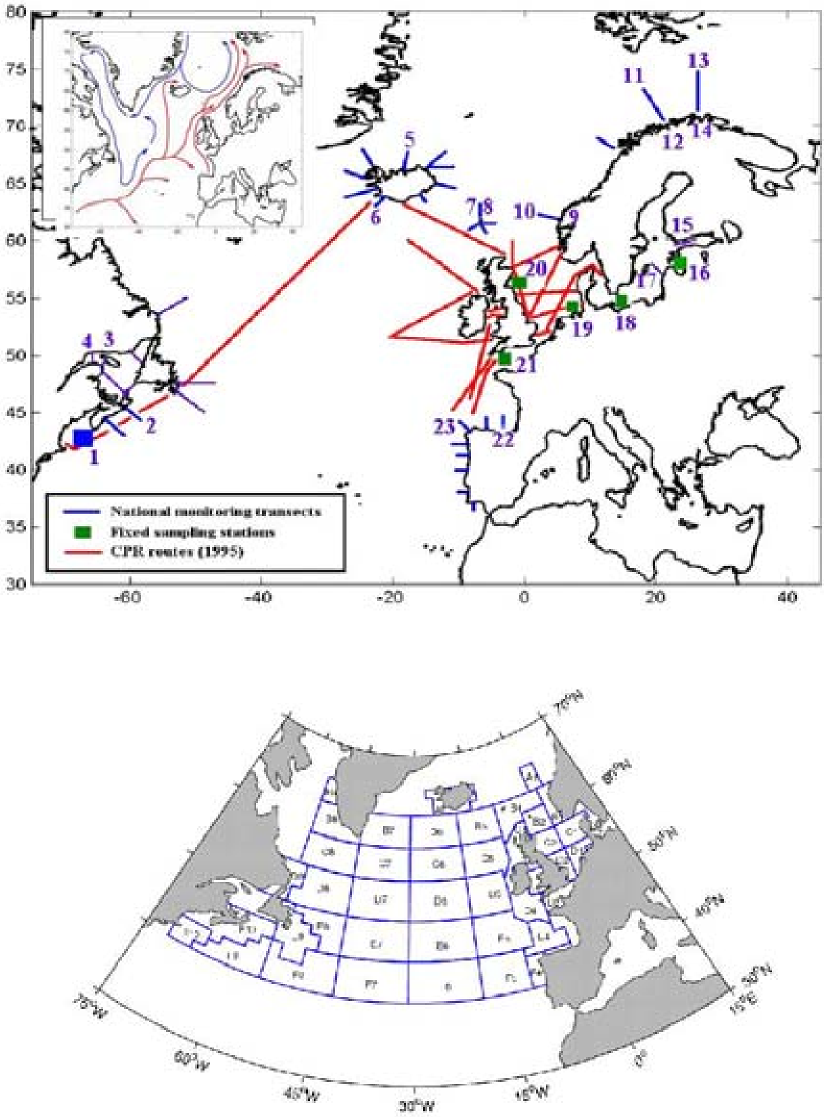

Figure 1: A: Zooplankton sampling network in the ICES area (only sampling programmes reported in the WGZE); numbers make reference to the collections used in this report. Map in the upper left corner represents the schematic general circulation of the North Atlantic. B: Map of CPR standard areas in the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

3 Regional descriptions

3.1 Western Atlantic

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.

The second type of monitoring is by Bongo net (333 µm mesh) samples, which are collected six times per year in a polygon of stations over the shelf region. Figure 2 shows the median plankton displacement volume on Georges Bank in the early spring and early autumn. The spring 2004 value was nearly three times larger than any other value in the 34-year series. This high volume was due to a phytoplankton bloom that was occurring over a wide area of the Bank at the time of the survey. The annual mean values combining the spring and fall data sets are quite stable around 40 ml m^{-3} of displacement volume. The yearly differences in the annual mean anomalies are also shown in the same figure.

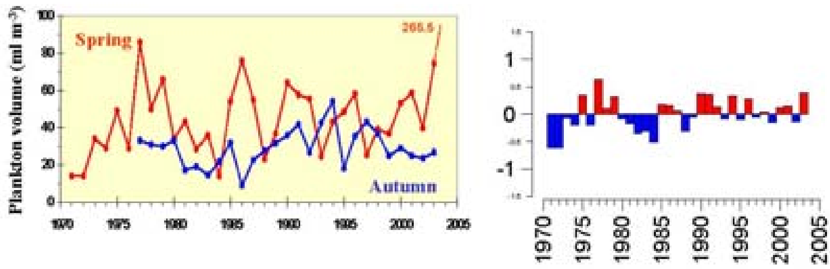

Figure 2: Plankton displacement volume on Georges Bank in the early spring and early autumn (left), and interannual variability in terms of normalised anomalies combining the spring and autumn data sets (right).

2: Halifax Line Station 2 (West Atlantic, Scotian Shelf)

Zooplankton are sampled every 2–4 weeks (if possible) using research ships, trawlers, and a small SAR vessel with a net of 0.75 m diameter ring 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 HL2 on the inshore edge of Emerald Basin, a 150-m depth station approximately 20 miles offshore from Halifax. CTD profiles are recorded, and also samples for phytoplankton, nutrients, and extracted chlorophyll are collected using Niskin bottles at fixed depths. Sub-samples are combined to give an integrated sample.

Zooplankton samples are split and one half is used for wet/dry weight determination. The second split is sub-sampled to give at least 200 organisms, which are identified, to genus or species, and enumerated. Another sub-sample is taken that contains at least 100 *Calanus* spp., which are identified and enumerated to species and stage. Biomass of the dominant groups are calculated using dry weights of various groupings (*Calanus, Oithona, Pseudocalanus,* and *Metridia*) and abundance data. The data are entered into the "BioChem" database at the DFO.

An ecosystem 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. During 1998 and 1999 the population was at high levels, decreasing to a low in 2002. This is also noted when the total population of copepods is plotted (Figure 3). In spring 2003 *Calanus finmarchicus* values were close to or a bit above the mean of the time-series. Copepods also increased in 2003 and 2004, but they are still below the mean (Figure 3, right).

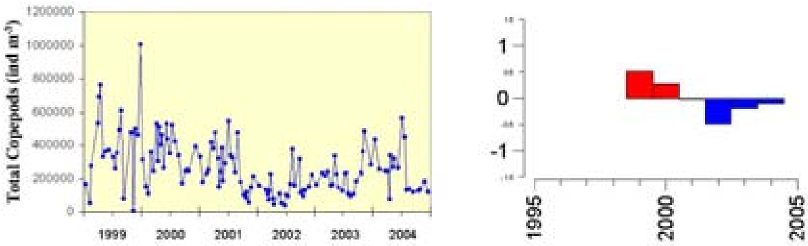

Figure 3: Abundance of copepods at HL2 (1999–2004) (left), and interannual variability in terms of normalised anomalies of annual means (right).

3-4: Gaspé Current and Anticosti Gyre (Northwest Gulf of St. Lawrence)

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 is shown in Figure 1. The zooplankton samples are analyzed following the same protocol as the one described above for the Halifax Line Station 2. An ecosystem status report on the state of the phytoplankton and zooplankton is also prepared every year and published on the web at http://www.dfo-mpo.gc.ca/csas/Csas/English/Status/general.htm.

Data presented in the present status report (Figure 4) are from two sampling stations: the Gaspé Current and the Anticosti Gyre, both in the northwest Gulf of St. Lawrence (GSL). The GSL is a coastal marine environment with a particularly high zooplankton biomass relative to other coastal areas, dominated by *Calanus* species (de Lafontaine *et al.*, 1991). In 2004, the overall abundance and biomass of zooplankton observed in the Gaspé Current and the Anticosti Gyre were comparable with what we observed from 1999 to 2003. Likewise, the mean annual zooplankton abundance and biomass observed in late spring and fall 2004 along all sections were comparable with observations made in 2000, 2001, 2002, and 2003 (Harvey *et al.*, 2005). Zooplankton abundance and biomass do not follow the same pattern as the concentration of chlorophyll *a*, e.g., the zooplankton peak observed in the Gaspé Current in 2003 corresponded to a chlorophyll *a* minimum and the chlorophyll *a* peak in the Anticosti Gyre in 2001 corresponded to a zooplankton minimum. This absence of coupling between zooplankton and algal biomass has been previously observed in the GSL (de Lafontaine *et al.*, 1991; Roy *et al.*, 2000) and was attributed to the complex estuarine circulation pattern observed in both the Gaspé Current and the Anticosti Gyre. Annual cycles of surface temperature in both cases are similar, with values below 0°C in winter and peaks above 14°C during the summer.

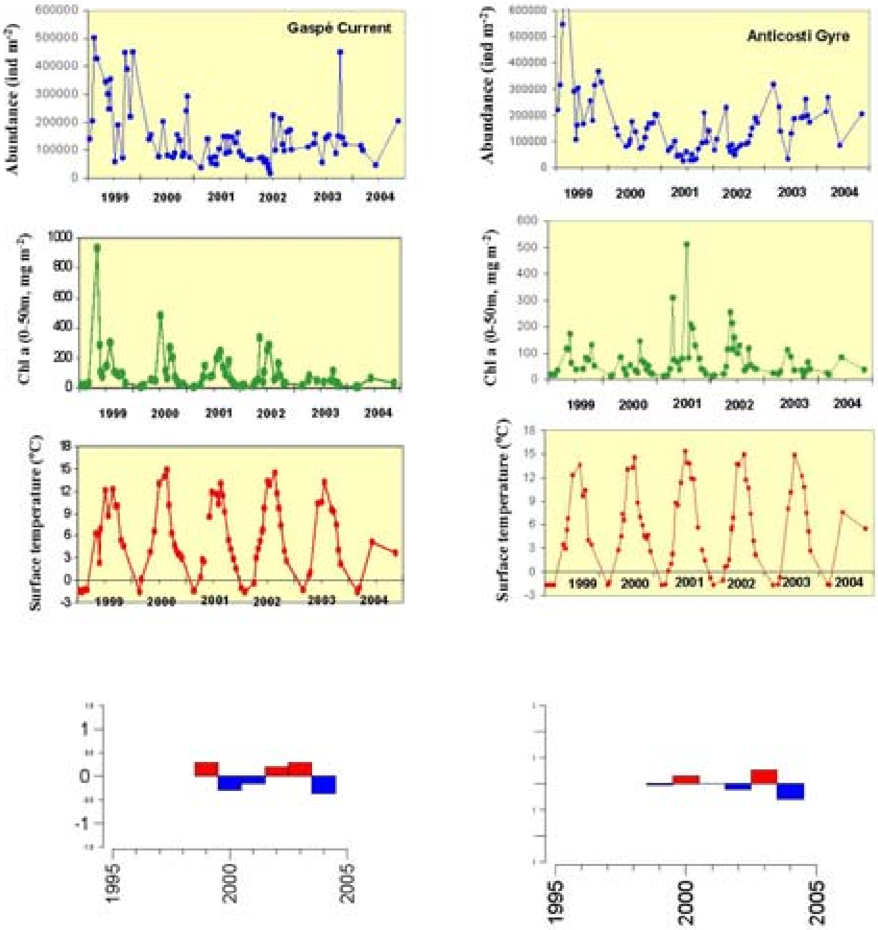

Figure 4: Time-series of zooplankton abundance and biomass, chlorophyll, and temperature in the northwest Gulf of St. Lawrence. Lower plots show interannual variability in terms of normalised anomalies of annual means.

3.2 Icelandic-Norwegian basin

5–6: 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 5. At Siglunes the values are averages from eight stations, while on Selvogsbanki the values represent averages from five stations.

At the Selvogsbanki transect the zooplankton biomass showed a peak during the early 1980s while a low was observed during the late 1980s. 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 year intervals. The last peak in zooplankton biomass occurred around 2000. In 2004 the values at both Siglunes and Selvogsbanki transects were among the lowest of the time-series.

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 is in turn influenced by the freshwater efflux from rivers and by the wind force and direction.

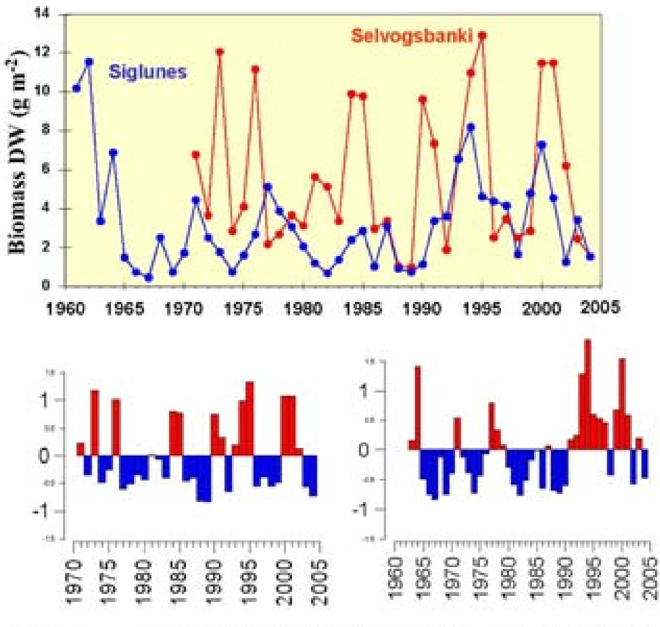

Figure 5: Year-to-year variability of zooplankton biomass at Siglunes and Selvogsbanki (upper panel), and interannual variability in terms of normalised anomalies of annual means (lower panel) of Siglunes (left) and Selvogsbanki (right).

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.

7–8: Faroe Islands

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

The northwards section penetrating into the Norwegian basin (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 is covered by warm Atlantic Water (AW), which 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 northernmost part of the section is covered by cold East Atlantic Current Water (EICW).

Figure 6 shows the average zooplankton biomass in the upper 50 m in these two water masses in the oceanic part of the section in May 1990–2004. 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 the presence of *Calanus hyperboreus* in the northern part. In the Atlantic water, much fewer large individuals are present, but higher numbers of small 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 AW than in the EICW, despite the lower biomass (Gaard, 1996, 1999).

However, in the last two years (May 2003 and 2004) the abundance of young *C. finmarchicus* copepodite stages in the northern part of the section has increased significantly, and there was no clear difference any more in the *C. finmarchicus* stage composition in these two water masses. This indicates an earlier reproduction in the EICW in the last two years compared to previous years. In May 1990–2002 the fraction of *C. finmarchicus* recruits in this water mass was only ~10%, but in 2003 it increased to ~45% and in 2004 to ~75%. Another change in the last two years is that no *C. hyperboreus* were found in the northern part of the section. These were quite numerous in most previous years.

Apparently the lower temperatures in the northern part of the section (Figure 6 lower panel, left) have been a main reason for the generally later *C. finmarchicus* reproduction between the two water masses in previous years. The difference does not seem to be explained by phytoplankton abundance, since the chlorophyll *a* concentrations in most years were higher in the cold EICW than in the warmer AW (Figure 6 lower panel, right).

Similarly, a possible reason for the apparently early reproduction of *C. finmarchicus*, and for the disappearance of *C. hyperboreus*, in the EICW in 2003 and 2004 compared to the previous years in the time-series may be that the temperature in this water mass has increased significantly. The average temperature in the upper 50 m in this water mass in May 2003 and 2004 was 5.5°C, which is 1.6°C higher than in 2002. This is also the highest temperature recorded in the time-series in the EICW part of the section (Figure 6 lower panel, left).

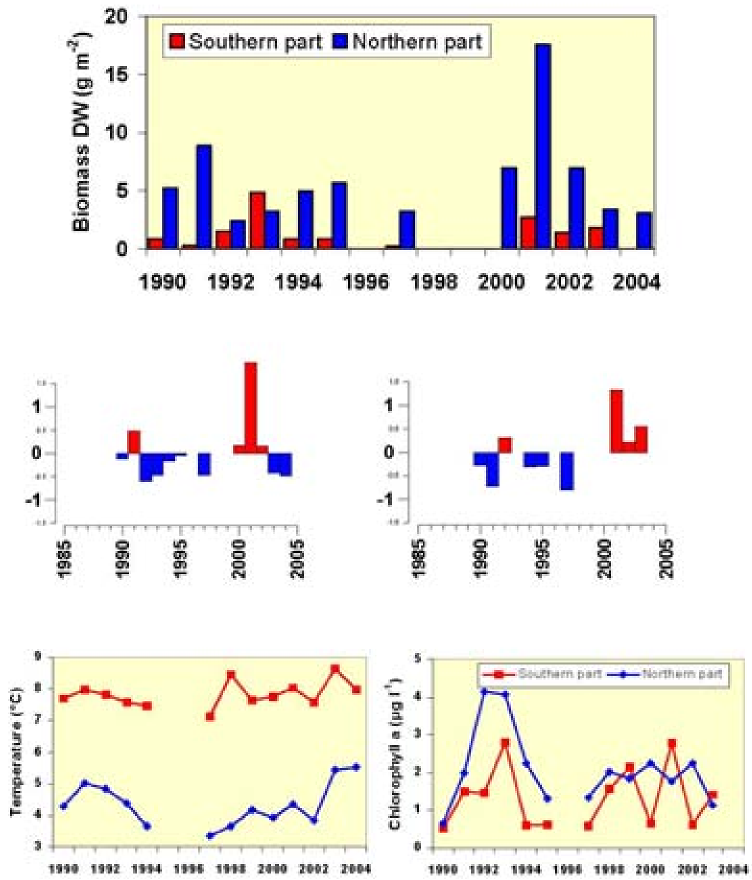

Figure 6: (upper panel) Zooplankton biomass at 0- to 50-m depth in Atlantic Water (southern part) and the East Icelandic Current Water (northern part) on Faroes section North in May 1990–2004. No data is available from 1996, 1998, 1999, 2000, and 2004 south due to too high phytoplankton abundance in the net samples. (middle panels) Interannual variability in terms of normalised anomalies of annual means, North and South (left and right, respectively). (lower panels) Temperature (left) and chlorophyll *a* (right) concentrations at 0- to 50-m depth on section North.

9–10: East and West off Svinøy (Norwegian Sea)

Two fixed transects are sampled within the "IMR Monitoring Programme" in the Norwegian Sea: the Svinøy transect (15 stations) and the Gimsøy transect (10 stations). These Norwegian Sea transects are sampled 4–10 times/yr. Additionally the Norwegian Sea is surveyed in May and July–August, both surveys ca. 50–100 stations. Data are stored at the TINDOR database at IMR. Periodic reports are made annually to the Ministry of Fisheries and in the IMR's Annual Report on Marine Ecosystems.

The development of zooplankton biomass in spring at the Svinøy transect showed very small variations among years in the period 1997–2004 (Figure 7), 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} (28–30 April) 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.

Chlorophyll at 10-m depth show that the bloom at the Svinøy transect occurs in late April and early May. A protracted post-bloom period persists through summer and early autumn, which is typical for the southern Norwegian Sea.

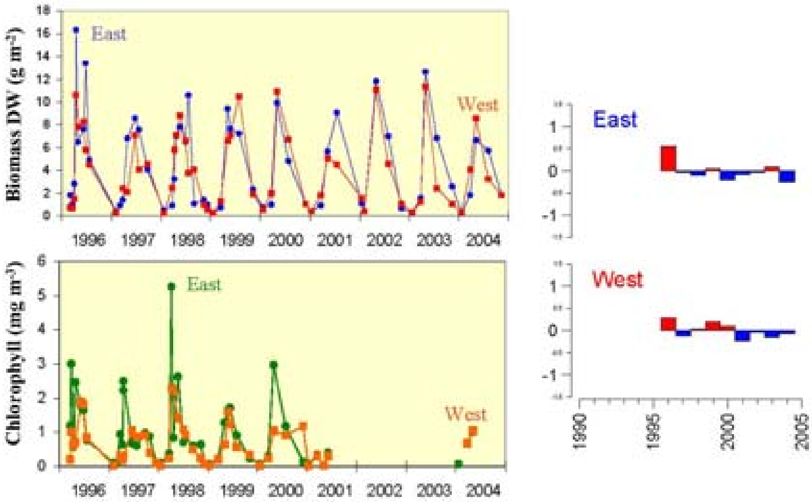

Figure 7: Left: Zooplankton biomass and chlorophyll at Svinøy transect. Right: Interannual variability in terms of normalised anomalies of annual means.

3.3 Barents Sea

Two standard sections are sampled within the "IMR Monitoring Programme" in the Barents Sea: the Fugløya-Bjørnøya transect (7 stations) and the Vardø N transect (8 stations). These Norwegian transects are usually sampled 3–6 and 2–3 times/yr, respectively. The zooplankton are sampled with two WP2-net hauls from 100 m to the surface, and from the bottom to the surface. Data are stored at the TINDOR database at IMR.

11–12: North and South off Fugløya-Bjørnøya

The data presented in Figure 8 stems from bottom-to-surface hauls. During the mid-1990s zooplankton biomass was high. Since then biomass has decreased, and the biomass in 2004 is the lowest observed in the sampling period. Fluctuations in biomass from year to year have also decreased over the years. Maximum biomass in the Barents Sea occurs somewhat later than in the Norwegian Sea.

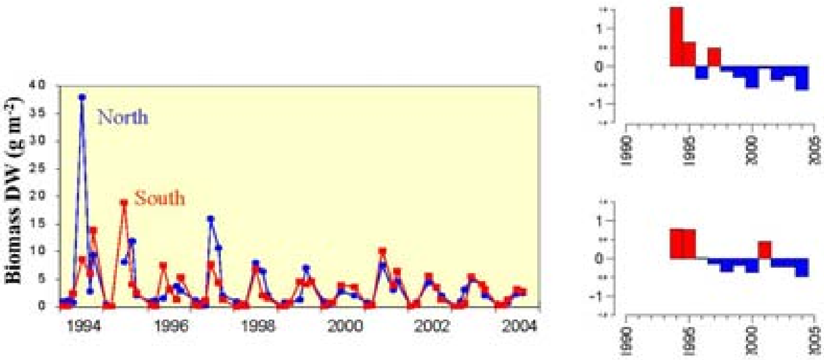

Figure 8: Left: Zooplankton biomass at Fugløya-Bjørnøya transect, divided in northern and southern sections. Right: Interannual variability in terms of normalised anomalies of annual means.

13–14: North and South off Vardø

Zooplankton biomass of the Vardø N standard section is high during the first three years, and low during the following years, except for 2003 (Figure 9). Low sampling frequency makes comparison with the other time-series difficult. Neither is the timing of seasonal cycles properly resolved with a sampling frequency of 2–3 per year.

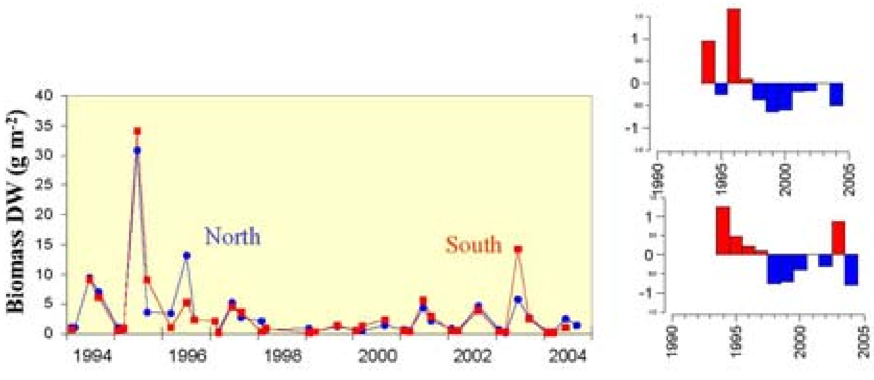

Figure 9: Left: Zooplankton biomass at Vardø transect, divided in northern and southern sections. Right: Interannual variability in terms of normalised anomalies of annual means.

3.4 Baltic Sea

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 from all HELCOM member states (http://www.helcom.fi; HELCOM, 1996).

15: Gulf of Finland (Estonia)

One sampling location was selected from the Estonian national monitoring programme to represent the Gulf of Finland. Zooplankton was collected by means of vertical hauls of Juday plankton net (mouth opening 38 cm and mesh size 168 µm). In recent years sampling stations have been visited at least 10 times per year, but sampling has been very infrequent in some years. Data are available since 1963, but because a good temporal coverage is needed to plot a time-series, only data since 1974 were used to illustrate the abundance of copepods (Figure 10).

Zooplankton in the Baltic Sea are typically rather small in size. The dominating copepod species in Estonian waters are *Eurytemora affinis* and *Acartia bifilosa*, the most numerous cladoceran is *Bosmina coregoni*, and rotifers also constitute a rather big share of the total zooplankton abundance. The maximum zooplankton biomass is usually observed in late summer; the abundance may reach in some years high numbers already in spring. The zooplankton abundance has been higher in the 1970s and lower in the 1980s. The decrease in zooplankton numbers in the early 1980s has been explained primarily by the beginning of stagnant conditions and lowered salinity (Lumberg and Ojaveer, 1991). The chlorophyll *a* in May as well as in August shows a slight increase, and water transparency has decreased.

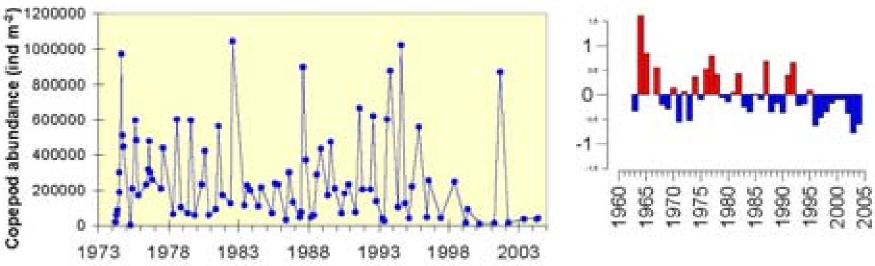

Figure 10: Left: Copepod abundance in the Gulf of Finland for the period 1974–2004. Right: Interannual variability in terms of normalised anomalies of annual means since 1963.

16: Gulf of Riga (Latvia)

The Gulf of Riga is the third largest gulf of the Baltic Sea and its monitoring is shared between Latvia and Estonia. The Latvian monitoring programme has ten monitoring stations for zooplankton sampled with various frequencies from three to fifteen times a year. The present data are from a station in the central Gulf, and months with the best data coverage through the years (May, August, and November) are used for illustration. The average abundance and biomass in May has always been low, as in 1996 and 2003 when the Gulf was covered with ice during the winter (Figure 11). The level of summer biomass is determined by the abundance of the cladoceran species *Bosmina longispina* and rotifers of the *Keratella* genus.

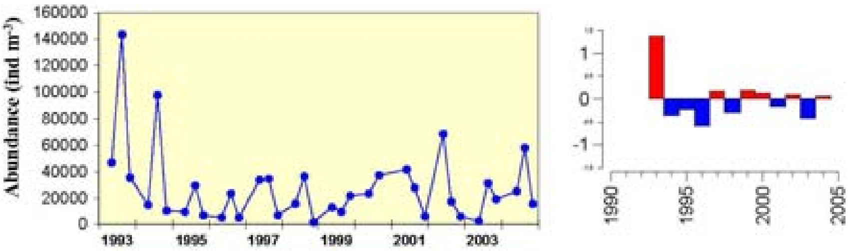

Figure 11: Left: Zooplankton abundance in the Gulf of Riga for the period 1993–2004. Right: Interannual variability in terms of normalised anomalies of annual means.

17: Central Baltic Sea (Latvia)

The mesozooplankton monitoring performed by the Latvian Fisheries Research Agency (LatFRA) has been conducted with varying intensity since 1959 with the goal to understand the effect of zooplankton on local commercial fish populations. Figure 12 shows the combined biomass development of the dominating calanoid copepods (*Pseudocalanus* sp., *Acartia* spp., *Temora longicornis, Centropages hamatus*) in the different seasons. Biomass was low at the beginning of the time-series and increased during the late 1970s/early 1980s. After a decreasing stock in the late 1980s/early 1990s the calanoid biomass has peaked in recent years.

A change in the dominance from *Pseudocalanus* sp. to *T. longicornis*/*Acartia* spp. during the last two decades has been documented. A decrease in *Pseudocalanus* sp. standing stocks has been caused by decreasing salinities due to the reduced inflow frequency of North Sea waters, while *Acartia* spp. and *T. longicornis* increased due to warmer temperatures (Möllmann *et al.*, 2000, 2003a). Both hydrographic effects were ultimately driven by climate changes (Matthäus and Nausch, 2003). The trends in these copepod species have been shown to affect cod recruitment (Hinrichsen *et al.*, 2002) as well as pelagic fish growth (Rönkkönen *et al.*, 2004; Möllmann *et al.*, 2003b, 2005).

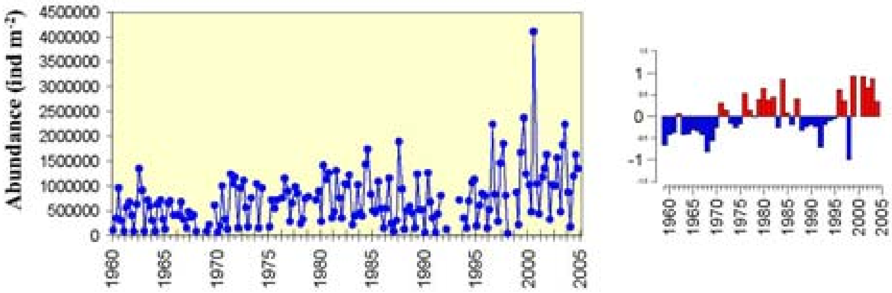

Figure 12: Left: Abundance of the main calanoid copepods in the Central Baltic Sea since 1960. Right: Interannual variability in terms of normalised anomalies of annual means.

18: Arkona Basin (Germany)

This station in Arkona Basin (54°55'N, 13°30'E, Germany) 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 of 10 000–50 000 ind m^{-3} are typically observed during the seasonal cycle in the western Baltic Sea (Figure 13). Peaks of plankton observed in spring in years 1983, 1988, 1995, 1998, 2000, and 2002 were due to mass developments of rotifers, which often happens 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 have occurred in the last 10 years. Chlorophyll concentration at the Arkona Basin shows high values all year round, with seasonal spring blooms over 6 µg l^{-1} and over 2 µg l^{-1} most of the year (Figure 13). A decreasing trend has been noted, however, since 1994 where maximum values reach 11 µg l^{-1} (Wasmund and Uhlig, 2003). Normalised anomalies of annual means in Figure 13 (right) show 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 and no trends are apparent.

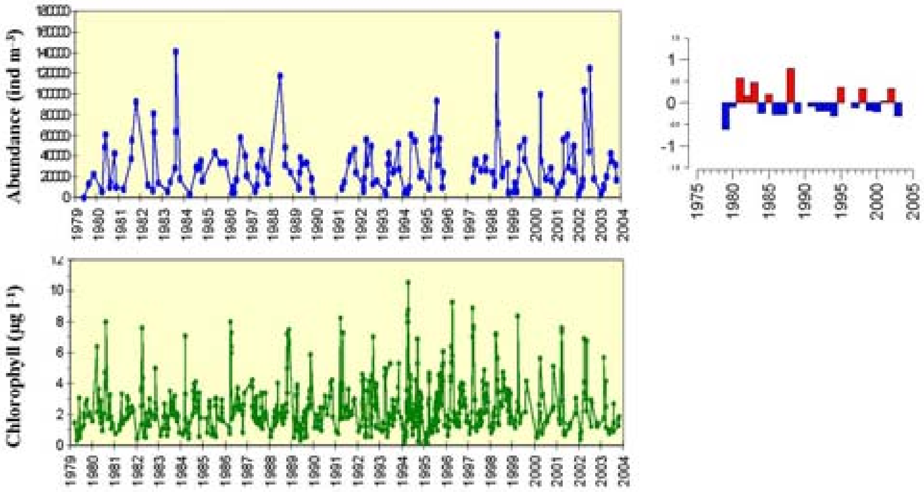

Figure 13: Left: Zooplankton and phytoplankton abundance in the Arkona Basin (Baltic Sea) in 1979–2003. Right: Interannual variability of zooplankton in terms of normalised anomalies of annual means.

3.5 North Sea and English Channel

19: 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. The time-series were started at the Biologische Anstalt Helgoland and have been continued after the institutional re-organisation in cooperation with the German Centre for Marine Biodiversity and the Federal Maritime and Hydrographic Agency.

The purpose of the program is to document 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.* (2001, 2004), Heyen *et al.* (1998), and Johannsen *et al.* (1999).

Small copepods represent a significant fraction of the total zooplankton in Helgoland. Seasonal cycles and year-to-year variability of small copepods can be observed in Figure 14. The ~30-year time-series 1975–2003 shows two periods (Figure 14, right). A first period 1975–1990 when the copepods showed an increasing trend; since then (1991–2003), the population has been oscillating quite regularly with the average values of abundances around halfway through the first period (4293 vs. 2441 ind m^{-3} in the first and second periods, respectively).

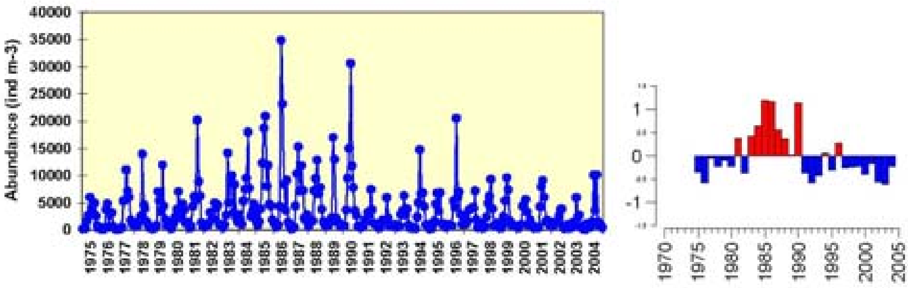

Figure 14: Left: Abundance of small copepods at Helgoland. Right: Yearly differences in the annual mean value.

In 2004 the composition of the mesozooplankton abundance was influenced by the mass recruitment of the warm water cladoceron *Penilia avirostris* that first appeared in the North Sea in 1990 in negligible numbers, reappeared at the end of the nineties at a higher abundance level, and reached an abundance level exceeding 10 000 ind m^{-3} in the last year. In addition to the higher abundance the population increase also happened earlier than in the preceding years.

Also in 2004 the calanoid copepods were less abundant (e.g., *Acartia* spp. reached 13% and *Temora longicornis* 67% less than their long-term mean abundance). The *Oithona* spp. ranked higher with almost twice the long-term mean. The abundance dynamics display a higher winter dynamics and a retarded spring increase of calanoid copepods. The summer abundance exceeds the long-term mean.

The response in seasonality of plankton to changing temperatures (which is common to all populations) is not the same in all species. Some copepod species (e.g., *Centropages* spp. and *Temora longicornis*) were observed much earlier in the year 2004; others like the *Acartia* spp., *Paracalanus* spp., and *Pseudocalanus elongatus* had their start of season six to eight weeks later than in mean years.

A paradigmatic example is that of the appendicularian *Oikopleura dioica*. This abundant filter-feeder depends on the winter temperatures in its phenological "start of season". A trend can be observed in the shift of the "start of season" from week 27 to week 24 in recent years. This trend is hardly seen in the "middle of season" and in the "end of season". The distance from the "start of season" to the "end of season" is a measure of the length of the season. While *Oikopleura dioica* was present in the plankton in the 1970s for eight to nine weeks, the length of the season has now reached a mean length of 12 weeks (Figure 15). This improves the living conditions of fish larvae predating upon the Appendicularia.

Figure 15: ***Oikopleura dioica*** **length of season at Helgoland Roads; yearly measurements and trend.**

20: Stonehaven (Scotland, NW North Sea)

The Stonehaven sampling site is located at 56°57.80'N, 02°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 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, 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 interannual variability evident. This is also seen in the variations observed in the phytoplankton and chlorophyll data (Figure 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 (Figure 16) but a lower observed abundance overall in 2001 and 2002. In 2003 zooplankton peaks again with the second highest values of the time-series.

The time-series, although short, is at a fairly high observational frequency, thus allowing 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.

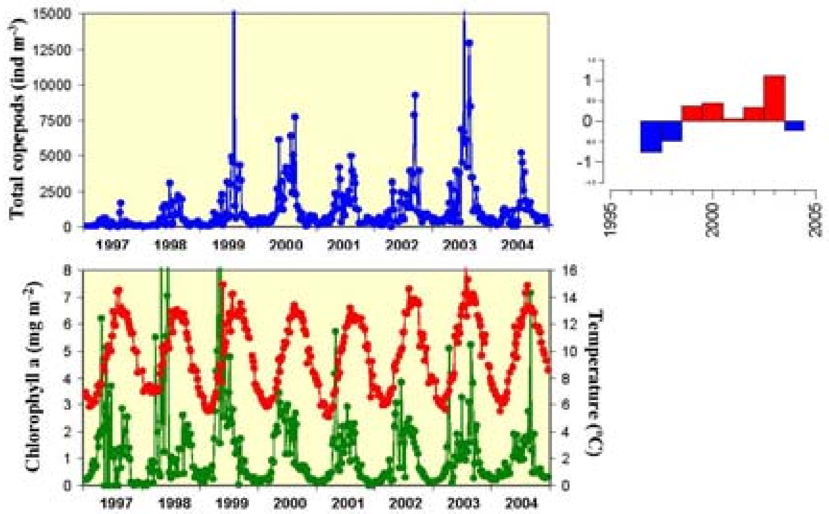

Figure 16: Left: weekly abundance of copepods and chlorophyll at Stonehaven and values of sea surface temperature. Right: Interannual variability in terms of normalised anomalies of annual means.

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

21: Plymouth (English Channel)

Zooplankton is collected weekly at station L4 (04°13'W, 50°15'N) about 10 miles SW of Plymouth in the Western English Channel. The station is about 50 m 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 sea floor to the surface. Samples are split and counted for major taxonomic groups as well as identifying some groups (particularly copepods) to species level. For chlorophyll *a* measurement, three replicates of 100 ml surface water from L4 are filtered through 25 mm GF/F filters. These filters are then stored in the freezer until extraction in 10 ml acetone. The extract is then analysed using a 10 AU Turner fluorometer. The L4 data are maintained at the Plymouth Marine Laboratory and are publicly available through a website (www.pml.ac.uk/L4).

Table 1: Percentages and averages of the top copepod species at Plymouth L4 station along the sampling period 1988–2003 time-series and in 2004.

RANK	TAXA	% TOTAL ZOOPLANKTON	YEARLY AVERAGE	% TOTAL ZOOPLANKTON	2004 AVERAGE
		1988–2003	1988–2003 (N/m³)	2004	(N/m³)
1	*Pseudocalanus*	12.34	393	5.08	202
2	*Oithona*	12.2	389	11.95	474
3	*Paracalanus*	10.28	323	4.62	184
4	*Oncaea*	9.97	318	20.59	818
5	*Temora longicornis*	9.37	299	6.98	277
6	Cirripede nauplii	8.82	281	7.22	287
7	*Acartia clausi*	6.39	204	3.37	134
8	*Evadne*	5.97	190	4.62	183
9	*Corycaeus*	2.43	77.5	2.96	118
10	Appendicularia	2.41	77	4.81	191
Total		80.18	2551.5	72.2	2867.1
Total zooplankton (N/m³)			3188.8		3970.1

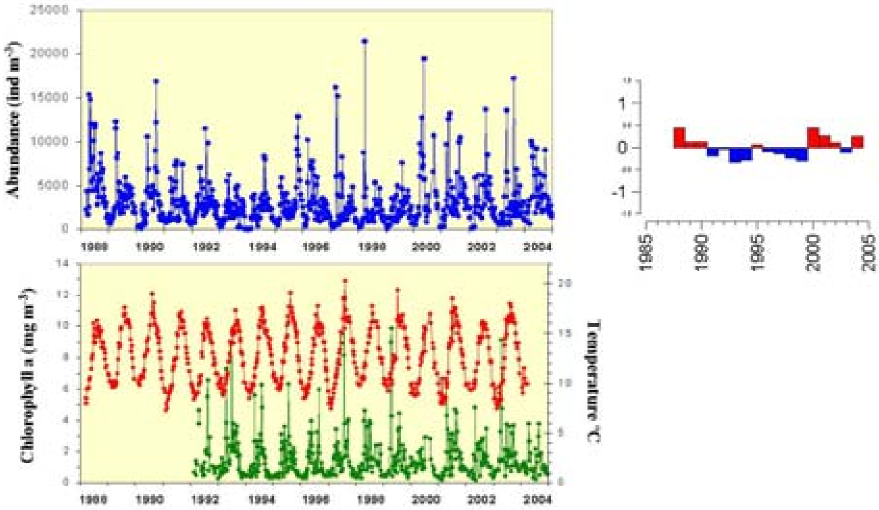

Figure 17: Left: Weekly chlorophyll *a* concentration and zooplankton abundance at Station L4 (Plymouth). Right: Annual mean zooplankton abundance (upper plot represents annual mean values and mean of annual means (dotted line), and lower plot stands by yearly differences in the annual mean value).

The ten most abundant species at L4 have been ranked according to their annual mean proportion of the total zooplankton (Table 1). In 2004, some drastic changes in the zooplankton composition can be observed within the top 4 species over the time-series. Whereas *Pseudocalanus* and *Paracalanus* contributions to the total population decreased by 49% and 43% respectively, the contribution of *Oncaea* increased by 157%. This is the second time over the time-series that *Oncaea* is the most abundant species in the zooplankton community. In 1995, *Oncaea* abundance reached 918 Nm^{-3} representing 27.5% of the zooplankton abundance.

Weekly zooplankton abundance as well as chlorophyll *a* concentration at L4 shows clear seasonal cycles (Figure 17). Peaks of high zooplankton abundance and Chlorophyll *a* concentration are regularly observed in spring and in late summer to beginning of autumn. Zooplankton abundance at L4 shows two decreasing trends from 1988 to 1995 and from 2001 to 2004 (Figure 17). This is mainly due to relatively low abundances of the spring species *Paracalanus* and *Acartia clausi*. Small copepods like *Oncaea*, *Oithona*, and *Corycaeus* contribute greatly to the total zooplankton population. 2004 shows a decline in zooplankton population with the top ten species all below their typical average values (*Corycaeus* and the Appendicularia showed little difference), apart from *Oncaea* whose abundance increased by 39%.

3.6 Bay of Biscay and Iberian coast

22: Santander (Southern Bay of Biscay)

Five 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), 1993 (Cudillero), and 2001 (Gijón) to the present.

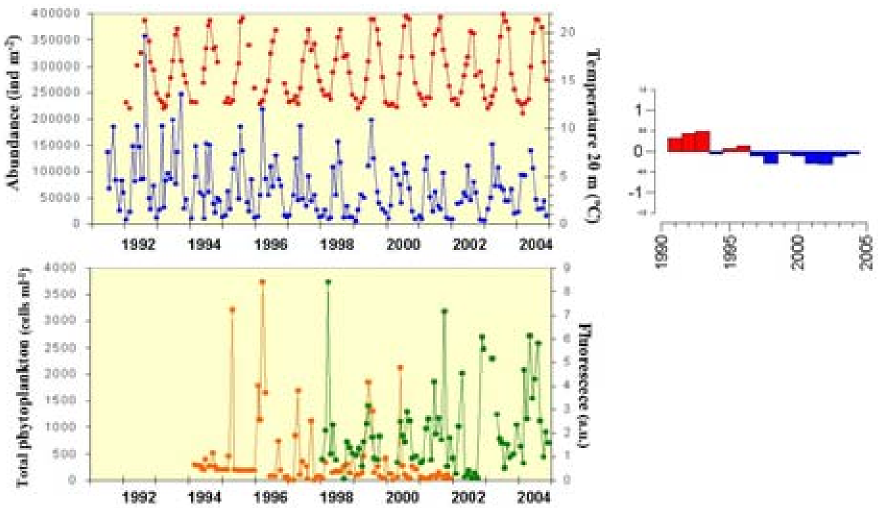

Figure 18: Left: (upper panel) Monthly zooplankton abundance and (lower panel) phytoplanton cells (orange line, left scale) and fluorescence in arbitrary units (green line, right scale) in a neritic station off Santander. Right: Interannual variability in terms of normalised anomalies of annual means.

Long-term changes of zooplankton abundance at Santander show a slightly decreasing trend (Figure 18). The result is in opposition to the upward trend shown by the water column stratification index (Lavin *et al.*, 1998). This relationship between zooplankton and environmental conditions highlights the importance that the longer duration of the water column stratification 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).

23: 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, showing a substantial year-to-year variability.

Zooplankton values in A Coruña (Figure 19) differ to those in Santander (Figure 18): zooplankton abundance is higher in A Coruña and the time-series shows an increasing trend since 1997. 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 19 is composed of two curves, one for zooplankton >250 µm, and the other for zooplankton >200 µm].

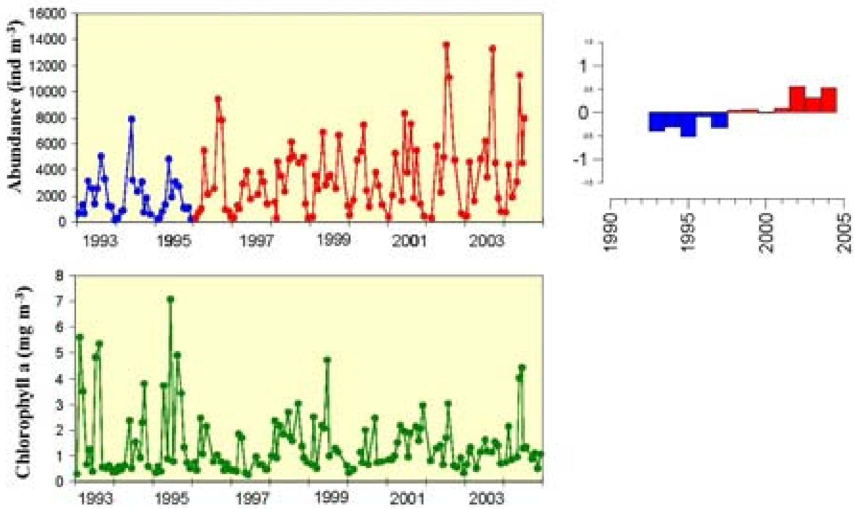

Figure 19: Left: Monthly zooplankton abundance and chlorophyll in a neritic station off A Coruña. Right: Interannual variability in terms of normalised anomalies of annual means.

4 Discussion

4.1 A general overview of the North Atlantic

The time-series of total copepod abundance (numbers per sample (~3 m^{-3})) from 1946 to 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. 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 a copepod abundance in 2002 that is slightly higher than usual. These results are coherent with the time-series shown in the regional description.

Figure 21 shows the long-term interannual values from 1946 to 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 content (Hays and Lindley, 1994) and is closely related to biomass estimates from satellite observations (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 interannual 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 northeast Atlantic can be divided into three hydroclimatic regions. The first division lies approximately north and south of a line of 53°N and in the region north of about 53°N, while the two other regions (the subarctic gyre and the North Sea) are defined on the basis of their long-term monthly changes in SST. 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 (Figure 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 realising the predatory pressure over the phytoplankton and trigger an increase in their biomass, which could explain the increase in the CPR colour index.

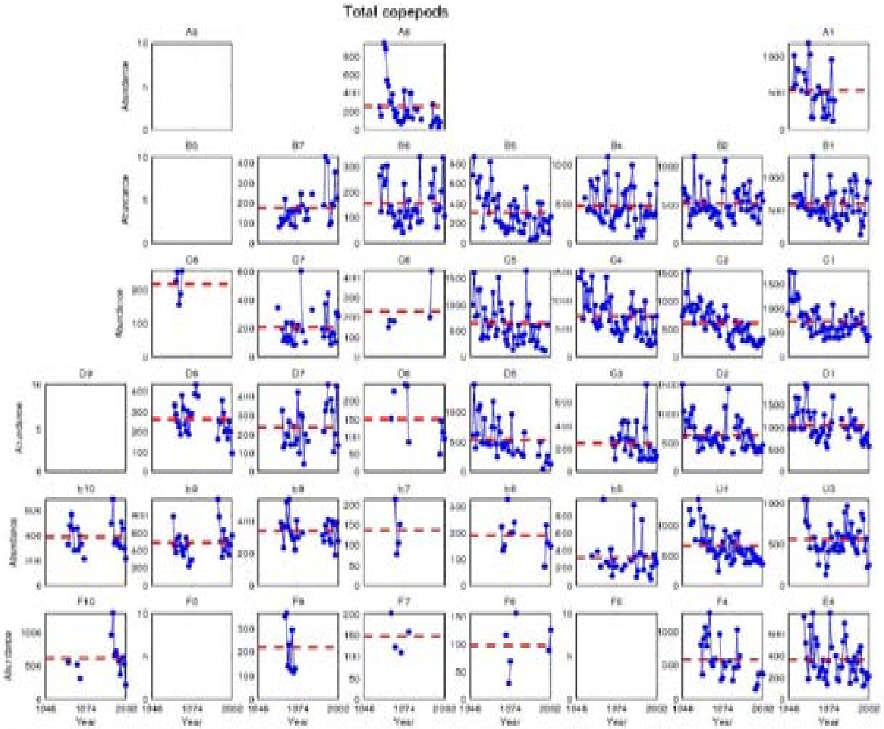

Figure 20: Time-series from 1946 to 2002 of the total copepod abundance in CPR standard areas in the North Atlantic (see Figure 1 for map).

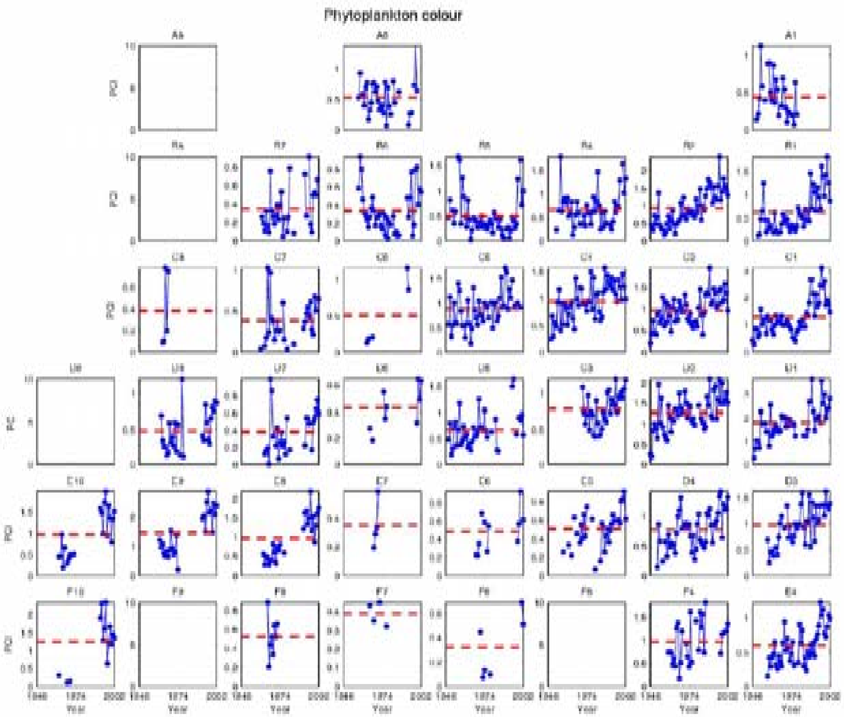

Figure 21: Time-series from 1946 to 2002 of the Phytoplankton Colour Index in CPR standard areas in the North Atlantic (see Figure 1 for map).

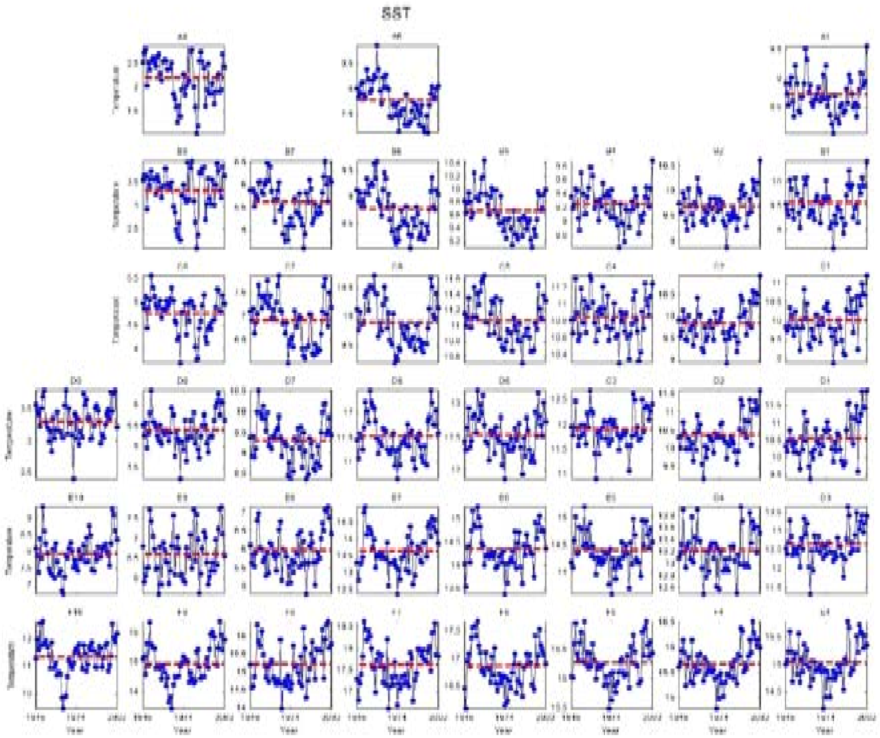

Figure 22: Time-series from 1946 to 2002 of the Sea Surface Temperature in CPR standard areas in the North Atlantic (see Figure 1 for map).

4.2 Latitudinal patterns and relationship with temperature

During the preparation of the anomaly fields for this status report, we noticed that the anomaly plots from times series in higher latitudes tended to have a visually greater span of variability (between the minimum and maximum anomaly values) than those in lower latitudes. To examine this quantitatively, we calculated a "Variability Span" for each time-series by subtracting the minimum yearly anomaly value from the maximum (for example, if a time-series had a minimum anomaly value of −0.5 and a maximum of 1.0, it would have a 1.5 variability span). Plotting these span values against the latitudes of the time-series sites, we found the variability span of most time-series correlated nicely with their location latitude (Figure 23).

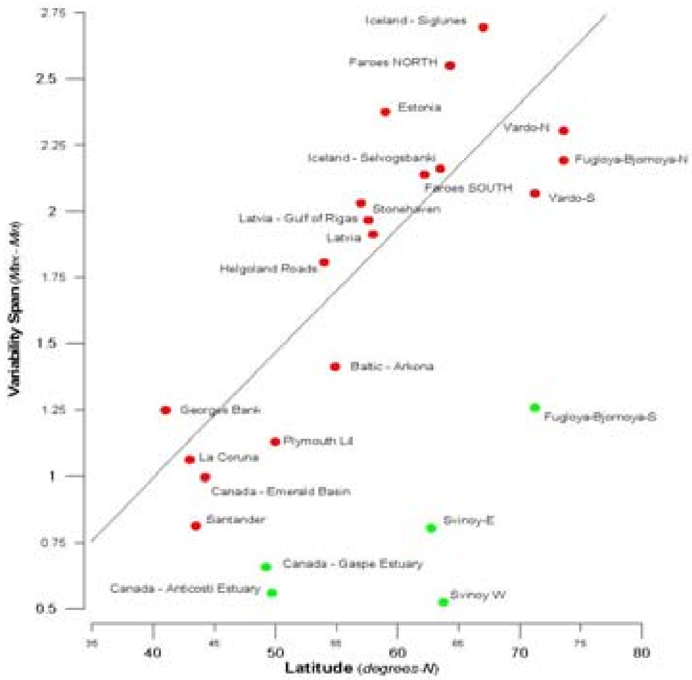

Figure 23: Time-series "variability span" as a function of sampling site latitude. Green dots were excluded from the regression calculation – see discussion below.

As zooplankton production is dependent on water temperature, which is also correlated with latitude, we then examined the variability span as a function of water temperature. Annual mean water temperatures, averaged from all values sampled from 0- to 50-meters depth, were calculated for each time-series using the World Ocean Atlas 2001 temperature fields (Stephens *et al.*, 2002). This average-over-depth value was used instead of surface temperatures because it better represented the vertical environment over which the zooplankton were actually sampled. Plotting the variability span against mean temperature, we found a strong correlation between variability span and mean water temperature (Figure 24).

In general, the year-to-year relative variability in zooplankton biomass or abundance decreases with increasing mean water temperature. It is already known that the growth and production of zooplankton are dependent on food availability and water temperature. In regions with colder water, the gradient between winter and summer air and water temperatures may be larger than those in the warmer water regions. These larger differences would lead to stronger seasonal winds and mixing between the surface and deeper nutrient-rich waters, resulting in stronger phytoplankton blooms and ultimately stronger zooplankton responses.

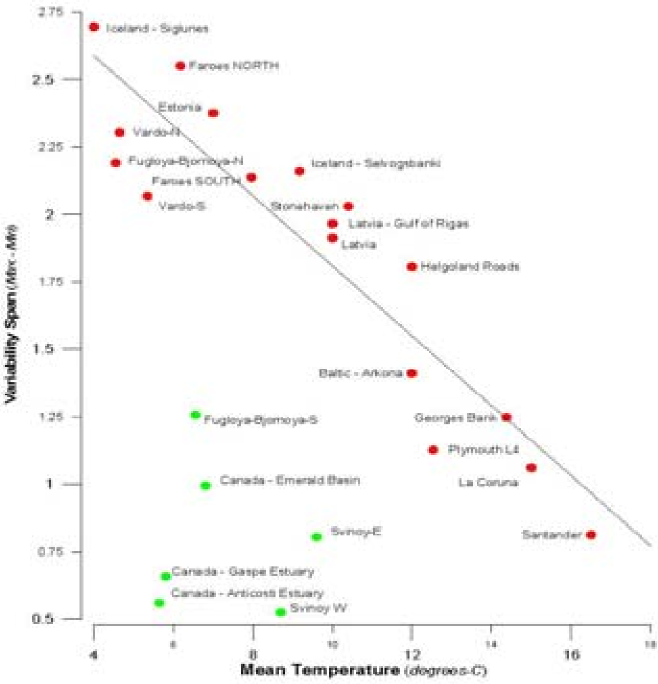

Figure 24: Time-series "variability span" as a function of sampling site mean temperature. *Green dots were excluded from the regression calculation.*

To examine the "outlying" time-series (green dots) in both figures, we first checked to see if it was an issue of outlying mean water temperatures versus latitude. We plotted the times series mean temperatures against their sampling site latitude (Figure 25).

The three remaining outliers in Figure 25 represent estuarine or very near-shore sampling sites. The dynamic physical environment of these sites is likely responsible for separating them from the other more "open ocean" time-series. Perhaps these environments experience consistently well-mixed (nutrient rich) waters, or are hindered by secondary factors (e.g., large salinity changes).

Unlike Figures 23 and 24, the Svinøy (East and West) sites and Fugløya-Bjørnøya (South) sites now fit nicely along the temperature vs. latitude regression line. Temperature seems to be reasonable, yet these sites exhibit very low "variability spans" relative to other sites in the same latitude and temperature ranges (Figures 23 and 24). Olsen *et al.* (2003) found that strong current patterns off the coast of Norway were responsible for spring bloom differences within and between the Fugløya-Bjørnøya North and South sampling sites (Figure 26). These differences would ultimately affect the zooplankton populations. The same currents also play a role in the Svinøy sites (Webjørn Melle, personal communication).

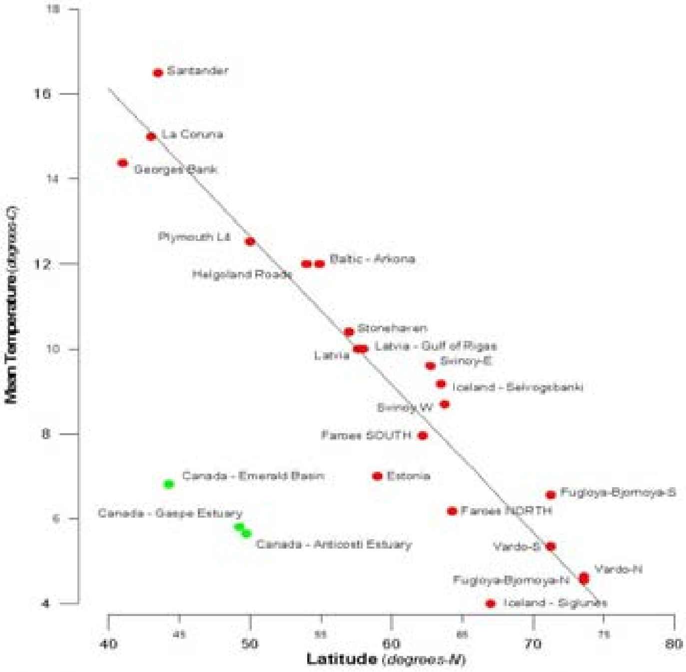

Figure 25: Time-series mean temperature as a function of sampling site latitude. ***Green dots were excluded from the regression calculation.***

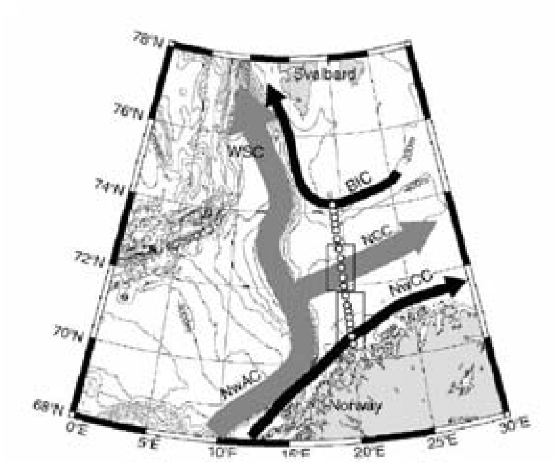

Figure 26: Water mass circulation along the northern Norwegian coast and in the Barents Sea (source: Olsen *et al.*, 2003).

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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, Narraganssett, RI	AZMP	AZMP	AZMP
Sampling location	Georges Bank	Halifax Line Stn 2 (HL2) West Atlantic, Scotian Shelf	Gaspé Current	Anticosti Gyre
Latitude (N)		44°16'N	49°24'N	49°72'N
Longitude (E-W)		64°19'W	66°20'W	66°25'W
Station Depth (m)		150	265	265
Period of data available	1971–ongoing	1998–ongoing	1999–on going	1999–on going
Frequency (number of cruises/yr)	4–6	Monthly/Bi-weekly (~20)	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	200	202*	202*
Depth of sampling (m)		150	Bottom-surface	Bottom-surface
Ancillary data		hydrography, nutrients, phytoplankton, chlorophyll		
Contact person	David G. Mountain	Erica Head/Glen Harrison	Michel Harvey	Michel Harvey
Email address	dmountain@ whsun1.wh.whoi.edu	HeadE@mar.dfo-mpo.gc.ca	HarveyM@dfo-mpo.gc.ca	HarveyM@dfo-mpo.gc.ca
Location of data		BIOCHEM database*, DFO, BIO	MEDS (Ottawa)	MEDS (Ottawa)
Observations (*)		Data will reside at MEDS in Ottawa, when database development is complete	* the mesh size of the net used in 1999 was 158 µm	* the mesh size of the net used in 1999 was 158 µm

Characteristics of the collections used (Table of Metadata, continued)

COUNTRY	ICELAND (5)	ICELAND (6)	FAROE (7)	FAROE (8)	NORWAY (9)
Monitoring programme	MRI-Iceland	MRI-Iceland	FFI-Faroe Islands	FFI-Faroe Islands	IMR-Bergen
Sampling location	Siglunes-transect	Selvogsbanki-transect	Faroe Shelf	Faroe Shelf	Svinøy transect East Norwegian Sea
Latitude (N)	*	*	62°20' to 63°N	63° to 64°30'N	*
Longitude (E-W)	*	*	6°05'W	6°05'W	*
Station Depth (m)	*	*	*	*	*
Period of data available	1961–ongoing	1971–ongoing	1989–ongoing	1989–ongoing	1993–ongoing
Frequency (number of cruises/yr)	Yearly (1 May–June)	Yearly (1 May–June)	Yearly (late May)	Yearly (late May)	6–10
Gear/diam (cm)	1971–91: Hensen; 1992–present: WP-2	1971–91: Hensen; 1992–present: WP-2	1990–1991: Hensen; 1992–present: WP-2	1990–1991 Hensen; 1992–present: WP-2	WP-2 (56)
Mesh (µm)	200	200	200	200	180
Depth of sampling (m)	0–50	0–50	0–50	0–50	0–200
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	Eilif Gaard	Webjørn Melle
Email address	astthor@hafro.is	astthor@hafro.is	eilifg@frs.fo	eilifg@frs.fo	webjorn@imr.no
Location of data	database MRI	database MRI	FFL	FFL	TINDOR database, IMR
Observations (*)	Transect of 8 stns from 66°16'N, 18°50'W (bottom depth: 80 m) to 68°00'N, 18°50'W (bottom depth: 1045 m)	Transect of 5 stns from 63°41'N, 20°41'W (bottom depth: 46 m) to 63°00'N, 21°28'W (bottom depth: 1004 m)	Transect with bottom depth from 50 to100 m	Transect with bottom depth from 50 to100 m	4 stations in the eastern part of a transect of 15 stns. 62°22'N, 5°12'E (bottom depth: 160 m) to 63°12'N, 3°24'W (bottom depth: 1000 m)

Characteristics of the collections used (Table of Metadata, continued)

COUNTRY	NORWAY (10)	NORWAY (11)	NORWAY (12)	NORWAY (13)	NORWAY (14)
Monitoring programme	IMR-Bergen	IMR-Bergen	IMR-Bergen	IMR-Bergen	IMR-Bergen
Sampling location	Svinøy transect West Norwegian Sea	Western Barents Sea (Fugløya-Bjørnøya; North)	Western Barents Sea (Fugløya-Bjørnøya; South)	Eastern Barents Sea (Vardø-North)	Eastern Barents Sea (Vardø-South)
Latitude (N)	*	*	*	*	*
Longitude (E-W)	*	*	*	*	*
Station Depth (m)	*	*	*	*	*
Period of data available	1993–ongoing	1994–ongoing	1994–ongoing	1994–ongoing	1994–ongoing
Frequency (number of cruises/yr)	6–10	4–10	4–10	4–10	4–10
Gear/diam (cm)	WP-2 (56)	WP-2 (56)	WP-2 (56)	WP-2 (56)	WP-2 (56)
Mesh (µm)	180	180	180	180	180
Depth of sampling (m)	0–200	0–100	0–100	0–100	0–100
Ancillary data	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll	hydrography, nutrients, chlorophyll
Contact person	Webjørn Melle	Webjørn Melle	Webjørn Melle	Webjørn Melle	Webjørn Melle
Email address	webjorn@imr.no	webjorn@imr.no	webjorn@imr.no	webjorn@imr.no	webjorn@imr.no
Location of data	TINDOR database, IMR	TINDOR database, IMR	TINDOR database, IMR	TINDOR database, IMR	TINDOR database, IMR
Observations (*)	4 stations in the western part of a transect of 15 stns. from 62°22'N, 3°08'E (bottom depth: 1100 m) to 64°40'N, 0°00'W (bottom depth: 2700 m)	3 stations in the northern part of a transect from 72°30'N, 19°34'E (depth 380 m) to 74°40'N, 19°13'W (depth 140 m)	4 stations in the southern part of a transect from 70°30'N, 20°00'E (bottom depth: 130 m) to 72°40'N, 19°41'W (bottom depth: 311 m)	7 stations in the northern part of a transect from 73°15'N, 31°13'E (depth 280 m) to 75°30'N, 31°13'W (depth 352 m)	5 stations in the southern part of a transect from 70°30'N, 31°13'E (depth 192 m) to 72°30'N, 31°13'W (depth 298 m)

Characteristics of the collections used (Table of Metadata, continued)

COUNTRY	ESTONIA (15)	LATVIA (16)	LATVIA (17)	GERMANY (18)	GERMANY (19)
Monitoring programme	Monitoring of fish food resources	National monitoring programme of Latvia	LatFRA-monitoring	IOW	BSH and DZMB
Sampling location	Gulf of Finland Baltic Sea	Gulf of Riga Baltic Sea	Baltic Sea	Arkona Basin, Baltic Sea	Helgoland
Latitude (N)	59°43'N	57°37'N	south of 58ºN	54º 55'N	54º11.18'N
Longitude (E-W)	25°01'E	23°37'E	east of 15ºE	13º 30'E	7º54'E
Station Depth (m)	100	54	variable, max. 200	48	
Period of data available	1974–2004	1993–present	1959–2004 (with gaps)	1973–ongoing	1975–ongoing
Frequency (number of cruises/yr)	1–4	3–4	seasonally (in general February, May, August, November)	Seasonally (4)	Monday, Wednesday, and Friday
Gear/diam (cm)	Juday net 38cm	WP-2	Juday/36 cm	WP-2	Hydrobios and Calcofi
Mesh (µm)	168	100	160	100	150 and 500
Depth of sampling (m)	0-bottom	50	variable, max. 100 m		
Ancillary data		hydrography, nutrients, chlorophyll a, phytoplankton species composition	temperature, salinity		hydrography, nutrients, chlorophyll, pigments (recently)
Contact person	Arno Põllumäe	Anda Ikauniece	Georgs Kornilovs, Christian Möllmann	Lutz Postel	Wulf Greve
Email address	arno@sea.ee	anda@monit.lu.lv	georgs.kornilovs@latzra.lv, cmo@dfu.min.dk	lutz.postel@ io-warnemuende.de	wgreve@ meeresforschung.de
Location of data	Estonian Marine Institute, University of Tartu	Institute of Aquatic Ecology, University of Latvia	LatFRA, Riga, Latvia	German Ocean Data Centre, IOW	
Observations (*)			variable number and location of stations		

Characteristics of the collections used (Table of Metadata, continued)

COUNTRY	UK (20)	UK (21)	UK	SPAIN (22)	SPAIN (23)
Monitoring programme	FRS-MLA	L4-PML/UK	Continuous Plankton Recorder	IEO-SPAIN	IEO-SPAIN
Sampling location	Stonehaven, Aberdeen	Plymouth	North Atlantic	Santander	A Coruña
Latitude (N)	56°57.80'N	50°15'N		43°34.4'N	43°25.3'N
Longitude (E-W)	02°06.80'W	4°13'W		3°47.0'W	8°26.2'W
Station Depth (m)	50	50	*	110	77
Period of data available	1997–ongoing	1988–1997*	1946–ongoing	1991–ongoing	1990–ongoing
Frequency (number of cruises/yr)	Weekly (52)	Weekly (~40)	approx 12, some missing mon/yrs	Monthly (12)	Monthly (12)
Gear/diam (cm)	Bongo/40	WP2	CPR, aperture 1.24 cm x 1.24 cm	Juday 50	Juday 50
Mesh (µm)	200	200	280	250	1971–96: 250; 1996–present: 200
Depth of sampling (m)	47	50	7–10	50	50
Ancillary data	hydrography, nutrients, chlorophyll	hydrography, CNH, chlorophyll, *Calanus* egg production	Temperature, colour index	hydrography, nutrients, chlorophyll, phyto. cells.	hydrography, nutrients, chlorophyll, phyto. cells.
Contact person	Steve Hay	Roger Harris/X. Irigoien	Chris Reid	Luis Valdés	Maite Alvarez-Ossorio
Email address	haysj@marlab.ac.uk	rph@ccms.ac.uk	pcre@wpo.nerc.ac.uk	luis.valdes@gi.ieo.es	maite.alvarez@co.ieo.e s
Location of data	SERAD, FRS MLA	PML/CCMS	SAHFOS database	Database SIRENO IEO	Database SIRENO IEO
Observations (*)		Later samples in process	Data correspond to several CPR routes and are presented here as the CPR standard areas of the North Atlantic		

Annex 7: Action Plan Progress Review

Year	Committee Acronym	Committee name	Expert Group	Reference to other committees	Expert Group report (ICES Code)	Resolution No.		
2004/2005	OCC	Oceanography	WKZE		2005/C:02	2C02		
Action Plan	Action Required	ToR's	ToR	Satisfactory Progress	No Progress	Unsatisfactory Progress	Output (link to relevant	Comments (e.g., delays, problems, other types of progress, needs, etc.
No.	Text	Text	Ref. (a, b, c)	S	0	U	Report code and section	Text
1.2, 1.3, 1.6, 1.7, 1.8, 1.10, 1.11, 1.12, 1.13, 2.2, 3.2, 4.2, 4.11, 4.14, 5.9, 5.16, 5.17, 6.1, 6.4, 10.1	Please see Action Plan Items listed below	Update 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;	a)	The Status Report has progressed with new sites/ data and new synthesis. Publication now in ICES Cooperative Research Report is good. New technologies are emerging which will allow enhanced efforts in future. Method standardisation and required sampling consistency are often conflicting needs in monitoring time series.				Integration with WGPE and Phytoplankton Monitoring Sites is not going well, though WGHABD more interested.
1.2, 1.6, 1.7, 1.8, 1.10, 1.11, 1.13, 2.2, 4.11, 5.9, 5.10, 5.16, 5.17, 6.1	Please see Action Plan Items listed below	Provide future development and collaborative approaches in plankton time series measurements and interpretation, including collaboration with global synthesis attempts and regional comparisons;	b)	Contacts and collaboration are established with SCOR WG on Global Comparisons of Zooplankton Time Series. Contact has been established with CIESM Zooplankton monitoring work and integration efforts. WGZE website established (non-ICES provision) to aid future communications, integration and collaborations.				
1.1, 1.2, 1.3, 1.6, 1.7, 1.8, 1.10, 1.11, 2.2, 3.2, 4.11, 4.14, 5.16	Please see Action Plan Items listed below	Review geographic and seasonal patterns across the range of plankton monitoring sites in the ICES area with emphasis on key species;	c)	Several sites and species reviewed and some interesting changes and variation noted. Workshop approaches to collaboration, data synthesis and comparison are productive/ insightful/ educational, and should be strongly encouraged. Operational models and phenological approaches are increasingly important to regional management				
1.1, 1.2, 1.3, 1.5, 1.6, 1.7, 1.8, 1.10, 1.11, 1.13, 2.2, 3.2, 4.2, 4.11, 4.14, 4.15, 6.4	Please see Action Plan Items listed below	Develop a workplan to deliver relevant data sets to the North Sea ecosystem assessment to be completed by REGNS in 2006;	d)	Plankton Status Report is the basis for contribution, some extensive data sets are in North Sea. REGNS contact with data originators will yield more detailed data sets as required. Interpretation of REGNS data complex will be problematic without some further gathering of the providers.				
1.1, 1.2, 1.6, 1.8, 1.10, 1.11, 1.14, 2.2, 2.8, 2.9, 3.2, 3.3, 3.12, 4.10, 4.11, 4.12, 4.15, 5.2, 5.10, 5.15, 5.16, 6.1, 6.4	Please see Action Plan Items listed below	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)	This topic was reviewed and these methods are considered highly relevant and a call was made for a future workshop approach.				

Action Plan Progress Review (continued)

		Review preparations and progress towards:	f)					
1.1, 1.2, 1.3, 1.6, 1.10, 2.2, 2.3, 3.2, 4.11	Please see Action Plan Items listed below	A Workshop on enzymatic and other biochemical and molecular methods to measure or assess rate processes in zooplankton,	(i)	Some progress towards organisation of seagoing and lab workshops in 2006 in Canary Isles, later perhaps others at other centres.				
		The 4th International Zooplankton Production Symposium to be held in Japan 2007,	(ii)	The announced Theme for the symposium is: Human and Climate Forcing on Zooplankton Populations. Arrangements are going well, please note WGZE resolution to publish output in ICES Journal of Marine Science edition.				WGZE felt that the ICES page needs some work and to be made more demonstrative
		A "virtual" Workshop to further the collaborative comparison and analyses of plankton time series and other zooplankton data in the North Sea areas,	(iii)	This is stuck to some extent due to ICES lack of provision/support for web based collaboration. WGZE has now established its own website and hopes to progress this area.				
		A further taxonomic Workshop to advance the ICES Identification Leaflets for Plankton, also to encourage the training and retention of plankton taxonomic skills. This should focus to a large extent on gelatinous plankton taxonomy.	(iv)	This has been an ongoing subject and a further workshop at SAHFOS ,Plymouth, UK is planned. Other efforts at revising and enhancing work on taxonomy were discussed, as were links to genetics and molecular approaches (e.g.CMarZ)				Need to revise ICES Fiches sheets approach to web based product. The web site is hard to navigate to get to the online downloadable pdf files, and should be improved.
5.13, 5.17, 6.1, 6.4, 6.5	Please see Action Plan Items listed below	Review and consider the role of meroplankton in pelagic shelf seas ecosystems and their contribution to productivity in these areas.	g)	Meroplankton research was reviewed and WGZE concluded that meroplankton are very important but understudied due to difficulties with identification of larvae of benthic organisms. There is high importance in this area for real ecosystem approaches, recruitment studies, fishing and other impact assessments, MPAs and variation in regional productivity and trophic fluxes. New molecular genetics approaches will soon allow species ID and so begins a new era in studies of plankton / benthos links, some are beginning already as examples show.				
	Please see Action Plan Items listed below	Discuss requirements for data management in ICES and provide input to SGMID.	h)	Much debated, general feeling that ICES approach too prescriptive, demands will inhibit data provision and exchange, although good data model as example to follow. Suggest start with metadata collection of complex biological data; Status Report/Helcom data as examples. Should encourage synthesis workers to approach data holders to collaborate in their efforts and analysis, aids data verification, widens collaborative approaches. Note also much data still in old paper or computer record formats, funding poor to impossible for data retreival, backward looking efforts. Many others attempting central data storage, good for physics and chemistry, hard for biology, not necessarily productive as often errors may be propogated very fast and data misinterpreted.				

Action Plan numbers crosslinked to WGZE ToRs

1.1	Provide feedback to Science Committees about research needs and priorities that are identified in the advisory process. [MCAP/Advisory Committees]
1.2	Increase knowledge with respect to the functioning of marine ecosystems. This will be achieved through continued basic research on the biological, chemical, and physical processes of marine ecosystems and specific activities directed at improved understanding of observed and potential variability in the marine environment due to physical forcing and biological interactions. [MHC/OCC/LRC/RMC/BCC/DFC].* Particular planned activities include the following:
1.2.1	Understand and quantify the biology and life history, stock structure, dynamics, and trophic relationships of commercially and ecologically important species. [LRC/OCC/BCC/MHC/DFC]
1.2.2	Quantify the changes in spatio-temporal distribution of the stocks of important species in relation to environmental change, using survey and commercial data. [OCC/LRC/RMC/BCC/DFC]*
1.3	Increase knowledge of the effects of physical forcing, including climate variability, and biological interactions, on recruitment processes of important commercial species. [MHC/OCC/RMC/LRC/MARC/BCC/DFC]*
1.5	Develop and apply biophysical modelling, and improve capacity in such modelling to cover biological–physical interactions in the sea. [LRC/OCC/BCC/MHC/DFC]*
1.6	Assess and predict impacts of climate variability and climate change, on scales from populations to marine ecosystems, including impacts on commercially important fish stocks. [OCC/LRC/BCC/DFC]
1.7	Play an active role in the design, implementation, and execution of global and regional research and monitoring programmes, in collaborations between the ICES and other international oceanographic research or monitoring programmes such as GOOS and GLOBEC. [OCC/LRC/MHC/BCC/DFC]
1.8	Implement a North Sea-oriented monitoring programme that incorporates oceanographic and fisheries data. [OCC/LRC/RMC/MHC/DFC]*
1.10	Develop better tools and training opportunities for monitoring and observation of physical, chemical and biological properties of marine ecosystems. [FTC]* [Other Science Committees]
1.11	Continue to improve the coordination, conduct, and analysis of oceanographic and biological surveys to assure their accuracy and precision. [LRC/RMC/OCC/MHC/DFC]
1.12	Address the substantial need for improved data and information on components of the marine ecosystem in the Baltic Sea including:
1.12.1.	Meteorological and oceanographic conditions (exchange processes, input to the Baltic);
1.12.2	Nutrient productivity and toxic blooms;
1.12.3	Evaluation of the biomass and production of the main prey of intensively exploited fish stocks;
1.12.4	Evaluation of the condition of seabirds and marine mammals;
1.12.5	Improved application of technology to surveys and monitoring;
1.12.6	Evaluation of the state of the Baltic Sea ecosystem.
	[BCC/OCC/LRC/RMC/MHC/FTC/DFC]
1.13	Enhance the efficiency of sampling tools and resource surveys by the following:
1.13.1	Improve the standardisation and performance of survey gears.
1.13.2	Promote the development of techniques and protocols for studies of fish and plankton behaviour relative to survey gears.*
1.13.3	Implement a common data format in acoustics for scientists and industry.
1.13.4	Promote the development and use of new survey designs, data analysis methods, acoustic instrumentation and survey gears.
1.13.5	Establish and evaluate a framework for the collection of hydroacoustic and ancillary data from commercial fishing vessels.
	[FTC/BCC/LRC/MHC/DFC]
1.14	Promote the development and use of hydroacoustics and other technologies, such as lidar, in quantifying the biological and physical components of the ecosystem. [FTC]*
2.2	Develop a process for conducting holistic assessments of the impact of human activities, and identify a suite of indicators or variables that will facilitate the monitoring of ecosystem status and evaluating whether ecosystem quality objectives (EcoQOs) are being met. This will be achieved by the following activities:
2.2.1	Contribute to the scientific advice for the development of EcoQOs that will ensure the environmental health of marine ecosystems. [MHC/LRC/OCC/BCC/DFC/ACFM/ACME/ACE]
2.2.2	Assist in the development of spatial and temporal assessments of the indicators for those EcoQOs. [MHC/LRC/OCC/BCC/RMC/DFC]*
2.2.3	Produce holistic assessments of spatial and temporal patterns of contaminants and their effects on marine ecosystems. [MHC/LRC/OCC/BCC/DFC]*
2.3	Evaluate and increase knowledge of the effects of fishing activities, particularly mobile gears, on seabed structures and benthic communities and habitats, and on the ecosystem consequences of such effects. [MHC/FTC/LRC /MARC/ACME/ACE]
2.8	Continue and further improve assessments of the transport, fate, and biological effect of contaminants on the marine ecosystem through sampling, analyses, data collection, and evaluation of sampling, analytical, and data processing techniques. [MHC/OCC/LRC/BCC]
2.9	Determine the biological response to eutrophication taking into account oceanographic conditions. [OCC/MHC/LRC]*
3.2	Further develop, and evaluate performance of, indicators of the status of stocks and ecosystems, relative to effects of fishing and other human activities by new analyses and modelling. [ACFM/ACME/ACE/LRC/ RMC/MHC/OCC/BCC/DFC]
3.3	Develop a framework for an integrated evaluation of the impacts of human activities in the coastal zone, (e.g., mariculture, dredging/extraction, building structures), as an aid to coastal zone management. [MHC/MARC/RMC/OCC/DFC/ACE/ACME]*
3.12	Collaborate on development of research methods for assessing the social and economic aspects of human interactions with marine ecosystems. [RMC/MHC/ACFM/DFC]*
4.2	Provide scientific advice and information on the status and outlook for the fish stocks, marine ecosystems, and the marine environment requested by the Commissions, other regulatory agencies, and Member Countries of ICES, and any other advice, which ICES may consider relevant. [MCAP/Advisory Committees]
4.10	Promote, through workshops, study groups, and training courses, the development and better application of methods for resource enumeration, status evaluations, and forecasts. [RMC/FTC/DFC]
4.11	Develop the scientific basis for an ecosystem approach to management, including assessments and the provision of scientific advice. Specifically, the following activities are needed:
4.11.1	Continue and expand the development of tools, possibly ecosystem models, that facilitate the assessment of monitoring and scientific knowledge of ecosystem functions in a holistic manner. [MHC/OCC/RMC/BCC]*
4.11.2	Incorporate scientific information on ecosystem components and processes into the advice that is provided to clients. [MHC/RMC/BCC/Advisory Committees]*
4.11.3	Consider more fully the impacts of human activities on the marine ecosystem, through provision of more integrated ecosystem advice. [MHC/RMC/OCC/BCC/Advisory Committees]
4.11.4	Work towards the use of indicators of sustainability for a wider range of ecological properties in the provision of scientific advice to clients. [Advisory Committees/MHC/RMC/LRC/BCC]
4.12	Review and advise on procedures for quality assurance of biological, chemical and physical measurements. [OCC/MHC/ACME]
4.14	Provide scientific advice relevant to integrated coastal zone management, including guidelines for sand and gravel extraction and mariculture, and for monitoring programmes that would be included in integrated coastal zone management. [MHC/MARC/DFC/ACME/ACE]
4.15	Improve the scientific basis for the application of the precautionary approach in advice on and management of human activities, including fisheries, mariculture, and other activities, in marine ecosystems. [RMC/all Advisory Committees]*
5.2	Encourage wider involvement by stakeholders, academics, and the public in ICES-sponsored Symposia and the ICES ASC, including evaluating the possibility of sessions for non-technical audiences. [CONC]
5.9	Further develop the existing informal relationship with SCOR, including closer collaboration on the development of quantitative ecosystem indicators for fisheries management, and collaboration on its planning effort to develop an integrative framework for ocean research. [RMC/MHC/ACFM]
5.10	Further develop joint activities with PICES in support of the ICES/PICES Memorandum of Understanding, including co-sponsorship of symposia, joint working groups, and collaboration on projects in marine ecology and environmental processes, and on advancing our capacity to understand marine ecosystems, climate variability, and marine ecosystem impacts. [OCC/MHC/LRC/DFC]
5.11	Consult with and provide technical advice to the fishing industry and fisheries management agencies in the development of technical devices to be used in harvesting technology and the modernisation of the methods and technologies currently used in the enforcement of technical measures. [FTC]
5.12	Provide advice on research design and in some cases participate in projects with research and development agencies in the acoustic and the fishing technology industries. [FTC]
5.13	Develop and maintain joint activities with IOC in support of the ICES/IOC Memorandum of Understanding, including the following:
5.13.1	Assist and participate in the implementation of GOOS and regional GOOS components (in particular EuroGOOS).
5.13.2	Continue to act as the North Atlantic regional implementation body for GLOBEC (The Cod and Climate Change Programme).
5.13.3	Provide input to the implementation of GEOHAB activities in the ICES Area, in particular the Baltic, and to other Harmful Algal Bloom initiatives such as the HAB event database and IOC Intergovernmental Panel on Harmful Algal Blooms.
5.13.4	Contribute expertise and know-how for the development of modern marine data management systems and maintain such systems that are of relevance to ICES activities.
5.13.5	Contribute expertise on IOC advisory and expert panels as appropriate, e.g., the SCOR–IOC Carbon Dioxide Advisory Panel and GESAMP.
5.13.6	Develop a specific plan of action for enhanced collaboration, taking into account the development and implementation of GOOS.
	[OCC/MHC]
5.14	Establish more consistent mechanisms such as joint working groups, co-sponsored symposia, and cross-attendance at meetings, for regular exchange of information and progress with other marine scientific organisations with which ICES does not have a formal Memorandum of Understanding, such as ICLARM, CCAMLR, the NAFO Scientific Council, the Arctic Council, the European Science Foundation Marine Board, and the World Fisheries Council. [CONC/all Science Committees]
5.15	Establish relationships with international marine science organisations that have a substantial academic membership, e.g., the American Society for Limnology and Oceanography (ASLO), the European Geophysical Society, and similar organisations. [CONC/all Science Committees]
5.16	Increase the sharing of ICES knowledge and experience with other non-Member Countries, through work with those that have official observer status, and through linkages with other marine science organisations. [CONC/all Science Committees]
5.17	Through co-sponsorship and collaboration with projects under the Census of Marine Life, improve knowledge of marine biodiversity and related fields of study. [LMR/BCC]*
6.1	Integrate and expand databases to support ICES programmes within a well-defined data management policy. [CONC/MCAP/all Science Committees]*
6.4	Assess and, where possible, improve, the quality of marine biological data. [LRC/RMC/OCC/DFC]
6.5	Ensure that ICES processes are embedded in quality management procedures to minimise errors, and increase transparency and efficiency, by the following:
6.5.1	Make the review process more transparent and inclusive of a wider range of expertise.
6.5.2	Adjust workloads of Working Groups and Advisory Committees to allow more thorough review of analyses and interpretations.
6.5.3	Further develop procedures for standardisation and certification of software for assessments and report preparation.
6.5.4	Carry out regular outside reviews in order to address the issues in a non-routine way, since Working Groups and Advisory Committees are already fully occupied with carrying out their routine tasks.*
10.1	Make the results of ICES-coordinated resource surveys available to a wide public (in an easily understood manner) via the World Wide Web. [LRC/PUB/Secretariat]