Oceanography Committee

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REPORT OF THE

Working Group on Zooplankton Ecology

Aberdeen, UK
18–20 March 2002

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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EXECUTIVE SUMMARY

The meeting was held at the Marine Laboratory Aberdeen (Fisheries Research Service) at Aberdeen, from 18–20 of March and was attended by 17 members of the Working Group on Zooplankton Ecology (WGZE) representing seven ICES countries.

The discussion of the Terms of reference was preceded by an introduction on the Oceanography Committee discussions during the 89^{th} Statutory meeting. This included an outline of the Oceanography Committee (OCC) 5 Year Action Plan (2002–2005), which describes many activities to be undertaken by this WGZE; the discussion on the current procedures for reviewing the WG/SG reports; the proposal for Theme Sessions for 2002 (2 from our group), etc. It was also mentioned that the four CDs set compiled and edited by P. Wiebe, R. Groman and M.D. Allison as result of the Sea-going Workshop (1993) would be published in the ICES Cooperative Research Report series (C.Res 1C02).

The second summary on zooplankton monitoring results in the ICES area (Tor a), continues a pilot study to further develop uses for and disseminate results from the ongoing time series monitoring programmes in the ICES region. One of the main objectives this year was to fill existing gaps in the regional coverage by attracting additional sampling programmes to contribute with their data sets. The new additions resulted in the following improvements: 1) Incorporation of four new data sets: Georges Bank, Faroe Islands, Dove (North Sea, W) and Helgoland (North Sea, SE), 2) Ordination of data sets in five different subdivisions corresponding to regional seas or basins: Western Atlantic, Iceland-Norwegian basin, Baltic sea, North Sea and English Channel, and Bay of Biscay and Iberian coast and 3) Inclusion of seasonal and year-to-year variability of two target species: *Acartia clausi* and *Calanus helgolandicus* in some regions. Discussions were addressed to find the ways to improve the status report for the year 2001–2002.

Time series studies on zooplankton long-term trends and their relationships with climate index and global warming suggest that important changes are occurring in zooplankton processes and community structure as a result of climate change (Tor b). Reported changes in the ecosystem, published in scientific literature, were reviewed. Observed patterns were grouped under two main headlines: 1) effects on biogeography and diversity (e.g., findings on copepod species distribution over a 40 year period study suggest that in the eastern North Atlantic, the geographic distribution of warm water species was expanding northward, while the distribution of cool water species was shrinking and receding farther north. In the western North Atlantic, this trend was reversed, with the geographic distribution of cool water species expanding farther south) and 2) effects on biomass production and the onset of plankton populations growth (e.g., the gonadal maturation and embryonic development of fish, crustaceans, echinoderms and planktonic organisms are temperature-dependent and the study of length and timing of the annual seasons in Helgoland monitoring site (1974-present) revealed a shift in early production (blooms) from 50 days to 12 weeks earlier that they were in the 1970s). More deeper discussion on different scenarios of climate change should be considered and their potential effects evaluated.

The use of environmental information, biological indices and data produced on a routine basis for the fisheries and environmental assessment groups (Tor c) is today a priority within different panels and agencies (US GLOBEC, SPACC, ICES, DFO, etc.). In 2001 we produced a list of indices of potential value for understanding zooplankton dynamics and ecosystem functioning. This year the discussions were focussed on reviewing and refining this list, and an annotation of these indices reflecting our discussion is included in this report as Annex 4. Additional refinement of the list under consideration is necessary, including appropriate documentation and justification (including references) for the indices.

The WGZE recognises the opportunities that electronic media offers in terms of maximising distribution of information to the scientific community. The WGZE has planned the edition of the ICES identification leaflets in a CD-ROM (Tor d). Six Fiches had been scanned, concentrating on examples of the Decapoda. This pilot project included both an index to the Fiches as well as hyperlinks within, and between Fiches. The group evaluate the work done which serve also as demonstration that the project was technically feasible. There was unanimous support for proceeding with the project. Concerning ICES involvement, it was noted that the project had been presented to the Oceanography Committee, and had received their support for further continuation. ICES had not raised any concerns about reproduction or distribution, or copyright issues. The group accepted Anthony Richardson's offer to complete the scanning of all the Fiches at SAHFOS in time for the next ASC.

A second Workshop on Zooplankton Taxonomy, Chaired by Alistair Lindley, is recommended for June 2003 (Tor e). The Workshop will focus on copepods and decapods taxonomy, with the following objectives: 1) Improve current zooplankton taxonomic expertise of scientists within the ICES area, 2) Aid synthesis of existing time series by inter-calibration of the taxonomic group analysed, 3) Supplement existing taxonomic work with new optical systems, and 4) Promote future taxonomic work. The Workshop is to be held by SAHFOS (Plymouth, UK), which is widely recognised for its excellence in plankton taxonomy and possesses the facilities necessary for holding such a workshop. The WZT will be widely announced and open to up to 25 scientists from ICES countries.

The discussion on the organization of the joint WGPE/WGZE Workshop on modelling phytoplankton-zooplankton interactions (Tor f) was centered by the fact that in 2003 both groups are involved in the organization of two international events, which demand an extra effort. It was also noted that the Gijón Zooplankton Symposium included a session on "New approaches to zooplankton modelling", and that in addition a workshop at the Symposium had been proposed on "copepod-diatom interactions", which could result in a duplication if the WGPE/WGZE workshop in modelling is programmed by 2003. For these reasons both, the WGPE and the WGZE decided to defer further planning of the proposed workshop on modelling phytoplankton-zooplankton interactions until a later time. Intersessionally, both groups, WGPE and WGZE, will decide if the plans for a Workshop on modelling should be included as a Tor for discussion in 2003 or later.

The 3rd International Zooplankton Production Symposium titled *"The role of Zooplankton in Global Ecosystem Dynamics: Comparative Studies from the World Oceans*", ICES/PICES/GLOBEC Symposium (Tor g) will be a major event for planktologists in 2003. This International Symposium was proposed by the WGZE at its meeting in Hawaii in 2000. Three members of the WGZE (Roger Harris, Peter Wiebe and Luis Valdés) are also working at the Symposium Steering/Organising Committee. Preparation of this event has demanded an intense intersessional work and a substantial co-ordination with our colleagues of PICES and GLOBEC. Progress on the local organization and on the scientific programme were reported and discussed within the group. These include arrangements with the Gijón Congress Center, proposals for funding, identification of scientific sessions (8) and workshops (7), nomination of chairpersons and keynote speakers, preparation and distribution of announcements, etc.

Future developments of Trans-Atlantic studies (Tor h) was discussed in depth. Prospects were evaluated for an international effort to conduct synthesis studies of the data sets that have been produced by the groups working under the GLOBEC banner during the past five to seven years. The working group is strongly supportive of the synthesis objectives expressed in the papers that appeared in the EurOcean 2000 Symposium Volume and those encapsulated in the document prepared at the ICES Annual meeting in 2000 at Bruges, Belgium. Globalisation in science is a trend that is being fostered on an institutional and a governmental basis. In our case, this is being built around the integration of hydrography and information about key species in the ecosystem. The WGZE view is that it is timely to begin the process of bringing the investigators that might become collaborative teams together in one or more workshops. The object of these workshop(s) would be to discuss the scientific topics and to define concrete steps to evaluate and model the impact of oceanographic and climate-related processes on the dynamics of plankton and fish populations.

The discussions on Zooplankton monitoring in environmental programmes with QA and standardisation procedures (Tor i) was introduced by pointing at the central role of zooplankton in marine ecosystems. The minor role of zooplankton monitoring in the EU Directive on water policy was brought into the discussion and the group stated that this was a very unfavourable situation. It was expressed that zooplankton monitoring could reveal the quality status of the ecosystem, natural large-scale variability and regime shifts, and that zooplankton monitoring should be included in the EU water directive at the same level as phytoplankton and benthic monitoring. The group suggested to increase the communication with the ICES/OSPAR SGQAE in order to include zooplankton in present and future monitoring programmes, together with criteria on the water quality status, QA and standardisation procedures.

Since 1997 the WGZE has included in its annual agenda several aims related with operational measurements of bio-ecological variables (Tor j) and at least three other Tors in the current agenda (a, c, i) are relevant for this topic. Although new automatic sampling instruments are developing fast, the cost of the equipment in moored lines strongly limits the use of such technology, and so the spatial resolution needed for an ocean observation system is a long-term goal. In the short and mid-terms the bulk of the existing bio-ecological observations in oceanography are based on standard sampling programmes. At this respect, the WGZE has: 1) identified the existing programmes within the ICES area including the CPR routes, 2) edited in 2001 and in 2002 a zooplankton status report that can be used as a basis for zooplankton abundance and trends in the ICES area, 3) identified several servers that provide on line data sets on zooplankton, 4) produced and evaluated a list of indices of potential value for understanding the zooplankton dynamics and ecosystem functioning. We consider that all these items are relevant and suitable for operational use.

In 2002 the present Chair will have covered his three-year period and the group propose that Steve Hay (UK) should take his place. The WGZE will meet in Gijón (Spain), 24–26 February 2003.

1 OPENING OF THE MEETING

The meeting was held at the Marine Laboratory Aberdeen (Fisheries Research Service) at Aberdeen, from 18–20 of March at the kind invitation of Steve Hay and started at 09:00 on the first day. Participants were welcomed to Aberdeen by Dr Robin Cook, Director, AML. He summarised the facilities available at what is the oldest marine research institute in Scotland. The group was also invited to visit the engineering workshop where the underwater plankton sampling "ARIES" and other prototypes are developed.

The meeting was attended by 17 members of the ICES Working Group on Zooplankton Ecology (WGZE) representing seven countries (Annex 1).

2 ADOPTION OF THE AGENDA

The agenda for the WGZE meeting (Annex 2) followed the terms of reference adopted as a resolution of the Annual Science Meeting in Oslo (C.Res. 2001/2C07). As stated in the same resolution the WG will report to ACME by 15 April 2002 and to the Oceanography Committee at the 2002 Annual Science Conference.

The terms of reference are:

a) review results from Standards Sections and Stations from member countries, update them into the Summary status report on the zooplankton monitoring structure in the ICES area and analyse possible links with other data sets.
b) analyse what are the consequences of ocean climate changes for zooplankton processes and community structure.
c) search and evaluate possible biological indices of ecological significance for the fisheries and environmental assessment groups.
d) review and evaluate the electronic version of the ICES leaflets.
e) prepare activities for a second Workshop on zooplankton taxonomy in 2003.
f) consider and review plans for a workshop on modelling phytoplankton-zooplankton interactions in 2003.
g) review and evaluate the advances in the organisation of the ICES/PICES/GLOBEC Symposium.
h) future developments of Trans-Atlantic studies.
i) provide the scientific merits and operational possibilities of incorporation of zooplankton as a monitoring goal in environmental programmes as e.g., the OSPAR/JAMP with inclusion of QA and standardisation procedures.
j) prepare a summary report listing relevant marine bio-ecological variables and indicators suitable for operational use.
k) any other business. (e.g., European networks of excellence: is there capacity to build a network of excellence in zooplankton research?)
l) nomination of new Chair.

3 REPORT OF THE OCEANOGRAPHY COMMITTEE MEETING AT THE 89TH STATUTORY MEETING

The discussion of the Terms of reference was preceded by an introduction on the Oceanography Committee discussions during the 89th Statutory meeting. This included:

- The discussion of a work-document on the Oceanography Committee (OCC) 5 year Action Plan prepared by a sub-group of the Oceanography Committee. This document was discussed in depth by the Oceanography Committee and it was concluded that the draft was very much in line with what the Consultative Committee requested. The Oceanography Committee Chair (Franciscus Colijn) explained that the Consultative Committee would refine this text and build it into a formal ICES Action Plan, which is to be published by ICES along with the Strategic Plan. This draft identifies and establishes priority areas of scientific activity, areas of work to support advisory process, and activities to contribute to the Annual Science Conference and Symposia.
- Among the activities to contribute to the 2002 Annual Science Conference, two members of our group will chair the following Theme Sessions: "Environmental influences on trophic interactions" and "Ocean-shelf sea interactions: Implications for biology and fisheries".
- The compilation of data, metadata, and additional visual material from the ICES/GLOC Seagoing Workshop for intercalibration of plankton samplers, compiled and edited by P. Wiebe, R. Groman and M.D. Allison as result of the discussion of the WGZE will be published in the ICES Cooperative Research Report series (C.Res. 1C02).
- Concerning the review of the WG's reports, not all reports were reviewed in 2001 because of time constrains. A discussion on the current procedures for reviewing WG's reports followed. It was suggested that a mechanism for correcting the reports after the review needs to be established. The Chair suggested that the Committee reviews a sub-set of the WG's reports each year in a rotation system. The OCC supported this suggestion.

- Among the matters raised by the ACME and ACE it was noted that ACME had made additions to the terms of reference of the WGZE. The Chair of ACE (H.R. Skjoldal) recognized the importance of increasing the relevance of the different annual status reports (oceanography, zooplankton, harmful algal blooms and pollution) to the fisheries assessment community. Special attention was drawn to Annex 6 of Doc C:07 (Report of Working Group on Zooplankton Ecology), which provides a list of indices of potential value for assessment groups.

4 RESULTS FROM STANDARD SECTIONS AND STATIONS: INPPUTS TO THE SUMMARY STATUS REPORT ON THE ZOOPLANKTON MONITORING STRUCTURE IN THE ICES AREA (Tor a)

Three points were discussed and reviewed, viz. (1) the results from Standards Sections and Stations from member countries and update them into the Summary status report on the zooplankton monitoring structure in the ICES area (Annex 3), (2) ways to improve the status report for the year 2001–2002 and (3) the feasibility of establishing possible links with other data sets.

4.1 Results from Standard Sections and Stations

The second summary on zooplankton monitoring results in the ICES area (Annex 3) continues a pilot study to further develop uses for and disseminate results from the ongoing time series monitoring programmes in the ICES region. One of the main objectives this year was to fill existing gaps in the regional coverage by attracting additional sampling programmes to contribute with their data sets. The new additions resulted in the following improvements: 1) Incorporation of four new data sets: Georges Bank, Faroe Islands, Dove (North Sea, W) and Helgoland (North Sea, SE), 2) Ordination of data sets in five different subdivisions corresponding to regional seas or basins: Western Atlantic, Iceland-Norwegian basin, Baltic sea, North Sea and English Channel, and Bay of Biscay and Iberian coast and 3) Inclusion of seasonal and year-to-year variability of two target species: *Acartia clausi* and *Calanus helgolandicus* in some regions.

4.2 Consideration of improvements to Status Report

The Group considered the possibilities for the standardization of the individual reports into a common format that would ease inter-comparison. The different sampling frequencies, gears, mesh sizes and units used in each Standard Section and Stations require conversion indexes to present all the monitoring series in the same scale. Wulf Greve suggested introducing statistical methods to provide an easier evaluation. Luis Valdés suggested the use of the graphical representation of the current year together with the long term average ± standard deviation as a valid approach and/or the normalization of the data. Regarding the units in which results are given (abundance, dry weigh, displacement volume, etc.) it was recommended to convert all the numbers to mg C by using algorithms from literature (e.g., Wiebe *et al*. 1975. Fishery Bulletin, 73(4): 777–786). The need to improve the metadata information to include other biological (e.g., phytoplankton) and environmental (e.g., temperature vertical profiles) data collected together with zooplankton information at each of the locations was also considered. The possibility of producing metadata information in the same format as the World Ocean Plankton Database was suggested. Todd O'Brien will provide the guidelines to produce metadata by the U.S. National Oceanographic Data Center, which could be used as a baseline to improve the ICES zooplankton metadata.

4.3 Links with other data sets

The combination of zooplankton and phytoplankton collections in order to produce a plankton summary status reports was discussed. It was agreed that this would create problems to complete the report in time and also increase the difficulty of interpretation of results (e.g., spatial variability of both communities is caused by different forcing causes, temporal variability occurs at different time scales, etc.). Nevertheless it was considered that at those monitoring programmes where zooplankton and phytoplankton are being sampled simultaneously, some results on phytoplankton could be included in future reports. The ICES WGPE will be approached and asked to produce a list of monitoring sites in order to know the potential of their contribution to the plankton status report.

The production of an annual Summary status report on the zooplankton monitoring structure in the ICES area is an extra task for the WGZE. It was discussed who should be the responsible of producing such a document in time for the annual WGZE meeting. This discussion will continue in the future, but there was general agreement that the Chair of the Working Group and the production of the status report should be led by different members of this Working Group.

Angel López-Urrutia presented the L4 plankton monitoring programme website (http://www.pml.ac.uk/L4) and a CD-ROM copy of the database was given to each participant. Todd O'Brien gave a guest presentation on the World Ocean

Database Plankton component. There were supportive comments on the usefulness of this dataset and suggestions on some other zooplankton datasets that could be included.

5 CLIMATE CHANGE, ZOOPLANKTON PROCESSES AND COMMUNITY STRUCTURE (Tor b)

Time series studies on zooplankton long-term trends and their relationships with climate index and global warming suggest that important changes may occur in zooplankton processes and community structure as a result of climate change. Their consequences on the ecosystem structure were analysed and discussed. Most of the members of the WGZE presented results from their own projects and observations. The following sections group observed patterns into "Ocean Climate Change can affect zooplankton biogeography and diversity" and "Ocean Climate Change can affect biomass production and the onset of plankton population growth".

5.1 Observed patterns – Ocean climate change can affect zooplankton biogeography and diversity

Anthony Richardson reported on the work of Gregory Beaugrand (SAHFOS) who examined the geographic distribution of dominant cold water (*e.g., Calanus finmarchicus*, *C. hyperboreus*) and warm water (*e.g., C. helgolandicus*) copepod species over a 40-year time period. Beaugrand's findings suggested that in the eastern North Atlantic, the geographic distribution of warm water species was expanding northward, while the distribution of cool water species was shrinking and receding farther north. In the western North Atlantic, this trend was reversed, with the geographic distribution of cool water species expanding farther south.

The working group noted that in the eastern North Atlantic, this shift was replacing the dominant copepod species *C. finmarchicus* (a larger copepod species) with *C. helgolandicus* (a slightly smaller copepod species). *C. finmarchicus* is usually the dominant contributor to biomass in the North Atlantic, and a crucial food source for the North Atlantic fisheries. It is known that various life stages of redfish, haddock, herring, mackerel, salmon, cod, and capelin all relied on *C. finmarchicus* as a food source. Since the smaller *C. helgolandicus* species may differ in its food content and availability as prey to the various fisheries species, further investigation is needed to determine how this geographic shift may affect the eastern North Atlantic fisheries.

M. Edwards (SAHFOS) reported that unusually high numbers of oceanic species were recorded in the North Sea during 1997 and 1998, including some previously unrecorded species in this area, which suggests an unusually high inflow of oceanic water, probably linked to meteorological anomalies [J. mar. Biol. Assoc. UK (1999), 79:737–739]. This influx contributed to an increasing trend in biodiversity of North Sea plankton, as measured by the CPR, seen over the last decade. An increase in the contribution of the meroplankton to the plankton community of the North Sea has also been noted.

A substantial year-to-year increase in the abundance of species with summer-autumn development in the Bay of Biscay was observed and attributed to the progressive warming (Villate *et al*. (1997), J. Plankton Res., 19(11): 1617–1636). Among these species, the case of *Temora stylifera* is paradigmatic because this species was very scarce in the whole Bay of Biscay during the 1980s but now it is a common species found at all the sampling sites along the North Spanish coast. A decline in copepod's species richness and diversity was also observed in the Bay of Biscay off Santander [Valdés and Moral (1998), ICES Journal of Marine Science, 55:783–792] and related to an increase of thermal stratification of the water column.

5.2 Observed patterns – Ocean climate change can affect biomass production and the onset of plankton population growth

Peter Wiebe reported on the findings of GLOBEC and other studies in the western North Atlantic. Here, the populations of *C. finmarchicus* appear to be expanding southward. Of special note, the temperature-dependent early production of *C. finmarchicus* has been seen starting earlier than usual in some areas, starting as early as January in the Georges Bank region. This earlier start production can lead to greater population biomass throughout the summer, and may also trigger earlier production in some *C. finmarchicus*-dependent fisheries species. Peter Wiebe summarized the correlation between the NAO and the populations and/or biomass of various zooplankton groups and fisheries. A common trend was found in groups which previously had no correlation with the NAO had recently shown a strong correlation with the NAO. Likewise, groups which previously had a strong correlation with the NAO have recently shown no correlation with the NAO.

Zooplankton biomass has decreased by 80 percent in the California current from 1951 to 1993 [Roemmich and McGowan (1995), Science, 267: 1324–1326]. This decline is a major perturbation in the biota and seems to be related with the increase in temperature difference across the thermocline. This increase of stratification results in reduced upward displacement, in less nutrients to surface, less new production and ultimately a decreases in zooplankton. The suppression of nutrient supply by enhanced stratification is not trivial. Roemmich and McGowan conclude that if there is a global temperature rise of 1º to 2ºC in the next 40 years and stratification increases globally, the biological impacts could be devastating.

Wulf Greve remarked the importance of temperature in many biological processes. The gonadal maturation and embryonic development of fish, crustaceans, echinoderms and planktonic organism in general are temperature-dependent and the study of length and timing of the annual seasons in Helgoland monitoring site (1974-present) revealed a shift in early production (blooms) from 50 days to 12 weeks earlier that they were in the 1970s. Examples were given for sea urchin larvae, polychaetes, ctenophores, and fish larvae.

5.3 Discussion on preliminary results of relevant research projects

Data from the Faroes shelf and off shelf waters, presented by Eilif Gaard, have revealed a strong relationship between primary production, *Calanus* abundance and cod recruitment. The timing of recruitment in the population of *C. finmarchicus* is later in the cold Arctic water north of the Faroe Islands compared to the shelf population. Based on a new analysis of long term hydrographic data from the Norwegian Sea it was concluded that the out flow of deep water from the Norwegian Sea might have decreased during the last years. If so the inflow of warm Atlantic water may have decreased as well. However, this does not seem to be coherent with current measurement and other hydrographical data of that region.

It is considered typical of winter driven systems that climate influences the life cycles of zooplankton. For example *C. finmarchicus* and *C. helgolandicus* have different strategies and there will be interplay between species and how they react to environmental variability. P.Wiebe raised the question why *C. helgolandicus* is not common in the western Atlantic. R.Harris mentioned that this could be an artefact due to the lack of e.g., CPR data from the southwestern Atlantic. Others suggested that more warming of the North Atlantic might introduce *C. helgolandicus* to the western Atlantic. S. Hay pointed at the dependency of cod and haddock of *C. finmarchicus*, and that we possibly will see a shift towards other species with an increase of *C. helgolandicus*.

Anthony Richardson described the use of new techniques to search for patterns in zooplankton abundance in CPR time series. He was able to extract patterns representing zooplankton communities from warm-temperate and neritic species to boreal and cool-temperate species. For example was a low salinity and cold anomaly period reflected in the pattern of certain species (on a large scale the Great Salinity Anomalies in the 1970s, 1980s and 1990s influence advection and zooplankton distribution as reflected in CPR data). The results agreed with published results about a shift towards meroplanktonic species in the North Sea. The presentation was followed by a discussion of how representative functional groups, such as holoplankton and meroplankton, are for life histories of the species.

Webjørn Melle presented results from the Norwegian Sea indicating a positive correlation between the NAO winter index, zooplankton biomass in May and individual condition of Norwegian spring spawning herring at the end of the feeding season in December. The existence of a one-year lag in the relationship between the climate index and zooplankton biomass was supported by a positive relationship between the overwintering stock of zooplankton as measured in July and the zooplankton stock in May the following year. The data showed no relationship between the spawning stock during spring and the summer stock of zooplankton. The relationship between climate and zooplankton indices and herring condition is used by the ICES WGNPBW to assess herring growth on a short term.

Pat Kremer asked whether the lack of correlation between spring and summer stock of zooplankton could be due to predation. Dr Melle answered that he did not know, but surely various recruitment processes such as predation and food supply were important to the production of the summer stock. P. Wiebe added that good recruitment from low overwintering stocks has been observed at Georges Bank as well. L. Valdés asked whether any data series had shown a relationship between jellyfishes and climate. Dr Kremer mentioned that abundance and timing of *Mnemiopsis* in the Narragansett Bay may be correlated with the NAO. In the Bering Sea a simultaneous increase in the abundance of jellyfishes and a decrease in fish biomass had taken place since 1989. Angel López-Urrutia referred to CPR data and mentioned that since the 1950s the abundance of appendicularians around the British Isles had increased.

6 USES OF BIOLOGICAL INDICES WITH ECOLOGICAL SIGNIFICANCE FOR THE FISHERIES AND ENVIRONMENTAL ASSESSMENT GROUPS (Tor c)

The use of environmental information, biological indices and data produced on a routine basis for the fisheries and environmental assessment groups (Tor c) is today a priority within different panels and agencies (US GLOBEC, SPACC, ICES, DFO, etc.). In 1999 the WG decided to be proactive on this discussion. In 2001 we produced a list of indices of potential value for understanding zooplankton dynamics and ecosystem functioning. This year the discussions were focussed on reviewing and refining this list, which needs to be considered carefully.

Annex 6 from the 2001 report from the WGZE (ICES CM 2001/C:07) was systematically discussed. An annotation of these indices reflecting our discussion is included in this report as Annex 4. It was noted in the discussion that it is essential to have some organization and prioritisation of the indices, if they are to be useful in helping to guide monitoring efforts. An index needs to be relatively easy to measure, clearly defined, and meaningful. Additional refinement of the list under consideration is necessary, including appropriate documentation and justification (including references) for the indices.

There was general agreement of the importance of enumerating particular "key" species. These can be **dominant species**, present in high numbers or biomass; **indicator species**, associated with particular environmental conditions; or **keystone species,** that strongly affect food web structure. All these "key" species are critical components of the ecosystem. It will take additional thought and discussion to determine the list of species that are "key" in the North Atlantic. These should be the species that will yield the greatest insights into fisheries, climate change, and ecosystem condition. Interesting patterns are likely to emerge examining the variability over time of these key species at a single location and comparison of different locations. It will be interesting to compare data from various monitoring efforts to look for changes in latitudinal distributions of key species over time that would reflect climate change. It is vital to have some standardization of methods and protocols in monitoring efforts to facilitate comparison between areas.

It was proposed by F. Pages that an index expressing the abundance of gelatinous zooplankton would be a valuable addition. To be most meaningful, the filter feeding pelagic tunicates (salps, doliolids, appendicularians and pyrosomes) need to be distinguished from carnivorous cnidarians and ctenophores. The categorization of the relative volume of freshly collected material into categories of tunicates, jellies, crustaceans, and total can be translated into dry weight and carbon. Partitioning of unpreserved material in the field may be difficult or impossible for mesozooplankton but suitable for macro-and megaplankton [MEPS (1996), 141:139–147]. A simple ratio of total displacement volume (live volume) to dry weight may therefore be the most practical index to be used routinely since the ratio of wet to dry weight in the gelatinous zooplankton (~25:1) is dramatically different from the much lower ratio for crustaceans of ~4:1.

Finally, there was discussion of the importance of NOT finding expected fauna. The absence of something that has been found in the past is qualitatively different in terms of monitoring from a zero produced by simply not noticing if something new is present. We need to be able to make the absence of particular species into some kind of meaningful index. The absence of a species could be used in a similar manner to the use of indicator species.

The course of the discussions evidenced the complexity behind the selection of "simple environmental indices".

We reached no more resolution at this time of which indices to choose, as we felt it was essential to consider this topic more thoroughly. This *Tor* was considered to have high relevance for the group and further discussions on the selection, interpretation and validation of these indices need to be continued before the objective of reducing the initial number of indices to about 10 key indices that reflect ecosystem health and have predictive power for fisheries assessment can be achieved.

7 ELECTRONIC VERSION OF THE ICES PLANKTON IDENTIFICATION LEAFLETS (Tor d)

Anthony Richardson reviewed the work that Alistair Lindley had carried out as a pilot project. Six Leaflets had been scanned, concentrating on examples of the Decapoda. Optical Character Recognition (OCR) had been used, and the pilot included both an index to the Leaflets as well as hyperlinks within, and between Leaflets. The use of OCR had resulted in a large number of errors, and these had been difficult and time-consuming to correct. Anthony concluded his presentation by saying that the pilot indicated that the project was technically feasible, but the WGZE would have to decide who would take the whole project forward as well as identifying a funding source for the considerable amount of work that would be involved.

In the ensuing discussion it was generally agreed that the hard-copy Leaflet were rather inaccessible to much of the community, and that younger scientists might well be unaware of them as a valuable taxonomic resources. There was unanimous support for proceeding with the project to make the Leaflets more widely available through modern electronic media. Matthijs Couwelaar noted that the ETI database for zooplankton and micronekton of the North Sea was based on the ICES Plankton Identification Leaflets, and raised the possibility that ETI might be able to take the project forward, depending on funding. There was some discussion on how to deal with the fact that some of the Leaflets were now taxonomically out of date. After an exchange of views, including the suggested revision of some of the Leaflets, it was accepted that the collection should be made available as published, together with a qualifying introduction to the user pointing out that some were outdated. It was agreed that this was a common feature of using the conventional taxonomic literature.

Roger Harris then reverted to the OCR problems that had been experienced with the pilot project. It was generally recognise that the careful checking of the scanned text, particularly taxonomic terms, would be a major undertaking. He pointed out that the only need for OCR scanning was to establish the hyperlinks within the text. If these were not needed a scanned image of the text, as for the Figures, was all that would be required. He proposed that the WGZE adopt a simpler approach to the project by scanning the Fiches themselves, and just confining the indexing to a conventional index enabling particular Leaflets and taxa to be readily located on the CD-ROM. This would be within the capabilities of the Group, should not require funding, and would still ensure that the basic identification material could be more widely available, and in an easily accessible form. Discussion then moved to technical issues and to whether ICES would be interested in, and able to, reproduce and distribute the CD-ROM. It was suggested that the scans be saved as PDF files at 300 dpi. Web-based access was also recommended in addition to the CD-ROM. Concerning ICES involvement, it was noted that the project had been presented to the Oceanography Committee, and had received their support for further continuation. ICES had not raised any concerns about reproduction or distribution, or copyright issues.

The concluding discussion centred on whether the Leaflets were copyright, and if so who held it. In addition it was queried whether ICES would wish to market the CD-ROM themselves. As a way forward the group accepted Anthony Richardson's offer to complete the scanning of all the Fiches at SAHFOS in time for the next Statutory Meeting and Luis Valdés agreed to check in the meantime on the copyright and distribution issues with ICES. [This was already checked and the answer from ICES was as follow: "ICES does own the copyright..., an appropriate way to proceed is to make a recommendation/resolution to the effect that you wish to publish a CD-ROM of the plankton fiche collection, making it clear who the owner is, what is to happen in the future re further publications and CD-ROM updates, and whether it is to be put on the web. The Publication Committee has yet to formulate a policy on electronic publications, so they will be interested to learn of this development"].

During the discussions, Matthijs Couwelaar gave a guest presentation on the "*Zooplankton and micronekton of the North Sea, a zooplankton database managed with the programme Linnaeus 2.2".* There were supportive comments on the usefulness of this expert system and suggestions on some taxonomic improvements needed in the duplication of Latin names in some parasitic organisms.

8 ACTIVITIES FOR THE SECOND WORKSHOP ON ZOOPLANKTON TAXONOMY (Tor e)

During years there were continuous concerns of the WGZE about the loss of taxonomic expertise within the ICES zooplankton community. After a long preparation a first Workshop on Copepod Taxonomy was held in Terramare (Germany, 2000) at the kind invitation of Dr Heino Fock. Given the success of this Taxonomic Workshop and current developments and plankton research directions the group felt that a further workshop should be considered in 2003.

The discussion was centred on the objectives of this second Workshop on Zooplankton Taxonomy (WZT). It was agreed that the WZT will focus on copepods and decapods taxonomy and the objectives will concentrate on:

- Improve current zooplankton taxonomic expertise of scientists within the ICES area.
- Aid in synthesis of existing time series by inter-calibration of the taxonomic groups analysed.
- Supplement existing taxonomic work with new optical systems.
- Promote future taxonomic work.

Sir Alister Hardy Foundation for Ocean Science (SAHFOS) offered its premises to hold the workshop and the group accepted its invitation. SAHFOS is widely recognised for its excellence in plankton taxonomy and possesses the facilities necessary for holding such a workshop. Anthony Richardson proposed best to schedule the WZT as a summer course in the second week of June 2003 (10–13 June).

The Expert Center for Taxonomic Identification (ETI) at the University of Amsterdam offers to present the latest computer-aided taxonomic keys. The Woods Hole Oceanographic Institution has shown interest in presenting the Woods Hole Silhouette recognition programme (running with Matlab) as a topic for the WZT. Peter Wiebe explained briefly how this programme works and the kind of results that are obtained. At present, the beta-version is tested and at Woods Hole five people use it for their own work. Steve Hay thinks it is a good idea to combine optical image recognition with the WZT. Professor Geoff Boxshall, a leading copepod taxonomist from the Natural History Museum of the U.K. has been approached and has indicated his willingness to participate. Plymouth Marine laboratory is also interested in presenting a comparison of data collected by the OPC (Optical Plankton Counters) and net samples.

Due to obvious requirements (e.g., microscopes) and previous skills on taxonomy, this WZT is open to a small group of participants (about 25 scientist). Invitations will be sent to most of the ICES marine research laboratories and personal letters will be also distributed to a large mailing list of planktologist covering all the ICES countries. The workshop will be funded by external funding, cost by participants and SAHFOS. There will be no financial cost to ICES.

9 PLANS FOR A WORKSHOP ON MODELLING PHYTOPLANKTON-ZOOPLANKTON INTERACTIONS (Tor f)

The discussion on the organization of this Workshop was preceded by some letters and conversations in order to co-ordinate the works of the WGPE and WGZE in an effective way.

The WGPE met in Middleburg (Netherlands) from 14–15 March and they conclude that 2003 was a very busy year because of the International workshop they are organizing which involves to mount the workshop and the subsequent effort to publication the papers is substantial and continuing intersessionally.

The discussion on our group was also centred on the fact that 2003 was a demanding year for the WGZE, dominated by the Gijón Symposium, and though the group recognised the merits of this joint initiative with the WGPE it would be better to plan an effective workshop when more time could be devoted to planning it. In addition, those in attendance at this Aberdeen meeting of WGZE felt that they did not have the necessary expertise within the group, and the aims of the workshop needed further definition. It was noted that the Gijón Zooplankton Symposium included a session on "New approaches to zooplankton modelling", and in addition a workshop at the Symposium had been proposed on "copepod-diatom interactions", which could result in a duplication if the WGPE/WGZE workshop in modelling is programmed by 2003. In addition the continuing activities of the GLOBEC Focus 3 Working Group are relevant to the issue. For these reasons it was decided to defer further planning of the proposed workshop on modelling phytoplankton-zooplankton interactions until a later time.

After the meeting a letter was sent to the Chair of the WGPE to find an agreement on postponing this workshop, which was replied on April 15 as follows: "Our group agrees that the workshop on modelling phytoplankton-zooplankton interactions should be postponed, especially since there will be the workshop during the Zooplankton Symposium in Gijón 2003. In any case, WGPE is most eager to play a very active role with great involvement in the workshop. Grazing issues are very relevant and important to our interests. So WGPE is anxious to be an active part of the workshop together with WGZE. The involvement of the WGHABD may also be of interest, although that group has up to now not dealt with grazing issues a lot."

Intersession ally both groups, WGPE and WGZE, will decide if the plans for a Workshop on modelling should be included as a Tor for discussion in 2003 or later.

10 ORGANIZATION OF THE ICES/PICES/GLOBEC SYMPOSIUM (Tor g)

The ICES/PICES/GLOBEC Symposium will be a major event for the marine ecologist in general and planktologists in particular in 2003. This International Symposium was proposed by the WGZE at its meeting in Hawaii in 2000. Three members of the WGZE (Roger Harris, Peter Wiebe and Luis Valdés) are also working on the Symposium Steering/Organising Committee. Preparation of this event has demanded intense intersessional work and a substantial co-ordination with our colleagues of PICES and GLOBEC. Progress on the local organization and on the scientific programme were reported and discussed within the group.

Luis Valdés introduced the discussion on this topic by reporting the background and the current advances in the local organization. The 3rd International Zooplankton Production Symposium titled *"The role of Zooplankton in Global Ecosystem Dynamics: Comparative Studies from the World Oceans*", will be held at the Gijón Congress Center (20–23, May 2003). The Congress Center offers rooms for scientific sessions, workshops and poster exhibition and counts with all the facilities for projections (overhead, slides and multimedia projectors), access to Internet, technical support, private offices for the Steering/Organising Committee and a service of press and communication which provides access to regional and national media. Facilities at the IEO Marine Laboratory (Centro Oceanográfico de Gijón) are also offered for workshops and for preparation and co-ordination of tasks before and after the Symposium.

Cost of the Symposium will be covered by the Symposium fee and by contributions from national and regional science foundations. Limited funds will be available to assist young scientist (35 years of age or younger) and scientists from countries with economies in transition to attend this Symposium. Costs of first and final announcements[1] (and one poster) were covered by PICES. The contribution from ICES includes 10,000 DKK for the book of abstracts and the publication of a special volume of the *ICES Journal of Marine Science*.

Roger Harris presented the Scientific Programme which include full day sessions on: 1) Physical variability and zooplankton population dynamics, 2) Role of zooplankton in biogeochemical cycles, 3) Climate influences: What are long-term zooplankton data sets telling us? 4) New approaches to zooplankton modelling, 5) Progress in molecular biology, 6) Application of new technologies, 7) Comparative life histories and life cycles of zooplankton populations within and between the North Pacific and North Atlantic, and 8) Microzooplankton in the marine pelagial: Recent advances from molecules to ecosystems. Two sessions will run concurrently each day and each session will include two chairs and two keynote speakers followed by contributed papers. Poster submission is encouraged for all sessions. A full detail on the rationale is given in Annex 5.

In addition to the scientific sessions, a great deal of interest was expressed in having special workshops associated with the Symposium. William T. Peterson (PICES) is acting as co-ordinator and up to date, we have seven proposals for workshops: 1) copepod egg-phytoplankton interactions, including effects of harmful algal blooms on zooplankton feeding and egg production rates; 2) microzooplankton: role in food webs; 3) ways and means of increasing interactions among ICES and PICES scientists; 4) zooplankton in the context of fisheries stock assessment; 5) standardization of zooplankton time-series methodologies: sampling and analysis; 6) assembly of a global data set of “length-weight” relationships for zooplankton groups; and 7) progress in the study of meso-and bathypelagic zooplankton.

The ICES WGZE was requested from PICES to nominate and select invited speakers. A discussion followed and the list provided from PICES was accepted with the addition of David L. Mackas as keynote speaker in session 3.

Deadlines are already fixed for the submission of proposal for workshops (before 1 July 2002), abstracts (15 November 2002) and registration forms (15 November 2002). The ICES/PICES/GLOBEC Steering/Organising Committee will continue with the preparation of scientific sessions and the local organization, and the advances reported and evaluated during the next WGZE annual meeting.

11 FUTURE DEVELOPMENTS OF TRANS-ATLANTIC STUDIES (Tor h)

11.1 Historical perspective

Roger Harris opened the discussion by presenting a historical perspective of the efforts to study the biology of *Calanus finmarchicus* in the North Atlantic that have led to the possibility of a future effort.

1) TASC: The Trans Atlantic Study of Calanus program was meant to be an international effort to study *C. finmarchicus* across the whole of the North Atlantic, but due to the mechanisms of funding only EU scientists formed a collaborative partnership and the effort was focused on the eastern Atlantic. There was some collaboration with U.S. and Canadian workers on Georges Bank and the Scotian Shelf, but the effort was not really Trans Atlantic. The final TASC meeting in Tromsø was successful, but it was recognized that the original idea to obtain a trans-Atlantic understanding of population biology of *Calanus* was not realized.
2) EurOcean2000 GLOBEC session in Hamburg in August 2000: At this session, the program was designed to explore the possibility of synthesis of North Atlantic GLOBEC data sets together with basin scale modelling and resulted in the publication of papers presented in the session. [Proceedings of the EurOcean 2000 Conference, 29 August - 2 September. (Eds.) K.-G. Barthel, C. Lecherf, M. Catizzone, M. Cornaert, A. Edwards, T. Fairley, C. Fragakis, D. Levieil, E. Lipiatou, P. Martin, G. Ollier, L. d’Ozovville, W. Schrimpf. Published by the European Commission, EUR 19408. Pages 71–114.]
3) ICES ASC Bruges in September 2000: A draft Announcement of Opportunity was written for an international synthesis effort and was given to program managers in the EU and NSF as an example of how a collaborative synthesis effort might be constructed and funded. There were three goals suggested for the programme:

   * *Within the context of the circulation and transport of biological, chemical and physical properties in the deep basin and shelf seas of the Northern North Atlantic, to determine what processes control the population*

[1] First announcement and posters were distributed during the last ICES Annual Science Conference (Oslo, September 2001). The final announcement was recently edited (mid April, 2002) and it is ready for distribution.

dynamics of the target zooplankton and fish species.

- * *To embody this understanding in conceptual and quantitative models capable of elucidating ecosystem dynamics and responses on a broad range of space and time scales, and leading to the identification of mechanisms and new hypotheses concerning the linkages between the environment, zooplankton, and fish.*

- * *To understand the affects of climate variability and climate change on the distribution, abundance and production of the target organisms.*

4) Halifax meeting in June 2001: This meeting was organized by Canadian GLOBEC investigators with participants from Europe and USA to discuss plans to extend sampling in the Western North Atlantic, Labrador Sea, and Irminger Sea and future synthesis work. A report [Proceedings of the Workshop on "The Northwest Atlantic Ecosystem - A basin scale approach" (Eds.): Head, E., P. Pepin, and J. Runge. Canadian Science Advisory Secretariat Proceeding Series 2001/23. 113 pgs] was prepared in which there was a call for the development of a coordinated program and research plan directed towards Calanus.
5) Meetings between NSF and EU: Several meetings have taken place between Program Directors of respective science funding agencies that culminated in the signing of a Memorandum of Understanding in October 2001. Another Steering Group Meeting for the NSF/EU Implementing Arrangement is planned in the next several weeks and the WGZE through communication between K.G. Barthel and R. Harris has been offered the opportunity to provide input to this next meeting.

11.2 Future developments

P. Wiebe provided additional background information on the efforts to put together an international effort to conduct a basin-scale integration of information about *Calanus*. The challenge is to create a collaborative program of physicists, biologists, and modellers to build and test coupled physical/biological models that can effectively caricature the space and time variation of broadly distributed and dominant members of the North Atlantic zooplankton community. The models would have to be basin-scale and include the shelf seas.

L. Valdés pointed out that *Calanus finmarchicus* only occurs in the northern part of the ICES community area of the North Atlantic Ocean and that there was a need to include species that occurred in the more southern areas. R. Harris suggested that relaxing the focus to *Calanus* (as opposed to *Calanus finmarchicus*) might provide a solution, since there are important questions about *C. helgolandicus* that also need to be addressed, as well as about other species of *Calanus* in the North Atlantic. For example, why is *C. helgolandicus* only found in the eastern North Atlantic and not in the western North Atlantic regions such as Georges Bank area?

There were also questions about the feasibility of doing basin-scale modelling with coupled physical/biological models in the near future. S. Hay said that 3D models were moving forward and that they will soon cover the entire North Atlantic. There are EU projects now in existence, which are directed towards this goal. P. Wiebe said that there are coupled ocean-basin and shelf seas models now in existence, although they do not cover the entire region occupied by *Calanus* and are not yet ready for the kind of modelling envisioned.

W. Greve stressed the need for information about the physiological and feeding responses of zooplankton and the incorporation of this information into prognostic models, which were developed, in their own right and not as a by-product of physical models.

S. Hay noted that within the European Union Framework VI now being formulated, programs must be multidisciplinary, which was viewed as positive. Globalisation in science is a trend that is being fostered on an institutional and a governmental basis. In our case, this is being built around the integration of hydrography and information about key species in the ecosystem.

L. Valdés, asked what the WGZE could do to foster this approach? R. Harris said that an immediate need was to respond to K. G. Barthel to keep the process of international program development and synthesis going. P. Wiebe suggested that ICES could help by fostering the connection between Iceland and Canada and the EU/NSF initiative so that they could participate in the collaborative efforts that take place in the future under a coherent administrative umbrella. W. Greve suggested that the networks of excellence (EU VI Frame Programme) could also assist in the development of the Trans-Atlantic objectives and a scientific program. The goals of ICES as articulated in the strategic plan contain the need for evaluation of marine populations response to climate change and this effort would be promoting this goal.

11.3 Conclusion

It was recommended that a response to K.G. Barthel's communication with R. Harris be prepared and sent before the end of the working group meeting (a response was prepared and a copy of what was sent appears in Annex 6). There was also consensus that a second recommendation be prepared soliciting ICES to assist in promoting future trans-Atlantic studies that involve the synthesis of GLOBEC data sets and basin-scale zooplankton population dynamics modelling.

12 ZOOPLANKTON MONITORING IN ENVIRONMENTAL PROGRAMMES WITH QA AND STARDARDISATION PROCEDURES (Tor i)

12.1 Background

Dr Wulf Greve introduced the working group to the TOR by pointing at the central role of zooplankton in marine ecosystems. Environmental agencies, however, do not seem to recognise the zooplankton as a key to the understanding of the structure and functioning of ecosystems. The minor role of zooplankton monitoring in the EU water directive[2] was brought into the discussion and the group stated that this was a very unfavourable situation. Dr Harris stated that zooplankton monitoring should be included in the EU water directive at the same level as phytoplankton and benthic monitoring. It was also expressed by the group that zooplankton monitoring could reveal effects on the ecosystems due to the intermediate rate of development of zooplankton communities compared to phytoplankton and benthos.

12.2 Discussion

Dr Steve Hays stressed the importance of looking at the effects of contaminants on zooplankton by field investigations. Dr Greve added that the biodiversity concept should be included in the monitoring programs. Dr Peter Wiebe suggested using the North Sea ecosystem to evaluate the anthropogenic effects on the zooplankton community. To do this one needs to know the undisturbed status of the ecosystem and it is not enough to focus on the benthic and phytoplankton communities. Dr Greve agreed by pointing at the problem of monitoring man-made effects on benthic and phytoplankton communities whose responses are either to slow or too fast, while response in zooplankton communities may develop with a pace more in line with the frequency of sampling in monitoring activities.

Dr Luis Valdés referred to the working group report from 2000, when the ICES SGQAE requested advice from the WGZE about the inclusion of zooplankton in the water quality monitoring programmes. The discussion of the WGZE and the text in the report stated that: *"The WGZE felt that there is a strong scientific support for the inclusion of a measure of zooplankton in ICES/OSPAR monitoring, because of the sensitivity of the organisms to changes in eutrophication status. WGZE therefore recommends that the ICES SGQAE consider the inclusion of zooplankton structural parameters (abundance and biomass), taxonomic identification and diversity indices (very sensible to environmental perturbations) as routine measurements in eutrophication-related monitoring studies. Regarding with the methodology to do it, we think that the recently published ICES Zooplankton Methodology Manual offers a good base of discussion, but for implementation purposes an agreement on standardisation and guidelines must be provided by the authorised body (OSPAR, JAMP, ICES SGQAE?). WGZE recognised that, in addition to considerations of the accuracy and precision of a selected method, critical QA aspects include the importance of coupling the process being measured with the timing and spatial scale of sampling effort. Automated measures (e.g., OPC) used in towed bodies may satisfy issues concerning spatial and temporal scales, but at the expense of sacrifice the taxonomic precision".*

A discussion on whether the group should point out a list of monitoring activities such as they are stated in the EU Directive for phytoplankton evolved. Steve Hay said that we already have the background or baseline information from ongoing monitoring programmes and only need to point to a few extra activities to meet the requirements of incorporating zooplankton in environmental programmes. Dr Roger Harris shared this view and added that long-term monitoring can reveal natural large-scale variability and regime shifts. Dr Luis Valdés suggested to build on the working group report from 2000, making better justification for including zooplankton in present and future monitoring programmes, together with criteria on the water quality status, QA and standardisation procedures.

Steve Hay reminded the group that inclusion of zooplankton monitoring in the EU water directive may be impossible this late in the process of implementing the EU directive on water policy. Therefore the WGZE should focus at

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[2] The EU Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy was published (22 December 2000) in the Official Journal of the European Communities. The EU Directive on water policy only considers phytoplankton, benthic invertebrate fauna and fish as biological quality elements.

incorporating zooplankton monitoring into environmental monitoring programmes such as OSPAR establishing bridges with the ICES/OSPAR SGQAE.

13 RELEVANT MARINE BIO-ECOLOGICAL VARIABLES AND INDICATORS SUITABLE FOR OPERATIONAL USE (Tor j)

The Tor was introduced by remembering that since 1997 the WGZE has included in its annual agenda several aims related with operational measurements of bio-ecological variables, such as: "*CPR surveys and ongoing monitoring activities in the ICES area*" (Kiel, 1997), "C*onsider technologies for the remote acquisition of zooplankton information on data-buoys and other remote platforms*" (Santander, 1998), "*Status of zooplankton stocks in the ICES area (North Atlantic regional GOOS)*" (Reykjavik, 1999), "O*perational uses for monitoring activities and environmental indices*" (Hawaii, 2000), "W*ays of improving the phytoplankton and zooplankton components in GOOS*" (Bergen, 2001).

The group also consider that the discussion regarding the summary status report on the zooplankton monitoring structure in the ICES area (Tor a), the search and evaluation of possible biological indices of ecological significance for the fisheries and environmental assessment groups (Tor c), and the operational possibilities of incorporation of zooplankton as a monitoring goal in environmental programmes (Tor i), are relevant to the discussion of this Tor.

In essence the group has noted that new sampling systems are becoming available that are suitable for operational purposes for measuring zooplankton parameters (acoustics, video plankton recorders, OPC, etc.). However the cost of the equipment for automated measures implemented in moored lines strongly limits the use of such technology, and so the spatial resolution needed for an ocean observation system is a long-term goal. In the short and medium-term the bulk of the existing marine bio-ecological observations are based on standard sampling programmes.

In this respect, the WGZE has:

- identified the existing programmes within the ICES area including the CPR routes
- edited in 2001 and in 2002 a zooplankton status report (Annex 3) that can be used as a basis for zooplankton abundance and trends in the ICES area
- identified several servers that provide on line data sets on zooplankton (e.g., CPR, Plymouth L4 station)
- produced and evaluated a list of indices of potential value for understanding the zooplankton dynamics and ecosystem functioning (Annex 4)

These items are considered relevant and suitable for operational use.

The discussion followed with a presentation by Dr Wulf Greve of a new project to establish an European Marine Biometeorology Network (EMBN) (Annex 7). He showed the evidences of many biological processes that are temperature dependent and concluded that global warming will force dramatic changes in marine seasonality and species distribution. Terrestrial ecologist observe and document population phenology on the basis of network of private observers recruited and organised by meteorological services and by the WMO International Phenological Gardens (IPG) distributed all over Europe (recent results of this IPG network were published, for example, in Nature (1999) 397: 659). Marine biometeorology will have to be developed using similar approaches. The EMBN project is designated to develop a monitoring strategy for the phenology of marine organisms which is applicable over most of European marine biota on a low expense level and can catch up with global warming and other disturbances of the marine ecosystem. Objectives, tasks and implementation time schedule are included in Annex 7.

With the caveat that such network of marine observers could be considered relevant or not in operational oceanography, the group agreed in its potential interest not only to get valuable information on ecosystem seasonality and disturbances, but also for educational purposes. The group agree to submit to the OCC a proposal for a Theme Session on such topic to be held during the ICES ASC 2003.

14 ANY OTHER BUSINESS (Tor k)

Two main points were covered in this section. The first related with a proposal presented by Pat Kremer to make gelatinous zooplankton became a more integral part of the activities of WGZE. The second one was proposed by the chair and formulated as "European networks of excellence: there is capacity to build a network of excellence in zooplankton research?".

14.1 Gelatinous zooplankton in the context of the WGZE

Pat Kremer proposed that the ecology, abundance and distribution of gelatinous zooplankton become a more integral part of the activities of WGZE. This is justified both in scientific terms and within the Action Plan (2002–2005) of OCC (see Annex 8). The WGZE was favourable to this proposal but did not think that it would be appropriate to form a study group on gelatinous zooplankton. The consensus was that it would be valuable to hold a short workshop/discussion of interested scientists at the Gijón Zooplankton Symposium, then an ICES Theme session at the Annual Science Meeting (perhaps 2004). An additional formal ICES Workshop may also be justified sometime in the future.

14.2 European networks of excellence: is there capacity to build a network of excellence in zooplankton research?

The discussion was preceded by a presentation given by Santiago Hernandez-León on the new research instruments defined within the EU VI Framework programme 2002–2006, i.e., Networks of excellence and Integrated projects. The justification and politics on why, how, what characteristics, what types of participants, what activities, selection, funding and implementation were presented and discussed in detail.

The idea of a Network of Excellence for Plankton Monitoring in the North Atlantic crystallised throughout the meeting. The objective of the Network would be to monitor the biological response of plankton to global change, including the impacts of climate change, eutrophication, pollution and over-fishing. The network would include two trophic levels: phytoplankon and zooplankton. It is envisaged that the combination of the basin-scale sampling of both phyto- and zooplankton provided by the CPR survey, together with the more-detailed finer-scale sampling using many other existing time series would provide an extensive Network for the monitoring of global change.

The basis for such a network already exists within the ICES WGZE, with 15 zooplankton monitoring time series currently included in the ICES Zooplankton Status Report. Other zooplankton time series would be included, as there are many time series within ICES countries not currently included (e.g., France and Ireland). It would also be expanded to included time series from the Mediterranean and North America. There are also many phytoplankton time series that could be incorporated into the Network. The ICES Working Group on Phytoplankton Ecology could help identify time series for inclusion, with the added benefit of increased collaboration between the ICES zooplankton and phytoplankton working groups.

The Network would produce an Annual Status Report of the Impact of Global Change on North Atlantic Plankton. This would require considerable standardisation of procedures, indices and statistical analyses to aid comparison among component time series. For instance, by standardising the taxonomic resolution of time series and conversions to derive abundance or biomass as much as is possible, time series could be compared using the same taxa and units. A set of indices for assessing impacts of climate change, eutrophication and pollution could be applied to all time series. Potential indices have been identified by the WGZE (Annex 4), and by working groups within SCOR and SPACC. Using a suite of indices for say eutrophication, the proportion of these indices that are outside agreed limits is then a useful summary of conditions. To aid comparison, it is also important that we apply standard analysis techniques such as time series analysis to the time series, and simple models could be also used to compare series.

The Network will also help identify lateral displacements of species, and will allow laboratories to share taxonomic expertise and thus more quickly identify new species to an area. Data from the time series could be archived in the World Ocean Database. Although some participants felt strongly that large-scale models should be integrated into the Network to add value to the plankton monitoring and to help identify gaps in understanding, the general mood was to focus on plankton monitoring, although there may be some scope to add value to our data by incorporation into models.

Our Network of Excellence for Monitoring the Impact of Global Change on North Atlantic Plankton will fit nicely within the "Sustainable development, global change and ecosystems" priority themes of research in EU Framework 6. The funding for such a network would comprise money for research activities that integrate the participants, and integration activities such as workshops, meetings, personnel exchange and standardisation of protocols. An invitation to submit Expressions of Interest for Networks of Excellence for FP6 was published on 20 March 2002, and the deadline for submission is 7 June 2002, although the final calls for proposals will be in 2003.

15 NOMINATION OF NEW CHAIR

Luis Valdés (Spain) has served as Chair of this WG for three years and the group propose that Steve Hay (UK) should take his place. Steve Hay is a longstanding member of the ICES Working Group on Zooplankton Ecology and he is willing to undertake the task of leading the group.

16 ACTIONS, RECOMMENDATIONS AND DRAFT RESOLUTIONS

Actions for the WGZE

The group will continue working intersessionally for the achievement of the following actions and deliverables:

Action I

The annual edition of a Summary status report on the zooplankton monitoring results in the ICES area is to be considered a priority for the WGZE. The third issue will be improved with new information and it will be edited in time for the next WGZE meeting. It will be distributed via the ICES web site and in the WG annual report.

Justification

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. It also recognised the opportunities that the electronic media offers in terms of maximising the distribution of information to a wider audience.

Action II

A scanned version of the plankton leaflets published by ICES since 1939 will be produced. All the fiches will be linked by a numerical and taxonomic index (i.e., Plankton Leaflet No. 187). A second version of a demonstration CD-ROM including all published Plankton Leaflets will be presented during the 2002 ASC.

Justification

The WGZE supported the conclusions of the workshop on taxonomy and recognises the opportunities that electronic media offers in terms of maximising distribution of information to the scientific community. The ultimate objective is that ICES could offer this product to a larger community of scientist.

Recommendations to the Oceanography Committee

Recommendation I

The WGZE recommends the support, at the ICES ASC 2003, of a Theme Session titled "Towards an European Marine Biometeorology Network: expectations, current experiences and results".

Justification

Marine ecosystems respond to ambient temperatures through the response of individual organism's nutrition, digestion, reproduction, growth and behaviour on various time scales. This results in shifts of the seasonal timing of plankton populations and in the spawning periods of fish and benthos which then interferes with the match or mismatch with prey and/or predators. In order to understand the effects on predator/prey interactions and the dynamics of marine population and their relations to ocean ecosystems in the context of the global climate system these relationships merit increased attention. Terrestrial ecologists observe and document population phenology on the basis of private observers recruited and organised by meteorological services and by the WMO International Phenological Gardens (IPG) distributed all over Europe. Marine biometeorology should be developed using similar approaches.

Convener

Dr Wulf Greve
Bundesamt für Seeschiffahrt und Hydrographie und Deutsches Zentrum für Marine Biodiversität
c/o DESY Gebäude 3
Notkestraße 85
D-22607 Hamburg
Tel.: +49–40–8998–1870 Fax: +49–40–8998–1871 e-mail: wgreve@meeresforschung.de

Recommendation II

The WGZE is concerned about the EU Directive 2000/60/EC establishing a framework for Community action in the field of water policy. The exclusion of zooplankton from the surveillance of coastal waters is a disappointing omission of European agencies.

Zooplankton abundance and distribution indicates:

- the regional productivity of marine ecosystems,
- the temporal clues to determine year class sizes of fish- and benthic populations,
- the changes of biodiversity through the immigration or loss of holoplanktonic and meroplanktonic populations
- the impact of global change/global warming and other perturbances produced by human impact

and thus the specific regional and temporal quality of the marine ecosystem.

The ICES WGZE recommends to the OCC and ACME to endorse this note of concern and to support modifications of the EU Directive 2000/60/EC to include zooplankton monitoring.

Recommendation III

Luis Valdés (Spain) has served as Chair of this WG for three years and the group recommends Steve Hay (UK) as new Chair. Steve Hay is a longstanding member of the ICES Working Group on Zooplankton Ecology and he is willing to undertake the task of leading the group.

Draft resolutions to ICES

Draft Resolution I

A Workshop on Zooplankton Taxonomy, under the auspice of the Working Group on Zooplankton Ecology (WGZE) and chaired by A. Lindley (UK) will be held at the Sir Alister Hardy Foundation for Ocean Science (SAHFOS), Plymouth (UK), from 10–13 June 2003 to:

a) Improve current zooplankton taxonomic expertise of scientists within the ICES area
b) Aid synthesis of existing time series by inter-calibration of taxonomic groups analysed
c) Supplement existing taxonomic work with new optical systems
d) Promote future taxonomic work

Supporting Information

Priority:	The current activities of the WGZE include issues related with taxonomy expertise. Practical exercises in taxonomy are considered to have a high priority
Scientific Justification:	1) There has been a general decline in taxonomic expertise because of funding cutbacks. It is thus important to maintain endeavour to improve the taxonomic knowledge of scientists in the ICES area. 2) An important component of the ICES WGZE is to synthesise time series in the ICES area. This requires inter-calibration of both taxonomic groups identified and the taxonomic resolution used in the different time series, which will be facilitated by a taxonomic workshop. 3) Owing to the high expense of taxonomic identification, it is useful to supplement existing work with new optical systems for plankton recognition and calculation of size distributions
Relation to Strategic Plan:	Methodological issues are within the OCC 5 year action plan (2002–2005)
Resource Requirements:	25 Microscopes, which will be provided by SAHFOS and the university of Plymouth
Participants:	Due to the obvious requirements of facilities (e.g., microscopes) and previous skills on taxonomy, this Workshop is open to a small group of participants (about 25 scientists)

Secretariat Facilities:	None required
Financial:	There will be no financial cost to ICES. The workshop will be funded by external funding, cost by participants and SAHFOS
Linkages to Advisory Committees:	The Group reports to OCC and WGZE
Linkages to Other Committees or Groups	Methodological issues are within the mandate of the WGZE and within the OCC 5 year action plan (2002–2005)
Linkages to Other Organisations:	The Expert Center for Taxonomic Identification (ETI) at the University of Amsterdam will present the latest computer-aided taxonomic keys. The Woods Hole Oceanographic Institution has shown interest in presenting an optical system for determining size distributions of plankton. Prof. Geoff Boxshall, a leading copepod taxonomist from the natural History Museum of the UK has been approached and has indicated his willingness to participate. Plymouth Marine Laboratory is also interested in participating a comparison of data collected by the OPC (Optical Plankton Counter) and net samples.

Draft Resolution II

The **Working Group on Zooplankton Ecology** [WGZE] (Chair: Steve Hay, UK) will meet in Gijón, Spain, from 24–26 February 2003 to review:

a) annual zooplankton summary status report: standardisation of data sets, critics and improvements.

b) approve and adopt guidelines for reporting monitoring zooplankton collections in the ICES area.

c) climate change and Trans-Atlantic studies on Calanus

d) perturbations in coastal marine ecosystems and changes in zooplankton community structure due to human impacts

e) search and evaluate possible biological indices of ecological significance for the fisheries and environmental assessment groups.

f) evaluate the local organization and facilities for the ICES/PICES/GLOBEC Symposium.

g) sampling and analytical methodologies focussed in gelatinous zooplankton

h) state of the art of enzymatic activity methods to estimate secondary production in zooplankton.

Supporting Information

Priority:	The activities of this group are a fundamental element of the Oceanography Committee, they are fundamental to understanding the relation between the physical, chemical environment and Living Marine Resources. Thus the work of this group must be considered of very high priority.
Scientific Justification:	a) This is a repeating task established by the Working Group in 2000 to monitor the zooplankton abundance in the ICES area. The material presented under this item will be utilised to prepare the annual Summary status report on zooplankton in the ICES area. Reporting results must be supported by significant observations and trends based on time series sampling programmes. b) Key information, such as net mesh size or the sample processing methods, are needed to examine these data in a meaningful way. While this information was available at the time of collection, in a log book or cruise report, effort must be made to ensure that this metadata remains with the data, preferably in a digital form. There is a need for general guidelines detailing the types of such ancillary information that should be included with these data, and stored alongside the data in a digital form. The Working Group on Zooplankton Ecology (WGZE), with guidance from the Working Group on Marine Data Management (WGMDM), is developing general metadata guidelines for plankton data collected and submitted to ICES. The existence of such guidelines will ensure that quality and usable plankton data sets will be preserved and available to ICES in the present and

	future. c) Global warming is forcing important changes in marine ecosystems. Shifts in spatial distribution of Calanus in the North Atlantic ocean were related in recent literature with climate variability. Response of Calanus populations to climate change and the cascade of relationships with their prey and predators need more attention. d) Zooplankton is highly sensitive to perturbances produced by human impact. Changes in biodiversity and loss of holoplanktonic and meroplanktonic populations were related to eutrophication processes in coastal areas of the North Sea. The minor role of zooplankton in the EU water Directive was a matter of concern in the WGZE, and a discussion on most important anthropic perturbances and the parallel changes in zooplankton ecology will be initiated. e) Incorporating environmental information for the fisheries and environmental assessment groups is an important task that the group has initiated in 1999. The discussion on the selection, interpretation and validation of the list of indices needs to be continued. The list of indices produced during 2001and 2002 needs to be reviewed, refined and supported with scientific literature. f) The proposed ICES/PICES/GLOBEC Symposium will be a major event for the marine ecologist in general and planktologists in particular in 2003. The local preparation of this event will be the responsibility of a Organising Committee, and by the time when the WGZE will meet in 2003 in Gijón the group, as originator of the idea, will have an *in situ* opportunity to review, evaluate and suggest improvements on the preparation of this event. g) Gelatinous zooplankton makes a significant portion of total zooplankton, however methodologies of sampling are often addressed to crustaceans. A review of sampling methods is needed in order to identify weakness in current methodologies h) Several analytical methods based on enzymatic activity are currently used to estimate zooplankton secondary production, after 15 years from the first experiments it is time to review the state of the art in these methodologies.
Relation to Strategic Plan:	This working groups activities embrace all elements of the scientific objective of understanding the physical, chemical, and biological functioning of marine ecosystems.
Resource Requirements:	The Working Groups programme encompass the ongoing work of all its members, hence there are no additional resource requirements beyond those required for the meeting.
Participants:	The group has a relatively small core membership, and needs to attract broader participation.
Secretariat Facilities:	None required
Financial:	None apart from the report's reproduction costs
Linkages to Advisory Committees:	The Group reports to ACME, mainly for the provision of scientific information on Ecosystems
Linkages to Other Committees or Groups	Links with the WGPE were established. Good contact is maintained Guidance from Working Group on Marine Data Management (WGMDM) is needed to develop clear metadata guidelines in zooplankton
Linkages to Other Organisations:	PICES, GOOS and GLOBEC have many activities of very close interest to the activities of this group. Good contact is maintained.

ANNEX 1: LIST OF PARTICIPANTS

ICES Working Group on Zooplankton Ecology

Aberdeen, 18–20, March 2002

Dr Roger Harris Plymouth Marine Laboratory Prospect Place West Hoe Plymouth PL1 3DH United Kingdom Tel: +44 (0) 1752 633400 Fax: +44 (0) 1752 633101 e-mail: rph@pml.ac.uk	Dr Steve Hay Aberdeen Marine Laboratory PO Box 101 Aberdeen AB9 8DB United Kingdom Tel: +44 (0) 1224 876544 Fax: +44 (0) 1224 295511 e-mail: s.hay@marlab.ac.uk
Mr Angel López-Urrutia Plymouth Marine Laboratory Prospect Place West Hoe Plymouth PL1 3DH United Kingdom Tel: +44 (0) 1752 633400 Fax: +44 (0) 1752 633101 e-mail: alop@pml.ac.uk	Mr Anthony Richardson SAHFOS Citadel Hill The Hoe Plymouth PL1 2PB United Kingdom Tel: +44 (0) 1752 633265 Fax: +44 (0) 1752 e-mail: anr@mail.pml.ac.uk
Mrs Johanna Sidey SAHFOS Citadel Hill The Hoe Plymouth PL1 2PB United Kingdom Tel: +44 (0) 1752 633265 Fax: +44 (0) 1752 e-mail: josi@mail.pml.ac.uk	Mrs Anna Ingvarsdottir University of Aberdeen, Dep. of Zoology Tillydrone Avenue Aberdeen United Kingdom AB24 2TZ Tel: +44 (0) 1224 273861 e-mail: ingvarsa@abdn.ac.uk
Dr Luis Valdés Instituto Español de Oceanografía Centro Oceanográfico de Gijón PO Box 4055 33213 Gijón Spain Tel: +34 985 308672 Fax: +34 985 326277 e-mail: luis.valdes@gi.ieo.es	Dr Santiago Hernández León Laboratorio de Oceanografía Biológica Facultad de Ciencias del Mar Universidad de Las Palmas 35017 Las Palmas de GC Spain Tel: +34 928 45 29 07 Fax: +34 928 45 44 90 santiago.hernandez-leon@biologia.ulpgc.es
Dr Francesc Pagés Institut de Ciències del Mar (CSIC) Passeig Marítim de la Barceloneta 37–49 08003 Barcelona Spain Tel: +34 93 2309560 Fax: +34 93 2309555 e-mail: fpages@cmima.csic.es	Dr Peter Wiebe Woods Hole Oceanographic Institution M.S. # 33 Woods Hole, MA 02543 USA Tel: + 1508 28 92 313 Fax: +1 508 45 72 169 e-mail: pwiebe@whoi.edu

Dr Pat Kremer Marine Sciences University of Connecticut Groton, CT 06340 USA Tel: +1 860 405 9140 Fax: +1 860 405 9153 e-mail: pkremer@uconn.edu	Mr Todd D. O'Brien Ocean Climate Laboratory-NODC 1315 East-West HWY E/OC52, SSMC-3, Room 4340 Silver Spring, Maryland 21044 USA Tel: +1 301 713–3291 Fax: +1 301 713–3303 e-mail: todd.o'brien@noaa.gov
Dr Eilif Gaard Faroese Fisheries laboratory PO Box 3051 FO-110 Torshavn Faroe Islands Tel: +298 31 50 92 Fax: +298 31 82 64 e-mail: eilifg@frs.fo	Mr Hogni Debes Faroese Fisheries Laboratory PO Box 3051 FO-110 Torshavn Faroe Islands Tel: +00298 31 50 92 Fax: +00298 31 82 64 e-mail: eilifg@frs.fo
Dr Webjorn Melle Institute of Marine Research PO Box 1870 Nordnes N-5024 Bergen Norway Tel: +47 55 238444 Fax: +47 55 238584 e-mail: webjoern.melle@imr.no	Dr Wulf Greve German Centre for Marine Biodiversity c/o DESY Gebäude 3 Notkestraße 85 D-22607 Hamburg Germany Tel.: +49–40–8998–1870 Fax: +49–40–8998–1871 e-mail: wgreve@meeresforschung.de
Dr Matthijs van Couwelaar ETI Biodiversity Center Universiteit van Amsterdam P.O. Box 94766 1090 GT Amsterdam Netherlands Tel: +31–20–5257177 Fax: +31–20–5257238 e-mail: couwelaar@science.uva.nl	

ANNEX 2: AGENDA AND PROGRAMME

Working Group on Zooplankton Ecology

Marine Laboratory Aberdeen, 18–20, March 2002

Monday 18 March

09:00–9:30	**Welcome, Agenda, Meeting Programme**
9:30–11:00	Review and evaluate the advances in the organisation of the ICES/PICES/GLOBEC Symposium. **[Tor g]** (Lead Role: Roger Harris, Rapporteur: Luis Valdés)
11:00–11:30	Coffee break
11:30–13:00	Review results from Standards Sections and Stations from member countries, update them into the Summary status report on the zooplankton monitoring structure in the ICES area and analyse possible links with other data sets. **[Tor a]** (Lead Role: Luis Valdés, Rapporteur: Angel López-Urrutia) Presentation on the *World Ocean Database Plankton component* [Todd O'Brien]
13:00–14:30	Lunch
14:30–16:00	Review and evaluate the electronic version of the ICES leaflets. **[Tor d]** (Lead Role: Anthony Richardson, Rapporteur: Roger Harris) Presentation of the "*Zooplankton and micronekton of the North Sea" a zooplankton database managed with the programme Linnaeus 2.2*, [Matthijs van Couwelaar].
16:00–16:30	Coffee break
16:30–18:00	Prepare activities for a second Workshop on zooplankton taxonomy in 2003. **[Tor e]** (Lead Role: Anthony Richardson, Rapporteur: Matthijs van Couwelaar)

Tuesday 19 March

09:00 – 9:30	Summary discussion. Next meeting
9:30 – 11:00	Analyse what are the consequences of ocean climate changes for zooplankton processes and community structure. **[Tor b]** (Lead Role: Peter Wiebe, Rapporteur: Todd O'Brien)
11:00 – 11:30	Coffee break
11:30 – 13:00	Analyse what are the consequences of ocean climate changes for zooplankton processes and community structure. **[Tor b]** (Lead Role: Peter Wiebe, Rapporteur: Webjorn Melle)
13:00 – 14:30	Lunch
14:30 – 16:00	Consider and review plans for a workshop on modelling phytoplankton-zooplankton interactions in 2003. **[Tor f]** (Lead Role: Steve Hay, Rapporteur: Roger Harris)
16:00 – 16:30	Coffee break
16:30 – 18:00	Future developments of Trans-Atlantic studies. **[Tor h]** (Lead Role: Roger Harris, Rapporteur: Peter Wiebe) *Gelatinous Zooplankton, from here to where?* [Pat Kremer]

Wednesday 20 March

09:00 – 9:30	Nomination of new Chair, Drafting of the WGZE report
9:30 – 11:00	Search and evaluate possible biological indices of ecological significance for the fisheries and environmental assessment groups. **[Tor c]** (Lead Role: Francesc Pages, Rapporteur: Pat Kremer)
11:00 – 11:30	Coffee break
11:30 – 13:00	Prepare a summary report listing relevant marine bio-ecological variables and indicators suitable for operational use. **[Tor j]** (Lead Role: Wulf Greve, Rapporteur: Eilif Gaard)
13:00 – 14:30	Lunch
14:30 – 16:00	Provide the scientific merits and operational possibilities of incorporation of zooplankton as a monitoring goal in environmental programmes as e.g., the OSPAR/JAMP with inclusion of QA and standardisation procedures. **[Tor i]** (Lead Role: Wulf Greve, Rapporteur: Webjorn Melle)
16:00 – 16:30	Coffee break
16:30 – 18:00	Any other business. European networks of excellence: there is capacity to build a network of excellence in zooplankton research? **[Tor k]** (Lead Role: Santiago Hernández-León, Rapporteur: L Valdés)

WGZE will report by 15 April 2002 for the attention of the Oceanography Committee and ACME, ACE

Scientific justification

a) This is a repeating task established by the Working Group to monitor the zooplankton abundance in the ICES area. The material presented under this item will be utilised to prepare the annual Summary status report on zooplankton in the ICES area. Reporting results must be supported by significant observations and trends based on time series sampling programmes. Links with other data sets (phytoplankton) will be considered.

b) Time series studies on zooplankton long-term trends and their relationships with climate index (NAO, Gulf Stream north wall index) and global warming, suggest that important changes may occur in zooplankton processes and community structure as a result of climate change. Their consequences on the ecosystem structure will be analysed and discussed.

c) Incorporating environmental information for the fisheries and environmental assessment groups is an important task that the group has initiated in 1999. The discussion on the selection, interpretation and validation of indices needs to be continued. The list of indices produced during 2001 needs to be reviewed and refined.

d) The WGZE recognises the opportunities that electronic media offers in terms of maximising distribution of information to the scientific community. The WGZE has planned the edition of the ICES identification leaflets in a CD-ROM. The group will work intersessionally on such an initiative. During its annual meeting the group wants to review and evaluate the contents and quality of such CD-ROM. The ultimate objective is that ICES could offer this product to a larger community of scientist.

e) The WGZE is concerned about the decline of expertise in zooplankton taxonomy. A workshop was auspiced by the WGZE in 2000 as a practical step towards strengthening taxonomic skills in the ICES area. Given the success of this workshop, the group felt that a further workshop should be considered to be held in two years.

f) The difficulties in modelling the ecosystem functioning imposed by our limits to understand the phytoplankton-zooplankton interactions is recognised in recent literature. There is a need to communicate with modellers to review the advances in integrate ecosystem models. A modelling workshop auspiced by the WGPE and the WGZE was proposed during the 2001 discussions. The WGZE wants to be proactive in this practical initiative and prepare activities for this workshop programmed in 2003.

g) The proposed ICES/PICES/GLOBEC Symposium will be a major event for the marine ecologist in general and planktologists in particular in 2003. The preparation of this event will be the responsibility of a

Steering/Organising Committee, but the group as originator of this initiative wish to have up-dated information on the details and contribute when necessary to the good end of this stimulating challenge.

h) GLOBEC is at its mid-life time and it is timely and valuable to evaluate further opportunities for practical Trans-Atlantic coordinated research.

Tors i) and j) were formulated to this WG by the Oceanography Committee during the ICES Annual Science Conference.

In 2002 the present Chair will have covered his three-year period and the group should elect a new member to take this position.

ANNEX 3: ZOOPLANKTON MONITORING RESULTS IN THE ICES AREA
SUMMARY STATUS REPORT 2000/2001

Prepared by the ICES Working Group on Zooplankton Ecology

Editor: Luis Valdés

Data provided by:

David G. Mountain, Doug Sameoto, Astthor Gislason, Anthony Richardson, Eilif Gaard, Webjorn Melle, Lutz Postel, Steve Hay, Robin A. Clark, Wulf Greve, Roger Harris, Angel L. Urrutia, Luis Valdés and M. Teresa Alvarez-Ossorio

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Contents:

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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 web site. The Working Group on Zooplankton Ecology (WGZE) consider as a priority action to produce a summary report on zooplankton activities in the ICES area based on the time series obtained in the national monitoring programmes.

This is the second summary on zooplankton monitoring results in the ICES area. It continues a pilot study to further develop uses for and disseminate results from the ongoing time series monitoring programmes in the ICES region. One of the main objectives this year was to fill existing gaps in the regional coverage by attracting additional sampling programmes to contribute with their data sets. The new additions resulted in the following improvements:

- Incorporation of four new data sets: Georges Bank, Faroe Islands, Dove (North Sea, W) and Helgoland (North Sea, SE).
- Ordination of data sets in five different subdivisions corresponding to regional seas or basins: Western Atlantic, Iceland-Norwegian basin, Baltic sea, North Sea and English Channel, and Bay of Biscay and Iberian coast.
- Inclusion of seasonal and year-to-year variability in some regions of two target species: *Acartia clausi* and *Calanus helgolandicus*.

2. Regional coverage

The information collated by the ICES WGZE on, zooplankton sampling programmes in the ICES area include 5 fixed stations and 27 standard sections (approx. 200 sampling stations) distributed on the continental margins of both America and Europe and covering from the temperate latitudes south of Portugal to the boreal regions north of Norway. 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 A3.1

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

The main characteristic of the zooplankton monitoring programmes is the temporal resolution of observations. Zooplankton is also sampled with a variety of nets, over a variety of temporal and spatial scales, so a comprehensive interpretation of the data sets requires information on metadata to describe the content, quality, and other data characteristics (sampling gear, mesh size, depth, sampling site, dates, person responsible for the data, etc.) are included in Section 5. These metadata will help a reader locate and understand the data presented in this document.

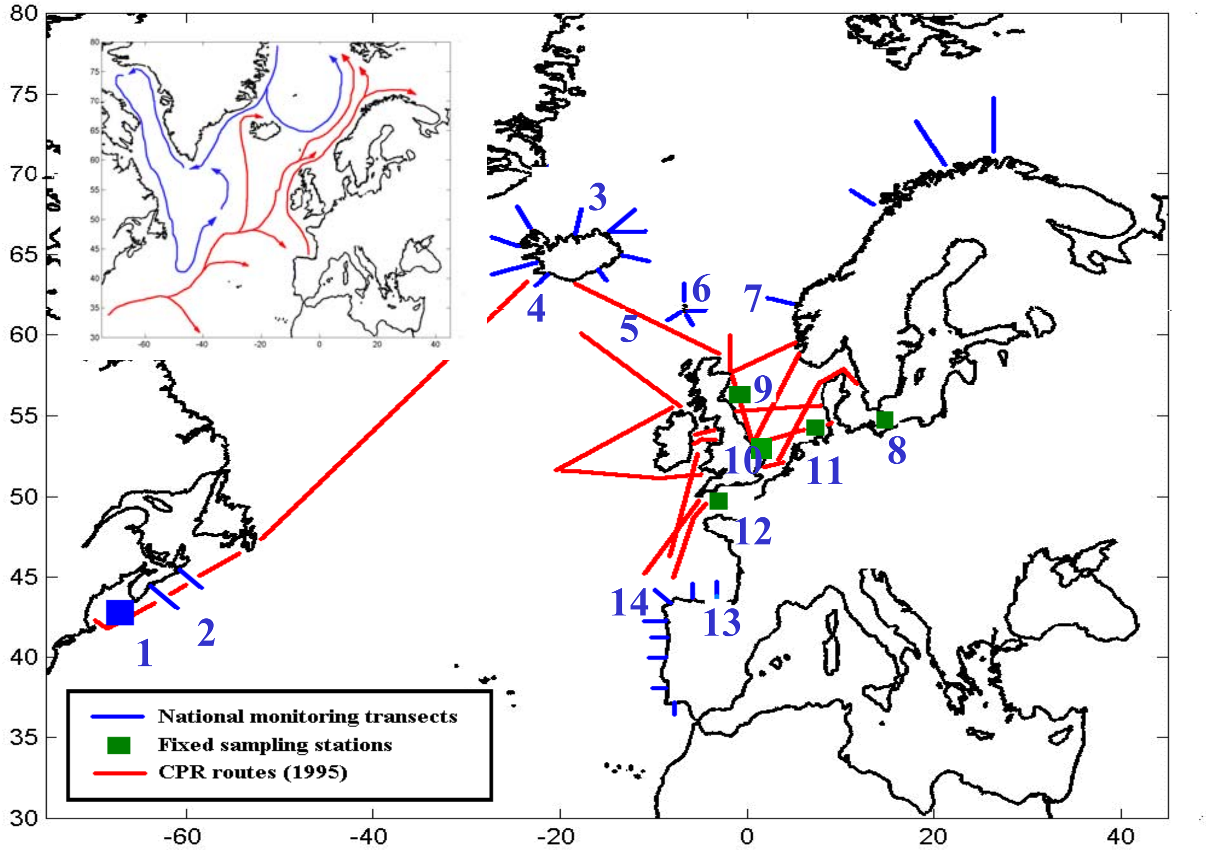


Figure A3.1: Zooplankton sampling network in the ICES area (only sampling programmes reported in the WGZE); numbers make reference to the collections used in this report. Map in the upper left corner represents the schematic general circulation of the North Atlantic.

3. Regional descriptions

Western Atlantic

Area 1: Georges Bank

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

The second type of monitoring is by Bongo net (333 µm mesh) samples collected four to six times per year over the shelf region. A number of possible indices could be provided. Two examples are presented here, showing the plankton displacement volume on Georges Bank in the early spring and early autumn (Figure A3.2). Indices of abundance for specific species or taxonomic groups could also be provided (e.g., *Calanus finmarchicus*, amphipods, euphausiids, cnidarians).

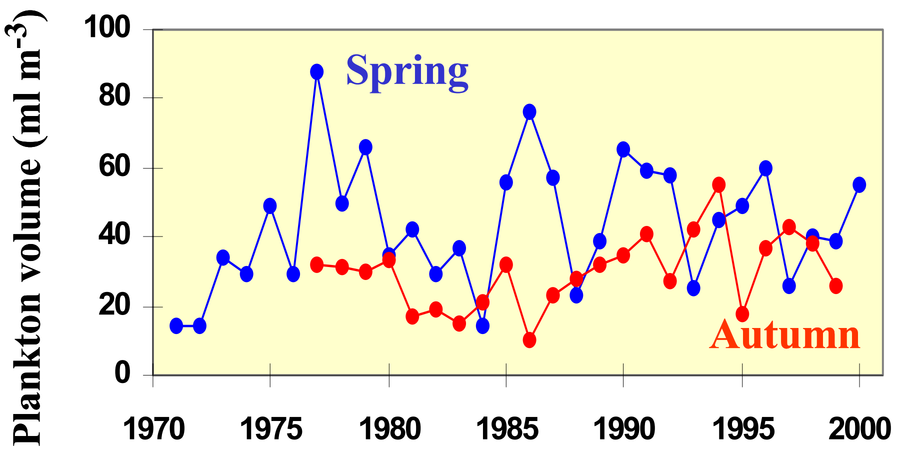


Figure A3.2: Plankton displacement volume on Georges Bank in the early Spring and early Autumn.

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

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

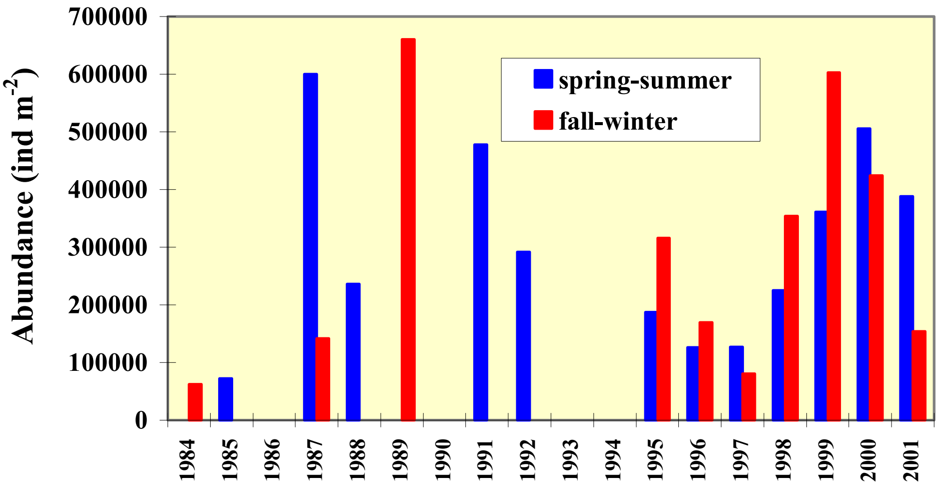


Figure A3.3: Abundance of zooplankton in Emerald Basin (1984–2001).

It is believed that the size of the autumn population of *Calanus finmarchicus* in Emerald Basin is a good indicator of the size of the population on the Scotian Shelf during the previous spring and summer (Sameoto and Herman, 1990). The *C. finmarchicus* population declined between 1995 and 1997 to reach the historical low levels of 1984. During 1998 and 1999 the population had recovered reaching maximum levels in autumn of 1999. *C. finmarchicus* accounts for a significant portion of total zooplankton, which shows the same general pattern in abundance (Figure A3.3). The temperature anomaly at 50 m in June and the numbers of *C. finmarchicus* appeared to be related, showing that, as the temperature increased, there was generally an increase in the size of the *C. finmarchicus* population.

Icelandic-Norwegian basin

Areas 3 and 4: 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 A3.4. At Siglunes the values are averages from 8 stations, while on Selvogsbanki the values represent averages from 5 stations.

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 highest and lowest values differ by a factor of about 24. The last peak in zooplankton biomass occurred in 2000.

The zooplankton biomass north of Iceland is influenced by the inflow of warm Atlantic Water to the area. Thus, in warm years, when the flow of Atlantic Water onto the northern shelf is high, the zooplankton biomass is almost twice as high as in cold years, when this inflow is less evident (Astthorsson and Gislason, 1998). The reasons for this may be the better feeding conditions of the zooplankton due to increased primary production in warm years, the advection of zooplankton with the Atlantic Water from the south, and the 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.

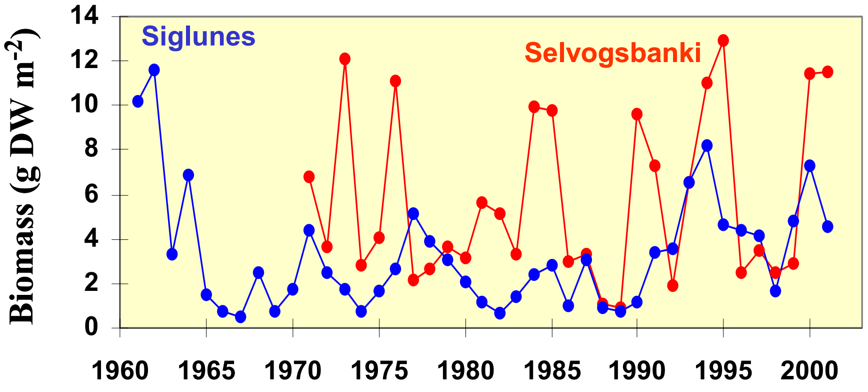


Figure A3.4: Year to year variability of zooplankton biomass at Siglunes and Selvogsbanki.

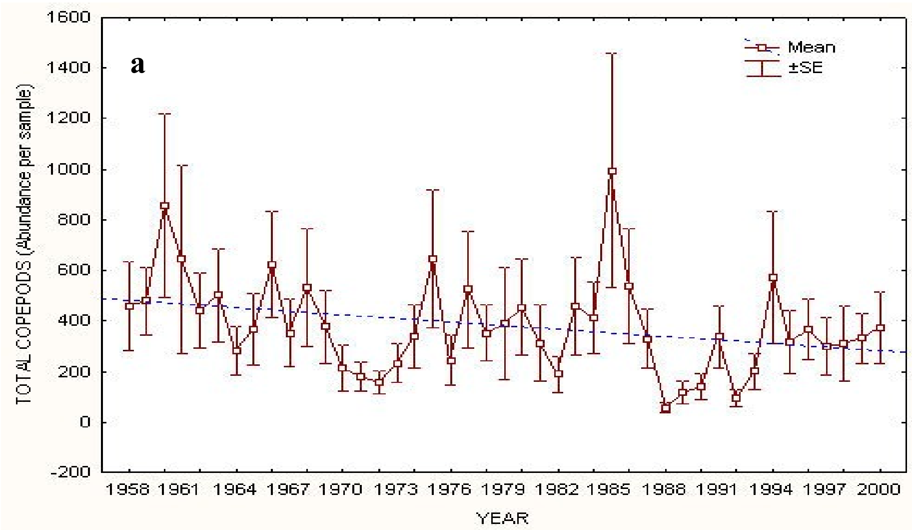
South of Iceland (Selvogsbanki transect) the links between climate and zooplankton biomass are not as evident as north of Iceland. Most likely the variability off the south and west coasts is related to the timing and magnitude of the primary productivity on the banks which in turn are influenced by the freshwater run-off from rivers and wind force and direction. 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. The period between zooplankton peaks on the Selvogsbanki transect has been 5–10 years.

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).

Area 5: Iceland-Scotland CPR line

The series shown in Figure A3.5a is for total copepods along a CPR route between the north of Scotland and Iceland during the period 1958–2000. In the Scotland-Iceland area, the mean total copepod abundance in 2000 was 373.6 individuals per sample, just below the overall mean for the series of 382.2 individuals per sample. There appears to be extended low periods (<250 individuals per sample) in 1970–1973 and 1988–1990, with only occasional high (>800 individuals per sample) periods in 1960 and 1985. Interestingly, the maximum and minimum abundances were only three years apart, with 1985 having the highest abundance of 994.8 individuals per sample and 1988 having the lowest of 57.6 individuals per sample. Without adjusting for autocorrelation, there is a significant negative slope ($p<0.05$, $n=43$), although the variance explained is only ~10%. Thus, there is considerable additional variability in the time series unaccounted for by the negative trend.

In terms of the seasonal cycle, maximum abundances (>650 individuals per sample) are found from May to September, with very low values at other times of the year (Figure A3.5b). The large standard errors for May to September show that the abundances are very variable at this time.



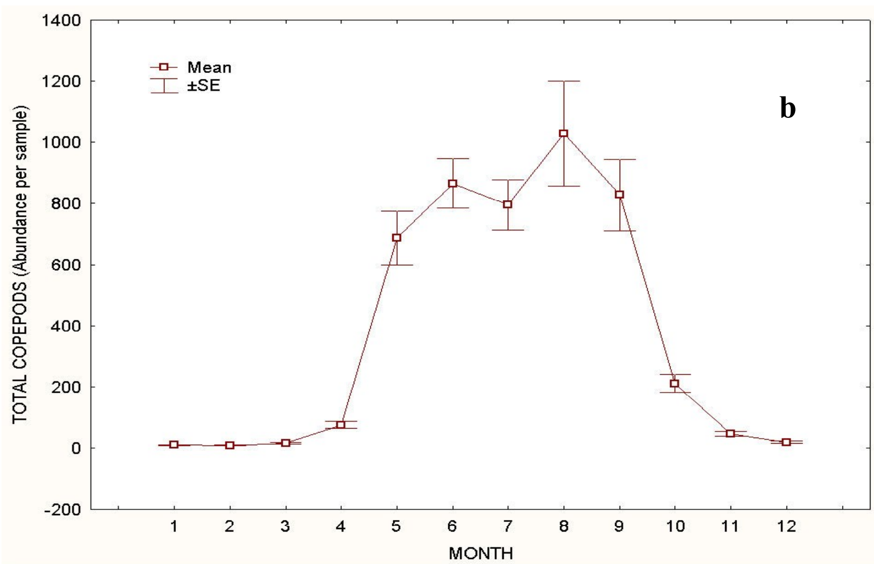


Figure A3.5: a) Year to year variability and long-term trend of copepod abundance in the CPR route Iceland-Scotland and b) Seasonal variability of copepod abundance in the CPR route Iceland-Scotland.

(http://www.npm.ac.uk/sahfos/sahfos2.html).

Area 6: Faroe Islands

The Faroese Fisheries Laboratory operates 4 sections radiating from the Faroes. One of these sections is from the Faroe shelf, northwards, into the southern Norwegian Sea. The section contains 14 stations with a distance of 10 nautical miles between each station. The southernmost end of the section is on the shelf, and contains essentially neritic zooplankton. From the slope and northwards, the southernmost part of the section covers warm Atlantic water, while the surface layer in the northernmost part of the section covers cold East Icelandic Current water. Thus, the oceanic part of the section covers two quite different water masses: warm water in the southern part and colder water in the northern part.

Figure A3.6a shows the average zooplankton biomass in these two water masses in the oceanic part of the section in May 1990–2001. *Calanus finmarchicus* is the dominant species in both water masses. With the exception of 1993, the biomass is clearly higher in the cold water mass in the northern part of the section than in the warmer southern part. The reason is a high abundance of overwintered *C. finmarchicus* (CV and adults) together with some *C. hyperboreus* in the northern part. In the Atlantic water, much fewer large individuals are present, but a high number of small recruits. Since the reproduction starts significantly earlier in the southern part of the section, the total numbers of copepods are much higher on average in the Atlantic water than in the East Icelandic current water, despite the lower biomass.

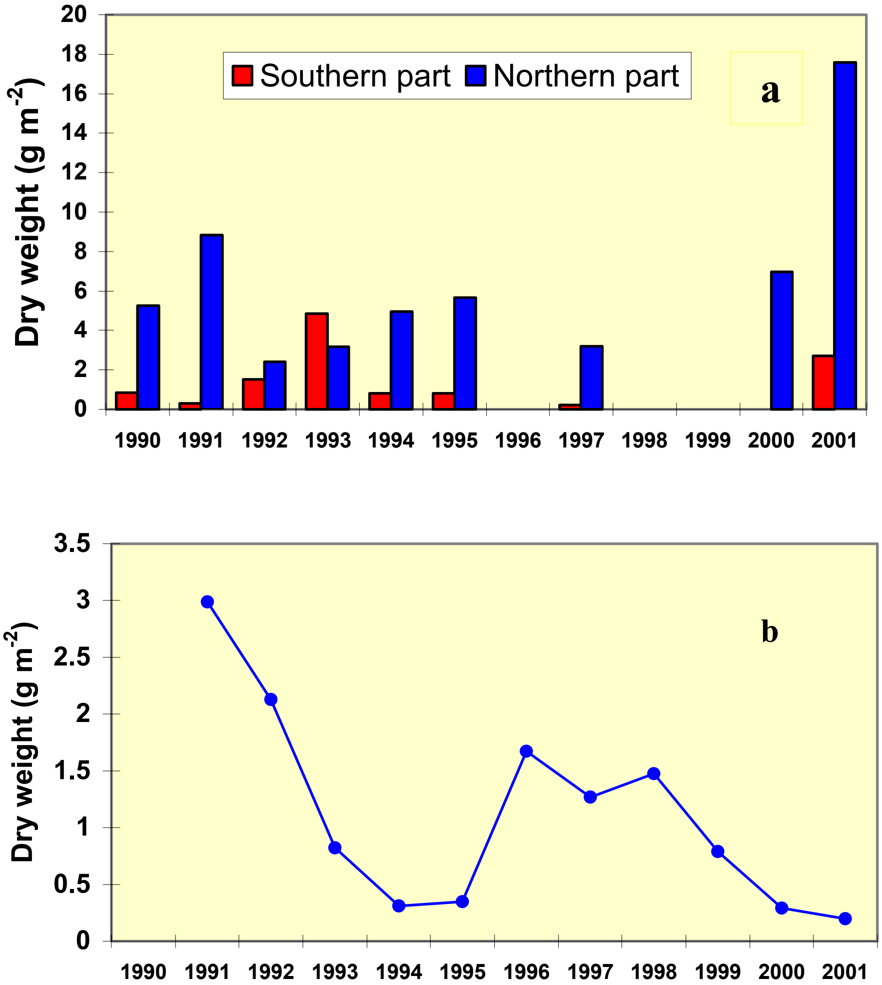


Figure A3.6. a) Zooplankton biomass at the ocean in the Atlantic water (southern part) and East Icelandic Current water (northern part) on section North in May 1990–2001. No data from 1996, 1998 and 2000 south. b) Zooplankton biomass on the Faroe shelf in late June 1991–2001.

On the Faroe shelf, neritic zooplankton dominates in most years. Advection of *C. finmarchicus* onto the shelf is highly variable each year. Due to the variable abundance of this large species (*C. finmarchicus*), the total zooplankton biomass has fluctuated considerably since 1991 (Figure A3.6b).

Area 7: Svinøy (Norwegian Sea)

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

The development of zooplankton biomass in spring at the Svinøy transect showed very small variations among years in the period 1997–1999 (Figure A3.7), and the maximum biomass in early summer varied from 8 to 9.3 g DW m^{-2}. In 2000, the maximum biomass as an average for all stations was 10.36 g DW m^{-2}, higher than previous years. In 2001, there was the lowest biomass since 1997 (6.93 g DW $m^{-2)}$. In May the biomass varied from one station to the other along the transect, however, there was no special trend towards higher or lower biomasses at any part of the transect. In July there was a clear trend towards higher biomasses at the ten easternmost stations (average 9.02 g DW m^{-2}), compared to the deep-water stations to the west (average 4.51 g DW m^{-2}). Due to the reduced coverage of the Svinøy transects in 2001 (4 times) no firm comparisons can be made with previous years with regard to the zooplankton development. However, it seems that the biomasses in the Atlantic water masses in the western part of the transects in May-July was significantly lower than in previous years.

The low biomass in the western part of the Svinøy transect in summer 2001 is consistent with observations in large parts of the Norwegian Sea. The zooplankton biomass in both Atlantic and Coastal water masses in May 2001 was far below those observed in the period 1998–2000, and at the same low level as in 1997.

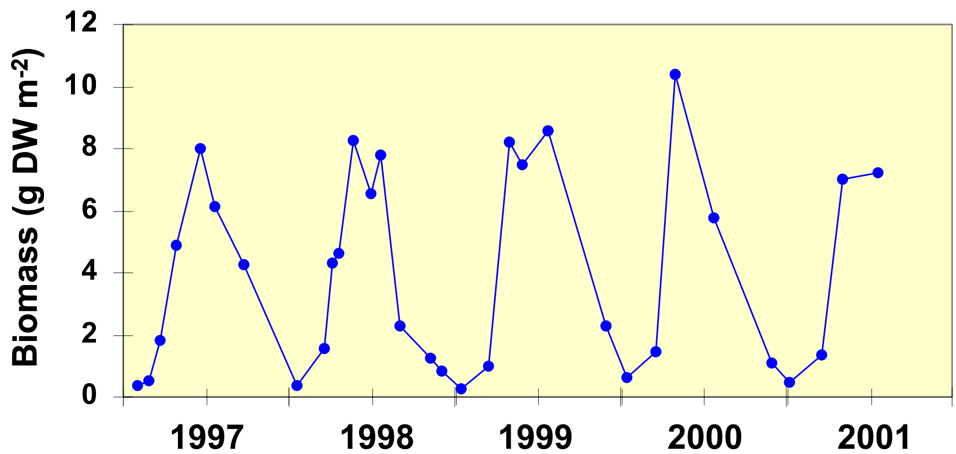


Figure A3.7: Zooplankton biomass at Svinøy transect (Norwegian Sea).

Baltic Sea

Area 8: Arkona Basin (Germany)

The Baltic Sea Monitoring Programme (BMP) consists of 24 international stations. The stations cover the different sub-areas of the Baltic Sea from the south-westerly Mecklenburg Bay to the north-easterly Gulf of Finland. Each station is sampled at least 4 times a year, but laboratories of all Baltic States contribute to the BMP increasing the amount and the frequency of data. Data are stored at HELCOM (Helsinki Commission) and will be stored at ICES in the future.

Periodic Assessment Reports are prepared every 5 years by contributions of all HELCOM member states (http//www.helcom.fi; HELCOM, 1996). Currently, the 4th report is under preparation.

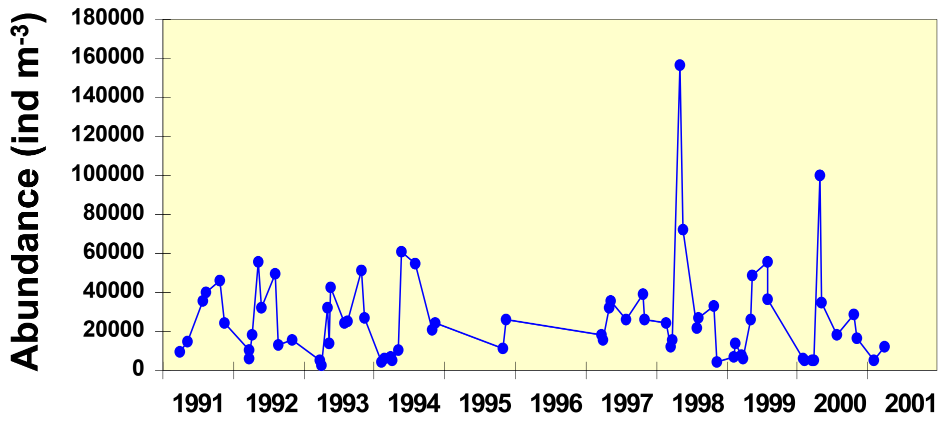


Figure. A3.8: Zooplankton abundance at Arkona Basin (Baltic Sea) in 1991–2001.

For purposes of illustration, one station (54°55′N, 13°30′E) has been chosen from the data base (Figure A3.8). This station is sampled from the surface down to 25 m or to the depth of the seasonal thermocline (30 m). A 10 year period (1991–2000) is shown, but the total series covers the period from 1973 to the present. In some years the sampling coverage is quite poor (e.g., 1995 and 1996). Variations in the range 10000–50000 ind m^{-3} are typically observed during the seasonal cycle in the western Baltic Sea. Peaks of plankton observed in spring 1992, 1998 and 2000 were because of mass developments of rotifers, which often happened after mild winters. In spite of these peaks, the cladoceran *Bosmina coregonii* is the dominant species during summer when water temperature reaches 16ºC (HELCOM, 1996).

North Sea and English Channel

Area 9: Stonehaven (Scotland, NW North Sea)

The Stonehaven sampling site is located at 56º57.80′N 002º06.20′W, approximately 5 km offshore from Stonehaven which is a fishing harbour 28 km to the south of Aberdeen. The water depth at the site is 50 m. Sampling for hydrographic parameters, concentrations of inorganic chemical nutrients and the abundance of phytoplankton and zooplankton species has been carried out on a weekly basis off Stonehaven since January 1997. The objective of the programme is to establish a monitoring base for assessing the status of the Scottish coastal waters ecosystem, and the responses to climate change. Comparison of the results with archive regional data on temperature, salinity and nutrients and phytoplankton biomass, indicates that the site off Stonehaven provides a reasonable index of the state of the coastal waters. The biological data illustrate the consistencies and variability in seasonal succession of plankton species and their abundance. It is evident that there are significant differences among seasons and years.

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

The seasonal pattern of plankton production is clearly evident in these data, as is the variability among years in its extent. 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 A3.9) but a lower observed abundance overall in 2001. Nutrient data also show strong seasonal cycles but again there is interesting inter-annual variability evident. This is also seen in the variations observed in the phytoplankton and chlorophyll data. The time series, although short, is at a fairly high observational frequency, this allows insight into the seasonal dynamics and succession of species throughout the annual cycle. This provides an excellent background against which to carry out process studies, modelling and comparisons with other sites. Data also provide assessment of the extent of local variability and allow consideration of the local effects of broader patterns of ocean climate change.

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

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

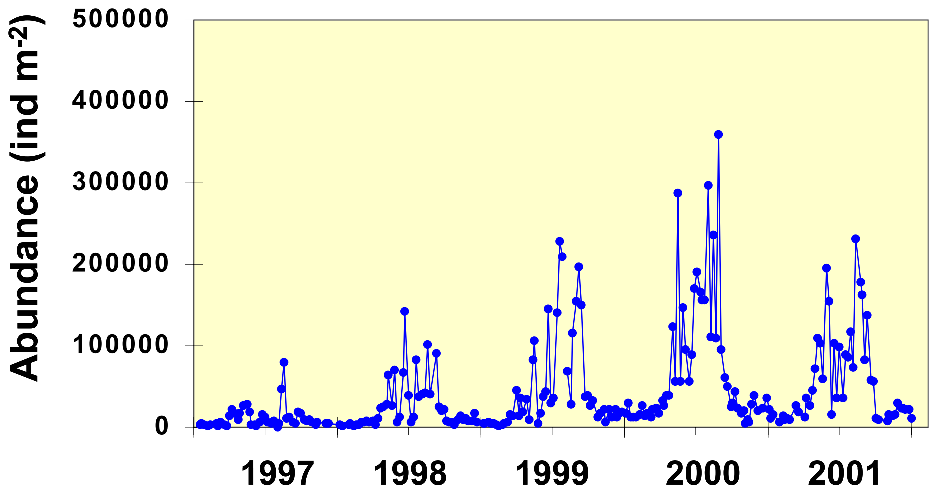


Figure A3.9: Weekly abundance of copepods (Calanoida) during 1997–2001 at Stonehaven sampling site (North Sea).

Area 10: Dove (Central-West North Sea)

Monthly sampling of the coastal central-west North Sea zooplankton community at a single station (55°07′N 01°20′W) by the Dove Marine Laboratory has been carried out from 1968 to the present (omitting 1989) (Figure A3.10), using a combination of WP2 and WP3 nets (UNESCO, 1968). Sampling consists of four vertical hauls from 50 m to the surface (water depth approximately 54 m), using a 200 µm meshed WP2 net. In addition, a 10 min. horizontal trawl at ~30 m depth is taken using a 1 mm meshed WP3 net.

Zooplankton are identified to species level where possible and abundances determined, according to its size, from either the WP2 or the WP3 net (see Evans and Edwards, 1993, for rationale). Certain taxa were further subdivided into sexes, or were categorised as juveniles and adults. Currently, data for this series are available from August 1968 to December 1996, although monthly samples are still being taken in the hope that future funding will allow the samples to be analysed (requests for data or further information should be sent to Chris Frid (c.l.j.frid@ncl.ac.uk) at the University of Newcastle).

Initial analyses of the time series data have been used to obtain productivity estimates and to observe the seasonal patterns of the Northumberland zooplankton community (Roff *et al*., 1988; Evans and Edwards, 1993). Further work observed that total zooplankton abundances were negatively related to the position of the Gulf Stream (Frid and Huliselan, 1996; Clark, 2000), contrary to that correlation observed in the northern and central-eastern North Sea regions using CPR data by Taylor (1995). Such opposite observations are not due to differences in sampling methods, as the relative interannual fluctuations in zooplankton abundance and community structure observed in the Dove series are comparable to those in the CPR series for an area in the central-west North Sea (Clark *et al*., 2001). Most recently, analyses have found that the zooplankton community displays strong evidence of top-down control, with the populations of the small-medium sized copepods (mostly *Pseudocalanus*) being controlled by the chaetognath *Sagitta*. This mechanism of top-down control was also found to be responsible for the negative correlation with the Gulf Stream - the signal observed in the zooplankton is inverted by the influence of the predators (Clark, 2000; Clark *et al.*, in prep).

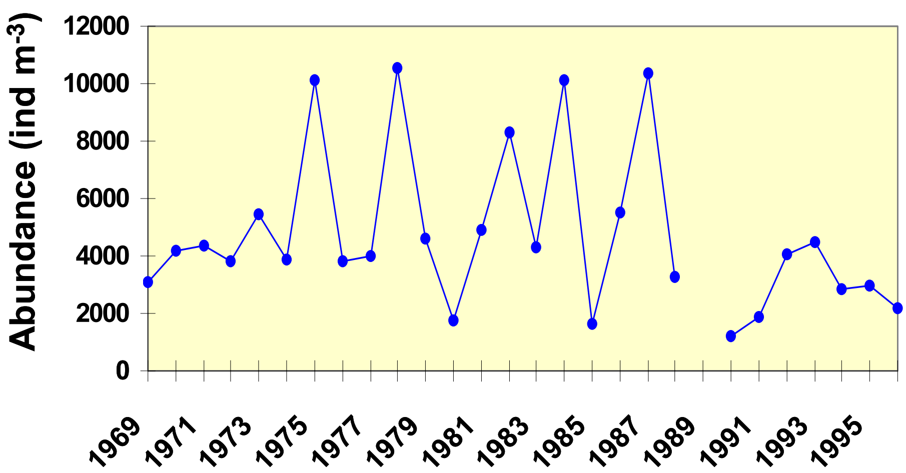


Figure A3.10: Year to year variability in zooplankton abundance at Dove (W, North Sea).

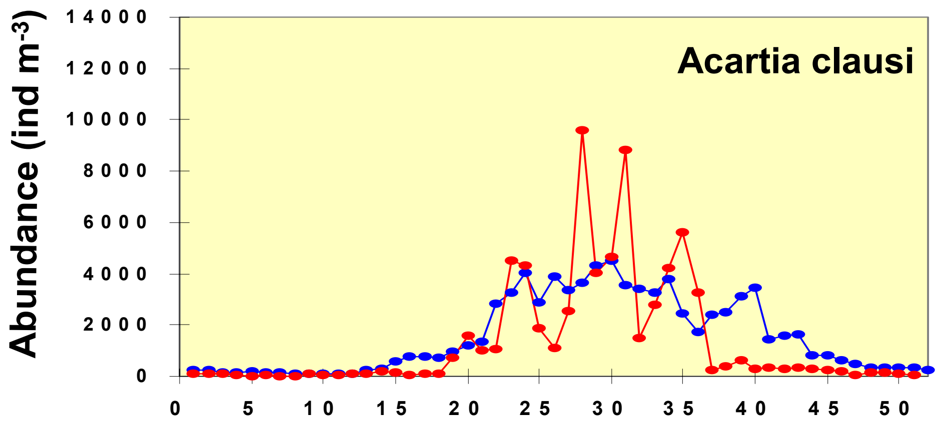
Area 11: Helgoland (SE, North Sea)

Since 1975 every Monday, Wednesday and Friday two oblique plankton net samples (150 µm, 500 µm) have been collected at the station Helgoland Roads (54°11′18”N, 7°54′E), Helgoland being the only offshore island of the North Sea. Almost 400 taxonomic entities of holoplankton and meroplankton (benthic-and fish-larvae) are counted.

Time-series were started within the Biologische Anstalt Helgoland and have been continued after the institutional re-organisation in a co-operation of the German Centre for marine Biodiversity, the Federal Maritime and Hydrographic Agency and the Biologische Anstalt Helgoland.

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

Acartia clausi represents a significant fraction of the total calanoid copepods. The annual cycle of both *A. clausi* and small calanoids during 2001 can be observed in Figure A3.11, and their abundances compared against the mean weekly abundance on the 20-year time series 1975–1994.



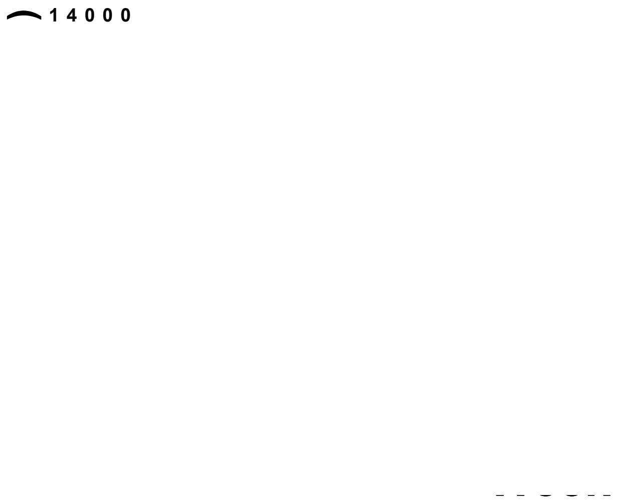


Figure A3.11: Upper panel: *Acartia clausi* population dynamics during 2001 (red line) compared with the mean weekly abundances of the years 1975–1994 (blue line). Lower panel: Small calanoid copepods population dynamics during 2001 (red line) compared with the mean weekly abundances of the years 1975–1994 (blue line).

Area 12: Plymouth (English Channel)

Zooplankton monitoring data are collected at a station (L4) situated about 15 miles SW of Plymouth in the English Channel. This station is about 50 m deep and influenced by seasonally stratified and transitional mixed-stratified waters (Pingree and Griffiths, 1978). Duplicate zooplankton samples are collected weekly with a 200 µm WP2 net towed vertically from 50 m to the surface. Animals are counted and identified to genera or species level under dissecting microscope. L4 zooplankton data are complemented with other environmental parameters such as temperature and phytoplankton. The L4 data are maintained at the Plymouth Marine Laboratory and are publicly available through a data CD and a web site, www.pml.ac.uk/L4. This is the end result of a project funded by the NERC thematic research programme Marine Productivity. L4 data has also been used for a number of seasonal studies into population dynamics, reproduction and feeding (Green *et al.,* 1993, Pond *et al.*, 1996, Irigoien *et al.*, 2000 a, b) in order to have a better understanding of the mechanisms underlying the changes in the long-term trends.

The ten dominant taxa at L4 have been ranked according to their annual mean proportion of the total zooplankton N m^{-3} (Table I). Over the time series, *Pseudocalanus* has been the most abundant making up 12% of the total population. Its mean abundance was 37% above the long-term mean in 2001. However, it is cirripede nauplii that were the highest group in 2001 being 156% over the long-term mean, making them 17% of the total population in 2001. *Temora*, *Acartia*, *Evadne* and appendicularia were all over 30% below the long-term mean, and *Oncaea* abundance 10%. *Paracalanus* and *Corycaeus* abundance was 37 and 41% respectively above the long-term mean. The top ten taxa took up a lower proportion of the total population in 2001 (74%) compared with the overall mean of 82%.

Rank	**Taxa**	**% total zooplankton 1988–2000**	**Yearly average N/m^3 1988–2000**	**% total zooplankton 2001**	**Yearly average N/m^3 2001**
1	*Pseudocalanus*	12.36	381	13.00	522
2	*Oithona*	11.88	366	9.97	400
3	*Oncaea*	10.69	330	7.81	313
4	*Paracalanus*	10.38	320	10.93	439
5	*Temora*	9.62	297	5.32	216
6	*Cirripede nauplii*	8.67	267	17.05	684
7	*Acartia*	6.89	212	3.53	142
8	*Evadne*	6.30	194	2.95	118
9	*Appendicularia*	2.46	81	1.27	51
10	*Corycaeus*	2.34	72	2.55	102
Total		**81.59**	**2521**	**74.38**	**2986**
Total Zooplankton N/m^3			**3083**		**4012**

Zooplankton abundance (Figure A3.12) at L4 shows a decreasing trend from 1988 to 1995, which then starts to pick up until 1999. This recovery was mainly due to two autumns developing small species of copepod, *Euterpina* sp. and *Oncaea* sp. During the years of relatively low zooplankton abundance, the development of the spring species *Pseudocalanus* sp. and *Acartia* had been relatively low. The higher abundance of cirripede nauplii from 1995 to 1998 and 2000 to 2001, contributes greatly to the total population when *Pseudocalanus* sp. and *Acartia* abundance in spring is sometimes low. *Paracalanus parvus* – a late autumn/winter species – has also added to the recovery of the zooplankton population since 1995. In 1999 there was a decline in the zooplankton population, with the top ten species (Table 1) all below their typical average values (apart from *Temora* and *Corycaeus*, which showed little variation). However, 2000 and 2001 shows a recovery in zooplankton population abundance comparable to that after 1995.

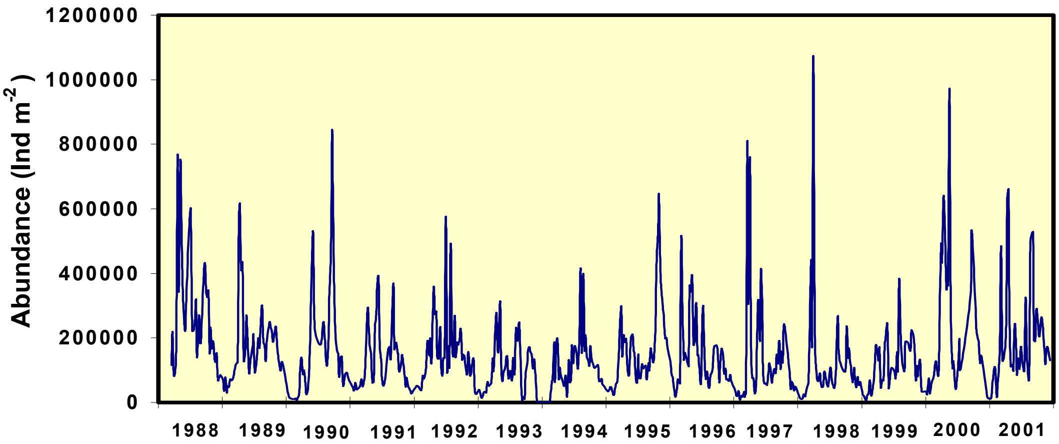


Figure A3.12: Weekly zooplankton abundance at station L4 (Plymouth, Celtic Shelf).

Bay of Biscay and Iberian coast

Area 13: Santander (Southern Bay of Biscay)

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

Long-term changes of zooplankton abundance at Santander show a slight decreasing trend up to 1998 (Figure A3.13). The result is in opposition to the upward trend showed by the water column stratification index (Lavin *et al.*, 1998). This relationship between zooplankton and environmental conditions highlight the importance of the longer duration that the water column remains stratified could have in limiting the interchange of nutrients from deeper to surface waters and consequently limiting the growth of phytoplankton and zooplankton (Valdés and Moral, 1998). A similar relationship between an increasing trend in the water column stratification and a decline of zooplankton biomass was reported by Roemmich and McGowan (1995) at the Californian coast (CalCOFI series).

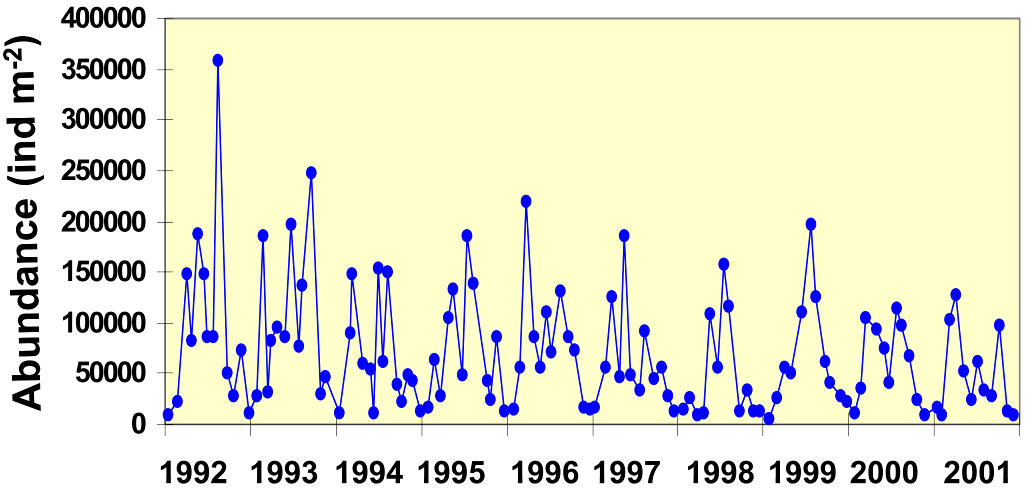


Figure A3.13: Monthly zooplankton abundance in a neritic station off Santander.

Figure A3.14 shows the year-to-year variability of *Acartia clausi* and *Calanus helgolandicus* at the shelf station off Santander. Monthly abundances of both species are superimposed on the mean monthly values for the time series 1992–2000, together with the 10 and 90% percentiles. The extreme variability of plankton populations can be observed. Annual peaks show variations of almost one order of magnitude among years (e.g., peaks of *A. clausi* in 2000 and in 1998, peaks of *C. helgolandicus* in 1996 and in 1998). For both species 1998 was the year when populations reached the lowest values for the time series.

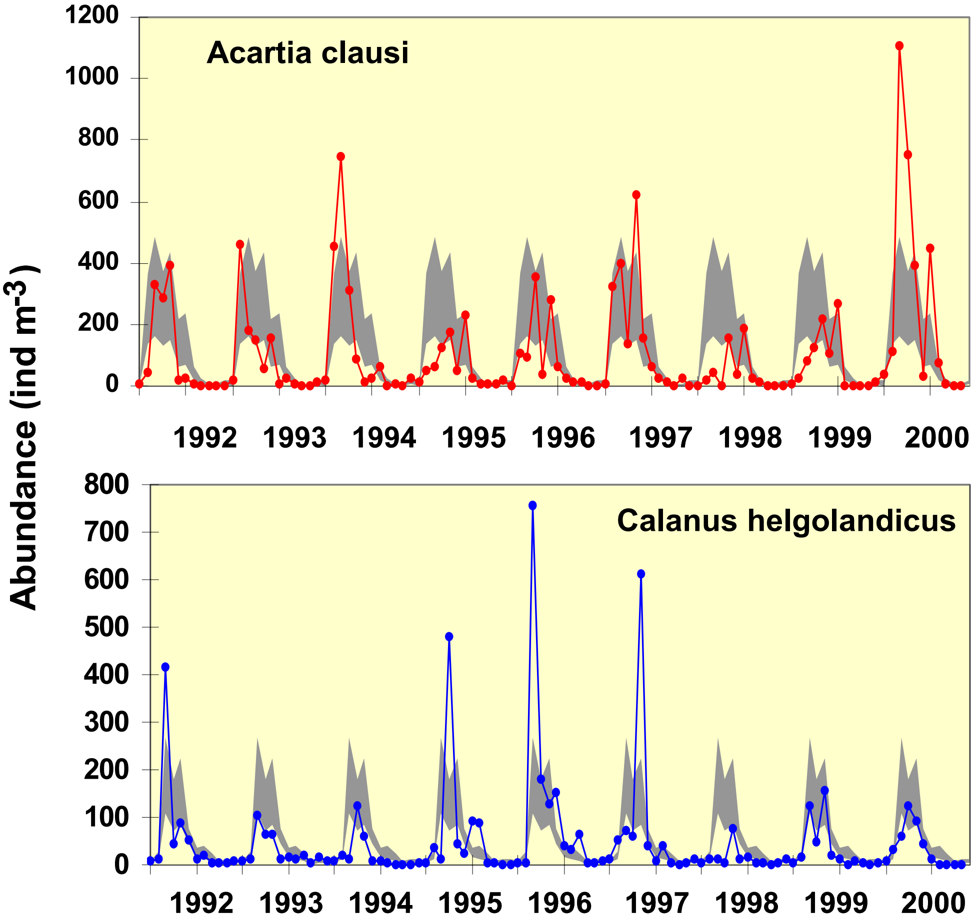


Figure A3.14: Monthly abundances (solid line) of *Acartia clausi* (upper panel) and *Calanus helgolandicus* (lower panel) at the shelf station off Santander. Superimposed are the 10 and 90% percentiles of the mean monthly values from 1992–2000 (shaded).

Area 14: A Coruña (NW Iberian Peninsula)

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

Zooplankton values in A Coruña (Figure A3.15) differ to that in Santander (Figure A3.13): zooplankton abundance is higher in A Coruña and the time series does not show any trend. Both characteristics are partly due to the influence of the seasonal upwelling, which prevents the water column from properly stratifying, reinforces the input of nutrients to the photic layer, enhances the growth of phytoplankton populations and therefore enhances the growth of zooplankton populations. [Note that the time series shown in Figure A3.15 is composed of two curves, one for the zooplankton >250 µm, and the other for zooplankton >200 µm].

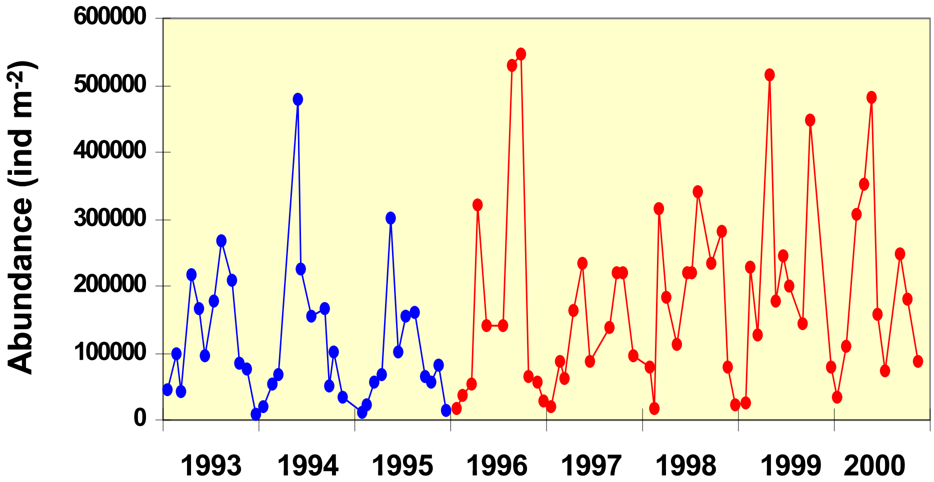


Figure A3.15: Monthly zooplankton abundance off A Coruña. (blue line= 250 µm mesh size; red line = 200 µm mesh size).

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

Country	USA (1)	CANADA (2)	ICELAND (3)	ICELAND (4)
Monitoring programme	NFSC, Narragansett, RI	Scotian Shelf	MRI-Iceland	MRI-Iceland
Sampling location	Georges Bank	Emerald Basin	Siglunes-transect	Selvogsbanki-transect
Latitude (N)		43º 57′N	*	*
Longitude (E-W)		62º 57′W	*	*
Station Depth (m)		265	*	*
Period of data available	1971-ongoing	1984-ongoing	1961-ongoing	1971-ongoing
Frequency (number of cruises/yr)	4–6 per year	random	Yearly (1 May-June)	Yearly (1 May-June)
Gear/diam (cm)	Bongo net	ring/75	1971–91: Hensen; 92-pres:WP-2	1971–91: Hensen; 92-pres:WP-2
Mesh (µm)	333	250	200	200
Depth of sampling (m)		0–265	0–50	0–50
Contact person	David G. Mountain	Doug Sameoto	Astthor Gislason	Astthor Gislason
Email address	dmountai@whsun1.wh.whoi.edu	sameotod@mar.dfo-mpo.gc.ca	astthor@hafro.is	astthor@hafro.is
Location of data		bio/chem database BIO	database MRI	database MRI
Observations (*)			Transect of 8 stns from 66°16′N, 18°50′W (bottom depth: 80m) - 68°00′N, 18°50′W (bottom depth: 1045m)	Transect of 5 stns from 63°41′N, 20°41′W (bottom depth: 46m) - 63°00′N, 21°28′W (bottom depth: 1004 m)

Country	ICELAND-SCOTLAND (5)	FAROE (6)	NORWAY (7)	GERMANY (8)	UK (9)
Monitoring programme	Continuous Plankton Recorder	FFl-Faroe Islands	IMR-Bergen	IOW	FRS-MLA
Sampling location	Iceland - N Scotland Transect	Faroe Shelf	Svinøy transect Norway	Arkona Basin, Baltic Sea	Stonehaven, Aberdeen
Latitude (N)	62º 30′N to 58º 50′N	62º20′N to 64º 30′N	*	54º 55′N	56° 57.80′N
Longitude (E-W)	18ºW to 4º 30′W	6º 05′W	*	13º 30′E	02° 06.80′W
Station Depth (m)	*	50–100	*	48	50
Period of data available	1946-ongoing	1989-ongoing	1993 -onging	1973-ongoing	1997 - ongoing
Frequency (number of cruises/yr)	approx 12, some missing mon/yrs	Yearly (late June)	6–10	Seasonally (4)	Weekly (52)
Gear/diam (cm)	CPR, aperture 1.24 cm x 1.24 cm	1990–1991 Hensen 1992-present WP2	WP-2 (56)	WP-2	Bongo/40
Mesh (µm)	280	200	200	100	200
Depth of sampling (m)	7–10	0–50	0–150		47
Contact person	Chris Reid	Eilif Gaard	Bj. Ellertsen	Lutz Postel	Steve Hay
Email address	pcre@wpo.nerc.ac.uk	eilifg@frs.fo	bjornar.ellertsen@iMrno	lutz.postel@io-warnemuende.de	haysj@marlab.ac.uk
Location of data	SAHFOS database	FFL	Helix database, IMR	German Ocean Data Centre, IOW	SERAD, FRS MLA
Observations (*)			Transect of 15 stns from 62°22′N, 5°12′E (bottom depth: 160m) - 64°40′N, 0°00′W (bottom depth: 2695m)		

Country	UK (10)	GERMANY (11)	UK (12)	SPAIN (13)	SPAIN (14)
Monitoring programme	CEFAS-Lowestoft	BSH and DZMB	L4-PML/UK	IEO-SPAIN	IEO-SPAIN
Sampling location	Dove	Helgoland	Plymouth	Santander	La Coruña
Latitude (N)	55º 07′N	54º 11.18′N	50° 15′N	43° 34.4′N	43° 25.3′N
Longitude (E-W)	1º 20′W	7º 54E	4° 13′W	3° 47.0′W	8° 26.2′W
Station Depth (m)	54		50	110	77
Period of data available	1968-ongoing	1975-ongoing	1988–1997*	1991-ongoing	1990-ongoing
Frequency (number of cruises/yr)	Monthly (12)	Monday, Wednesday and Friday	Weekly (~40)	Monthly (12)	Monthly (12)
Gear/diam (cm)	WP2 and WP3	Hydrobios and Calcofi	WP2	Juday 50	Juday 50
Mesh (µm)	200	150 and 500	200	250	1971–96: 250; 96-pres: 200
Depth of sampling (m)	50		50	50	50
Contact person	Robin A. Clark	Wulf Greve	Roger Harris/X. Irigoien	Luis Valdés	Maite Alvarez-Ossorio
E-mail address	r.a.clark@cefas.co.uk	wgreve@meeresforschung.de	rph@ccms.ac.uk	luis.valdes@st.ieo.es	maite.alvarez@co.ieo.es
Location of data	CEFAS		PML/CCMS	Database SIRENO IEO	Database SIRENO IEO
Observations (*)			Later samples in process		

ANNEX 4: ANNOTATION FOR LIST OF INDICES

A. Physical Indices to consider:

1) The North Atlantic Oscillation (NAO) has been shown in several instances to correlate well with abundance of several species of zooplankton.
2) The position of the north wall of the Gulf Stream has been shown to correlate well with copepod abundance around the British Isles. This index may be of limited geographic use, applicable to some areas, but not others.
3) Air and sea surface temperature (values and annual range) have been shown to have a direct effect on the species composition of zooplankton and their life history/ecology.
4) The amount of stratification of the water column direct affects nutrient availability and the food web structure of the upper waters, including the composition of phytoplankton, microzooplankton and larger zooplankton.
5) Turbulence is influenced by wind mixing (a cubic function of energy applied to surface), tidal mixing, and internal waves. Turbulence can directly affect zooplankton behaviour, feeding, and fish recruitment.
6) Upwelling influences the nutrients, phytoplankton, and in turn zooplankton
7) Fresh water discharge influences the strength and configuration of coastal currents, correlating with both zooplankton composition and abundance.

B. Nutrients and Phytoplankton

1) The stoichiometry of nutrients can directly influence the body composition and species composition of phytoplankton.
2) Although chlorophyll is commonly measured, it is of limited value in determining the abundance and composition of zooplankton. Size fractionation and measurements of pigments by HPLC are valuable additional measurements that should be made when possible.
3) The timing of phytoplankton blooms can be critical, particularly as they relate to the life history and ontogenic migrations of important zooplankton (e.g., *Calanus finmarchicus*). This can translate directly into copepod fecundity and availability of zooplankton as prey for fish.
4) An index of the ratio of diatoms and dinoflagellates has been demonstrated to directly affect survival of fish larvae. The relative balance between picoplankton (<3 µm) and larger phytoplankton strongly affects the food web structure.

C. Zooplankton

1) The timing and duration of the zooplankton reproductive season can be influenced directly by changes in physical variables (i.e., temperature), in turn influencing the structure of the food web.
2) The abundance of copepods, generally or specifically (i.e., *C. finmarchicus*), is likely to be most meaningful if expressed as a ratio (a value between 0 and 1). The units of abundance may be either biomass or numbers, as each has a different meaning.
3) The ratio between large and small copepods (in terms of both numbers and biomass) could be a meaningfully index. Perhaps a size fraction ratio of the zooplankton may be a more meaningful index, but it warrants further discussion.
4) The slope of the normalized biomass spectrum is an indication of community size structure. Another index might express spectrum of abundance with size.
5) Species richness and diversity indices need to define the target group in order to be meaningful. Unless the target groups are standardized, comparison between studies will not be useful.

D. Fish

1) Timing of spawning may reflect temperature change

2) Abundance of fish eggs and larvae can be a recruitment index for a particular species and geographic area.

3) Condition indices to indicate if larvae are feeding and growing well. Ratio of RNA/DNA in fish larvae can indicate the growth rate. Condition indices are of 3 types: morphometric, histological and biochemical. The ratio of RNA/DNA in fish larvae is a particular case of biochemical condition index (see Ferron and Leggett 1994. An appraisal of condition measures for marine fish larvae. Adv. Mar. Biol. 30: 217–303). However, there is much discussion to correctly use it, due to problems of intercalibration between species and season. The ratio of weight to length is a morphometric index. There may be other condition indices that are more useful than these examples.

ANNEX 5: 3RD INTERNATIONAL ZOOPLANKTON PRODUCTION SYMPOSIUM

Gijón, 20–23 May 2003

Convenors

The Symposium has three Convenors representing the three sponsors: Dr Roger Harris (GLOBEC Scientific Steering Committee), Dr Tsutomu Ikeda (PICES Biological Oceanography Committee) and Dr Luis Valdés (ICES Working Group on Zooplankton Ecology).

20 May - Session 1 **Physical variability and zooplankton population dynamics**

Session convenors:
Miquel Alcaraz (Institut de Ciencies del Mar, Spain) - miquel@icm.csic.es
Xabier Irigoien (Technological Institute for Fisheries and Food, Spain) - xirigoien@pas.azti.es

In marine pelagic systems, structure and function are controlled to a large extent by physical forcing. The interaction between physical and biological processes occurs at a wide range of temporal and spatial scales, from µm and msec, to hundreds of kilometres, and months or years. Zooplankton live at low Reynolds numbers, in the border between viscous and inertial forces, so the physical variability relevant for population dynamics starts around the Kolmogorov length scale, and affects mainly zooplankton encounters (with prey, mates, predators, etc.) and individual rate processes. Physical variability at larger time and space scales includes advective processes, changes that occur at hydrographic discontinuities and transition zones (fronts, pycnoclines, gyres, from m to km) at daily-monthly periods, as well as large-scale oceanic circulation patterns and latitudinal gradients, induced by atmospheric forcing and climatic changes occurring at multiyear frequency. This session is intended as a discussion forum in which any aspect of the interaction between physics and zooplankton can be discussed, and contributions involving research on the significance of physical variability at any of the scales relevant for zooplankton population dynamics are welcome, especially those including multi-approach studies.

Invited speakers:
Mark Ohman (Scripps Institution of Oceanography, U.S.A.) - mohman@ucsd.edu
J. Rudi Strickler (Center for Great Lakes Studies, U.S.A.) - jrs@uwm.edu

20 May - Session 2 **Role of zooplankton in biogeochemical cycles**

Session convenors:
Hans Dam (University of Connecticut, U.S.A.) - hans.dam@uconn.edu
Roger Harris (Plymouth Marine Laboratory, UK) - rph@pml.ac.uk

Zooplankton (both metazoan and protozoa) affect the elemental stoichiometry and material fluxes between particulate and dissolved matter directly through processes associated with the selective consumption and subsequent processing of their food. In addition, the degree of coupling of zooplankton and producers gives rise to regional and seasonal variations in the abundances of producer stocks, nutrient utilization and recycling efficiencies, and elemental export ratios. Hence, there is a growing recognition of the essential role that zooplankton play in regional and global biogeochemical cycles. This session will consider contributions related to zooplankton-mediated processes in modifying sinking particulate fluxes, and in recycling and distributing inorganic and organic materials throughout the water-column. The session will also consider the role of trophic interactions on elemental cycles. We seek contributions on theoretical and empirical approaches and new techniques that lead to new or improved understanding of zooplankton effects on regional, particularly the North Atlantic and North Pacific, and global biogeochemical cycles and processes.

Invited speakers:
Thomas R. Anderson (Southampton Oceanographic Centre, UK) - tra@soc.soton.ac.uk
Deborah K. Steinberg (Virginia Institute of Marine Science, U.S.A.) - debbie@vims.edu

21 May - Session 1 **Climate influences: What are long-term zooplankton data sets telling us?**

Session convenors:
Takashige Sugimoto (Ocean Research Institute, Japan) - sugimoto@ori.u-tokyo.ac.jp
Hans Verheye (Marine & Coastal Management, South Africa) - hverheye@mcm.wcape.gov.za

The session will consider papers that discuss physical variability and zooplankton population dynamics from the viewpoint of long-term physical and biological data sets. We are particularly interested in papers that discuss relations between large-scale climate oscillations (such as the North Atlantic Oscillation, Pacific Decadal Oscillation, and El Niño/Southern Oscillation) and interannual and decadal variability in zooplankton biomass and species composition. Topics of interest include shifts in "normal" distribution patterns, shifts in zoogeographic boundaries, changes in community structure and physically-driven changes in top-down and/or bottom-up processes. We anticipate contributions that discuss long-term studies in the Atlantic, Pacific, Indian and Southern Oceans, as well as from estuaries, fjords, coastal and inland seas, and coastal upwelling regions. We strongly encourage contributors to offer ideas for debate about the physical or biological mechanisms through which interannual and decadal-scale atmospheric signals are translated into a zooplankton response. We hope to receive contributions from many different ecosystems to facilitate comparisons of the ways in which zooplankton populations respond to physical forcing at longer time scales.

Invited speakers:
David L. Mackas (Institute of Ocean Sciences, Canada) - MackasD@pac.dfo-mpo-gc.ca
P. Christopher Reid (Sir Alistair Hardy Foundation for Ocean Science, UK) - pcre@pml.ac.uk

21 May - Session 2 **New approaches to zooplankton modelling** (morning session)

Session convenors:
Eileen E. Hofmann (Old Dominion University, U.S.A.) - hofmann@ccpo.odu.edu
Michio J. Kishi (Hokkaido University, Japan) - kishi@salmon.fish.hokudai.ac.jp

Physical variability and population dynamics of zooplankton are studied through long-term observations, process studies, retrospective analysis of existing data sets, and modelling. This session seeks papers that discuss innovative applications of models that advance our understanding of zooplankton population dynamics and the role of zooplankton in biogeochemical cycles. Modelling is an especially powerful tool because it allows one to conduct novel experiments and to test hypotheses that are otherwise too expensive or too difficult to conduct *in situ*. We anticipate papers that discuss advances in, and new approaches to, the building and running of coupled bio-physical models, models of the populations dynamics of zooplankton species or taxa, biogeochemical models, individual based models, and predator-prey models. Papers that consider novel techniques for visualization of multidimensional model output are encouraged.

Invited speakers:
François Carlotti (Université Bordeaux I, France) - carlotti@biocean.u-bordeaux.fr
Eugene Murphy (British Antarctic Survey, UK) - ejmu@bas.ac.uk

21 May - Session 3 **Progress in molecular biology** (afternoon session)

Session convenors:
Ann Bucklin (University of New Hampshire, U.S.A.) - Ann.Bucklin@unh.edu
Serge Poulet (CNRS - Station Biologique, France) - poulet@sb-roscoff.fr

Zooplankton exhibits complex responses to environmental variability through changes at the individual (e.g., physiological growth and condition), population (migration, reproduction, and mortality), and community (species composition) levels of organization. These processes have important consequences for the dynamics of oceans ecosystems; all of these processes may be examined using molecular biological and molecular genetic approaches and techniques. This session will highlight molecular biological approaches to understanding zooplankton diversity, dynamics, and production, focusing on studies that demonstrate useful applications and that have yielded new insights into the role of zooplankton in ocean ecosystems. Of particular interest are molecular studies that employ recent techniques, focus on genomics, and examine production parameters (growth, reproduction, diapause, selective mortality).

Invited speakers:
Penelope Lindeque (Plymouth Marine Laboratory, UK) - p.lindeque@pml.uk
Tomaso Patarnello (University of Padua, Italy) - patarnel@civ.bio.unipd.it

22 May - Session 1 **Application of new technologies (morning)**

Session convenors:
Gabriel Gorsky (Station Zoologique, Observatoire Oceanologique, France) - gorsky@obs-vlfr.fr
Peter H. Wiebe (Woods Hole Oceanographic Institution, U.S.A.) - pwiebe@whoi.edu

This session will highlight new technologies that are enabling zooplankton populations in aquatic systems to be studied spatially and temporally, directly or remotely, actively or passively and concurrently with other parameters. Advances in optics, acoustics, and genetics have all contributed to the development of new tools and methods for counting zooplankton in the laboratory and at sea, and for process studies of zooplankton. This session invites papers that focus on the application of new technologies (hardware and/or software) to conduct surveys or for process studies (including assimilative modelling strategies used to direct field sampling efforts), to conduct laboratory sorting and counting, to make physiological, biochemical, and genetic measurements, and to conduct other experimental aspects of zooplankton research. Contributors are also encouraged to focus on comparisons of instrument systems based on new technologies with those more conventional instruments that are widely used to sample zooplankton or measure their process rates.

Invited speakers:
Scott Gallager (Woods Hole Oceanographic Institution, U.S.A.) - sgallager@whoi.edu
Kurt Tande (Norwegian College of Fishery Sciences, Norway) - kurtt@nfh.uit.no

23 May - Session 1 **Comparative life histories and life cycles of zooplankton populations within and between the North Pacific and North Atlantic**

Session convenors:
Hans-Juergen Hirche (Alfred Wegener Inst.. for Polar and Mar. Res., Germany) –hhirche@awi-bremerhaven.de
Tsutomu Ikeda (Hokkaido University, Japan) - tom@pop.fish.hokudai.ac.jp

While the North Atlantic Ocean and the North Pacific Ocean are located in a similar range of latitudes, they differ in hydrographic conditions and zooplankton community structures. Key trophic positions are often occupied by congeners or closely related species of the genera *Calanus* and *Metridia* in the copepods, *Euphausia* and *Thysanoessa* in the euphausiids, *Sagitta* and *Eukrohnia* in the chaetognaths, and *Themisto* in the amphipods. In recent years, studies have revealed the potential for several life history traits within one species and among congeners, especially with regard to reproductive traits. However, the cues controlling the choice of a particular trait are largely unknown. Many species undergo large ontogenetic migrations, but the triggers for initiation and termination of resting phases and for the depth of overwintering stages are mostly obscure. The session invites papers focused on life history strategies and interactions of life history and environment (biotic and abiotic) of copepods and other zooplankton, in an attempt to explore key biological and environmental factors by between-ocean comparison. Papers on zooplankton life history/cycle patterns viewed from evolutional or genetic aspects are also welcome.

Invited speakers:
Charles B. Miller (Oregon State University, U.S.A.) - cmiller@oce.orst.edu
Makoto Terazaki (Ocean Research Institute, Japan) - terazaki@u-tokyo.ac.jp

23 May - Session 2 **Microzooplankton in the marine pelagial: Recent advances from molecules to ecosystems**

Session convenors:
Dian Gifford (University of Rhode Island, U.S.A.) - dgifford@gso.uri.edu
Suzanne Strom (Western Washington University, U.S.A.) - stroms@cc.wwu.edu

The influence of microzooplankton (broadly, heterotrophic organisms <200 μm) on pelagic ecosystems is disproportionate to their small size. This taxonomically and functionally diverse group performs a number of quantitatively important roles in pelagic ecosystems including grazing, nutrient cycling, trophic transfer and primary production. Recognition of the significant role of microzooplankton is relatively recent, and their study has resulted in numerous methodological advances and paradigm shifts. These range from the molecular level (application of tools including flow cytometry and PCR to hypotheses regarding taxonomy, cell-cell interaction, and community ecology) to the ecosystem level (findings regarding microzooplankton over larger temporal and spatial scales in coastal studies as well as global programs such as JGOFS and GLOBEC). Recent models confirm and further elucidate the often pivotal role of this zooplankton group in structuring planktonic ecosystems and their response to perturbations. We suggest that the time is ripe for an explosion of research and discovery on microzooplankton paralleling that of copepods during the 1970s and 1980s. We solicit oral and poster contributions on all the above aspects of microzooplankton research, as well as biological/physical linkages, nutrition, advances in sampling and quantification, and advances in taxonomy and genomics.

Invited speakers:
Michael R. Landry (University of Hawaii, U.S.A.) - landry@soest.hawaii.edu
Diane Stoecker (Horn Point Laboratory, U.S.A.) - stoecker@hpl.umces.edu

Special Workshops

19–20 May **Special Workshops**

Co-ordinator:
William T. Peterson (Hatfield Marine Science Center, U.S.A.) - Bill.Peterson@noaa.gov

A great deal of interest was expressed in having special workshops associated with the Symposium. To date, we have seven proposals for workshops:

- copepod egg-phytoplankton interactions, including effects of harmful algal blooms on zooplankton feeding and egg production rates;
- microzooplankton: role in food webs;
- ways and means of increasing interactions among ICES and PICES scientists;
- zooplankton in the context of fisheries stock assessment;
- standardization of zooplankton time-series methodologies: sampling and analysis;
- assembly of a global data set of "length-weight" relationships for zooplankton groups;
- progress in the study of meso-and bathypelagic zooplankton.

ANNEX 6: LETTER FROM THE WORKING GROUP ON ZOOPLANKTON ECOLOGY TO THE SECOND STEERING GROUP MEETING FOR THE NSF/EU IMPLEMENTING ARRANGEMENT

Dr Klaus-Guenther Barthel,
Dr Luis Fariña Busto,
Dr Mike Reeve,

20 March 2000

Dear Colleagues,

EU/NSF Research Collaboration

We have just concluded a very successful meeting of the ICES Working Group on Zooplankton Ecology here in Aberdeen, Scotland. The meeting was well attended and the discussions animated and fruitful. Among the TORs that we worked on was TOR "h" entitled "Future developments of Trans-Atlantic studies". During this session, we discussed in depth the prospects for an international effort to conduct synthesis studies of the data sets that have been produced by the groups that have been working under the GLOBEC banner during the past 5 to 7 years. The working group is strongly supportive of the synthesis objectives expressed in the papers that appeared in the EurOcean 2000 Symposium Volume and those encapsulated in the document prepared at the ICES Annual meeting in 2000 at Bruges, Belgium.

The possibilities are exciting for collaborative studies involving the synthesis of data sets about the life history processes of important zooplankton species. Essential to these studies is the development of coupled biological/physical basin-scale modelling of climate change scenarios regarding the distribution and abundance of zooplankton in the North Atlantic. Hence our community welcomed the positive news last year that the National Science Foundation and the European Commission had signed an Implementing Arrangement for Co-operative Activities in a number of research areas, including climate research and marine science. We understand that designing and implementing the mechanisms to enable groups of investigators from Europe and North America to conduct such collaborative studies will take time. We also understand that the Second Steering Group Meeting for the Implementing Arrangement will shortly be held in Brussels, that colleagues from NSF will attend, and that GLOBEC is on the agenda. This meeting might identify possible topics for launching joint actions such as calls for proposals for projects to be implemented in FP6 on the European side This is also a very positive development.

The working group view is that it is timely to begin the process of bringing the investigators that might become collaborative teams together in one or more workshops. The object of these workshop(s) would be to discuss the scientific topics and to define concrete steps to evaluate and model the impact of oceanographic and climate-related processes on the dynamics of plankton and fish populations. We suggest that a good next step would be hold such a workshop as a precursor to a call for proposals under EU/NSF sponsorship for topics that might include integration and synthesis of North Atlantic GLOBEC studies. This workshop could build on the detailed rationale and draft Research Plan developed earlier.

We hope that we can work with the NSF and EU over the coming months on practical implementation of this vision and look forward to working with you on this joint endeavour.

Kindest regards,

Luis Valdés (Chair, ICES Working Group on Zooplankton Ecology)
Roger Harris (Chair, GLOBEC Scientific Steering Committee)
Peter Wiebe (Chair, U.S.GLOBEC Georges Bank)

ANNEX 7: EUROPEAN MARINE BIOMETEOROLOGY NETWORK (EMBN)

Dr Wulf Greve

Bundesamt für Seeschifffahrt und Hydrographie und Deutsches
Zentrum für Marine Biodiversität

c/o DESY Gebäude 3
Notkestraße 85
D-22607 Hamburg
Tel.: x49–40–8998–1870
Fax: x49–40–8998–1871
e-mail: wgreve@meeresforschung.de

Objective: Marine organisms equally respond to climatic forcing as terrestrial organisms do (Greve *et al.* 2001). The biometeorological surveillance of marine organisms lags far behind terrestrial supervision of climatic effects on life at land. The anticipation of global warming and the increased economic and social utilisation of coasts requires an improved understanding of climatic affects which interfere with trophic processes, anthropogenic stress and monitoring strategies for the surveillance of marine biota.

According to the few available results climate response of marine organisms functions mainly on the basis of temperature. It is an element of the functional biodiversity of species and varies in the response direction (positive and negative temperature correlation), in the length and timing of the period of the reception of the temperature impact and with the gradient and the extremes of the thermal forcing.

The EMBN project is designated to develop a monitoring strategy for the phenology of marine organisms which is applicable over most of European marine biota on a low expense level as can be continued by one or several agencies for a long period expected in order to catch up with global warming disturbances of the marine ecosystem.

List of tasks:

The establishment of the EMBN will have

- to define the phenological criteria to be observed,
- to recruit, train and establish EMBN observers,
- to organise the data collection, certification and distribution,
- to analyse the observations.

These tasks will be organised as follows:

1. Investigation of phenological candidates

Regional and ecological expertise (plankton, benthos, nekton) will be gathered in iterative conferences, literature studies and local feasibility studies in order to define populations which can be phenologically monitored and promise biometeorological results on a regional and/or Europe wide basis. This group of experts will generate a list of phenological indicators to be considered. The transferability of the phenological garden concept will be tested.

2. EMBN phenological checklist

The production of a EMBN phenological checklist is the assigned task of this exercise. This checklist must be accompanied with a precise description of the organism, the observation conditions and the rules for reporting. The checklist will be printed in the languages of the observers following a standard format.

3. Selection of EMBN observers

The EMB observers are expected to serve as public volunteers, accepting a lasting duty for the community, safeguarding a high accuracy of their contribution for a limited financial reward. To recruit them from the possible interest groups (environmentalists, sailors, fishermen, divers, national park rangers and others) will require a clear concept, a precise documentation and a public recognition of this work. This recognition will include the professional training by research institutes, the certification of this training, technical support, privileged access to EMBN information and the continuous notification by the responsible agency (newsletter). The EMBN observers are expected to develop an attitude of a public solicitor for the life in the sea.

4. Definition of EMBN training

According to the EMBN checklist a concise teaching program for public education will have to be developed including the access to marine organisms, the rules of conduct for the handling of these, the possibilities of taxonomic confusion, the phenological definitions and the means of reporting. These steps have to be formulated and printed in the languages of the participating nations and structured according to the didactic experience of adult education.

5. Training for EMBN observers

The training of EMBN observers will follow the textbooks developed for this purpose. The timing and effort to be put into the education has to be found according to the experiences.

6. Test observation

Comparative test observations shall be started soon after the training of the EMB observers. The feasibility of analysing such information, establishing an IT dialogue, and improving the complete EMBN monitoring is part of this exercise.

7. Establish data management

The phenological data management has to be technically as simple and safe as possible. A data bank system will be established which follows the principles:

- easy storage of raw data,
- precise but partially automated certification,
- graded and protected access to data by the participants, the EU, the EMB observers, interest groups.
- standardised lasting storage in one or several government agencies.

The preparation of a public dialogue program will be started.

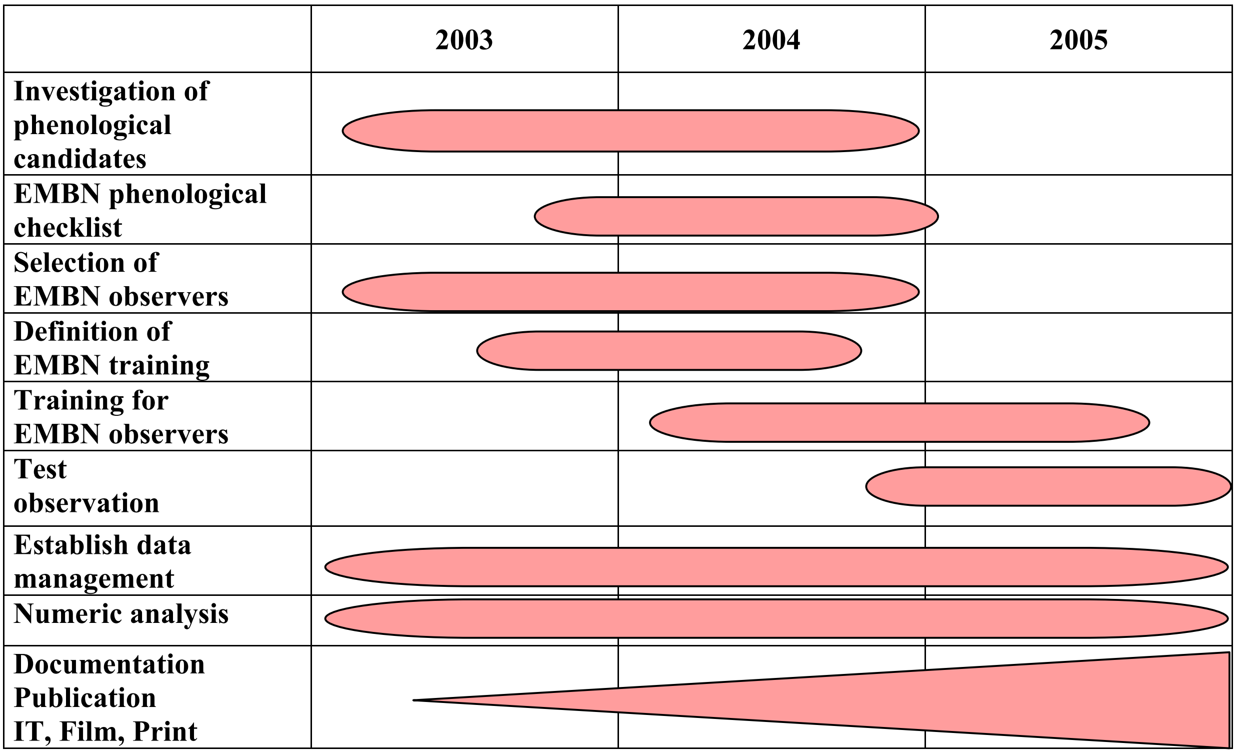
8. Numeric analysis

The scientific analysis of the biometeorological information is based on long documented time-series. This cannot be accomplished in the period of this project but on the basis of the available marine time-series and the terrestrial statistical tools a set of modules will be established that enables the biometeorological analysis of documented and future information. Marine Biometeorological theory, the options to transfer locally analysed functional relationships on other areas and the definition of principles will be started.

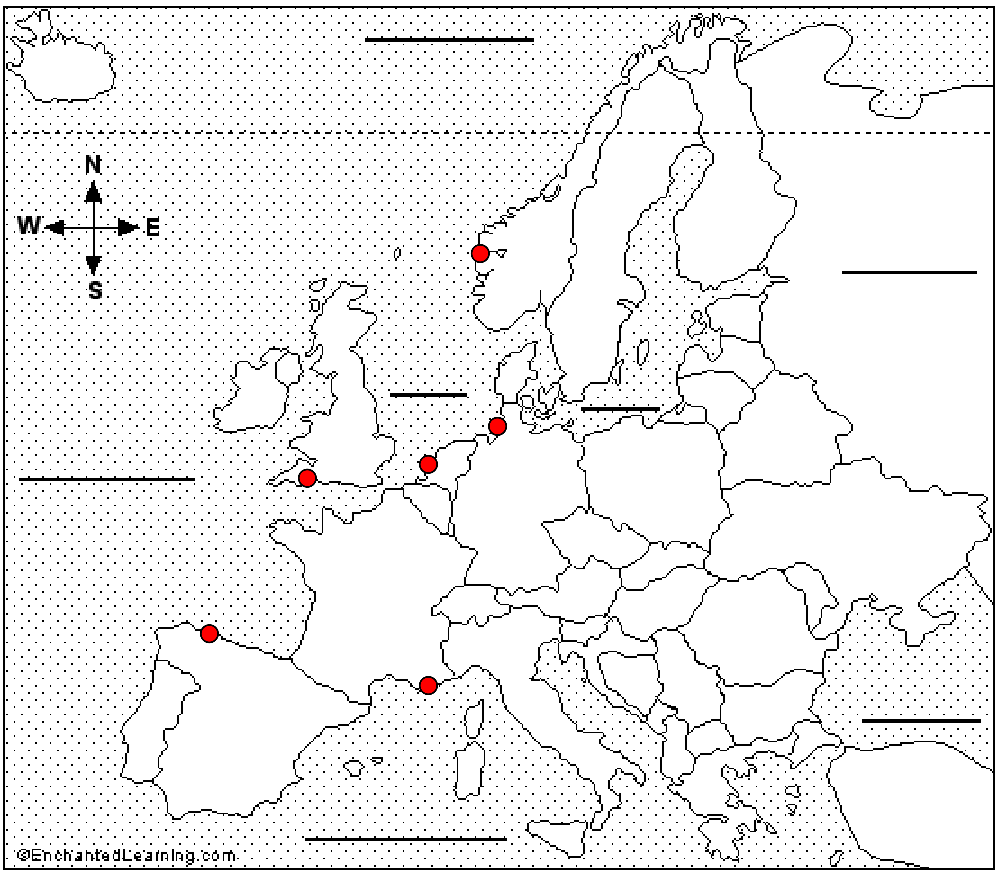
9. Documentation Publication (IT, Film, Print)

The process of the definition of the EMBN checklist, the recruitment and training of the EMBN observers, the observational routines and the data treatment and analysis have to be documented for future modification as scientific communications, as brochures and as posters, as training modules for future EMBN observers and, possibly, as videos for the public.

Time schedule



Potential participants should represent the major European marine climatic variance as given in the following sketch.



ANNEX 8: GELATINOUS ZOOPLANKTON INITIATIVE

Proposed by Pat Kremer, member of the WGZE of ICES at the 2002 meeting in Aberdeen.

Objective: To have gelatinous zooplankton ecology, abundance, and distribution become a more integral part of the activities of the WGZE.

Scientific Justification:

1) When abundant, many jellies (including scyphomedusae, siphonophores, and ctenophores) can be both predators and competitors with fish, consuming fish eggs and larvae directly, and feeding also on crustacean zooplankton. Other gelatinous forms (such as pelagic tunicates: appendicularians, salps, and doliolids) feed on small particulates and may be food for fish.
2) When abundant, jellies are often seen as a nuisance as they clog fishing nets, sting bathers, and clog water intake pipes.
3) Given the episodic pattern of abundance and patchy abundance of many forms of gelatinous zooplankton, they are more problematic to study and therefore their ecological significance is not well known.
4) Changes in pelagic food webs, due to climate change or overfishing, may lead to Òregime shifts where jellies become more abundant, and crustaceans and fish further decline.
5) Currently we are faced with fairly high degree of ignorance about the seasonality and spatial distribution of all but a few species of gelatinous zooplankton. We do not know much about interannual variability or regularity/irregularity of distribution relative to physical and biological conditions.

Justification within ICES (WGZE and Action Plan (2002–2005) of OCC):

1) As high abundance of gelatinous zooplankton have been shown to have a large ecological impact as both predators and prey, they should be included in the description, understanding, and quantification of biological processes listed as Objective #1 of the OCC Action Plan.
2) Climate variability and climate change(OCC Objective #2)can shift patterns of feeding, growth, and reproduction in gelatinous species, that can in turn lead to changes in food web structure. Especially the large gelatinous carnivores may have detrimental influence on fish recruitment.
3) Past and present regional and global monitoring often is inappropriate for gelatinous zooplankton. Sampling techniques are part of the problem. For example, some species of ctenophores leave next to no trace in nets, or gut contents. Species bias on the part of the investigators is also a problem. For example, the CalCOFI plankton surveys off the west coast of the U.S. routinely discarded large organisms that were caught in the plankton net. Furthermore, when salps were very abundant, whole samples were discarded. This has led to a systematic under representation of gelatinous forms in data reports.
4) Surveys for fish larvae and larger fish sample larger volumes and use larger mesh nets that are appropriate for several gelatinous species, but as invertebrates, these jellies are seldom included in reports and publications, and much valuable scientific information is lost. This hurts both research and monitoring of the gelatinous forms (OCC objective #5).
5) Improved knowledge of the variability in the distribution and abundance of gelatinous zooplankton would contribute to help determine the processes controlling the recruitment of some fish. (Issue 2a of Objective 1 in OCC Plan).
6) Understanding the ecology of gelatinous zooplankton may contribute significantly towards understanding shrifts in food web structure (Issue 2b) as affected by climate variability and climate change (Issue 2d).

What Should the WGZE do? Options:

1) Encourage a workshop (either to proceed or follow up on a Theme session at an Annual Meeting.
2) Form a special Study Group on Gelatinous Zooplankton to highlight their importance. This Study Group would then hold a workshop and advocate/organize a Theme session.
3) Other options to be suggested.