**Oceanography Committee** **ICES CM 1998/C:6**

**REPORT OF THE**

# WORKING GROUP ON ZOOPLANKTON ECOLOGY

**Santander, Spain**
**6–8 May 1998**



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

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## 1 BACKGROUND AND OPENING OF THE MEETING

The meeting was held at the Instituto Español de Oceanograpfia from 6–8 May 1998 at the kind invitation of Luis Valdés. The meeting was opened at 09:30 on Wednesday 6 May, and was attended by 15 scientists from 7 countries.

The Working Group met with the following terms of reference (ICES C.Res. 1997/2:50):

a) *complete a final review of the Zooplankton Methodology Manual and to agree plans for its publication;*

b) *carry out the first annual review of the results of zooplankton monitoring g activities in the ICES area using the summary map(s) and information in tabular form in this report as a basis;*

c) *carry out a comparison of CPR results with other data-sets and to review the CPR "intercalibration" made during the sea-going Workshop;*

d) *consider technologies for the remote acquisition of zooplankton information on data-buoys and other remote platforms.*

e) *consider recommendation for maintaining and preserving zooplankton taxonomic skills within the ICES scientific community;*

f) *assist the Convenor of the fourth Third ICES/GLOBEC Backward-Facing Workshop (1999) on the 1960s and 1970s anomalies in the North Sea in preparing monitoring information on zooplankton populations during this period;*

g) *consider future work programme in relation to the remit of the Oceanography Committee and the development of the ICES Five-Year Plan, including co-operation with other Working Groups.*

## 2 ZOOPLANKTON METHODOLOGY MANUAL

The discussion was introduced by Roger Harris and Ken Foote acted as rapporteur.

At the beginning of the first of two sessions, the chair R. Harris introduced the subject of the Zooplankton Methodology Manual (ZMM) by reviewing the history of its planning. Originally, the work was to consist of a review of methodology, recommendations of standard protocols, and a compact-disk version which could also include additional materials and data too voluminous for the printed text. The book was to be limited to about 300 pages, or roughly 20 pages per chapter exclusive of references, based on thirteen chapters. It is appreciated that length is an important consideration in publishing, although some Working Group on Zooplankton Ecology editors feel that this is not especially critical.

Contacts are being made with prospective publishers. An inquiry to Academic Press elicited the counter proposal that the cost of the publication be underwritten by Working Group on Zooplankton Ecology. An appeal to the EU provoked the observation that it would be strange to have to pay for a commercial publication. The sentiment was expressed within the WG that the ZMM is a potential best-seller. In any case, the EU is exploring the possibility of publishing the work in-house. It was noted that there is no obligation to stay with the ICES journal publisher. Three alternative means of publishing the work were described. (1) Pay-to-print could be considered by ICES so that the sales price could be held at a level that would aid wide dissemination. (2) Publication could be effected on a strictly commercial basis, hence be supported entirely by sales. (3) Publication could be undertaken as a commercial enterprise, but with the guarantee that ICES purchase a fixed number of copies.

The status of the ZMM was then reviewed chapter by chapter.

***Chapter 1 Introduction*** J. Lenz reported receiving a single review in the year since submission of the first draft. A second draft has been prepared on this basis and distributed to participants at the Working Group meeting. In discussing the matter of how to introduce the subsequent chapters, it was agreed that the coordinating editors should write a preface. This would outline the history of the ZMM project and describe the organisation of the book by chapters.

***Chapter 2 Sampling and experimental design*** H. R. Skjoldal reported that this is still being drafted, but that this is to be completed by June 1998. One assigned contribution was submitted in November 1995. Some conceptual difficulties in integrating physics and ecology into the framework of the chapters were mentioned.

***Chapter 3 Collecting zooplankton*** D. Sameoto has received comments from J. Lenz and revised the first draft. In the course of discussions, the problem of use of copyrighted figures was raised. This is common to a number of chapters, hence further discussion was postponed until the second plenary session.

***Chapter 4 Biomass and abundance*** L. Postel informed the Working Group on Zooplankton Ecology that the first draft would have been complete but for his attendance of the Working Group on Zooplankton Ecology meeting. A detailed outline was presented and discussed. It is presented in Appendix 3. In response to questions, L. Postel stated that a numerical example of an abundance calculation would be given and that this would also include a consideration of errors. Community structure is also to be considered. Gelatinous zooplankton are to be included in Section 4.4. A discussion on conversion factors indicated that there is a significant if eclectic literature on the subject. Apropos of the chapter, adequacy of treatment of such factors cannot be judged before a draft is circulated. Evaluation of biomass by acoustics and optics is considered to be a remote sensing technique belonging to the domain of Chapters 6 and 7, hence need not be considered with the direct-measuring processes reviewed in Chapter 4. It was emphasised again that statistical techniques will not be described, but reference will be made to the textbook literature. The matters of standardisation and balance were discussed at some length, with background in the early recognition of the desirability of recommending standard protocols. Particular topics were cited: organic weight measurement, abundance and species identification, mesh size for sampling mesozooplankton, and methods of hauling, among others. Pitfalls of standardisation were exemplified through the case of mesh size, which varies both by country and research program. The discussion ended in a debate over the nature of the manual: whether it is to consist in concise descriptions of how to do something or whether it may provide lengthier textual description. The second possibility was admitted.

***Chapter 5 Microzooplankton biomass*** In the absence of the author, R. Harris stated simply that the chapter has been reviewed and is ready for publication.

***Chapter 6 Acoustical methods*** K. Foote reviewed the history of this chapter. The first draft has so far elicited two thorough reviews, from an acoustician and an electrical engineer, but the third review, from a professional educator and user of acoustics, is still awaited. In the absence of the third review, revision is pending, but the authors anticipate major revision on the basis of the comments made in the two received reviews. Inclusion of mathematical formulas was not regarded as disadvantageous by the editorial committee. The authors anticipate submission of the second draft by June 1998.

***Chapter 7 Optical methods*** Again, K. Foote introduced the status of a chapter manuscript by briefly reviewing its history. Because of the emphasis on specific devices, individual parts have been sent to those researchers whom it might be thought would be most concerned about representation of their current work, much of which is described only through pre-prints or less formal communications. A number of informal personal reviews has been received, but a number is still outstanding. Pending receipt of these, a formal first draft may be submitted by September 1998. The matter of balance of this chapter, as well as that of Chapter 6, was discussed. It is first at this time that this can begin to be addressed, for balance is defined by the whole work.

***Chapter 8 Feeding*** R. Harris indicated that U. Baamstedt has recently made rapid progress. X. Irigoien believes that a new submission will be made by the end of May 1998. In response to a question about elaboration of feeding by optical methods, it was stated that this is described. It is moreover mentioned in Chapter 7, but through an application. The need for cross-referencing here, as well as in other instances, is noted.

***Chapter 9 Growth*** R. Harris mentioned that this is largely complete. However, extensive discussion was held on secondary production, cohort development, and rates of production as topics for possible inclusion. Contact with an author of Chapter 13 was recommended. The statement was made that the sum of Chapters 9 and 10 still does not fully cover the subject.

***Chapter 10 Metabolism*** S. Hernandez Leon stated that reviews had recently been received, and the chapter was being revised. The chapter is written in two parallel sections, but with some duplicate numbering that should be remedied.

***Chapter 11 Genetics*** R. Harris mentioned that two reviews have been received. Advantages of illustration, which is presently lacking, were mentioned.

***Chapter 12 Population dynamics*** R. Harris distributed a copy of the author's publication of their work in SARSIA, 82, 279–296 (1997). It is suggested that some alteration might be necessary and that resubmission of the work would be highly desirable.

***Chapter 13 Modelling*** R. Harris described progress made by F. Carlotti, who acknowledges problems requiring editorial guidance. A request for completion by June 1998 is being made.

At the outset of the second session, the chair R. Harris summarised the result of the meeting of the four-member coordinating editorial panel with M. Huntley, held after the plenary session on 7 May. This was done through a pronouncement on the subject of style issues, particularly on "principles, comparative approaches and techniques," and "specific measurement protocols or examples thereof." Draft details are given in Appendix 3. Advance notice was given of a letter to be sent to chapter authors on 22 May 1998. Some details of a "publication timetable" were also given. Both the letter contents and the timetable are included in Appendix 3. Finally, authors present at the Working Group meeting were informed of individual meetings to be conducted with them on the afternoon of 8 May.

A free-flowing discussion ensued. It was observed that, in effect, a style guide was being imposed with retroactive force, notwithstanding publication of detailed chapter outlines in the document ICES C.M. 1995/L:5. In the absence of specific comment on these in the intervening three years since the meeting of Working Group on Zooplankton Ecology at Woods Hole in June 1995, authors had made the apparently reasonable assumption that the contents, as outlined, were acceptable. This was emphatically not the case. It was acknowledged that authors who had already submitted their manuscripts were being penalised, while those who had not, had pursued the personally judicious course.

Justification for the retroactive imposition of a style guide was offered: standardisation and balancing of the several chapters. No allowance was made for those authors who had submitted their manuscript in accordance with the chapter outlines published in 1995.

In further discussion, the useful qualification was volunteered that Part I of the Style Issues, Appendix 2, describes elements of composition, not necessarily the order to be followed. It is appreciated that insofar as some manuscripts are written in an organic manner, conforming them after the fact to a new standard is not merely a matter of rearranging blocks of text, since order is important. Authors of submitted manuscripts were also urged by the editorial committee to adopt a pragmatic approach in rewriting their manuscripts, with the possibility of negotiating details with the editorial committee. Additional deference was shown to authors of submitted manuscripts by promises that (1) the publisher's detailed style guide would be included with the editor's letter of 22 May 1998, and (2) no requests would be made for additional rewriting or rearrangement or other modification of chapter manuscripts for formal reasons of style.

There was expression of renewed interest in electronic publication of the ZMM. It was flatly stated that should parts or all of the ZMM be published electronically, the work proper would still be published in conventional book form. Agreement on this was unanimous.

## 3 ZOOPLANKTON TAXONOMIC SKILLS

At the 1997 meeting of the Working Group on Zooplankton Ecology, in Kiel, Germany, concern was expressed about the loss of taxonomic expertise within the ICES zooplankton community. As a result the Working Group recommended as a term of reference for the 1998 Working Group on Zooplankton Ecology meeting (ICES CM 1997/L:4) to consider specific recommendations for the maintaining and preserving zooplankton taxonomic skills within the ICES scientific community. The Working Group dedicated part of a session to address this subject. Roger Harris introduced the subject, Luiz Valdés chaired the session and Emília Cunha acted as rapporteur.

There was unanimity among the members of the Working Group about the importance of the use of taxonomy in zooplankton ecology studies. The understanding and support of the use of such a tool in zooplankton ecology was so high that the members decided not to continue with the discussion of the already known importance of such a subject. Therefore they started almost immediately considering several possibilities in order not only to preserve but also to maintain zooplankton skills within the ICES area.

Luis Valdés started by referring some work done by the Benthos Ecology Working Group that presented in the last meeting (ICES CM 1997/L:7) a list of the main species that belong the several benthic communities and asked if it would be advisable for this Working Group to prepare something similar.

Peter Wiebe commented on the expertise and taxonomy effort that is being deployed in GLOBEC projects as an example where such studies are being successfully applied and how GLOBEC is spreading beyond its original area, the North Atlantic into the Pacific. He also referred the necessity to consider the inclusion of genetic studies in taxonomy to help to distinguish different population of the same species.

Heine Rune Skjoldal added also the importance of keeping taxonomic skills in supporting of the biodiversity framework and suggested the realisation of a workshop on zooplankton taxonomy that would put together different taxonomic specialist.

It was mentioned by several members during the session the difficulty that projects involving taxonomy have to be get financial support and on the lack of understanding that such projects have from the financing entities.

Emília Cunha said that NATO had sponsored several courses on phytoplankton taxonomy and that, as an example, the Working Group on Zooplankton Ecology could seek for the possibility of the realisation of such an workshop under the same framework. She referred also the necessity to have a list of the scientists within the ICES scientific community with taxonomic skills that could be contacted.

Peter Wiebe recommended that the Working Group on Zooplankton Ecology make an effort to seek support for a long term program on Zooplankton Biogeography to which Emília Cunha considered that this could be considered as an activity of the Working Group on Zooplankton Ecology within the ICES five-year Plan following the recommendation of the delegates of the Oceanography Committee.

Another issue that was considered was the fate of the "old samples". The information contained in the samples collected along the years is formidable since they are irreplaceable reflecting the evolution of the community structures along those years. These samples need to be kept in good conditions and in a state where they would be available to the scientific community. This will allow the experts to make intercomparisions on the biogegraphy at decadal time scales and infer on climate oscilations.

At the conclusion of the discussion it was recommended that the Working Group on Zooplankton Ecology should consider the following with regard to this topic: To create a checklist of the zooplankton species belonging to the different communities within the ICES area, To produce a list of the "approved" zooplankton taxonomist within the ICES area, To carry on an workshop on zooplankton taxonomy, To have the information on the ICES Zooplankton Identification Sheets on a CD-ROM that would be available to the scientific community, To create a data base that would contain the information of the "old samples" To create a mailing list of the zooplankton ecologist within the ICES area.

## 4 COMPARISON OF CPR RESULTS WITH OTHER DATA-SETS

The discussion was introduced by Luis Valdés and Maria Cunha acted as rapporteur.

The CPR survey is one of the major ongoing zooplankton monitoring activities in the ICES area. The session was held to compare CPR results with other zooplankton data-sets and to review the CPR "intercalibration" made during the sea-going Workshop organised by Working Group on Zooplankton Ecology.

Doug Sameoto provided an introduction to CPR and to the CPR data to the participants and gave a brief account of the results he obtained during 61–76 and 91–94 study he has been carry on the a CPR line along the Scotian Shelf. He referred similar results to the ones published in Nature, 1998, by C. Reid, that reflect a decrease in the CPR Colour Index in the Northwest North Atlantic in the recent years.

Hein Rune Skjodal referred to the data set that was obtained during the Norwegian sea-going Workshop that conducted direct comparison of the CPR with a range of other sampling systems including acoustics information. There was already a preliminary report that was presented in 1993 at the ICES science meeting in Dublin (C.M. 1993/L:45). He referred that he would like to turn public the results that were already obtained by presenting them to the members of the Working Group on Zooplankton Ecology in an electronic form. By doing this he hoped to get some feed back from the members of the Working Group in the prosecution of the CPR "intercalibration". Peter Wiebe suggested that the data set should be analysed by a group of "key persons" and that they should meet in November with the following phased objectives: first, to carry on the gear intercomparison and second, to compare the biological information obtained with the different gears with the acoustic results

## 5 REVIEW OF ZOOPLANKTON MONITORING ACTIVITIES

The discussion was introduced by Hein-Rune Skjoldal and Doug Sameoto acted as rapporteur

### CANADA

Doug Sameoto presented an overview of the types of monitoring activity conducted on the east Coast of Canada, particularly in the Maritime region which included the Scotian Shelf. He described the annual report on the State of the Plankton that is presented to the fisheries managers and representatives of the fisheries industry. The philosophy behind presenting simple environmental indices in the annual reported was described in detail. An over view of the zonal monitoring program that will start in 1999 was given.

### USA

Peter Wiebe described the annual plankton surveys conducted by the US Fisheries Service in the region from the Gulf of Maine and Georges Bank to Cape Hatteras. This included about 150 sampling stations as part of the MARMAP survey for zooplankton and fish larvae. The MARMAP survey was conducted 4 to 6 times a year. An overview of the Georges Bank GLOBEC project was presented with some resulted on recent trends in the temperature and salinity on the Bank given. These have shown a general decline in the salinity from 1995 to 1997 as there has been an increased influence in the Labrador Current water on the Bank. Wiebe noted that this spring they saw the largest level of cod spawning and numbers of cod larvae on the bank that have been seen in decades.

He speculated that these levels may be as high as the gadoid outburst seen in the 1960s a time when the Labrador Current also had a large influence on the Bank. A strong case was presented to the continuation of long term monitoring of physical and biological parameters on the Bank if scientist hope to understand the fluctuations in fish populations.

### SPAIN

Luis Valdés described the location of 7 transects around the Iberian region all running perpendicular to the coast. The survey was monthly, with zooplankton, ichthyoplankton, phytoplankton, chlorophyll, and nutrients being measured. The standard protocol for sampling and handling of the samples was described. The Data base and the method of producing maps from these data were described. A detailed discussion was given on the methods used to describe zooplankton diversity when the samples were analysed. A high negative correlation was found between the level of stratification and zooplankton diversity.

### SPAIN (Bay of Biscay)

Luis Valdés presented data on the zooplankton biomass in the Bay of Biscay that showed a decreasing trend form 1991 to 1995, after which time the biomass increased. These changes were related to changes in the salinity, as salinity decreased so did the zooplankton biomass.

### SPAIN (Mediterranean region)

Ma Luz Fernandez de Puelles described recent trends in zooplankton in the Mediterranean Sea particularly changes in the salinity as a result of influences of Atlantic water. Associated with the Atlantic water were changes in the species composition of zooplankton.

### PORTUGAL

Emilia Cunha described the ichthyoplankton and zooplankton monthly survey for the Portugal coast. This also included a survey of ground fish, fish eggs and larvae. Recent results have shown an increase in the temperature and salinity of waters of this region resulting in a change in the distribution of fish and fish larvae particularly a decrease in sardine numbers.

### UK

Roger Harris reported on the web sight for the CPR information from the Sir Hardy Foundation. He also described a program for remote sensing basin scale regions of the Atlantic Ocean using flow through pumps on board ship to measure zooplankton with the OPC. The aim of the program is to develop new methods of underway sampling and to make optical measurements for the SeaWiFS program and to collect data to expand the Longhurst biogeochemical provinces concept. The SOMARE program to integrate methods of underway sampling from Europe to the Antarctic was described.

**UK Plymouth region**

Xabier Irigoien discussed statistical methods for analysing trends in time series data using the accumulated deviation from the mean. He applied the methods to a zooplankton data series collected near Plymouth from 1988 to 1996. A negative correlation was seen between *C. finmarchicus* and *Pseudocalanus*, and principal component analysis showed a grouping of *C. finmarchicus*, *Temora* and *Centropages* in one group and *Pseudocalanus* and Acartia in another group. This was similar to findings by Sameoto for these species in data collected by the CPR on the Scotian Shelf. *C. finmarchicus* and numbers of *C. finmarchicus* eggs tended to follow the fluctuations of the chlorophyll pattern on the Plymouth station.

Interest was expressed in obtaining more information and references to the cumulative deviation methods used to analyse these data.

**GERMANY**

Heino Fock gave a detailed description of the monitoring program of the North Sea at Helgoland. The recent data showed a trend for the spring species to occur earlier in the year and this was attributed to the influence of the Gulf Stream. It was noted by Sameoto that these changes at Helgoland were similar to changes occurring on the Scotian Shelf seen in the CPR data.

**GERMANY (Baltic Sea Monitoring)**

Lutz Postel gave a detailed account of the international co-operation between countries around the Baltic Sea in the biological monitoring program. The field experiments and the work involved in the quality control of the sampling and handing of samples was extensive and impressed the working group. The strength of a co-operative program was obvious when he presented results from the program that showed period changes in the data over 10 years that would have been missed if all countries did not cooperate in producing a common data base.

**NORWAY**

Hein-Rune Skjoldal described the process followed in Norway for their monitoring program that utilises the time-series data to make predictions for the following year. Physical and zooplankton data are used to predict the potential size of the stock of certain species of fish (i.e., Capelin). He showed data that indicated flow patterns have changed off the coast of Norway in the last decade.

An annual zooplankton survey is conducted in the Barents Sea that started in the 1980s. In the Norwegian Sea 2 transects are run for the sampling of zooplankton and CTD stations. There are 8 coastal hydrographic stations where fishermen used mini-CTDs, in addition about 5000 CTD profiles are taken on the fisheries cruises. In 1997 the water temperature was above the long term mean reaching 21 C. Results from the monitoring program were discussed, some being the harmful algae data which is on the web, the long term trend in capelin populations that showed large fluctuations related to the populations of Calanus, krill and cod populations.

## 6 ANOMALIES IN THE NORTH SEA: 1960'S AND 1970'S

The discussion was introduced by Peter Wiebe and Xabier Irigoien acted as rapporteur.

The zooplankton working group dedicated a session to discuss available data and methodology in order to assist the convenor of the four Third ICES/GLOBEC Backward-Facing Workshop (1999) on the 1960's and 1970's anomalies in the North Sea in preparing monitoring information on zooplankton populations during this period.

Roger Harris reported that he had contacted Cisco Werner, Chairman of Third ICES/GLOBEC Backward-Facing Workshop, and he had provide the following guidance for the Working Group on Zooplankton Ecology discussion:

*"In some sense, a census of available zooplankton data could be a place to start. (This includes publicly available - for possible distribution to workshop participants - as well as proprietary data, such as the CPR data, which only a few people will be able to analyse and present, e.g., Doug Sameoto on this side of the ocean).*

*For the NW Atlantic we have the MARMAP data base (77–87), the CPR (mid-60's to mid 80's with some unfortunate gaps) and surveys that the Canadian researchers have conducted on the Scotian shelf. Once these data sources are identified in space and time, the possibility of examining and selecting overlapping time periods of good zooplankton coverage and good/bad fish recruitment years is facilitated.*

*So, I may not have helped you too much, but ideally for BF-IV (looking at the North Sea), a rough census would be a good place to start. Target species are also always a question. While Cal-fin is clearly important, the role of smaller/other copepods such as Pseudocalanus has been suggested to be of equal, or greater importance, for different life stages of fish larvae, e.g., the youngest larvae may prefer to feed on smaller copepods, and hence survival to later stages when Calanus becomes the preferred prey item may hinge on the abundance/avail- ability of other prey types at other times"*

Heino Fock presented the monitoring program conducted on Helgoland since 1974. An example of simulated hindcast for *Noctiluca scintillans* based in the relation between winter SST and the summer integrated log-abundance of *Noctiluca scintillans* was given. Also, shifts on the seasonal biocenoses as response to major climatic shifts (North Atlantic Oscillation, Gulf Stream Index) were presented.

D. Sameoto asked whether the CPR data can be used to validate modelling results.

H. Fock equally presented different statistical techniques to analyse zooplankton time series depending on the number of available data sets:

**1 Data set available:**

- Randomisation techniques

- Crossvalidation (jack-knifing, Monte Carlo simulation).

  *Van der Meer, J. 1991.J. Exp. Mar. Biol. Ecol. 148: 105–120*

- Randomization, i.e., of independent regressors.

  *Pollard, E. et al., 1987. Ecology 68: 2046–2055*

  *Solow, A.R., 1989. Ecology 70: 1546–1549*

- Path analysis

*Wootton, J.T. 1994. Ecology 75: 151–65*

**Several independent data sets**

- repeated comparative approach, meta-analysis.

  Biomass dynamics depending on nutrients vs. Abundance dynamics depending on interactions

  *Reiners, W. A., 1986. Am. Nat. 127: 59–73*

  *Mann, C., 1990. Science 249: 476–480*

- complementary hypothesis approach.

(i.e., regional data sets derived from climatological models vs. Local measurements)

Suggestions were made to apply those techniques to herring data previously presented by H.R. Skjoldal and D. Sameoto asked about the time necessary for those analysis. P. Wiebe asked about the relevance of *Noctiluca* as indicator and R. Harris asked about key species such as *Calanus* or *Pseudocalanus* suggesting the CPR or the Helgoland time-series as source for the data. H. Fock answered that *Calanus* was scarce whereas *Pseudocalanus* is abundant in the Helgoland area.

Lutz Postel presented data from the Baltic sea where 2 years cyclic variations apparently related with sunspot activity and tropospheric winds were identified. Sea surface temperature was related to atmospheric temperature and zooplankton biomass increased with temperature. Less data were available on fisheries but they seem to agree with zooplankton ones.

Peter Wiebe presented literature data on the great salinity anomaly suggesting an 8 to 10 years periodicity in this phenomenon. He suggested that Cod and Haddock may be answering to some of those major cyclic events but that overfishing can be shadowing the effect. The effects of the North Atlantic Oscillation on fisheries and on *Calanus finmarchicus* were discussed by E. Cunha and P. Wiebe.

Luis Valdés commented that quasi-biannual oscillations related to tropospheric winds were well documented in the literature on subjects ranging from crops to marine biology and warned about the necessity of identifying quasi-biannual (28 months) oscillations and North Atlantic (7 years oscillations). The forcing cause of the QBO seems to be related to the quasi-periodic reversal of tropical atratospheric winds (Reed et al., 1961). However, the mechanism of trasmission of the QBO from its climatic origin to the oceanographic processes and the planktonic communities remains unclear. Evidence of a QBO with time periods of 28-30 months have been reported in atmospheric data and in the biomass of zooplankton in the Gulf of Alaska (Hameed and Conversi, 1995; Conversi and Hameed, in press), in the Mediterranean sea level (Vilibic and Leder, 1996), in the atmospheric pressure and precipitation in the Bay of Biscay (Fromentin and Ibanez, 1994) in the copepod diversity and species richness in the Bay of Biscay (Valdés and Moral, in press), and in the hydroclimatic parameters and zooplankton abundance in the North Sea (Le Fevre-Lehoerff et al., 1995) among others. P. Wiebe discussed the possible influence of those events on deep circulation.

## 7 TECHNOLOGIES FOR REMOTE ACQUISITION OF ZOOPLANKTON INFORMATION

The discussion was introduced by Peter Wiebe and Xabier Irigoien acted as rapporteur.

Recent technological developments were presented by Doug Sameoto:

- A Moving Vessel Profiler which can produce CTD and fluorometry profiles to 200 m steaming at 12 knots and to 500 m steaming at 1–2 knots. The MVP is connected to the vessels echosounder and uses a kevlar conducting cable. The complete system, the gear, controlling panel, cable and CTD is very compact and automated requiring only a person to manipulate it. The system is already commercially available and costs about 125.000 Canadian dollars (including CTD).

- A laser Optical Plankton Counter. The new system has the advantages of a reduction of coincidence, a lower detection limit (50 – 100 microns) and measuring of the particles shape outline. The system is designed to be incorporated into the Moving Vessel Profiler. Prototypes are in use but at the moment limited by the hardware speed to process the data (8 Mb collected every 4 sec). A commercially available version is expected in 1 – 2 years with a price lower than 25.000 Canadian dollars.

## 8 FUTURE WORK PROGRAMME: ICES 5 YEAR PLAN

The discussion was introduced by Juergen Lenz and Lutz Postel acted as rapporteur.

Zooplankton provide an important link between ocean physics on the one hand and fish stocks and fisheries on the other. Therefore work on zooplankton should be an important issue in the activities of ICES. This relates both to monitoring and research activities. Important research activities in the current GLOBEC programmes (ICES, CCC, etc.) need to over the coming years to be translated into practical applications in fisheries and environmental management. Monitoring of zooplankton and routine use and assessment of data from the monitoring could constitute an element in a regional North Atlantic GOOS component.

The following are priority issues on the work plan for Working Group on Zooplankton Ecology:

**MONITORING**

- Co-ordinate national zooplankton monitoring activities into a harmonised ICES zooplankton monitoring programme.
- Oversee the development of QA procedures for monitoring of zooplankton. The Zooplankton Methodological Manual is an important milestone in this respect. (ref. to other WGs/SGs on QA of Biological Measurements)
- Consider application of new methods and technologies to improve zooplankton monitoring

**ASSESSMENT**

- Oversee the development of procedures/systems/structures for zooplankton data management. This would require contributions / assistance for WG MDM.
- Assess the status of zooplankton stocks in the ICES area.
- This will be based on national reports in the short term. In the longer term, data from co-ordinated monitoring will be compiled and assessed. The aim is to provide an input of information on zooplankton stocks into the process of assessing the fish stocks. It will also provide an input to environmental assessment.
- Prepare reports on the status of zooplankton stocks on e.g., an annual basis as contribution to the regular reporting on the state of the environment in the ICES area.

**RESEARCH**

- The GLOBEC programme constitutes an important research agenda for the work of ICES. There are two main aspects of the GLOBEC research activities in the ICES area:

– climatic driving forces for the ecosystem variability

– biological interactions in marine ecosystems, e.g., between zooplankton and fish.

- The role of grazing in influencing the dynamics of phytoplankton species including harmful algae and in regulating vertical fluxes in the ocean.
- Biodiversity and biogeography of plankton and the relationship between species diversity and ecosystem functioning.
- Development of new methods and technologies for studies of zooplankton.

INTERACTION WITH OTHER Working Groups

The Working Group on Zooplankton Ecology needs to work in close co-operation with several other ICES Working Groups. These include:

WG MDM with regard to management of zooplankton data

WG OH and WG SSO on issues of physical influence on zooplankton population dynamics.

WG PE and WG HAB on issues of zooplankton grazing, phytoplankton and vertical flux of matter

Fish stock assessment WGs on issues of zooplankton and fish stocks

## 9 RECOMMENDATIONS

The Working Group on Zooplankton Ecology will meet for three days in the second half (19–21) of April 1999 at the Marine Research Institute, Reykjavik to:

1. further review the results of, and plans for publication of the 1993 Sea-Going Workshop organised by the Working Group on Zooplankton Ecology.

2. continue by correspondence, and then report on the final aspects of publication of the Zooplankton Methodology Manual.

3. report on the status of zooplankton stocks in the ICES area, and consider plans for a co-ordinated zooplankton monitoring programme for the ICES area, based on national programmes, as a contribution to the North Atlantic regional GOOS.

4. consider the development and application of environmental indices involving zooplankton populations, and the standardisation of products from zooplankton monitoring data

5. consider plans for Trans-Atlantic co-ordinated research activities in the context of GLOBEC.

6. by correspondence before the meeting prepare an inventory of zooplankton taxonomists for the major taxa.

7. further review and elaborate the draft 5 year plan for the Working Group on Zooplankton Ecology.

The Working Group considered it desirable to explore the possibility of holding a co-ordinated meeting with another Working Group, for example WGHAB, Working Group on Oceanic Hydrography, or perhaps in association with a PICES initiative in the N Pacific. In the context of the latter suggestion, an invitation for a meeting in Hawaii in the year 2000 has been received.

## 10 REFERENCES


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## ANNEX 1

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ANNEX 2

## AGENDA AND PROGRAMME

## ICES Working Group on Zooplankton Ecology

## Santander, 6–8 May 1998

### Wednesday 6 May

| | |
|---|---|
| 09:30 - 13:00 | **OPENING, AGENDA, MEETING PROGRAMME** |
| | **ZOOPLANKTON METHODOLOGY MANUAL** |
| | (Chair: Roger Harris, Rapporteur: Ken Foote) |
| | *TOR a) complete a final review of the Zooplankton Methodology Manual and to agree plans for its publication;* |
| 13:00 -14:30 | lunch |
| 14:30 - 17:30 | **ZOOPLANKTON TAXONOMIC SKILLS** |
| | (Chair: Luis Valdes, Rapporteur: Maria Cunha) |
| | *TOR e) consider recommendations for maintaining and preserving zooplankton taxonomic skills within the ICES scientific community;* |
| | **COMPARISON OF CPR RESULTS WITH OTHER DATA-SETS** |
| | (Chair: Luis Valdes, Rapporteur: Maria Cunha) |
| | *TOR c) carry out a comparison of CPR results with other data-sets and to review the CPR "intercalibration" made during the sea-going Workshop;* |

### Thursday 7 May

| | |
|---|---|
| 09:30 - 13:00 | **REVIEW OF ZOOPLANKTON MONITORING ACTIVITIES** |
| | (Chair: Hein-Rune Skjoldal, Rapporteur: Doug Sameoto) |
| | *TOR b) carry out the first annual review of the results of zooplankton monitoring activities in the ICES area using the summary map(s) and information in tabular form in this report as a basis;* |
| 13:00 -14:30 | lunch |
| 14:30 - 17:30 | **ANOMALIES IN THE NORTH SEA: 1960s and 1970s** |
| | (Chair: Peter Wiebe, Rapporteur: Xabier Irigoien) |
| | *TOR f) assist the Convenor of the fourth Third ICES/GLOBEC Backward-Facing Workshop (1999) on the 1960s and 1970s anomalies in the North Sea in preparing monitoring information on zooplankton populations during this period;* |
| | **TECHNOLOGIES FOR REMOTE ACQUISITION OF ZOOPLANKTON INFORMATION** |
| | (Chair: Peter Wiebe, Rapporteur: Xabier Irigoien) |
| | *TOR d) consider technologies for the remote acquisition of zooplankton information on data-buoys and other remote platforms* |

**Friday 8 May**

| | |
|---|---|
| 09:30 - 13:00 | **ZOOPLANKTON METHODOLOGY MANUAL contd.** |
| | (Chair: Roger Harris, Rapporteur: Ken Foote) |
| | **FUTURE WORK PROGRAMME: ICES 5 YEAR PLAN** |
| | (Chair: Juergen Lenz, Rapporteur: Lutz Postel) |
| | *TOR g) consider future work programme in relation to the remit of the Oceanography Committee and the development of the ICES Five-Year Plan, including co-operation with other Working Groups.* |
| 13:00 -14:30 | lunch |
| 14:30 - | **SUMMARY DISCUSSION, DRAFTING AND COMPLETION OF REPORT, FUTURE PLANS, WORK ON METHODOLOGY MANUAL** |

**Justification:**

a) Timely completion of the Zooplankton Methodology Manual is the highest priority in the coming year; to that end the 1998 meeting has been set as the final step in the completion of this project.

b) Having identified the active zooplankton monitoring activities in the ICES area, the members of Working Group on Zooplankton Ecology agreed that the work done so far should form the basis for an annual report, and exchange of information on, significant observations and trends in those zooplankton surveys and time-series.

c) Working Group on Zooplankton Ecology has given some recent attention to the CPR survey, which is one of the major ongoing zooplankton monitoring activities in the ICES area. It is considered important to compare CPR results and other zooplankton data-sets; the Norwegian sea-going workshop organised by Working Group on Zooplankton Ecology, conducted direct comparison of the CPR with a range of other sampling systems, which will aid in this evaluation.

d) To extend monitoring of zooplankton population dynamics, the WG members consider that new technologies may provide efficient, and cost-effective solutions; a review of current and emerging technologies for autonomous deployment should be carried out.

e) Concern was expressed at the last meeting of the Working Group on Zooplankton Ecology about the loss of taxonomic expertise within the ICES zooplankton community; specific recommendations for addressing this problem should be considered.

f) The Chairman should consult with F. Werner about specific needs required by the Workshop.

## ANNEX 3

## ZOOPLANKTON METHODOLOGY MANUAL

**ZOOPLANKTON METHODOLOGY MANUAL: ELEMENTS OF MAY 22ND LETTER TO AUTHORS (incomplete draft)**

- Acknowledge effort and contribution
- Provide Publication timetable
- Request changes to manuscripts:
  1) Part I/Part II format

  2) Specific response to peer review for reviewed MSs

  3) From specific guidance by editorial committee

- Specify precise format for final MS

  - Reference format, citation format
  - Margins, pt size
  - Figures on tables, keywords for index
  - Disk (electronic) version in standard word-processor
- Action item: Request first or final draft/MS by certain time

**STYLE ISSUES: COMMON CHAPTER FORMAT**

Part I: General discussion of principle, comparative approaches and techniques

*Elements*

- Review (Background, history)
- Basic Principles
- Variability sources
  a) Natural
  b) Introduced by measurement
- for equipment: representative platforms, deployment methods
- for procedures: representative methods
- Comparative evaluation of equipment and/or procedures
  - Rely heavily on tables and figures *
  - Provide ranges of typical measurements for typical targets/species/applications *
  - Discuss pros and cons
- General recommendations
- Extensive use of literature references

**STYLE ISSUES: COMMON CHAPTER FORMAT**

Part II: Specific measurement protocols or examples thereof

*Specific format:*

- Facilities and equipment
- Supplies
- Procedure
- Data analysis and interpretation
- note, comments and special precautions

*Note*:

1. Protocols should be very specific and explicit, with high level of detail
2. Protocols should serve as
   - standard methods (e.g., dilution experiment, NH+4, Sample Preservation)
     <u>or</u>
   - Examples of little-known methods (e.g., OPC)
3. If many methods are used, or many instruments, then choose,
   - most highly recommended <u>or</u>
   - most often used, or likely to be used

**ZMM: PUBLICATION TIMETABLE**

| ACTION | COMPLETE BY |
|---|---|
| Editorial review | May 20 |
| Letter to authors | May 22 |
| MS due for peer review | June 30 |
| Peer reviews complete by | July 31 |
| Editors comments to authors | |
| Final manuscript due | |
| Final selection of publisher | |
| Editorial final changes by | |
| Complete volume to publisher | |
| Publication date | |

**ICES Zooplankton Methodology Manual: Status of manuscripts at 6 May 1998**

| new | Chapter | Main author | collaborating authors | ms status | review status | revision status | Pages | Lead editor |
|---|---|---|---|---|---|---|---|---|
| 1 | Introduction | Lenz | | complete | | | 18 | |
| 2 | Sampling / exp. design | Skjoldal | Foote | still being written | | | | JL |
| 3 | Collecting zooplankton | Sameoto | Wiebe, Runge, Miller? | complete | reviewed | revised | 35 | JL |
| 4 | Biomass and abundance | Postel | | still being written | | | | JL |
| 5 | Microzooplankton Biomass | Gifford | Caron | complete | reviewed | being revised | 37 | RPH |
| 6 | Acoustical methods | Foote | Stanton | complete | in review | | 126 | HRS |
| 7 | Optical methods | Foote | | complete | in review | | 91 | PW |
| 8 | Feeding | Båmstedt | Harris, Irigoien, Gifford, Roman, Atkinson | almost complete | | | 66 | RPH |
| 9 | Growth | Runge | Roff | complete | reviewed | being revised | 76 | RPH |
| 10 | Metabolism | Ikeda | Torres, Geiger, Hernandez - Leon | complete | reviewed | being revised | 104 | RPH |
| 11 | Genetics | Bucklin | Boyd, Clarke, Dahle, Sundt | complete | reviewed | being revised | | HRS |
| 12 | Population dynamics | Aksnes | Miller, Ohman, Wood | complete (withdrawn) | | | | HRS |
| 13 | Modelling | Carlotti | Giske, Werner, de Young | almost complete first draft | | | > 31 | HRS |

## ANNEX 4

## ZOOPLANKTON MONITORING ACTIVITIES IN THE ICES AREA

**Zooplankton monitoring activity record**

**Country: CANADA**

| | | |
|---|---|---|
| Monitoring location: | Halifax line 44°24N 63°28Wto 42°33N 61°4W | Louisbourg line 45°49N 59°51W to 43°46N 57°49W |
| Frequency | 2x / year | 2x / yr |
| Duration | 12 yrs | 3 yrs |
| Contact address/location of data | doug.sameoto@maritimes.dfo.ca | same |
| Items sampled/measured | | |
| zooplankton | ✔ | ✔ |
| chlorophyll | ✔ | ✔ |
| | ✔ | ✔ |

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**Zooplankton monitoring activity record**
**Country: FAROE ISLANDS**

| Monitoring location: | Section N, E &W | Section S | Faroe Shelf | Faroe Bank |
|---|---|---|---|---|
| Frequency | 4 $yr^{-1}$ | 4 $yr^{-1}$ | Annual (June) | Annual (June) |
| Duration | 1990 - pr | 1995 - pr | 1989 - pr | 1990 - pr |
| Contact address/location of data | * | * | * | * |
| Items sampled/measured | | | | |
| Zooplankton | ✔ | ✔ | ✔ | ✔ |
| Fluorescence / Chlorophyll | ✔ | ✔ | ✔ | ✔ |
| Nutrients | spring - summer | spring - summer | ✔ | ✔ |
| | | | | |
| Gear | WP2 200µm | WP2 200µm | WP2 200µm | WP2 200µm |

Contact: Eilif Gaard
Fisheries Lab of the Faroes
P.O.Box 3051, Noatun
FR-110 Torhavn
Faroe Islands
Tel +298 15092
Fax +298 18264

**Zooplankton monitoring activity record**

**Country: GERMANY**

| Monitoring location: | Baltic Sea | Island of Helgoland (54° 11'3"N 7°54'0"E) |
|---|---|---|
| Frequency | 3 monthly (March, May, Aug, Oct) | 3 times a week (Mon-Wed-Fri) |
| Duration | 1979 – present | 1974 - present |
| Contact address/location of data | see below<br>EDC, HELCOM | see below |
| Items sampled/measured | | |
| Mesozooplankton | ✔ | ✔ |
| Chlorophyll | ✔ | ✔ |
| Primary production | ✔ | ✔ |
| Hydrography | ✔ | ✔ |
| Phytoplankton | ✔ | |
| Gear | WP-2 100µm vertical haul | mesozooplankton with 150 µm net macrozooplankton with a CalCoFi 500 µm net. |

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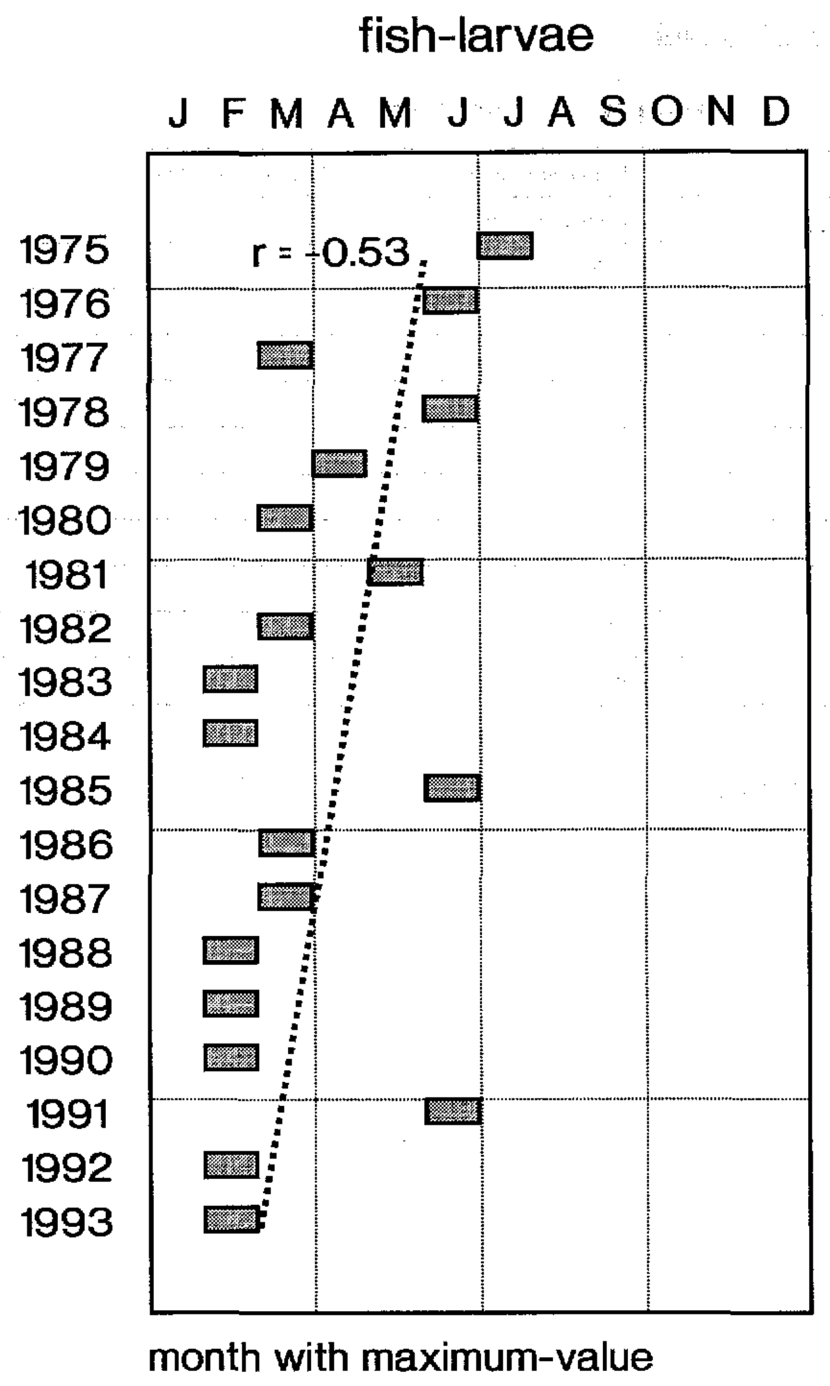


Figure The time of maximum abundance of fish larvae in the Helgoland Roads zooplankton samples shifted forward in the 80's and 90's. This indicates a shift in plankton community structure, characterised by an increasing contribution of the early spawned sandeel larvae (Ammodytes sp.) to the plankton.

**Zooplankton monitoring activity record**

**Country: ICELAND**

| | |
|---|---|
| Monitoring location: | 9 standard transects around Iceland (see fig) 80 stns |
| Frequency | Annually (May-June) |
| Duration | 1961 - pr |
| Contact address/location of data | * |
| Items sampled/measured | ✔ |
| Zooplankton | ✔ |
| Phytoplankton | ✔ |
| Primary production | ✔ |
| Chlorophyll | ✔ |
| Nutrients | ✔ |
| Salinity | ✔ |
| Temperature | ✔ |

Olafur Astthorsson / Astthor Gislason
Marine Research Institute
101 Reykjavik
ICELAND

**Zooplankton monitoring activity record**

**Country: NORWAY**

| Monitoring location: | Transect A | Transect B | Transect C | Transect D |
|---|---|---|---|---|
| Frequency | monthly 2*month$^{-1}$ in spring | monthly | 5–6 yr$^{-1}$ | 3–4 yr$^{-1}$ |
| Duration | 1990-pres | 1990-pres | 1993-pres | 1993-pres |
| Contact address/location of data | IMR | IMR | IMR | IMR |
| Items sampled/measured | | | | |
| Mesozooplankton | ✔ | ✔ | ✔ | ✔ |
| Chlorophyll a | ✔ | ✔ | some | some |
| T/S | ✔ | ✔ | ✔ | ✔ |
| Nutrients | ✔ | ✔ | ✔ | ✔ |

Data supplied by Dr B. Ellertsen
IMR
PO Box 1870
N-5024 Bergen
Norway

Transect A Svinøy transect. 17 stations. Zooplankton sampling with WP-2 net at all locations and with MOCNESS at 3 locations. Chl a, CTD, nutrients at all locations.
Innermost location 62°22'N 005°12'E
Outermost location 64°40'N 000°00'E
Transect B Gimsøy transect. 15 stations. Zooplankton sampling with WP-2 net at all locations and with MOCNESS at 3 locations. Chl a, CTD, nutrients at all locations.
Innermost location 68°25.8'N 014°00.8'E
Outermost location 70°24'N 008°12'E
Transect C Fugløya-Bjørnøya transect. 18 stations. Zooplankton sampling with WP-2 net, Chl a, nutrients at 7 locations. CTD, at all locations.
Southern (innermost) location 70°30'N 020°00'E
Outermost location 74°15'N 019°10'E
Transect D Vardø-N transect. 18 stations. Zooplankton sampling with WP-2 net, Chl a, nutrients at 7 locations. CTD, at all locations
Innermost location 70°24'N 031°13'E
Outermost location 74°30'N 031°13'E

**Zooplankton monitoring activity record**

Country: PORTUGAL

| Monitoring location: | Lagos | Sines | Figueira | Espinho | Sines | Figueira | Espinho | Off the coast |
|---|---|---|---|---|---|---|---|---|
| Frequency (number of cruises) | Monthly (27) | Monthly (27) | Monthly (27) | Monthly (27) | Occasional (1) | Occasional (1) | Occasional (1) | Occasional (1) |
| Duration | Oct. 86- Jan. 89 | Oct. 86- Jan. 89 | Oct. 86- Jan. 89 | Oct. 86- Jan. 89 | Dec. 95 | Apr.- May 88 | Sep.96 | Nov.- Dec. 94 |
| Contact address/location of data | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Items sampled/measured | | | | | * | ** | *** | **** |
| Zooplankton | ✔ | ✔ | ✔ | ✔ | ✔ | | ✔ | ✔ |
| Ichtyoplankton | ✔ | ✔ | ✔ | ✔ | | ✔ | | ✔ |
| Phytoplankton | | | | | | | ✔ | |
| Chlorophyll | | | | | | | ✔ | |
| T/S | BT | BT | BT | BT | BT | CTD | CTD | CTD |
| Nutrients | | | | | | | ✔ | |
| Dissolved oxygen | | | | | | | ✔ | |
| Gear | Bongo 60 | Bongo 60 | Bongo 60 | Bongo 60 | Bongo 60 | WP-2 | Bongo 60 | Bongo 60 IKMT |

**Lagos transect** (08° 35'W): 4 stations with oblique hauls
Innermost location: 37° 05.5'N; Outermost location: 36° 39'N.
**Sines transect** (38° 00'N): 3 stations with oblique hauls
**Figueira transect** (40° 00'N): 7 stations with oblique hauls
Innermost location 08° 53'W; Outermost location: 09° 25'W
**Espinho transect** (41° 00'N): 6 stations with oblique hauls
Innermost location: 08° 53'W; Outermost location: 09° 25'W

* - Sines, Dec. 95: 6 stations located near 38° N; 08 52'W
** - Figueira, April/May 1988: 42x3 verticaly stratified hauls
Sampled area: 41° 05'N,08° 45'W; 41° 05'N,09° 45'W; 40° 20'N,08° 55'W; 40° 20'N,09° 55.5'W
*** - Espinho, Sep. 1996: 8 stations with oblique hauls

Innermost location: 08° 52'W; Outermost location: 09° 05'W

Innermost location: 41° 07'N,08° 43'W
Outermost location: 41° 07'N,09° 38'W
**** - 8 stations with oblique hauls along 38° 40'N, transect from 09° 32'W to 13° 47'W + 3 station at 37° 02'N, 14° 31'W; 36° 46.1'N,14° 15.5'W; 36° 49.2'N, 10° 55.3'W

**Zooplankton monitoring activity record**

Country: PORTUGAL

| Monitoring location: | South shelf | South shelf | South shelf | South shelf | Southwest shelf | Southwests outh shelf | Southwest shelf | Northern shelf | Northern shelf |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (number of cruises) | Annual (1) | Annual (1) | Annual (1) | Monthly (3) | Monthly (7) | Monthly (3) | Seasonal (4) | Occasional (1) | Occasional (1) |
| Duration | Feb.90 | Jan.91 | Aug.93 | Jan.94-Mar.94 | Apr.-Nov.78 | Apr.-Jun.84 | Jan.-Nov.94 | Oct.94 | Mar.96 |
| Contact address/location of data | 2 | 2 | 2 | 2 | 3 | 4 | 4 | 1 | 4,5 |
| Items sampled/measured | * | ** | *** | **** | * | ** | *** | * | ** |
| Zooplankton (Decapod larvae) | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | |
| Ichtyoplankton | ✔ | | | ✔ | ✔ | ✔ | ✔ | | ✔ |
| Phytoplankton | | | | | | | | | |
| Chlorophyll | | | | | | | | | |
| T/S | Nansen | CTD | CTD | CTD | Nansen | BT | CTD | CTD | CTD |
| Nutrients | | | | | | x | | | |
| Dissolved oxygen | | | | | x | x | | | |
| Gear | Ø-1 m | Bongo 60 | Bongo 60 | Ø-1 m IKMT | Ø-1 m | Ø-1 m | Bongo 60 | Bongo 60 | Multi-closing Bongo 60 |

South shelf

* - 30 vertical hauls. Area sampled: 36° 46'N, 07° 45'W; 36° 49'N, 07° 51'W; 36° 52'N07° 44'W; 36° 55'N, 07° 30'W; 36° 53'N, 07° 27'W.

** - 33 oblique hauls. 4 stations x 3 transects + 7 stations x 4 transects. Area sampled: 08° 07.4'W (36° 50'N; 36° 35'N); 07° 30'W (36° 55'N; 36° 25'N).

*** - 18 oblique hauls. Area sampled: 36° 54'N, 07° 48'W; 36° 52'N, 07° 43'W; 36° 45'N, 08° 17'W; 36° 46'N, 08° 55'W; 36° 51'N, 08° 43'W.

**** - 22 oblique hauls + 7 IKMT hauls. Area sampled: 36° 52'N, 08° 03'W; 36° 32'N, 08° 03'W; 36° 57'N, 07° 25'W; 36° 32'N, 07° 25'W.

Southwest shelf

* - 3 to 6 stations x 19 transects with surface horizontal hauls. Northernmost transect: 38° 45'N (09° 30'W; 09° 43'W); Southernmost transect: 38° 07.5'N (08° 50'W; 09° 04.5'W)

** - 3 to 4 stations x 19 transects with oblique hauls. Northernmost transect: 38° 22'N (08° 50'W; 09° 15'W); Easternmost transect: 07° 24'W (37° 04.5'N; 36° 55'N)

*** - 17 stations with oblique hauls. Area sampled: 38° 00'N (09° 05'W; 09° 03'W); 37° 20'N (09° 08'W; 09° 02.8'W)

Northern shelf

* - 13 stations along 3 transects. Horizontal hauls at surface. Northernmost transect: 41° 30'N (09° 02'W; 08° 50'W); Southernmost transect: 40° 50'N (09° 24'W; 08° 45'W)

** – 3/4 stations x 6 transects. Oblique stratified hauls. Northernmost transect: 41° 26'N (09° 21'W; 09° 06'W); Southernmost transect: 38° 50'N (10° 21'W; 09° 55'W)

**Zooplankton monitoring activity record**

Country: PORTUGAL

| Monitoring location: | Shelf | Shelf | Shelf | Shelf | Shelf | Shelf | Shelf | Shelf | Shelf | Shelf | Shelf |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency (number of cruises) | Seasonal (14) | Seasonal (4) | Seasonal (4) | Occasion (1) | Occasion (1) | Seasonal (13) | Annual (1) | Annual (1) | Annual (1) | Monthly (2) | Monthly (3) |
| Duration | Oct.70-May.74 | Feb.81-Mar. 82 | Aug.85-Mar.86 | Jun./ Jul. 86 | Apr./ May 87 | Jul.90-Nov.93 | Feb./ Mar. 92 | Apr.94 | Aug./ Sep. 94 | Feb.-Apr.95 | Jan.-Mar.98 |
| Contact address/location of data | 1 | 2 | 1 | 2 | 1 | 3, 4, 6 | 6 | 6 | 4 | 6 | 6 |
| Items sampled/measured | * | ** | *** | ** | *** | *** | *** | **** | ***** | **** | **** |
| Zooplankton | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Ichtyoplankton | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Phytoplankton | ✔ | | | | | | | | | | |
| Chlorophyll | ✔ | | ✔ | ✔ | | | | | | | |
| T/S | Nansen | Nansen | Nansen | Nansen | Nansen | CTD | CTD | CTD | CTD | CTD | CTD |
| Nutrients | ✔ | | ✔ | ✔ | ✔ | | | | | | |
| Dissolved oxygen | ✔ | | ✔ | ✔ | ✔ | | | | | | |
| Gear | WP-2 | WP-2 | Ø-1 m | Ø-1 m | Bongo 60 | Bongo 60 | Bongo 60 | Bongo 60 | Bongo 60 | Bongo 60 | Bongo 60 |

* - 5/8 stations x 29 transects from 41° 44'N to 36° 13'N and from the coast to 10° 30'W
**- 3 stations x 10 transects
***- 6 stations x 17 transects
**** - 6 stations x 12 transects from 43° 00'N to 36° 00'N and from 11° 00'W to 06°30'W
***** - 5/7 stations x 4 transects from 40° 45'N to 39° 15'N and from the cost to 10° 00'W + 4/6 stations x 3 transects from 08° 45'W to 07° 45'W and from the costa to 36° 25'N

Data supplied by: [1] - M.E.Cunha; [2] – A. dos Santos; [3]- H. Afonso; [4]- P. Lopes; [5] – I. Meneses; [6] - A. Farinha
Instituto de Investigação das Pescas e do Mar (IPIMAR)
Av. Brasília, s/n
1400 Lisboa
PORTUGAL

**Zooplankton monitoring activity record**

**Country: SPAIN (North and West coasts)**

| Monitoring location: | Santander | Cudillero | La Coruna | Vigo |
|---|---|---|---|---|
| Frequency | Monthly | Monthly | Monthly | Monthly |
| Duration | 1991- pr | 1993- pr | 1989- pr | 1987- pr |
| Contact address/location of data | * | * | * | * |
| Items sampled/measured | | | | |
| Zooplankton | ✔ | ✔ | ✔ | ✔ |
| Ichthyoplankton | ✔ | ✔ | ✔ | ✔ |
| Phytoplankton | ✔ | ✔ | ✔ | ✔ |
| Chlorophyll | ✔ | ✔ | ✔ | ✔ |
| Nutrients | ✔ | ✔ | ✔ | ✔ |
| | | | | |
| Gear | Jud-Bog 50ø 250μm | WP-2 200μm | Jud-Bog 250μm | Jud-Bog 250μm |

**Country: SPAIN (Mediterranean)**

| Monitoring location: | Fuengirola | Cabo Palos | Palma | |
|---|---|---|---|---|
| Frequency | 3-Monthly | 3-Monthly | Monthly | |
| Duration | 1992- pr | 1996- pr | 1993- pr | |
| Contact address/location of data | * | * | * | |
| Items sampled/measured | | | | |
| Zooplankton | ✔ | ✔ | ✔ | |
| Ichthyoplankton | ✔ | ✔ | ✔ | |
| Phytoplankton | ✔ | ✔ | ✔ | |
| Chlorophyll | ✔ | ✔ | ✔ | |
| Nutrients | ✔ | ✔ | ✔ | |
| Gear | Bongo-40 250μm | Bongo-40 250μm | Bongo-40 250μm | |

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Centro Oceanogr. Santander,
P.O.BOX 240
39080 Santander
Tlf 34 42 27 50 62
Fax 34 42 27 50 72

**Zooplankton monitoring activity record**
**Country: USA**

| Monitoring location: | Georges Bank | Georges Bank | Georges Bank | Georges Bank | Georges Bank | Georges Bank | Georges Bank | Georges Bank | Georges Bank |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (number of cruises) | Occasional (1) | Occasional (1) | Occasional (1) | Occasional (1) | Occasional (1) | Occasional (1) | Occasional (1) | Occasional (1) | Occasional (1) |
| Duration | 1–30 Oct '97 | 22–30 Jan 98 | 2–13 Feb 98 | 17–28 Feb 98 | 2–13 March 98 | 16–27 March 98 | 30 March-10 April 98 | 13–24 April 98 | 26 May-12 June 98 |
| Contact address/location of data | | | | | | | | | |
| Items sampled/measured | | | | | | | | | |
| Zooplankton | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Ichtyoplankton | | | | | | | | | |
| Phytoplankton | | | | | | | | | |
| Chlorophyll | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| T/S | CTD | CTD | CTD | CTD | CTD | CTD | CTD | CTD | CTD |
| Nutrients | | | | | | | | | |
| Dissolved oxygen | | | | | | | | | |
| Gear | Bongo 253, 333 | Bongo 253, 333 | Bongo 253, 333 | Bongo 253, 333 | Bongo 253, 333 | Bongo 253, 333 | Bongo 253, 333 | Bongo 253, 333 | Bongo 253, 333 |

**Zooplankton monitoring activity record**
**Country: USA**

| Monitoring location: | Georges Bank | Georges Bank | Naragansett Bay | NYC to Bermuda | Boston to Halifax |
|---|---|---|---|---|---|
| Frequency (number of cruises) | Occasional (1) | Occasional (1) | Monthly | Monthly | Monthly |
| Duration | 21Aug-2 Sept 98 | 8–19 Sept 98 | Feb. 98- | ??? | ??? |
| Contact address/location of data | | | | | |
| Items sampled/measured | | | | | |
| Zooplankton | ✔ | ✔ | ✔ | ✔ | ✔ |
| Ichtyoplankton | | | | | |
| Phytoplankton | | | | | |
| Chlorophyll | ✔ | ✔ | ✔ | | |
| T/S | CTD | CTD | CTDF | | |
| Nutrients | | | | | |
| Dissolved oxygen | | | ✔ | | |
| Gear | Bongo 253, 333 | Bongo 253, 333 | UOR/CPR | CPR* | CPR* |

* CPR towed at 10m depth at 15–20 knots. Silk bolting cloth mesh size 224µm.

Contact: Donna Busch
Narragansett Lab

**Zooplankton monitoring activity record**
**Country: UK**

| | | |
|---|---|---|
| Monitoring location: | L4 | Wide coverage |
| Frequency | weekly | continuous |
| Duration | 1988 - pr | 1931 - pr |
| Contact address/location of data | R. Harris, PML | SAHFOS |
| Items sampled/measured | | |
| CTD | ✔ | some years |
| Zooplankton | ✔ | ✔ |
| Phytoplankton | ✔ | ✔ |
| POC | ✔ | |
| PON | ✔ | |
| Nutrients | some years | |
| Lipids | some years | |
| Egg production | some years | |
| Gut fluorescence | some years | |
| Bacteria | some years | |
| Microzooplankton | some years | |
| Viruses | some years | |

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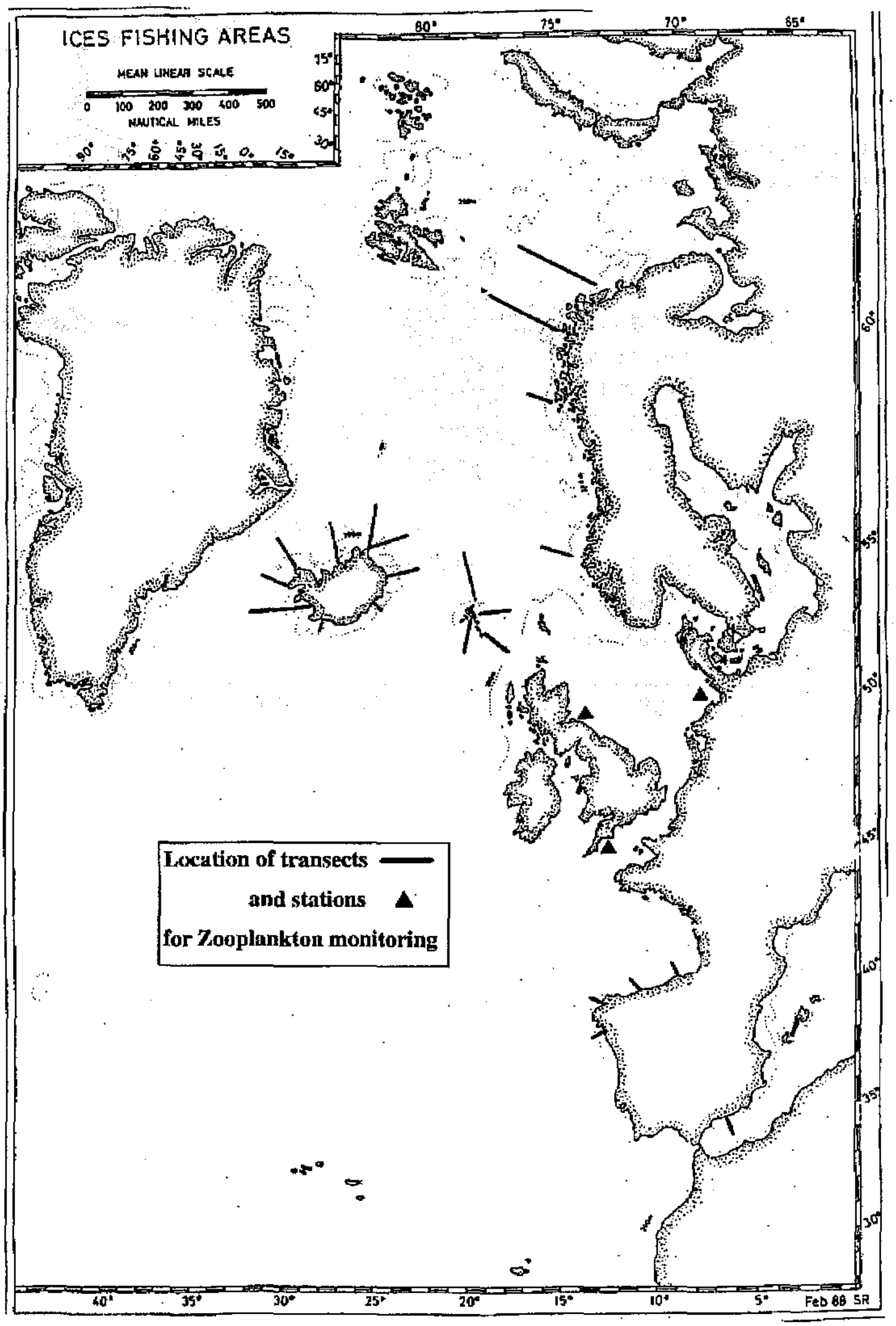
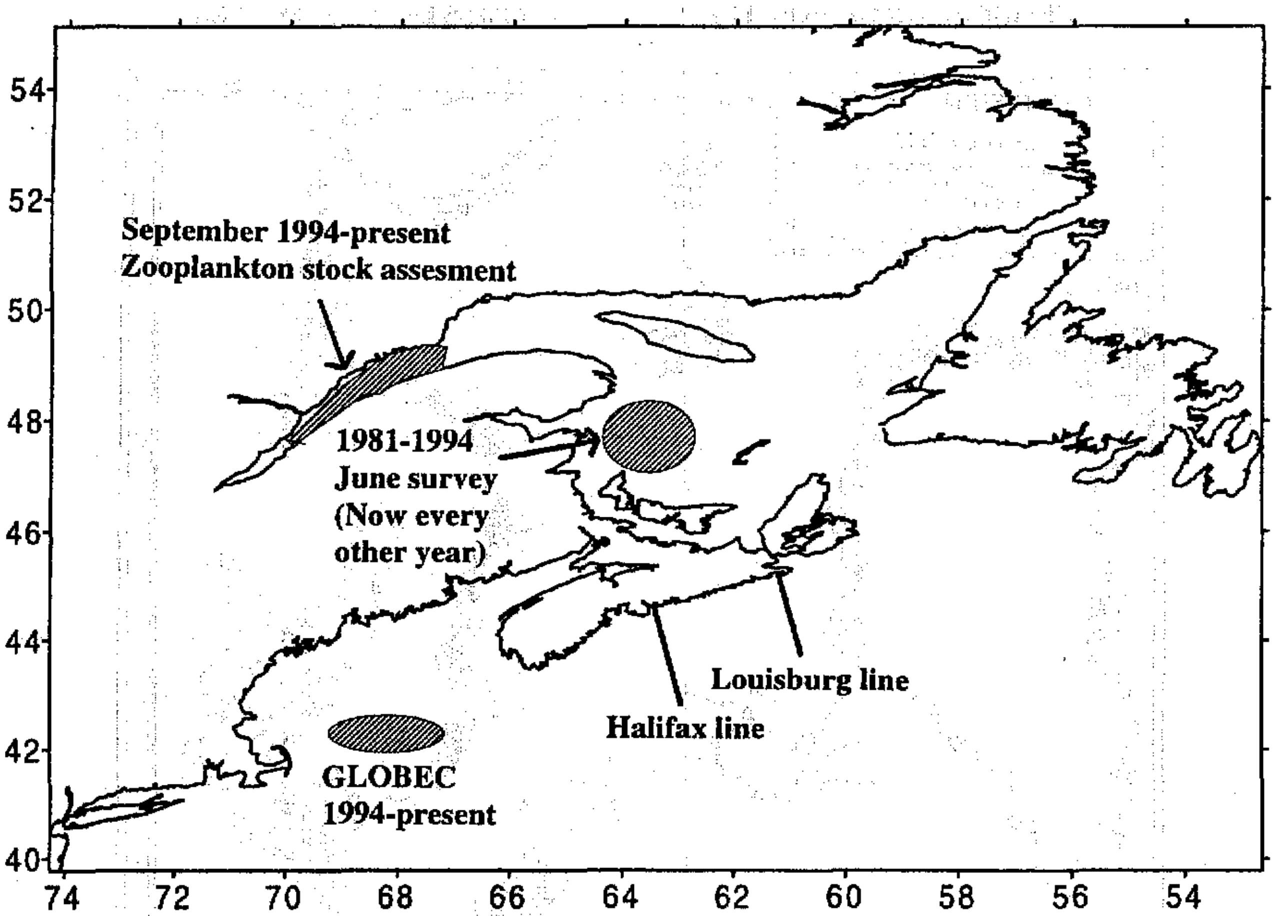
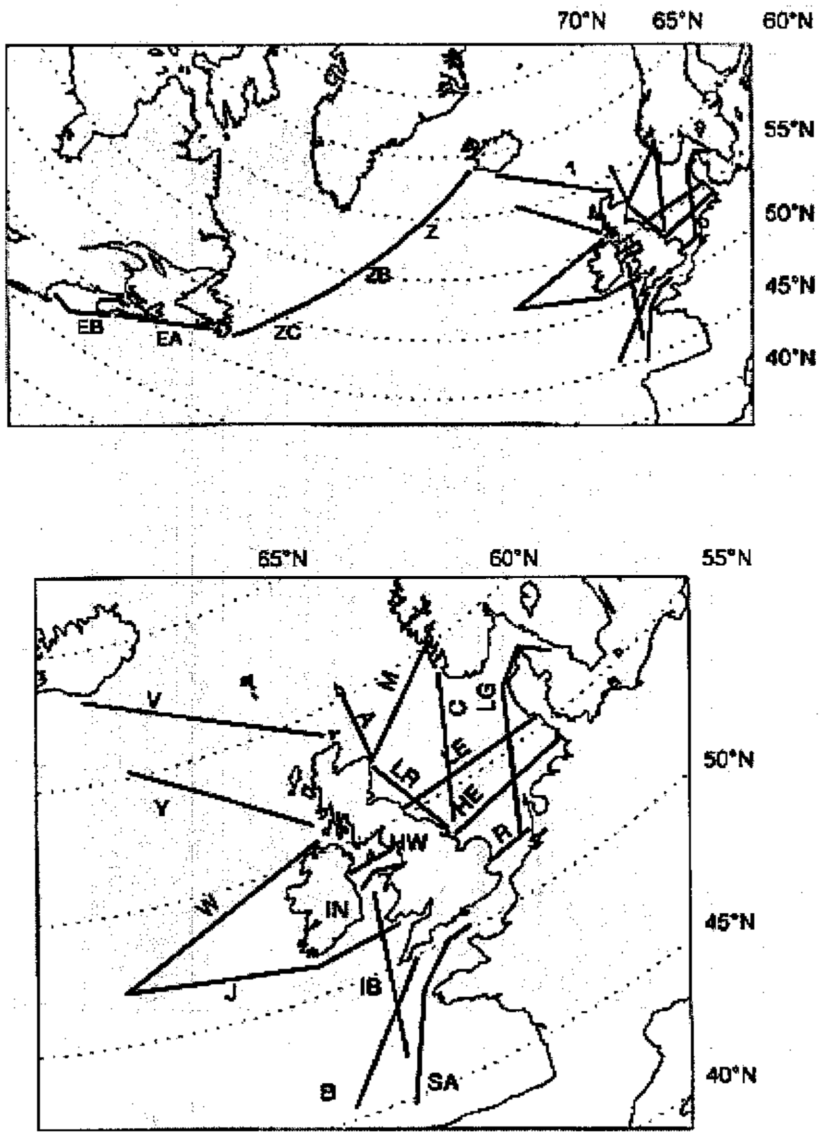
## ANNEX 5

## DISTRIBUTION OF MONITORING PROGRAMMES IN THE ICES AREA

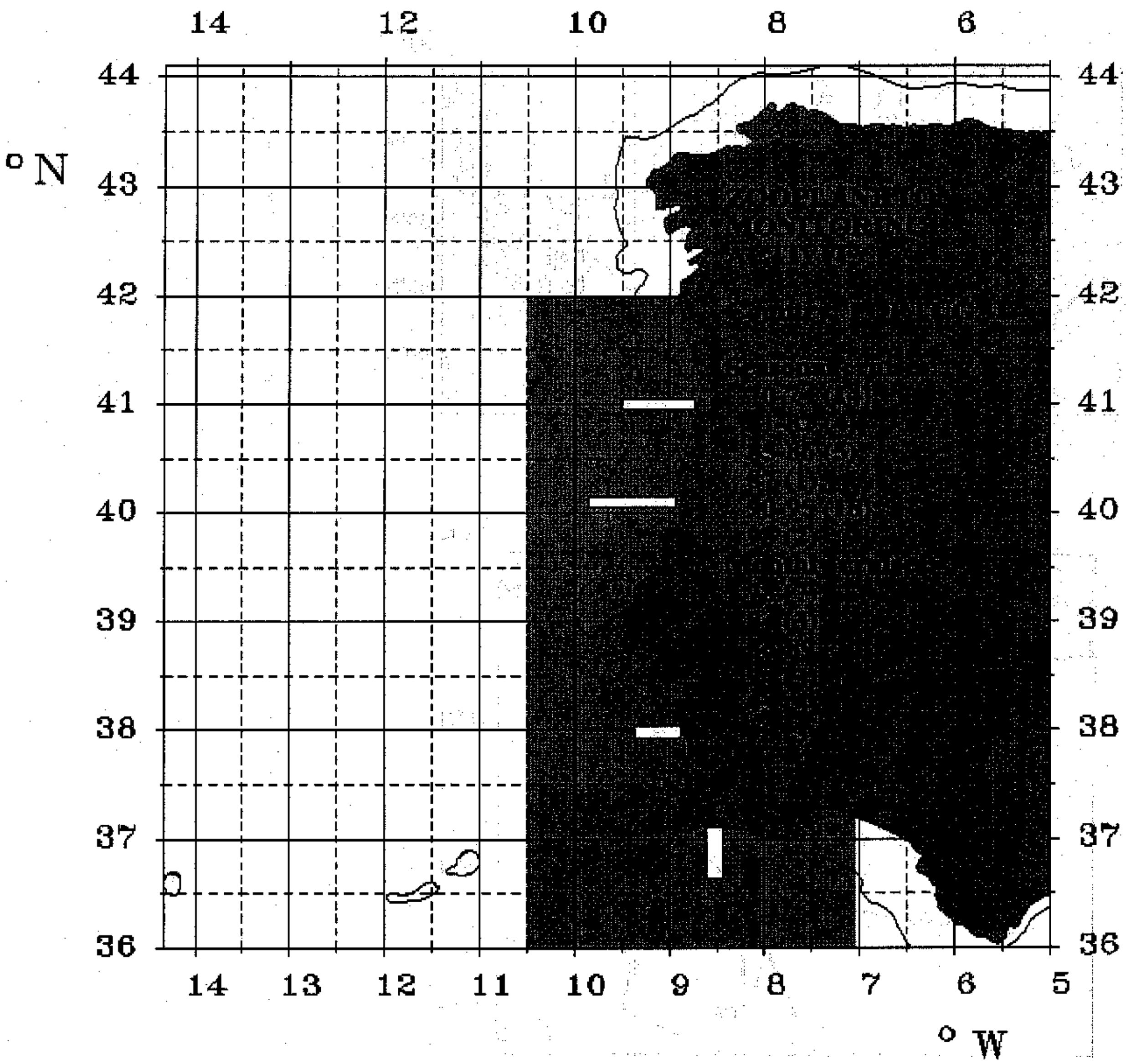



September 1994-present
Zooplankton stock assesment
1981-1994
June survey
(Now every
other year)
Louisburg line
Halifax line
GLOBEC
1994-present
54
52
50
48
46
44
42
40
74
72
70
68
66
64
62
60
58
56
54




Standard CPR tow routes sampled during 1995

**PORTUGAL:** Zooplankton Monitoring Activity



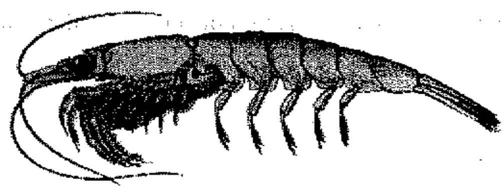
ANNEX 6

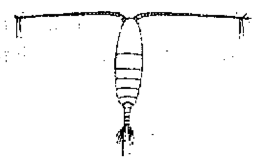
## REPORTS OF MONITORING ACTIVITIES IN THE ICES AREA

## CANADA

Fisheries Pêches
and Oceans et Océans
Maritimes Region

DFO Science
Stock Status Report G3–02





### State of phytoplankton, zooplankton and krill on the Scotian Shelf in 1996

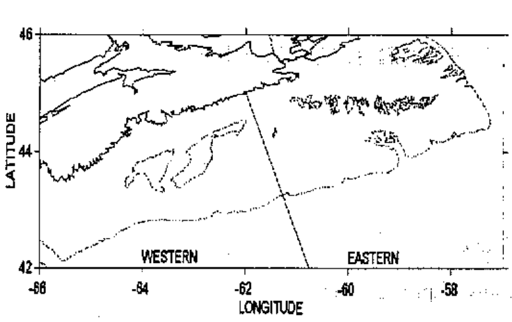
***Background***

*Zooplankton range in size from smaller than 1 mm (e.g., copepods) to about 4 cm (krill). They are eaten by all species of fish at some time in the fishes life cycle. There is evidence that the abundance of some species of zooplankton can influence recruitment and growth of fish such as cod, herring and capelin. The most important copepods to fish are **Calanus finmarchicus** and **Pseudocalanus spp.**; **Meganyctiphanes norvegica** is the most important krill species. The eggs and young of zooplankton are eaten by the youngest stages of fish and as the fish grow they feed on larger zooplankton. Many fish species also feed heavily on the adult krill.*

*Temperature can have a large influence on production of zooplankton and can cause large seasonal, yearly and multi-year changes in zooplankton population size. Zooplankton are sampled with a variety of nets, multifrequency acoustics and optical instruments in the area twice a year. These data are used to monitor long-term changes in the levels of zooplankton species. Zooplankton abundance between 1961 and 1994 were measured with the Continuous Plankton Recorder (CPR) and trends are examined.*

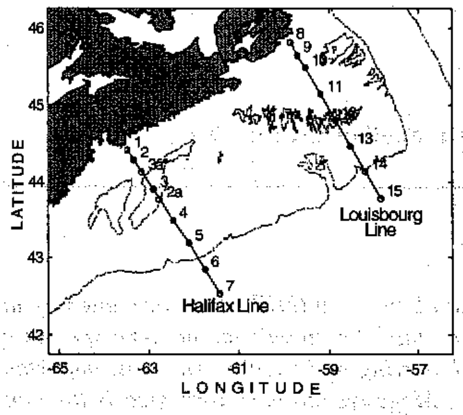
***Long-Term Plankton Trends***

The Continuous Plankton Recorder (CPR) is an instrument that collects phytoplankton and zooplankton on a long slowly moving continuous ribbon of silk while being towed from commercial ships. The position on the silk corresponds to the location of different sampling stations. Historical CPR data were analysed to detect differences in indices of phytoplankton and zooplankton abundance for different years between the eastern and western halves of the Scotian Shelf. All CPR data, from 1961 to 1994, were grouped into eastern or western Shelf regions, and the two regions compared over time. The phytoplankton greenness index (a measure of the amount of chlorophyll on the silk) was significantly higher in both regions of the shelf between 1991–1994 than during 1961–1975. The index of abundance of krill was higher on the eastern shelf during 1961 to 1975 than during 1991 to 1994. There was no significant difference between 1961–75 and 1991–94 in the krill index for the western shelf. Data were not collected between 1975 and 1991.

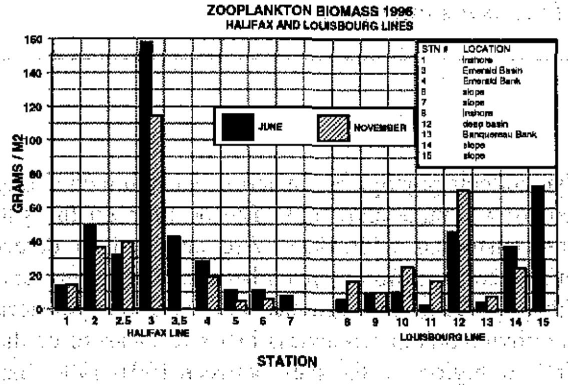



### *Conditions in 1996*

The Halifax and Louisbourg lines were sampled during the spring and fall of 1996 using conventional plankton nets and multifrequency acoustics (Sameoto and Herman 1990).

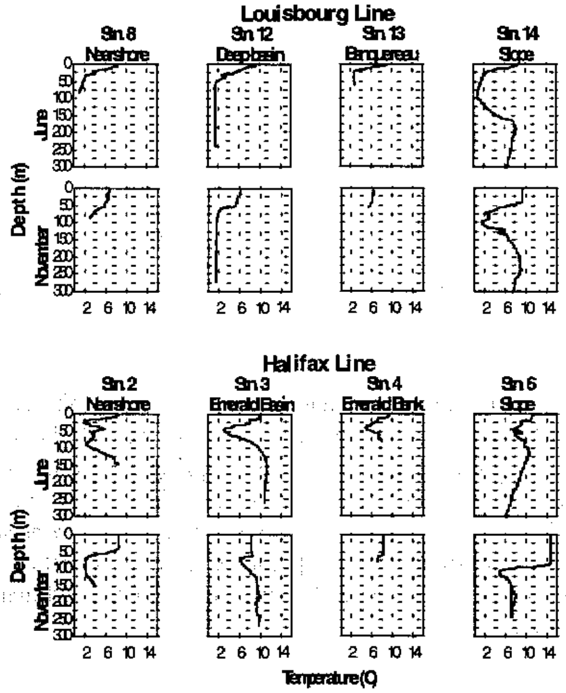



The **mean zooplankton biomass** values on the Halifax Line stations (1 to 5) in June were significantly higher than those on the Louisbourg Line. There was no significant difference between the November means. A comparison between Banquereau and Emerald banks (stations 13 and 4) showed Emerald Bank had a higher biomass in both months. The same pattern was found for the deep basin (station 12), and the Emerald Basin (station 3).




**Temperature profiles** are shown below for selected stations on the two transects for comparison. During June, the temperature profiles in the top 50 m on both transects were similar, but below 50 m, the water was significantly warmer on the Halifax line. The deep basin station 12 and Emerald Basin station 3 showed the most extreme contrast in temperature. Station 12 had temperatures < 2 C° below 50 m in June and November, whereas the coldest water in Emerald Basin was about 3 C° in June. These data show that **zooplankton** living in the top

50 m on the two transects would be exposed to similar temperature regimes between June and November. Animals that vertically migrated between day and night from deep water into the upper 50 m would spend about half of their life in colder water on the Louisbourg transect than would animals on the Halifax transect and therefore would likely have slower growth rates.

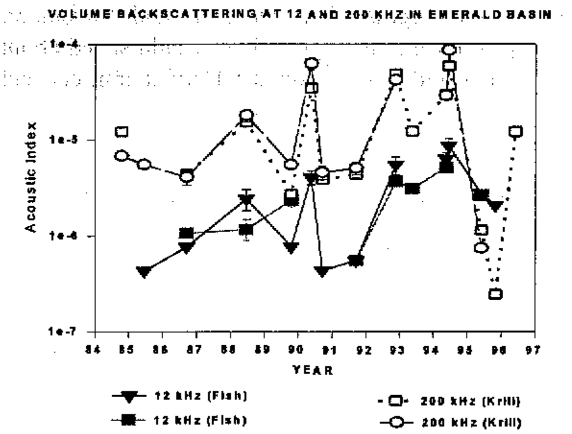



**Acoustic data** are good indicators of changes in krill abundance both across the shelf and between different months of the year. The levels of acoustic backscattering at 200 kHz were higher in 1996 than those of 1995. The krill acoustic index on the Louisbourg line indicated a biomass five times lower than that on the Halifax line. The pelagic fish index, primarily silver hake and sandlance, was not measured in June, 1996. There was little evidence of significant numbers of pelagic fish larvae and / or juveniles.

***Krill and Pelagic Fish Trends in Emerald Basin 1984–1996***

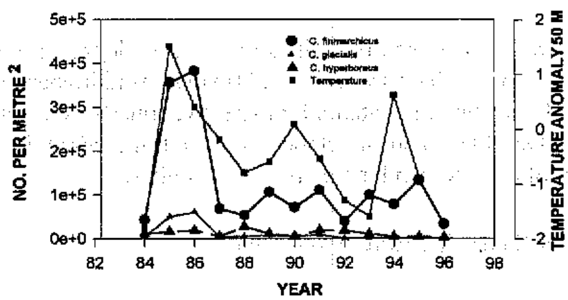
Acoustic data indicate a close relationship between the fish and krill in Emerald Basin. These data collected over the last decade have shown a close relationship between backscattering at 12 and 200 kHz. The 12 kHz frequency data reflects the concentrations of pelagic fish in the basin and the 200 kHz frequency data provides an accurate estimate of the krill concentrations. The relationship between these two frequencies over the years 1985 to 1995 showed a significant positive correlation. Both frequencies showed a general increase between 1985 and 1994 followed by a significant decrease in 1995.

Silver hake and redfish, the two dominant pelagic species, feed primarily on krill in the Basin (Waldon, 1988). In June 1996, there was a large increase in the levels of the 200 kHz backscattering, indicating the krill stocks had increased from the low values seen in 1995. Data at 12 kHz were not collected in June, 1996.




***Zooplankton trends in Emerald Basin, 1984–1996***

The copepod *C. finmarchicus* accumulates in Emerald Basin during the summer and fall and remains in the deep water until the breeding season in the late winter and early spring. It is believed that the size of the fall population of *C. finmarchicus* in the Basin is a good indicator of the size of the previous spring and summer's population on the Scotian Shelf (Sameoto and Herman 1990). The *C. finmarchicus* population declined between 1995 and 1996 to reach the historical low levels observed in 1984 and 1992. *C. glacialis* and C. *hyperboreus* (both Arctic species) had very low concentrations in the Basin in 1996. 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 *C. finmarchicus* population.




***Outlook***

The eastern shelf has been influenced by abnormally cold bottom temperatures in recent years and it is possible that this cold water has effected the size of the krill population in the area. Long-term time series data show that the levels of krill in the eastern region were lower in the 1990s than in the period between 1961 to 1975 when bottom temperatures were warmer.

The Emerald Basin *Calanus finmarchicus* data indicated that since 1987, population levels have been stable but much lower than in 1985 and 1986. Zooplankton samples and the acoustic index showed there was a gradual increase in both krill and fish populations in the Basin between 1984 and 1994 followed by a steep decline in their population size in 1995. The krill abundance increased in 1996 to levels observed between 1984 and 1994. The causes for the large fluctuations during 1994 and 1996 are not known.

It is postulated that if the bottom temperatures on the eastern shelf remain cold (i.e., in the range of 1 C°), *C. finmarchicus* populations and possibly krill populations will remain low in the eastern region. Krill populations on the western half of the shelf are near their long term average.

***For more Information***

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***References***

Sameoto, D. D. and A. W. Herman. 1990. Life cycle and distribution of *Calanus finmarchicus* in deep basins on the Nova Scotia shelf and seasonal changes in *Calanus* spp. Mar. Ecol. Prog. Ser. 66: 225–237.

Waldron, D.E. 1988. Trophic behaviour of the silver hake (*Merluccius bilinearis*) population on the Scotian Shelf. Ph.D. thesis, Dalhousie University, Halifax, N.S.

This report is available from the:

Maritimes Regional Advisory Process
Department of Fisheries and Oceans
P.O. Box 1006, Stn. B105
Dartmouth, Nova Scotia
Canada B2Y 4A2
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e-mail address: MyraV@mar.dfo-mpo.gc.ca
Internet address: http://csas.meds.dfo.ca

*La version française est disponible à l'adresse ci-dessus.*

## GERMANY

Trends for copepods at Helgoland Roads 1975–1994

Heino Fock & Wulf Greve, Senckenbergische Naturforschende Gesellschaft, Hamburg, Germany

Multivariate analyses on 77 taxa revealed a change in community structure between 1979 (ortho-oblique clustering) and 1982 (MDS). Start and end of the community change period coincided with a decrease of sea surface temperature and salinity in 1979 and a severe decrease of salinity in 1981 (Fig. 1, lower graph).

The trends for holoplankton (excluding *Noctiluca scintillans*) and total copepods as part of the holoplankton depict a similar development (Fig. 1, above graph). Trends are calcuclated by subtracting the long-term mean from each single datum and then cumulatively summing up the differences. Until 1980 low abundance values prevailed for holoplankton and total copepods (steadily decreasing curve). *Noctiluca scintillans* already reached a massive increase in 1979. In 1981 abundances for total copepods and holoplankton began to increase, were low in 1982, and then stayed on relatively high levels up to the begin of the nineties, when a further increase occurred. After 1991 abundances were again on a low level.

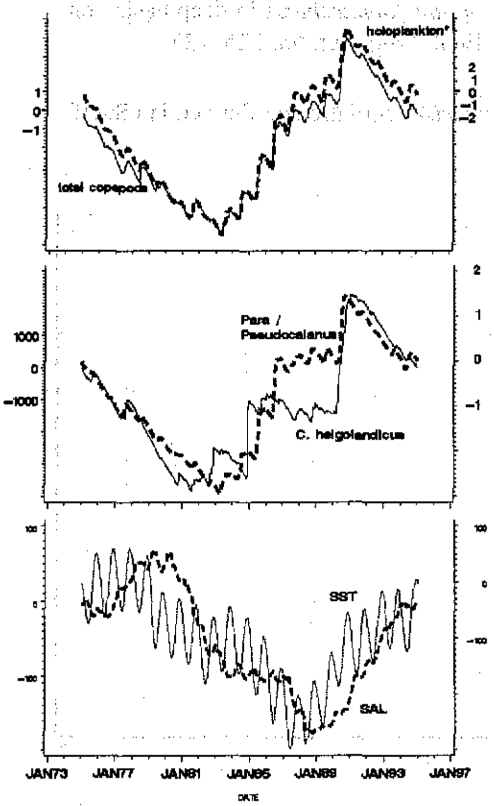



**Figure 1**: Trend analysis for holoplankton (dashed, * = except *Noctiluca scintillans*) and total copepods (above graph); *Calanus helgolandicus* and *Para/Pseudocalanus* spp. (dashed - middle graph); and sea surface temperature and salinity (dashed - lower graph). Cumulative deviations from the mean are plotted against time. Values for holoplankton, total copepods and *Para/Pseudocalanus* divided by 100000.

On species level, the dynamics are more diversified (Fig. 1, middle graph). The main turning point for *Calanus helgolandicus* occurred in 1980, after then the population density stayed on a higher level. For the *Para/Pseudocalanus* spp.-group the turning point happened in 1983. Both species (groups) already showed a minor increase in 1978 and a minor decrease from 1986 to 1989.

From 1979 to 1982 salinity and SST values were low (negative slope of the curve). From 1983 to 1986 values increased slightly. The turning points for plankton development fall into this period. Salinity and SST then decreased until 1989. This is reflected in the lower values of *C. helgolandicus* and *Para/Pseudocalanus* at that time. However, this developmental pattern is not reflected in the values for holoplankton and total copepods.

## PORTUGAL

Following the terms of reference for the 1998 Working Group on Zooplankton Ecology meeting in Santander to:

- carry out the first annual review of the results of zooplankton monitoring activities in the ICES area using the summary map(s) and information in tabular form in the 1997 Working Group on Zooplankton Ecology report ((ICES CM 1997/L:4) as a basis. Since Portugal did not participate in the 1997 Working Group on Zooplankton Ecology meeting in Kiel, Germany, there was no information on the Portuguese zooplankton monitoring activities in tabular form as requested by the Chairman. Therefore the existing information on the zooplankton monitoring programs in Portugal was summarised in the tabular form suggested by the WG and is presented as a Annex.

The zooplankton monitoring programs started in Portugal in 1970 and were, in general, connected with the specific needs (eggs and larvae) of the different fisheries. Therefore they involve different temporal and/or geographical coverage according to the fish/crustaceans species involved. Generally speaking there are seasonal monitoring that involve sampling all along the shelf (see map for the area covered) and monthly sampling in more restrict areas. Of these more restricted areas the best temporal coverage correspond to 4 lines perpendicular to the coast line whose location is shown in the map in Annex.

Off the west coast of Portugal the temperature at surface (10 m) and at the mixed layer during February/March 1996 suffered an increase of 1 to 1.5° C when compared with the long term monthly means of the same time of the year and at the same depths during the 70's and 80's decades (Dias, 1996). This increase is of 2° C at surface The increase of temperature at surface is of 2° C when compared with after Also it has been a decrease in the abundance of the sardine eggs and larvae in the sardine northern spawning area. This decrease is reflected in the decline in the recruitment and adult stock observed in the area during the last years.

**References:**

Anon. 1997. Report of the Working Group on Zooplankton Ecology. ICES CM 1997/L:4.

## SPAIN

Luis Valdés reported the activities of the Instituto Español de Oceanografía (IEO). The IEO research programme include 7 transect sites around the Spanish coast, 4 in the ICES area and 3 in the Mediterranean (Figure 1). These involved an extensive physical, chemical and biological monthly sampling series at each site, with special attention to the sampling and analysis of hydrography, nutrients, chlorophyll a, phytoplankton and zooplankton species. Depending on the transect, the time series extend from 1988 (La Coruña and Vigo), 1991 (Santander), 1994 (Asturias) in the ICES area. In order to ensure that the data are processed in a similar manner, sampling is being carried out according with JGOFS protocols where possible, and/or following our own guidelines. In response to the need to deal effectively with the large and varied volumes of data that have been accumulated as result of the above activities, the IEO has developed a database that acts as an archive of the data and as a tool for data analysis and elaboration of reports.

**In the Cantabrian and Atlantic areas** the temperature shows an increasing trend through the time series. This increase results in the opposition in long-term trends of the water column stratification, which follows a clear upward trend, and the zooplankton species richness and diversity index, which show a downward trend (Figure 2a). this opposition in long-term trends is confirmed by the significant negative correlation between both sets of data (Figure 2b). This result stress the importance that lengthening of the time during which the water column remains stratified and an increase in the degree of stratification could have in limiting the interchange of nutrients from deeper to surface waters and consequently limiting the growth of phytoplankton, which diminishes the abundance of zooplankton.

**In the Mediterranean Sea (Baleares monitoring station),** Mª Luz Fernández de Puelles showed the results of the last 5 years in a neritic station sampled weekly in the SW of Mallorca island (Western Mediterranean Sea). The main physical, chemical and planktonic data were shown with the main focus on zooplankton biomass (expressed as dry weight/$m^3$). A slightly increasing trend of the sea surface temperature was observed. This is connected with a decreasing of the biomass zooplankton trend (Figure 3). It was pointed out the importance of the temporal series studies in the Mediterranean Sea with a temporal scale solving the seasonal and interannual variability on the shelf area in relation to both: global warming and fisheries stocks assessment.

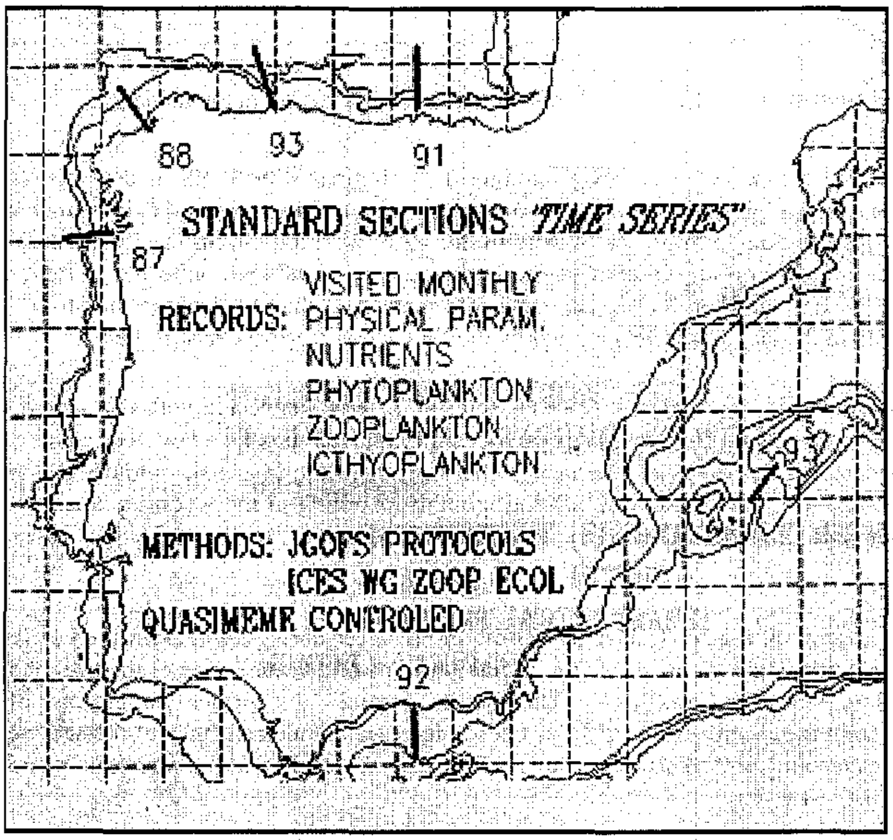
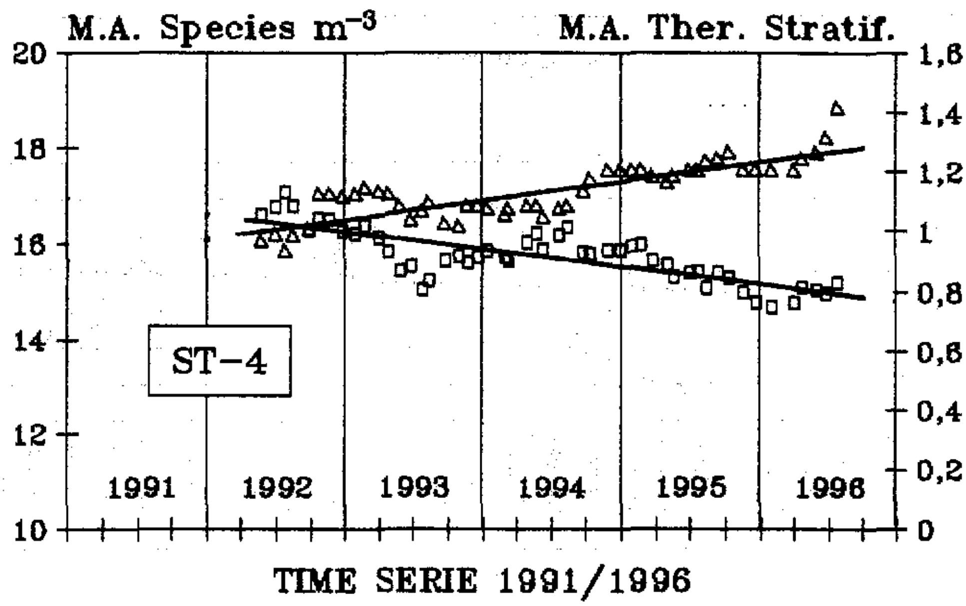
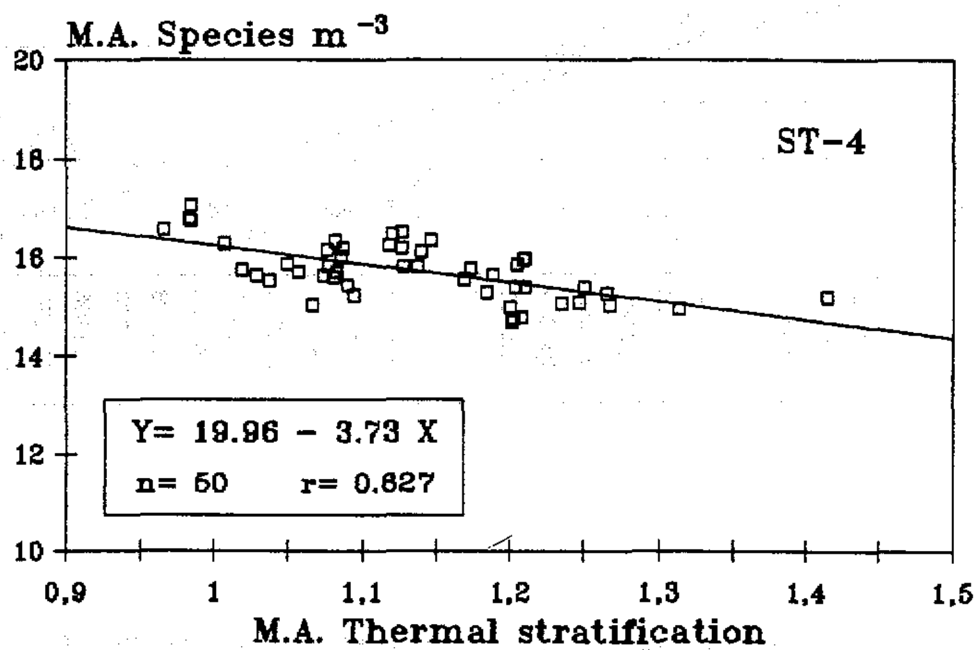

88
93
91
STANDARD SECTIONS "TIME SERIES"
87
VISITED MONTHLY
RECORDS: PHYSICAL PARAM.
NUTRIENTS
PHYTOPLANKTON
ZOOPLANKTON
ICTHYOPLANKTON
METHODS: JGOFS PROTOCOLS
ICES WG ZOOP ECOL
QUASIMEME CONTROLED
92

Figure 1

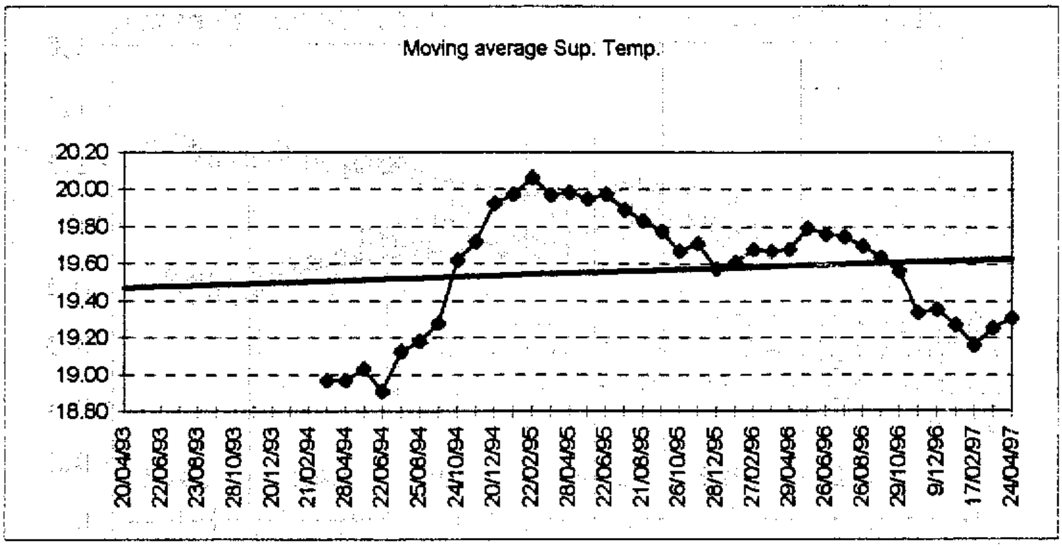


M.A. Species m-3
M.A. Ther. Stratif.
20
18
16
14
12
10
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
ST-4
1991
1992
1993
1994
1995
1996
TIME SERIE 1991/1996


Figure 2



M.A. Species m -3
20
18
16
14
12
10
ST-4
Y= 19.96 - 3.73 X
n= 50 r= 0.627
0,9
1
1,1
1,2
1,3
1,4
1,5
M.A. Thermal stratification



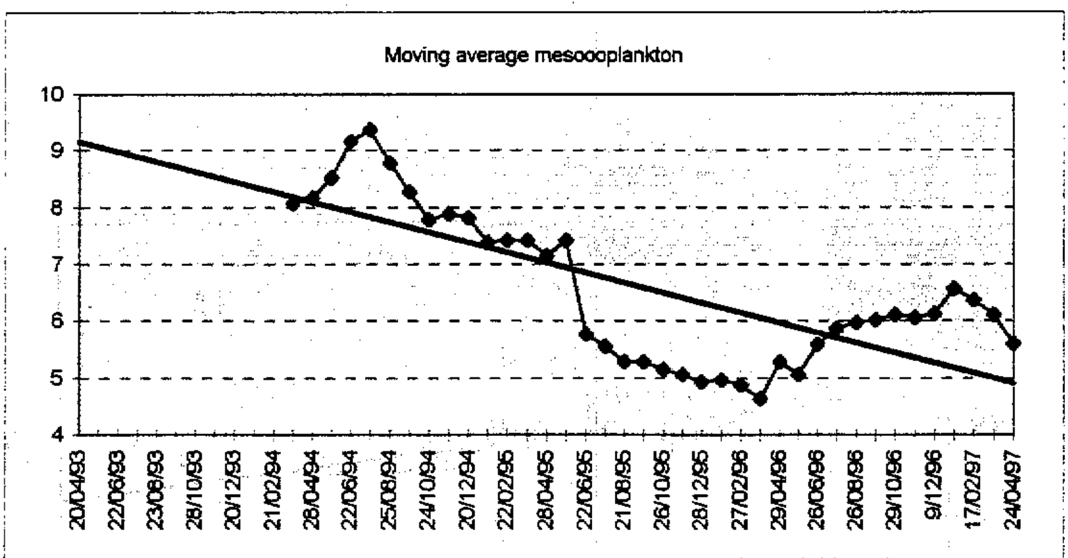




Figure 3 Baleares Time Series (temperature and mesozooplankton) since April 1993 to April 1997-Western Mediterranean Sea.

**UNITED KINGDOM**

Analyses of zooplankton monitoring data collected off Plymouth.

General trends on the zooplankton composition were analysed using the cumulated function suggested by Ibanez et al (1993). In this function for a chronological series with data x (t) sampled each t we choose a reference value k (in this case the average of the series) and after subtracting k from all the data we add successively these residuals obtaining:

$S_1 = (x_1 - k)$

$S_2 = (x_1 - k) + (x_2 - k) = S_1 + (x_2 - k)$

Etc...

The total zooplankton abundance and the copepods abundance off Plymouth shows a decreasing trend from 1988 to 1995 with some recovery on 1996 (fig 1). Applying the same approach to the percentage composition of the copepods population changes in the population composition were identified and species presenting similar trends were grouped using a principal components analysis (fig 2).

**References:**

Ibanez, F., Fromentin, J.M., Castel, J., 1993. Application of the cumulated function to the processing of chronological data in oceanography. C. R. Acad. Sci. Paris, Sciences de la Vie 316: 745–748. (in French with abridged version in English).

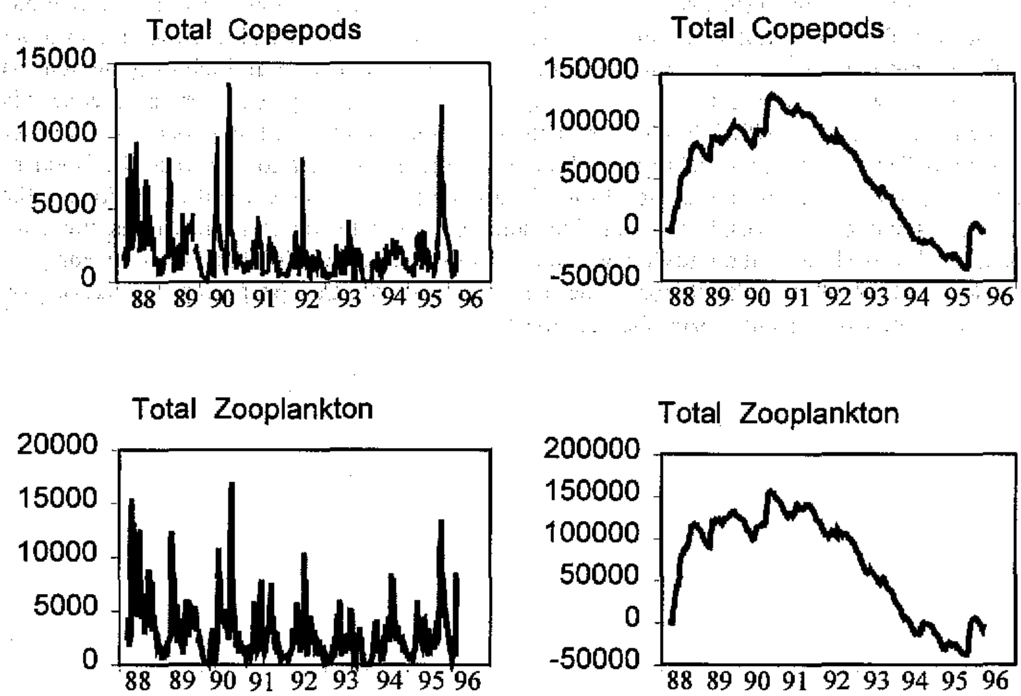



Figure 1: Evolution of copepod and total zooplankton abundance from 1988 to 1996 off Plymouth. Real data on the left and cumulated deviations from the mean in the right.

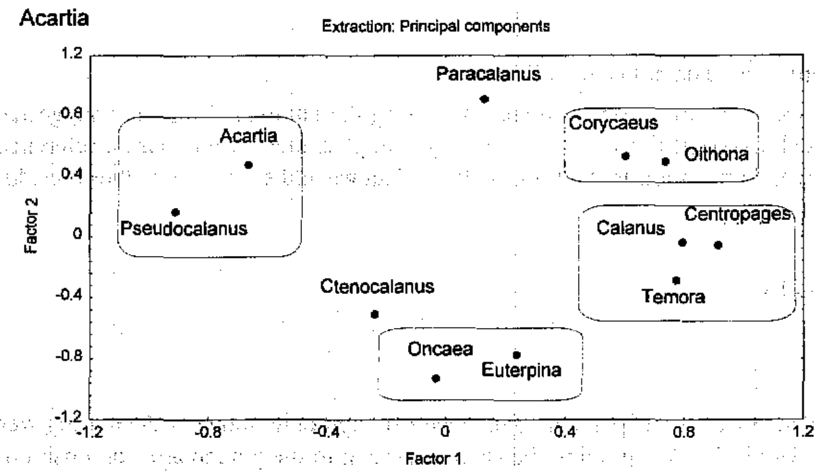



Fig 2: Results of the principal component analysis grouping the species presenting similar trends in the variation of their percentage contribution to the copepods population.

## UNITED STATES

US GLOBEC Georges Bank Project has been conducting broad-scale surveys of Georges Bank at monthly intervals nominally from January to June (in one year we went from February to July) and at each of (now) 41 Standard Stations we sample at a minimum with a CTD rosette (all with fluorometry, chlorophylls, and 16O/18O samples and more recently transmissometry), Bongo net tow, and a 1 $m^2$ MOCNESS tow for both zooplankton and ichthyoplankton. At some of the highest priority stations (which number 18), we also sample with a pumping systems for larval copepods (microzooplankotn) and also with a 10 $m^2$ MOCNESS trawl for predators. But the actual sampling depends on weather and season. We also take a Bongo Tow with CTD for ichthyoplankton at an intermediate station between the Standard Station during most of the cruises, weather permitting. So for a lot of cruises we actually take about 80 stations in the Georges Bank area. On all cruises some form of ADCP is operated to gather current data and on some cruises, there has been a high frequency acoustic fish towed along the trackline as well to gather a form of biological data. In Phase II, nutrient samples have been taken at each of the CTD stations. There are a number of other projects piggy backing on the broad-scale cruises, for example genetics and microzooplankton to name two.