INTERNATIONAL COUNCIL
FOR THE EXPLORATION OF THE SEA

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# Report from the 2nd meeting of the ICES Study Group on Zooplankton Production, Las Palmas, Canary Islands, Spain, 8-11 March 1993

CONTENT:

## 1. Opening of meeting.

The meeting was held of Hotel Imperial Playa in Las Palmas, with excellent meeting facilities provided by the host Dr. Santiago Hernández León from the host institution, the Universidad de Las Palmas de Gran Canaria, Facultad de Ciencias del Mar. The meeting started at 09:30 on 8 March 1993, and was chaired by Hein Rune Skjoldal.

A list of participants to the meeting is given as Annex I. The chairman noted that the participation was lower than what had been expected, and that several members of the SG had conveyed appologies for not being able to attend. Several new participants represented on the other hand a broadening of the expertice present at the meeting.

The chairman reminded the meeting of the terms of reference for the SG. He noted that the agenda for the meeting was based on these terms of reference and represented a continuation of work agreed upon at the 1st meeting of the SG in Bergen in 1992.

## 2. Adoption of agenda.

The proposed agenda for the meeting was adopted. The agenda is given as Annex II.

Rapporteurs for the varions agenda points were appointed. These were: Steve Hay, Peter Tiselius and Lutz Postel (3), Jürgen Lenz (4), Tor Knutsen and Lutz Postel (5), Santiago Hernández León (6), Steve Coombs (7), and Hein Rune Skjoldal (1,2, 8, 9, 10).

## 3. Review of methods for determining biomass and production.

At the meeting in Bergen in 1992 the SG made an inventory and a first start at reviewing methods for determination of biomass and production. At the present meeting this activity was continued, with the aim to take note of recent developments and produce a list of methods which the SG consider potential candidates for standardization and improvements. This list is given as Annex III.

### General Aspects.

Discussions opened with suggestions that reports of other recent workshops, such as GLOBEC, JGOFS and the workshops of the Baltic Marine Biologists (BMB) would be of benefit and relevance for the study groups efforts. This was accepted and copies of such reports were presented for perusal by the members. Discussions initially revolved around some of the more general considerations including the natural separation into sampling technologies to define biomass and experimental techniques to estimate physiological process rates, in particular production from which the productivity of a system is derived.

Two particular factors should be born in mind when assessing productivity. Firstly behavioural interactions with environment will affect considerations of trophodynamics, physical dispersion and population dynamics and therefore some sampling and experimental strategies. Secondly estimates of production are made over particular spatial or temporal scales and so some methods are often more appropriate to the scales under investigation. Often too, studies are made of particular phenomena or upon targeted species or trophic groups, thus particular scales will be targeted. It is important however to consider the influences of phenomena occurring at scales greater or smaller than those proposed for an individual method or study.

The chairman remarked that it is at the heart of ecology to integrate large and small scale phenomena, but that it is usually best to start large and include smaller scales as required and appropriate. It was considered that the lists of techniques for rate determinations made at the previous Bergen meeting should be annotated with the appropriate scales for their use. An overview of methods for determination of rate processes was elaborated. This overview is given as Annex IV and contains information on operating level, time scale, advantages and problems.

The choice of methods will ultimately depend on the purpose of particular studies. When evaluating and recommending methods, it is therefore required to pay due attention to the various research and monitoring purposes. One important purpose is linked to the current need to characterize zooplankton biomass and production at the scale of commercial fish stock or large marine ecosystems (LMES). Within this LME frame it is required to link zooplankton to circulation pattern and small-scale physics on one hand, and to the feeding and growth of fish and other higher trophic levels on the other. These are the central topics of the GLOBEC program. Another important purpose for zooplankton studies is to characterize the role of zooplankton in mediating and regulating the vertical flux of material from the upper ocean layer. This is a central issue for the questions addressed in the JGOFS program.

The discussion then moved to particular newly developed methods and in particular to the possibilities of standardisation and suggestions for improvements. Agenda points 3 and 4 were discussed in parallel as there is no sharp distinction between improvements of methods in current use and development of new methods and technology.

**The Egg Production Method.**

The egg production method was considered to be an important recent development which directly addresses the problems of secondary production estimation in the field yet it is a process which in experimental work relates to many other rate measures. The observation was made that egg production as a measure of birth rate links the physiological model approach to ecosystem studies with the population dynamic approach. It was considered that studies of zooplankton production were frequently under-represented in many large scale research proposals. However,

zooplankton studies form major components in many fields of study such as fish stocks and recruitment, vertical carbon flux studies, partitioning of " new " versus recycling based primary production, ecosystem modelling, monitoring, studies of seasonal cycles and comparisons between different regions and ecosystems. Importantly there are increasing demands from modellers of marine systems at all scales for accurate zooplankton parameter estimates and data sets to test model performance.

Peter Tiselius delivered an illustrated description of the egg production method ( after Kiørboe ) as used extensively during the SKAGEX investigation. Steve Hay described a modified procedure, similar to that used by J. Runge and which he has used extensively in the North Sea over a number of years. The technique was dicussed generally in some detail and it was considered a good example of a method which could be standardized in its basic form with the proviso that to work with particular species, environments or experimental designs might require elaborations of the method. A procedure for measurements of egg production of copepods is given as Annex V, as an example of a proposal for a standardized method. It is envisioned that this proposal will form the basis for further discussion among experts and lead to a recommended standard procedure.

It was pointed out that the Egg production method should be included in both the sea and laboratory based practical workshops. Also there was a need to calibrate the technique against other less well known methods particularly the artificial cohort method. It was thought important that the relationship between specific egg production estimates and specific total production of populations should be determined quite rigorously. It was also pointed out that in tropical and sub tropical regions the species diversity and problems of identification of species made the egg production method a poor choice in comparison to the artificial cohort method.

Lutz Postel pointed out that these and other physiological measurements and biochemical techniques had been simultaneously employed in an extended study on size fractionated plankton in the Baltic Sea which should provide considerable useful comparative data once all the data are analysed. Further it was suggested that past work on feeding and respiration should give insights into effects so that for example confinement densities could be recommended. It was also noted that there had been some GLOBEC proposals for a workshop on the egg production method and that a combined effort may be helpful to both initiatives.

**Biochemical Methods.**

Jean Pierre Bergeron gave an introduction to biochemical techniques with emphasis on the ATC (aspartate transcarbamylase) method to assay productivity on mixed zooplankton species samples. It was reminded that ATC regulates a first step of the metabolic pathway leading to pyrimidine bases. As such, ATC activity gives information about rates of nucleic acids biosynthesis needed for protein synthesis and cell division, both processes involved in the production of living matter. Results of

measurements carried out in the Channel were presented, illustrating two main features of ATC activity variations: global coherence regarding integrated hydrobiological factors and evidence of a fundamental behaviour at the considered perception level, i.e. an allometric relationship between ATC and biomass in certain conditions of stability of the system. Some specific aspects of the conditions required to perform this approach were briefly pointed out concerning sampling design, relevant spatial and temporal scales, especially hydrodynamics and spatial cohesion of the community. The method was shown to have some limitations, especially when used in areas dominated by small scale fluctuations, i.e. near hydrological fronts.

In the discussion following, it was considered that the case was as yet undecided on the general utility of the ATC method. However it was decided that it should be included in the list of methods for study at the experimental workshop. There followed a presentation by Lutz Postel of the strategy and methods employed in the aforementioned Baltic Sea work. The chairman emphasized that such comparative exercises were rare and that there was a particular need to identify standard methods and to describe standard procedures for them.

It was noted that recent literature reviews should be identified and considered in relation to setting standards and in relation to the proposed experimental workshops. There followed some discussion of the range of biochemical techniques including ETS, GDH and RNA/DNA measurements. Many of these techniques are known to have drawbacks and points of contention, however all have validity when applied to investigations of particular processes and scales. The trick is to be aware of the limitations and strengths when designing field or experimental investigations. The manual and workshops should review and help define the procedures and limitations.

**Methods for feeding and metabolic rate measurements.**

There is a wide range of techniques in use for measuring rates of feeding and metabolism. Feeding and bioenergetics are important areas of research on zooplankton and the wide range of techniques is to some extent a reflection of the diversification of approaches taken in such studies. The SG recognized the value of such diversified approaches. For some purposes, such as comparison of rates and efficiencies across studies and ecosystems, the group felt that much was to be gained by having a higher degree of harmonization or standardization of methods. Gut fluorescens, incubation methods for determination of clearance rates, feeding, and metabolic rates, and 14C-based techniques were all methods which the SG will consider further for possible standardization.

**Optical Methods.**

There was some general discussion concerning the several very new methods in this field. The recent report of the GLOBEC workshop was summarized and key features described by Jürgen Lenz (see section 4). He also presented a description of the

optical Ichthyoplankton Sampler under development in his group.

**Acoustical Methods.**

As with the optical methods the field of acoustics has seen some remarkable new work and technical development in the past few years, many are ongoing. As means of both determining and describing distribution of biomass in a nonobtrusive manner they currently have great value and realistically promise greatly enhanced capabilities. They will be of major importance in both integrating studies of the distribution of biomass in relation to hydrobiological features of the environment, and in assessing the nature and importance of behavioural factors in determining ecosystem functions. There was some discussion of these techniques and it was noted that the GLOBEC workshop report on acoustics which had been considered at the Bergen meeting, was still of importance to the study group's work.

**Sampling Gears.**

A variety of gears were briefly discussed, some such as the WP2 net have become fairly standard routine sampling gears at many institutes. There has however been a proliferation of sampling net designs over the past two decades and it was felt that the study group should suggest or reinforce the benefits of a few obvious favourites. Concerning standardization one option could be to limit recommendations to general aspects such as optimum mesh sizes, mouth openings, area ratios, towing speeds and methods of deployment.

It is the case that certain categories of net sizes are appropriate to their plankton size ranges and that vertical and double oblique haul profiles are the norm. In addition there are a range of high speed samplers and many new (often prototype) multidepth samplers in use. Older gears are often retained on the grounds of consistency and the maintainance of long time series. An obvious example is the CPR silks with not well defined mesh size.

With the wider role CPRS may play in future LME monitoring programs on a global basis, one should now consider whether a change to or addition of a more well defined mesh size would augment the usefulness of CPR collected data.

It is evident from the literature that the question of size fractionation is another area where standard separatory meshes would be of benefit in making results more strictly comparable.

Yet another area ripe for standardization is in the units of biomass employed and in the multitude of techniques and units used in conversions of biomass units or morphometrics.

## 4. Review of new developments.

The Study Group took note of the very informative U.S. GLOBEC Report No. 8 (Draft Febr. 1993) of the U.S. GLOBEC Workshop on Optics Technology. This Workshop took place in Savannah, Georgia, USA at the Skidaway Institute of Oceanography on February 20-22, 1992, and was convened by Gustav Paffenhöfer.

The Workshop evaluated the potential of optical instrumentation to determine in situ biomass and rate processes of zooplankton in relation to their physical and biotic environment as two main objectives of the GLOBEC Program. Optical methods based on video have the advantage of providing taxonomic information on zooplankton distribution and species composition. In addition to the potential of quantifying biomass by means of image analysis, optical methods are regarded as useful complement to acoustical methods for assessing zooplankton size distribution. The advantage of acoustical methods is, at least at present, the easier data processing than in video systems. It is thought that such a combination of optical and acoustical methods would significantly enhance the success of field studies on the interaction of zooplankton populations with their physical and biotic environment.

Video systems not using the preconcentration approach by means of plankton nets have the disadvantage of producing a vast amount of empty pictures due to low in situ concentration of zooplankton. A promising approach in overcoming this deficiency is the so-called "Smart Sampling" proposed by Peter Ortner. It consists of a video system for strobe-illuminated silhouette photography combined with an Optical Particle Counter (OPC). The OPC is the primary sampler. It counts and sizes the particles and video images are solely taken for target identification.

The high spatial and temporal resolution of optical methods make them an ideal tool for the second task, the quantification of rate measurements and zooplankton behaviour, such as swimming, feeding, swarming and escape reactions when attacked by predators. These observations will greatly enhance our basic understanding of space and time scales involved in main life processes under in situ conditions. It may not yet be possible, however, to use such observation systems on a routine basis for measuring zooplankton production or mortality as they require highly sophisticated recording and image analysing systems which will need well trained specialists to operate.

The recent publication "Advanced techniques for in situ studies of zooplankton abundance, distribution, and behavior", edited by W.G. Sprules, P.C. Schulze and C.E. Williamson, Arch. Hydrobiol. Beih. Ergebn. Limnol. 36 (1992) is recommended as very useful background information.

## 5. Sea-going workshop in Norway.

The SG had recommended that a series of 3 seagoing workshops should be conducted in 1993. It was apparent that the workshop on Georges Bank and around Hawaii would not take place. The workshop in Norway is scheduled to take place in June 1993, using the Norwegian RV "Johan Hjort" and the German RV "A.v. Humboldt".

Tor Knutsen gave a presentation describing the fjord areas, the Storfjord at Møre, where the work should be performed, giving an outline of the hydrographic regime, the biological components and an outline of the strategy to be used at the workshop.

Lutz Postel gave a presentation describing the facilities of the RV "A.v. Humboldt" and plans for the German participation including rate measurements.

The meeting discussed the purpose and aims of the workshop. It was agreed that the main purpose was to intercompare and evaluate methods for studying zooplankton distribution and biomass. Some rate measurements will also be carried out in order to allow calculation of zooplankton production from abundance and biomass data.

The following objectives were formulated for the workshop.

**Principal objective:**

Intercompare, characterize, and evaluate the performance of gear and techniques for quantitative description of zooplankton distribution, biomass and production in a fjord habitat.

**Specific objectives:**

1. Quantitative description of structure and abundance of the pelagic community through use of a range of sampling gears and acoustical and optical instrumentation.
2. Direct and indirect quantification of avoidance.
3. Evaluate and characterize sampling performance with regard to resolution and selectivity of single and combination of gears and techniques.
4. Compare and evaluate different methods for estimating zooplankton production and metabolism.

Further details of the plan for the sea-going workshop in Norway are given in Annex VI. Provisional lists of sampling gear and instrumentation and of participants to the workshop are given in Annex VII.

## 6. Laboratory workshops.

### Workshop in 1993.

Hein Rune Skjoldal presented a proposal by Ulf Båmstedt for a laboratory workshop organized by the University of Bergen. The workshop will be held at Espegrend field laboratory in September-October 1993. This laboratory experiment will be an introductory exercise to a more extensive exercise in 1994. The 1993 experiment will focus on different approaches to measuring growth of the neritic copepod Acartia clausi, while the 1994 experiment will be an exercise on Calanus finmarchicus. In this way we will have an intercomparison between coastal and more oceanic copepods.

The 1993 workshop will utilize cultures of Acartia clausi fed the alga Rhodomonas sp. and grown at two different temperatures (12 and 20°C). Growth will be estimated from measurements of size and stage duration and compared to estimates from egg production, molting rate, metabolic rates, and biochemical indices.

Discussion at this point of the meeting was related to the experimental design outlined by Båmstedt on the use of two different temperatures (12 and 20°C) or the possibility to work using different food concentrations instead of temperature differences. A final decision on the experimental design must be taken when facilities and personnel available for the experiment are known. The task should be an intercomparison between different techniques to measure growth. Feeding and respiration experiments could also be performed but the workshop should focus on the estimation and intercomparison of different techniques to measure growth.

### Workshop in 1994.

This workshop will be carried out on the basis of field population (field cohorts) and land based cultures of Calanus finmarchicus. The copepod will be exposed to different feeding conditions and a suite of methods to measure feeding, egestion, assimilation, metabolism and growth will be carried out. Close cooperation with persons planning similar exercises under GLOBEC must be considered. The workshop will take a minimum of three weeks during early spring and the place is at present under consideration.

There is a need to know names and institutions interested in this workshop in order to produce a list of processes and rates to be measured (see the first report of the study group).

## 7. Zooplankton Methodology Manual.

The previous manuals on zooplankton methods are over 15 years old, and there is now a requirement for an upgrade in the light of methods and technological developments.

The aims of the Manual are to review current methodologies and to recommend a set of procedures, or at least guidelines on procedures. Sufficient latitude should be allowed for variations in each particular application. Pitfalls and minimum levels of quality/standards will be emphasised.

At the 1992 meeting in Bergen an outline of structure and content of the manual was agreed. This was further developed at the present meeting and a more detailed table of content with chapters and subheadings was prepared. This is given as Annex VIII.

A list of prospective main and associate authors for each chapter of the manual was produced (Annex IX). These authors will be contacted by the editors to establish their willingness to undertake these roles.

A guideline on length and content of each chapter will be provided to the authors. The availability of existing compilations on novel methodologies was noted e.g. GLOBEC reports on acoustics and optics, and Advances in Limnology Vol. 36.

It is suggested that a final draft version of the Manual is ready for presentation at the 1994 ICES symposium on ZOOPLANKTON PRODUCTION. This may be as a poster display or as summary presentations of selected topics.

The value of acoustic and optical/image analysis techniques for biomass measurement and identification was recognized. However it was felt that the most effective use of these technologies was still by interaction with trained taxonomists and that an over-emphasis of development of these methods as stand-alone systems was not yet appropriate.

**8. ICES Zooplankton Symposium in 1994**

An ICES Symposium on Zooplankton Production co-sponsored by SCOR and IOC will be held at Plymouth 15-18 August 1994. The Symposium will address the importance of zooplankton as intermediate links in pelagic food webs and in biogeochemical cycles.

A suggestion made by Mark Huntley to use the ICES Symposium as a final deadline for completion and a forum for presentation of the manual was discussed and endorsed. Presentation of the manual could be usefully done in the form of one or more posters. It was also considered that some of the topics reviewed in the manual might be appropriate for presentation by their principal authors at the symposium.

The meeting discussed possible topics for invited contributions to the symposium program. These included methodological aspects like optics, acoustics, physiological and biochemical approaches to rate measurements, and statistical and theoretical aspects of sampling. Possible ecological topics were light as an ecological factor for predation, life

history theory, food limitation or predation control of zooplankton, small scale feeding behaviour, food quality, and ecology of gelatinous plankton. The chairman will bring these suggestions forward to the symposium planning commitee of which he is a member.

**9. Plans for completion of Study Group work.**

At the first meeting in Bergen a tentative time table for activities was drawn up. The aim was to complete the work of the Study Group in 1994. The meeting agreed that this should still be the aim.

The work with the manual will be a major task within the Study Group. A revised time table is as follows:

- May 1993 Author list finalized.
- November 1993 First draft of chapters to editors.
- February 1994 Revised draft to editors.
- March 1994 Draft reviewed by Study Group.
- August 1994 Final draft version presented at Symposium.
- November 1994 Editorial work completed.
- Primo 1995 Manual printed.

The Study Group recommends that it should go forward and implement the plans for the practical workshops. There are 3 workshops planned for 1993 and 1994:

- June 1993 Sea-going workshop in Norway on board RV "Johan Hjort" and "A. v. Humboldt".
- Oktober 1993 Laboratory workshop on Acartia clausi at the University of Bergen.
- Spring 1994 Laboratory workshop on Calanus.

In conjunction with the workshops it is intended to conduct discussions in smaller groups of experts concerning evaluation, standardization and improvement of methods. This work will also be carried out intersessionally within the Study Group.

The Study Group recommends that it should meet in March 1994 with the following main tasks:

1) Review results from the seagoing and laboratory workshops in Norway.
2) Review draft of Zooplankton Methodology Manual.
3) Evaluate and recommend standardization and improvement of methods.
4) Review plans for the Laboratory workshop on Calanus.

A venue for this third and final meeting of the Study Group has not yet been decided.

## 10. Closing of the meeting

The meeting was closed at 17:00 on 11 March 1993. The chairman thanked Santiago Hernández León for the excellent working conditions and the warm hospitality that had been offered the Study Group.

**Annex I**

**List of participants:**

Hein Rune Skjoldal, Norway

Jürgen Lenz, Germany

Lutz Postel, Germany

Santiago Hernández-León, Spain

Jean Pierre Bergeron, France

Peter Tiselius, Sweden

Steve Hay, U.K.

Eilif Gaard, The Faroe Islands

Tor Knutsen, Norway

José García Braun, Spain

Steve Coombs, U.K.

Irene Montero González, Spain.

**Annex II**

AGENDA

1. Opening of meeting.

2. Adoption of agenda.

3. Review of methods for determination of zooplankton biomass and production.
   a) Inventory of methods
   b) Evaluation of methods
   c) Standardizaton and improvements

4. Review of new developments.

5. Review plans for seagoing workshop in Norway.

6. Review plans for laboratory workshops.

7. Review plans for the Zooplankton Methodology manual.

8. Consider plans and contributions to the ICES Zooplankton Symposium in 1994.

9. Plans for completion of the study group work.

10. Any other business.

11. Closing of the meeting.

**Annex III**

## LIST OF METHODS THAT ARE POTENTIAL CANDIDATES FOR RECOMMENDED STANDARDIZATION OR IMPROVEMENT.

Biomass and distribution

| | |
|---|---|
| Sampling gear (vertical, oblique, depth stratified) | standardization and improvement |
| Mesh size (incl. CPR) | |
| Size fractionation | standardization |
| Biomass units and Conversion factors | standardization |
| Acoustics | improvement |
| Optics | improvement |

Processes and rates

| | |
|---|---|
| Egg production method | standardization |
| Artificial cohort method | improvement |
| ETS | standardization |
| Metabolic rates (respiration, remineralization) | standardization |
| Gut fluorescence | standardization |
| Grazing, clearance rate,filtering rate, feeding rate | standardization |
| Optical methods | improvement |
| GDH | improvement |
| ATC | improvement |

Annex IV

## OVERVIEW OF METHODS FOR DETERMINATION OF RATE PROCESSES.

The following table (p. 16) gives an overview of methods to measure the flux of matter in and out of compartments, which could be organisms, populations, size classes, and communities, and their production.

The various processes or components of the bioenergetic budget are given in the first column, whereas different methods are listed in column 2. Columns 3 and 4 describe the specific aims and principles of the methods. Information on the operation level and time scale of the process for which the methods are appropriate are given in columns 5 and 6. Key words regarding advantages and problems of the various methods are given in columns 7 and 8.

The table is provided as an example of an overview which could be usefully included to guide readers to the Zooplankton methodology manual. It is suggested that the editors and authors of the manual should extend the table and revise it as appropriate.

| Process | Method | Aim | Principle | Operating level: cell | juv. organisms | adult organisms | popul-ation | commu-nity | Time scale | Remarks: Advantages | Problems |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ingestion (I) | High speed Cinematography | *feeding behaviour *food selectivity *etc. | Convert real to observational velocities | | # | # | | | Minutes | | *Artifical, (fixed animals) *Advanced method (needs expertise, expensive) |
| | Digestive enzymes * amylase * trypsine etc. | Quantify potential food requirements | Fixation of the in situ enzyme activity | # | | | | | | *Fixation of in situ conditions; high data density in comparisons to balance methods | *Artifical (saturated substrate condition) |
| Assimilation (A) | | | | | | | | | | | |
| Respiration (R) | Balance methods * WINKLER | Oxygen consumption | Oxygen difference between sample and control bottle | | # | # | # | # | About half a day | | *Artifical organism concentration *Lime integrated sampling *Starvation during incubation |
| | * Micro electrode | dto. | dto. | | # | # | # | # | About 5 hrs | Dynamic method | |
| | Enzymatic methods e.g. ETS etc. | Quantify potential oxygen demand | c.f. digestive enzymes | # | | | | | Minutes | | c.f. digestive enzymes |
| Excretion (U) | Balance method | Nutrient release | Nutrient difference between sample and control | | # | # | # | # | About half day | | c.f. respiration |
| | Enzymatic method etc. | Quantify potential ammonia release | c.f. digestive enzymes | # | | | | | Minutes | | c.f. distigsive enzymes |
| Defacation (F) | | | | | | | | | | | |
| Elimination (E) | Counting exhuvias | Determine the loss during moulting | | | # | | | | Day(s) | | |
| Production (P) | Balance calculations (e.g. P=I-R-U-F-E) | Determine the net matter surplus vs. time | Measurement of compartments input and outputs, to calculate the difference | | # | # | # | # | About half a day | Nearly real results | Time consuming, needs measurements of several processes |
| | Model calculations etc. | dto. | Calculation of growth and reproduction | | # | # | # | # | Time invariant | | Results depending on model quality |
| *Body growth | Cohort analysis | dto. | Counting cohorts | | # | | # | | Weeks | | Time consuming |
| | Artifical cohort analysis etc. | dto. | Determining changing spectra of sample composition by counting, or silhouette photography or particle determin. | | # | | # | # | Weeks | | dto. |
| *Reproduction | Egg production method etc. | dto. | Reproduction is equal to net production when females are adults | | | # | | | at least 24 hr's | Easy to carry out | Restricted to egg producing plankton (e.g. Copepods) |

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Annex V

# EXAMPLE OF A STANDARDIZED PROCEDURE FOR DETERMINING EGG PRODUCTION OF COPEPODS

## General aspects

This method provides a simple and robust technique for estimating the growth and production of copepods, suitable for field and laboratory use. The method estimates a key process and when combined with biomass estimates and other rate measurements such as ingestion and excretion, may be used to derive carbon flow budgets for planktonic communities. In brief, adult female copepods are incubated for 24h and eggs produced are counted. Estimates of egg and female biomass allow specific egg production rate to be derived. This has been shown to be close to an estimate of the growth rate of juvenile stages for some species of copepods. The estimate reflects short term feeding history and therefore can be used when short temporal and spatial scales (h-day, m-km) are under investigation. Examples would be transects across frontal systems, or system responses to wind events or comparisons between different evironmental regimes. The method has been in use for about ten years and fairly similar procedures have evolved among investigators. It should be possible to standardize the technique, although elaborations of the basic method may be required to work with particular species, environments or experimental designs.

The egg production method may not always be the most appropriate choice in field studies. In oligotrophic tropical areas, high species diversity and the common difficulties of specific identification and small species size combine to make alternative methods more appropriate. Over the last decade a number of workers have developed a technique for direct measurement of growth by incubating and measuring size changes of artificial cohorts created by sieving. This procedure is tedious due to the counting and measuring involved. However, with the development of automated processing of the samples using video imaging analysis this method could be more widely used and could provide calibration of the more widely used egg production method.

## Procedure

1. Collect animals by gently towing a 200 µm plankton net. The cod end should be replaced by a 2-5 liter "dead space" container to avoid excessive damage to and concentration of the animals. The tow should be short, 5- 10 min duration. If more animals are needed several tows should be made.

2. Upon retrieval the catch is gently released in several 10 - 15 l buckets filled with

water from collection depth. The water should preferably be slightly cooler (<2 C°) than ambient water temperature and shaded from direct sunlight. "Freezer Packs" commonly used to keep foods cool may be used to chill the water, including that to be used in the sorting procedures.

3. Immediately sort out females for incubations by using a stereomicroscope and pipette. Keep animals cool and work fast. Cold light sources, cooled cages and trays are useful and should be used where possible. Never leave animals for longer than 2 - 3 minutes under the microscope when sorting, then sort from a fresh selection. Sorted animals may be placed into receiving pots filled with 10 ml of filtered seawater and held on a cooled tray. After checking quickly to see if all individuals are in good condition, they are carefully released into the incubation bottles. Animals may also be sorted directly into the filled incubation bottles as long as these are not allowed to warm up. Cooled bottles should be filled with water from collection depth filtered through a 64 m mesh. If a larger mesh size is used to exclude other mesozooplankton, then control bottles should be incubated with the same volume of water to check for eggs introduced in the seawater. When the females have been placed in the bottle, note the time and fill the bottle to the rim. Be careful not to let the females get trapped in the surface film and cover the surface with plastic film (Glad Pack, Saran Wrap). Put the lids on.

Note that perspex tubes with mesh and funnel bases as used by S. Hay and J. Runge, provide a useful but more elaborate alternative to bottles and may allow easier study where repeated sampling or manipulation of food supplies is required in the investigations. It is best if the incubation flask is the same when field and more detailed laboratory studies are to be integrated.

4. Incubate bottles at ambient temperature and light regime. This can be done on deck in shaded crates with circulating surface water. If done in a temperature controlled laboratory, set the right light cycle and use dim light. It has generally been found unnecessary to incubate on a slowly revolving wheel unless considerations of feeding are of importance, such as when unfiltered natural water is used and faecal pellet production is to be measured simultaneously with egg production.

5. After 24 h incubation the contents of each bottle is poured through a 200 µm mesh to remove females and subsequently through a 20 - 50 µm mesh to retain the eggs. Handle females carefully, count and check for physiological status. Measure some representative individuals. Rinse the bottle carefully at least 3 times to make sure all eggs and females are found. Include only living females in the egg production estimate. Mortality should be very low, otherwise the incubation is to be discarded.

6. Rinse the eggs into a small petri dish check the 50 µm sieve since eggs may tend to stick to the mesh. If 20 µm mesh is used, eggs can be counted directly on the mesh. Count eggs, hatched nauplii and crumpled egg membranes. Crumpled egg membranes indicate cannibalism whereas smooth, broken membranes should correspond to hatched nauplii in species such as Acartia.

7. Calculate egg production as follows.

EP=((E+N+C)/F) * 24/T
where
EP=egg production (eggs/female/day)
E=eggs
N=hatched nauplii
C=crumbled egg membranes
F=living females
T=incubation time (h)

**Comments**

Recommended volumes, copepod densities and mesh sizes to be used for small and large copepods are given in the following table.

Calanus is best incubated in bottles with a bottom mesh to prevent cannibalism (J. Runge). Caution is required with Centropages typicus eggs which often remain in long double stranded chains after spawning and these chains may be retained on the 200 µm mesh together with females. Temora eggs often float on the surface in the petri dish when one counts the eggs. It is quite possible to incubate egg carrying species such as Oithona or Pseudocalanus. However, egg masses are frequently broken off the females in capture, and such species should be investigated and handled with special care. Egg to female data from water column sampling is valid for egg production estimates if used in combination with water temperature data and relevant literature and laboratory results.

Table V-1. Recommended volumes, copepod densities and filling mesh sizes for egg production incubations.

| | Small copepods 1) < 1.5 mm | Large copepods 2) > 1.5 mm |
|---|---|---|
| Bottle volume (ml) | 620 | 1000 |
| No. females/bottle | 3-5 | 2-3 |
| No. replicates | 4 | 10 |
| Prefiltering of water | 64 µm | 120 µm |
| Final filtering of females | 200 µm | 200 µm |
| - " - eggs | 20-50 µm | 20-50 µm |

1) include Acartia, Centropages, Temora, Paracalanus
2) include Calanus, Metridia, Labidocera, Aetideus, Chiridius

ICES SGZP, 2nd meeting, Las Palmas, 8-11 March 1993

Annex VI

# PLAN FOR SEA-GOING WORKSHOP IN NORWAY IN JUNE 1993.

## General description of study area

The Workshop will be carried out in the Storfjord at Møre, western Norway ($62^0$30'N,$05^0$E) (Fig. 1). Storfjorden is part of a larger fjord system with several branches (Fig. 2). It is an intermediate sized fjord with depths from 350 to 650m. The mean width of the fjord is approximately 2 km while the length of the fjord is 50 nm (93 km) long. A narrow channel 200-250 m deep extends as a prolongation of the fjord onto the about 150 m deep continental shelf which acts as a barrier or sill with respect to intrusion of atlantic water to the fjord basin. Renewal of the deep fjord water below sill level is most prominent during spring.

The summer situation is characterized by river runoff and outflow of brackish water in the surface. Restricted exchange between coastal shelf water and intermediate layers of the fjord can also occur. Figure 3 shows the temperature, salinity and nitrate conditions along a transect from Storfjorden to the continental slope region during June 1991. Special features to be noted are the lower nitrate values (<1 M) in the upper 25m, both in the fjord and in the open ocean areas. The salinity and temperature show strong stratification in the upper 75m of the fjord, and the Norwegian coastal current can be easily seen as a lower salinity wedge extending seawards across the continental shelf.

During the last decade the shelf area outside the fjord has been of major interest in several Norwegian research programs aimed at studying larval fish ecology and zooplankton population dynamics. The hydrography, current patterns and general biology of the area are well known. The narrow continental shelf, approximately 40 nm wide, makes it possible to quickly reach the shelf break and to undertake studies along the continental margin and deeper parts of the Norwegian Sea.

## Biology

The Storfjord offers good working conditions to plankton ecologists. The plankton community of the fjord is dominated by a restricted number of zooplankton species from small copepods to large macroplanktonic euphausiids and mesopelagic shrimps. Of the mesozooplankton Calanus finmarchicus is the dominating species.

The fish assembly consists of the mesopelagic lanterne fish Benthosema glaciale, Müller's pearlside (Maurolicus muelleri), herring (Clupea harengus), sprat (Sprattus sprattus), the Greater argentine (Argentina silus) and blue whiting (Micromesistius poutassou). Also larger fish like Arcto-Norwegian cod (Gadus morhua) and saithe (Pollachius virens) are regular inhabitants of the fjord ecosystem.

The different components of the pelagic ecosystem usually inhabit different strata in the water column. During daytime the large mesopelagic shrimps Sergestes and Pesiphea sp., the krill Meganyctiphanes norvegica, Benthosema glaciale, and the older age groups of Maurolicus muelleri occupy the deep layers of the fjord below 200 m depth. Juvenile M. muelleri is usually confined to a shallow scattering layer between 100-150 m depth. Other inhabitants of the deep pelagic community are the copepods Calanus hyperboreus and Euchaeta norvegica and chaetognaths (Eukrohnia sp. and Sagitta sp.) which at certain times of the year constitute a consideral part of the deep pelagic biomass.

During vertical migration there is an increased interaction among the different components of the pelagic ecosystem. The major migrants are the krill M. norvegica, Pasiphea sp. and the 0-group Maurolicus muelleri which rise to the surface layer during night. The other components of the deep pelagic community might extend their vertical distribution at night but the light conditions during June still favour these organisms to stay deep. Fig. 4 shows the vertical and horizontal distribution of the night time scattering layers of macroplankton, micronekton and fish in a restricted part of Storfjorden in June 1991.

In the upper part of the water column (0-50 m) smaller copepods and especially Calanus finmarchicus dominate. Herring larvae might also be an important component at this time of the year, being introduced from the shallow shelf spawning areas outside the fjord.

Figure 5 shows typical scattering layers of the deep ocean and shelf areas outside Storfjorden and indicate that the fjord community constitute an integral part of the open ocean ecosystem. The pelagic communities of the fjord are as such influenced by advective processes and intrusion of new populations from the open ocean. Due to the short duration of the workshop and the time of the year it is however unlikely that major changes in the zooplankton populations take place.

**Scientific aim**

The main scientific goals of the Workshop as outlined in the report from the first meeting of the Study Group on Zooplankton Production (Bergen, Norway, March 23-26 1992) is to

a) provide a basis for evaluating the performance of a variety of methods or gears; and

b) explore combinations of instruments and experimental approaches that can most effectively be used to measure zooplankton production.

The principal objective was more specificially stated at the meeting in Las Palmas March 8-12 1993:

Intercompare, characterize and evaluate the performance of gear and techniques for quantitative description of zooplankton distribution, biomass and production in a fjord habitat.

Specific objectives were stated as follows:

1. Quantitative descriptions of structure and abundance of the pelagic community through use of a range of sampling gears and acoustical and optical instrumentation.

2. Direct and indirect quantification of avoidance.

3. Evaluate and characterize sampling performance with regard to spatial resolution and selectivity of single and combined application of gears and techniques.

4. Compare and evaluate methods for estimating zooplankton production and metabolism.

The primary variables to be measured are biomass, species composition, size distribution and vertical and horizontal distributions of the organisms studied. Data obtained with sampling gears will be used in combination with simultaneously sampled acoustical and optical data.

When sampling with traditional sampling gear like trawls and different types of nets, sampling efficiency and avoidance of gear by zooplankton are central problems. One of the key issues of the Workshop will be to apply and evaluate methods for determining the magnitude of zooplankton avoidance of sampling gear. One technique is to use a short range scanning sonar to quantitatively study the distribution of zooplankton in front of plankton trawls and nets.

In situ target strength mesurements of mesopelagic fish, shrimps and krill will be attempted. Such measurements are few and new results could improve the precision in acoustic estimates of the biomass of these species which constitute important links in pelagic food webs.

**Sampling design and statistical procedures**

A particular part of the fjord e.g. 30 nm will be chosen as the main study area. Within this area a shorter main sampling track, along fjord, e.g. 10 nm will be repeatedly sampled with different gears. However specific details concerning the sampling programme must be worked out up to the Workshop. It might also be necessary to adjust the sampling programme along the course of the Workshop if local conditions should impose specific constraints.

Statistical aspects will be given consideration, e.g. replicate and between sample variance. Geostatistical techniques will be used when analyzing the data.

### Calibration and survey design

To assure good and comparable quality of data sampled a calibration programme of all acoustical equipement should be carried out. Intercalibration of the hull mounted transducers on board the RV Johan Hjort and RV A. v. Humboldt should be performed.

To assess variability in biomass and distribution and to get information on possible advection of zooplankton in the study area, an acoustical survey with sampling will be carried out at intervals during the period of investigation (eg. start, middle, end). The survey will be designed to cover the area of investigation wihtin the fjord either in a zig-zag pattern or in a pattern which assures a proper coverage both of the shallow and deeper parts of the fjord. Information on the night and day differences in biomass and distribution within the area will be obtained. Due to the short night and long day, the major intercomparison exercises will be carried out during day time.

### General description of environmental conditions

There is a need for a description of the environmental conditions where the comparison of gears will be performed. To monitor the current pattern and trace advective transport of water, current meters should be deployed at the mouth of the fjord. Small transportable current meters could be used to monitor local currents in the area investigated. Also the shipborne ADCP will give information on the local current patterns and will be run concurrently with the acoustical survey.

Additional environmental parameters will also be measured, such as salinity and temperature to characterize water masses, and also oxygen and nutrients. The food conditions of herbivores in terms of phytoplankton biomass (chlorophyll, chlorophyll fluorescence, phytoplankton abundance), species composition (in a limited number of samples), and primary production in the euphotic layer will be determined. In relation to primary productivity, zooplankton vertical distribution, and zooplankton net avoidance, the vertical light regime must be known. Therefore Secchi depth readings and radiation measurements (PAR) should be carried out while CTD-, oxygen- and fluorescence profiles are measured on R/V "Johan Hjort" and on R/V "A.v.Humboldt".

### Vertical sampling systems

It is suggested that one set of comparison takes place in the upper 0-100 m of the watercolumn. The gears to be compared are Multinet, WP2 nets, water bottles (30L Niskin and others), and pump systems. Replicate hauls (e.g. 10) will be performed for each net. Replicate profiles (e.g. 5) with pump and water bottle will be taken, each set constituting 8 sampling depths.

An equivalent series of net hauls should be performed in the deeper part of the watercolumn (100-400 m), covering a different community and size range of organisms.

Both the deep and shallow net sampling series will be compared to samples from towed gears like the MOCNESS, LHPR and optical systems covering the same depth interval.

**Towed samplers**

The following sampling procedures are suggested:

a) Discrete scattering layers are sampled simultaneously along a parallel track using different gears. In this way one obtain estimates of abundance and biomass either in one specific depth interval or several depth intervals if the gear is a multiple plankton sampler.

Simultanoeus sampling of acoustical data using echosounders with 3-4 different frequencies will give additional acoustical estimates of zooplankton and micronekton biomass which can be compared to traditional sampling gear estimates of zooplankton abundance and biomass.

b) The Longhurst-Hardy Plankton Recorder (LHPR) could be used to study the spatial distribution and small scale patchiness (10-100 m level) of zooplankton both within and outside scattering layers. Biomass, species composition and size distribution could be compared to samples obtained with MOCNESS operating in the same depth interval and equipped with a similar meshed net.

c) Measure the avoidance of zooplankton on sampling gear by a 2Mhz Mesotech 971 short range (<5m) scanning sonar. The sonar will be mounted on different types of plankton trawls to scan either horizontally or vertically. Thus it should be possible to study the distribution of organisms both in front and on the side of the mouth opening.

**Optical system**

The Ichtyoplankton recorder (IPR), Optical plankton counter (OPC) and the Video plankton profiler (VPP) will hopefully be available during the Workshop.

The IPR is designed mainly to sample fish larvae. It concentrates the organisms by a Gulf III like net prior to "sampling" by a video camera on the cod-end side of the system. The OPC is a different system, towed or vertically deployed and designed to count and size zooplankton. Thus the OPC record the organisms as they are dispersed either vertically or horizontally *in situ* . The VPP is a french system which is operated vertically as a drop sonde and data are logged continuously on a video recording system. An intercomparison of these gears are of prime importance in understanding their strenghts and limitations. However it is also necessary to compare them to more traditional gear like WP2 nets, Multinet, MOCNESS and LHPR systems.

Other techniques include the use of an underwater photo camera and strobe mounted on a specificially designed frame, and operated as a drop sonde. This technique might be a valuable supplement to estimate the relative and/or absolute vertical abundance of meso-, macrozooplankton and small mesopelagic fish. It might also be a valuable tool to help identify organisms.

**Acoustics**

Traditional hull mounted echosounders using several different fequencies (18, 38, 120 and 200kHz) will be used from RV Johan Hjort. Acoustic data from all frequencies will be obtained and stored during each sampling case and then analyzed and compared to biomass estimates obtained by traditional sampling gear. Postprocessing of data will be possible both on board the RV Johan Hjort or later on shore.

A towed split beam transducer working at 38 kHz with 800m conducting cable operated from RV Johan Hjort makes it possible to study the deep scattering layers with a better resolution than the hull mounted transducers. It might be a valuable tool when trying to measure *in situ* target strength of organisms in deep scattering layers consisting of one or a restricted number of species. The use of towed transducers is especially important when rough weather conditions limit the use of hull mounted transducers and might thus improve the acoustic estimates of plankton and fish.

A 2Mhz Mesotech 971 short range scanning sonar will be used to study the avoidance of zooplankton.

It is emphasized that acoustical techniques and instrumentation must be applied and operated together with traditional sampling gear. Thus these techniques will be an integral part of the comparison case studies using traditional sampling gear.

**Target strength determination**

Experiments to measure target strength of macrozooplankton and mesopelagic fish like *Benthosema glaciale* and *Maurolicus muelleri* will be performed both *in situ* and in a tank on board RV "Johan Hjort". These experiments will be supplemented by measurements of biochemical composition, (total lipids and protein), sound speed, and density of key species. Such data are important when modelling target strength as is usually done when using multiple frequency techniques.

**Rate measurements**

Especially on board R/V "A.v. Humboldt" rate measurements will be performed to get some information on the zooplankton metabolic conditions. This will be done in size fractions (50 - 100 µm, 100 - 200 µm, 200 - 500 µm, 500 - 1000 µm, and 1000 - 2000 µm). To convert specific rates to <u>in situ</u> total rates (per $m^3$), biomass of zooplankton of

at least one net type (e.g. WP-2) should be available for the same size classes. Respiration and excretion (ammonia and phosphate release) will be measured. This can be performed in one experiment and gives information on the general metabolic condition and of the food quality used by the plankton (O/N - ratio). Furthermore the respired part of primary production is estimated by this approach. The measurements will be carried out by the classical balance method using near surface plankton. A vertical resolution of these metabolic rates can be obtained by using enzymatic methods (ETS, GDH). In the same assay ATC (aspartate transcarbamylase) could be measured. It gives some information on potential growth. To compare it relatively with another method, egg production measurements of *Calanus finmarchicus* should be performed.

**Research vessels**

The field work will be conducted from the Norwegian research vessel RV Johan Hjort and the German vessel RV A. v. Humboldt. A brief outline of the research vessels instrumentation and facilities are given below.

**RV Johan Hjort**

The Norwegian research vessel RV Johan Hjort was built in 1990, is of the size of 1950 Gross Tons, is 64.4 m long and travels with 14 kn in maximum. Of special interest is the standard acoustic instrumentation:

- SIMRAD EK 500 Scientific Echosounder
  - Transducers: 18, 38, 120 and 200 kHz.
  - Bergen Echo Integrator. A Unix wokstation and a set of software for postprocessing echosounder data.
- Acoustic Doppler Current Profiler (ADCP).
- Towed 38kHz split beam transducer with 800m conducting cable.

During the workshop the following additional instrumentation will be available:

- Mesotech 2Mhz Scanning sonar
- Transportable 120 kHz splitbeam transducer with 200m conducting cable.

The ship is equipped with several winches. One winch is equipped with an 8 mm, 3000 m coaxial cable dedicated to deploy the CTD. Another winch is dedicated to vertical net sampling, while at least two other winches can be used to deploy towed instruments and gear. These winches are however not equipped with conducting cables. A large winch operating across the stern and equipped with a 12 mm, 3000 m long coaxial cable, is used to deploy the MOCNESS and other gear where a single conducting coax is sufficient to transmit signals between the instrument and the deck display or control unit.

One portable winch (with 9 mm,1000 m long coax), will be mounted on board R/V Johan Hjort to run the Multinet system or other vertically operated gears which need a conducting cable.

Scanmar depth sensors can be attached to trawls and gear both to trace actual depth, distance to bottom and the opening area of pelagic trawls.

The ship has 5 laboratories in front of the main deck. From one of the laboratories the CTD, water bottles and vertical nets are deployed. One laboratory is speceficially designed to handle large trawl catches and another for treating zooplankton samples. The remaining laboratories are large and generally built to store and mount different types of equipement, and to perform chemical and other analyses.

An instrumentation laboratory contains the echosounder display units, the BEI acoustical postprocessing workstation, the MOCNESS and CTD display and control units, operated from network attached PC´s. Several IBM compatible PC´s are also available for personal use, statistical analysis and presentations.

The ship also offers good facilities for small working groups and plenary discussions.

**RV A. v. Humboldt**

R/V "A.v.Humboldt" belongs to the country of Mecklenburg / Vorpommern (Germany), is of the size of 1270 Gross Tons, is 64 m long and travels with 12 kn in maximum. It´s equipped with an ATLAS echosounder, satellite navigation, and communication. There are two winches with conductivity cable, one for CTD, oxygen, and fluorescence probe, the other for operations with multiple nets, videosystems, LHPR, etc. Furtheron there are two winches with wires of 3 mm and 5 mm respectively. Both can work together with the CTD winch during calm weather conditions. There is also an A - frame at the stern, but net chatches could also be performed at one of the ships sides. Meteorology will be measured automatically, including solar radiation.

There are 4, so called dry laboratories, 1 wet lab, 1 CTD lab, a workshop and a fotolab. For hosting double cabins are available.

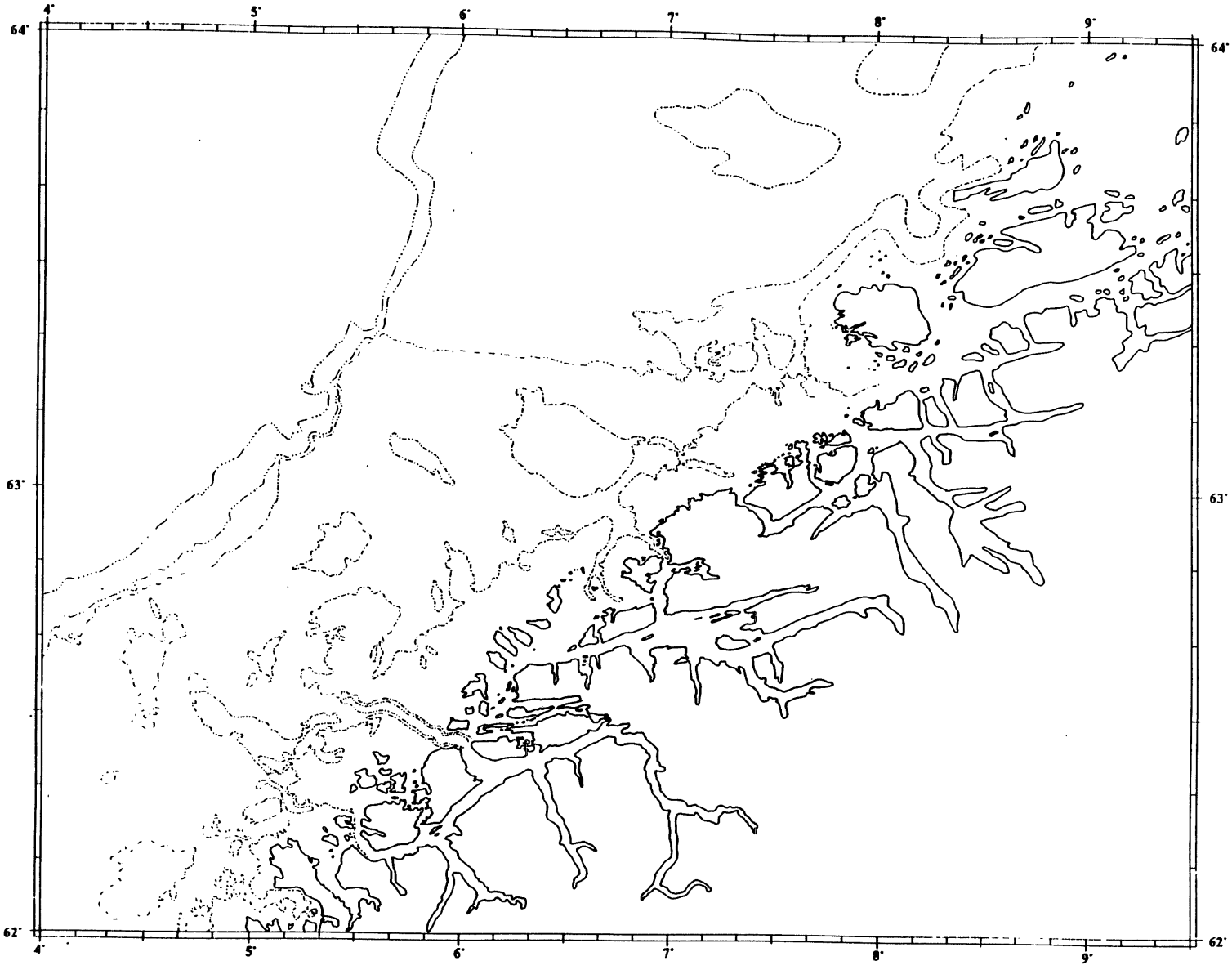


**Figure 1. The Møre shelf, slope and fjord area with bottom contours. Dotted lines represent 100m depth intervals.**

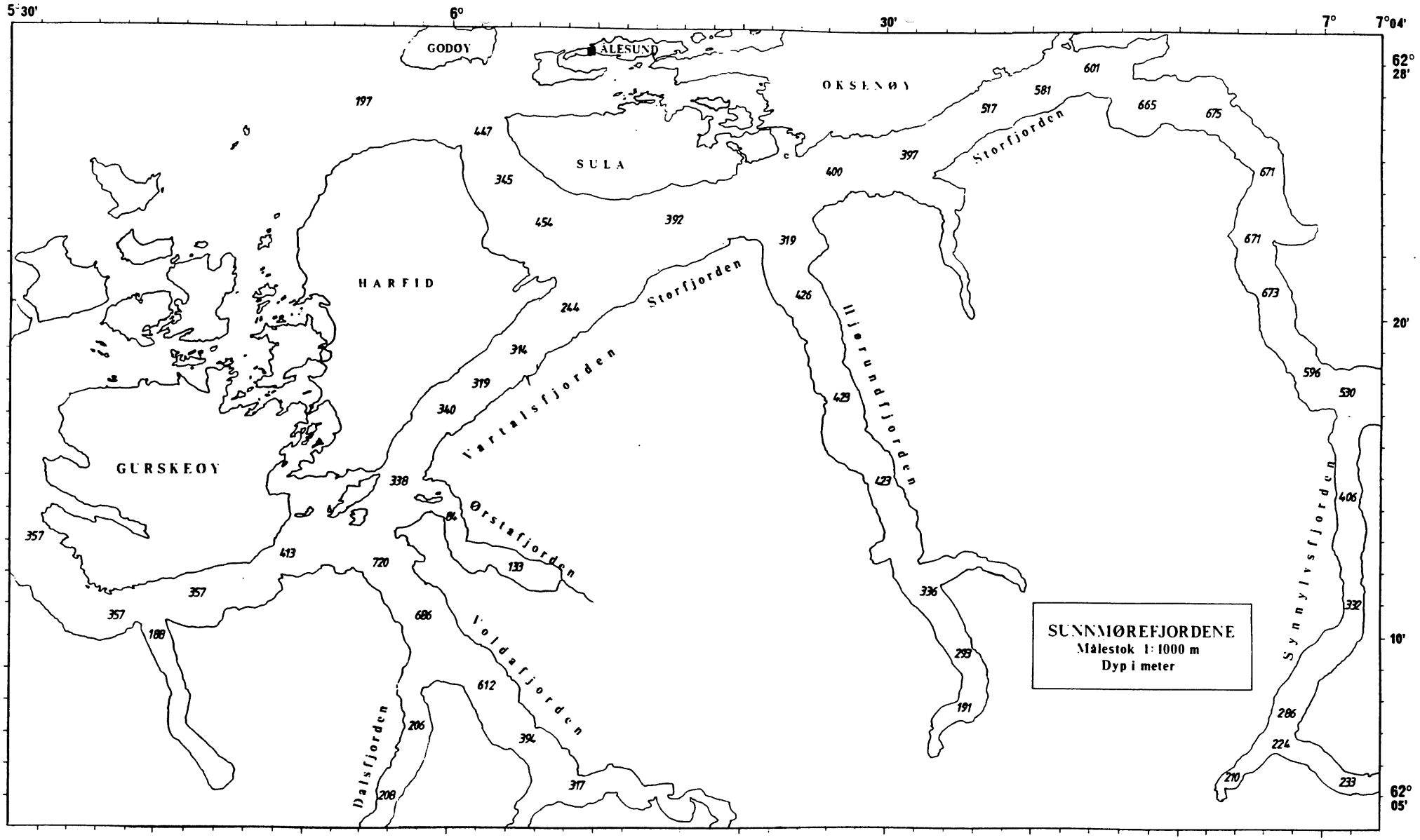


**Figure 2. Storfjorden and adjacent fjords at Møre. Numbers represent depth in meters.**

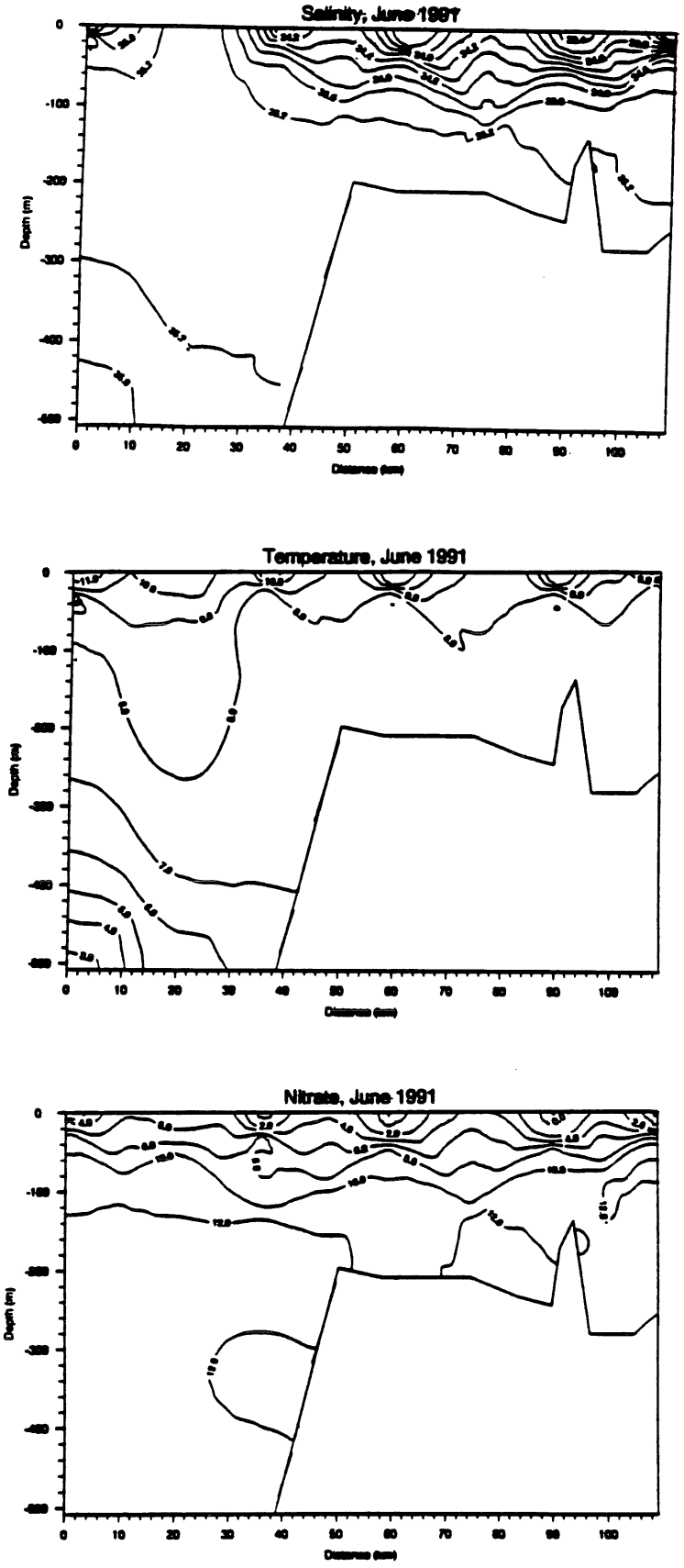


Figure 3. Salinity ($^0/_{00}$), temperature ($^0$C) and nitrate (μM) along a transect from Storfjorden to the eastern part of the Norwegian Sea during June 1991.

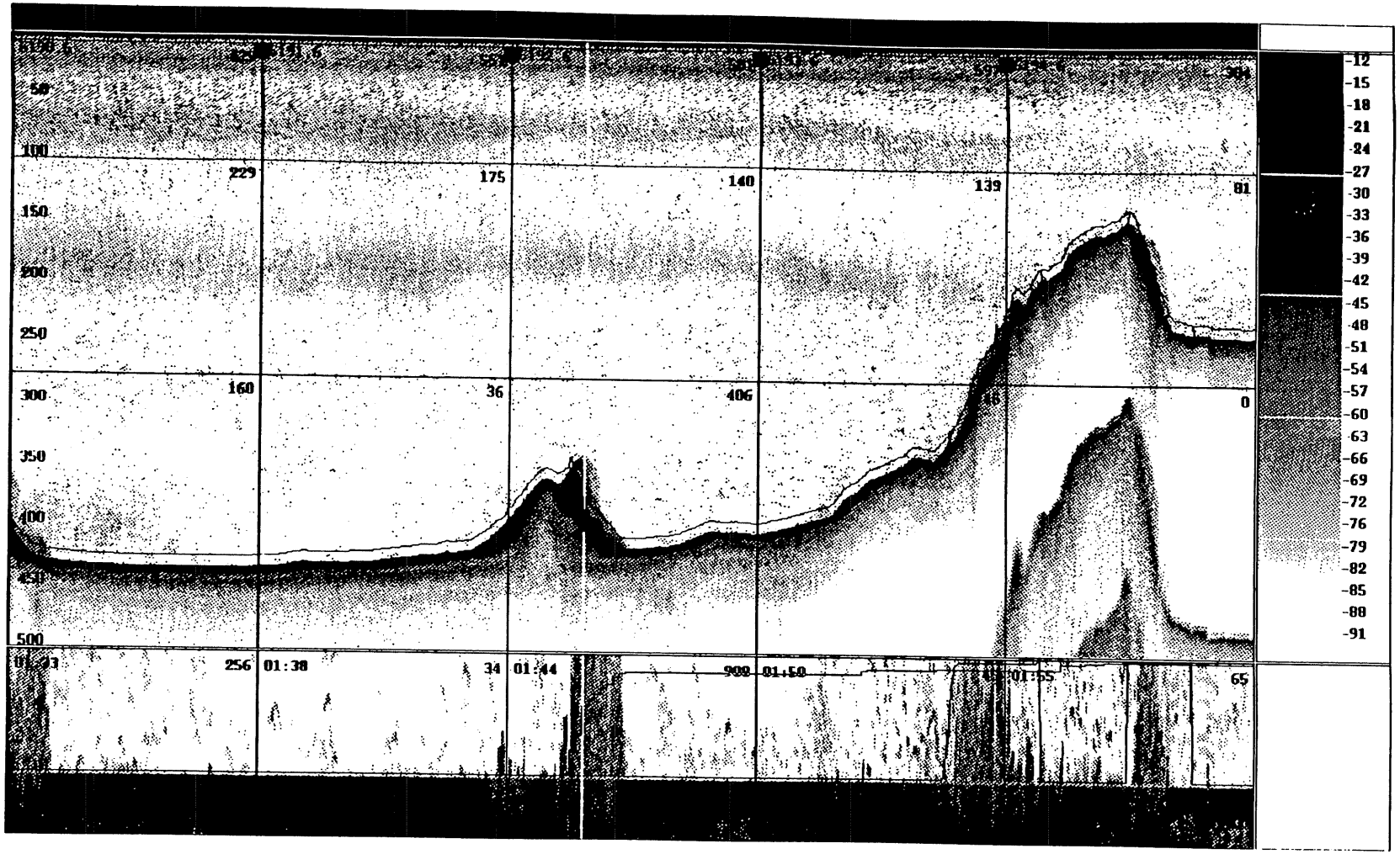


Figure 4. Night time acoustic scattering profile (5nm) from Storfjorden during June 1991 as detected by the SIMRAD EK 500 Scientific echosounder at 38 kHz.

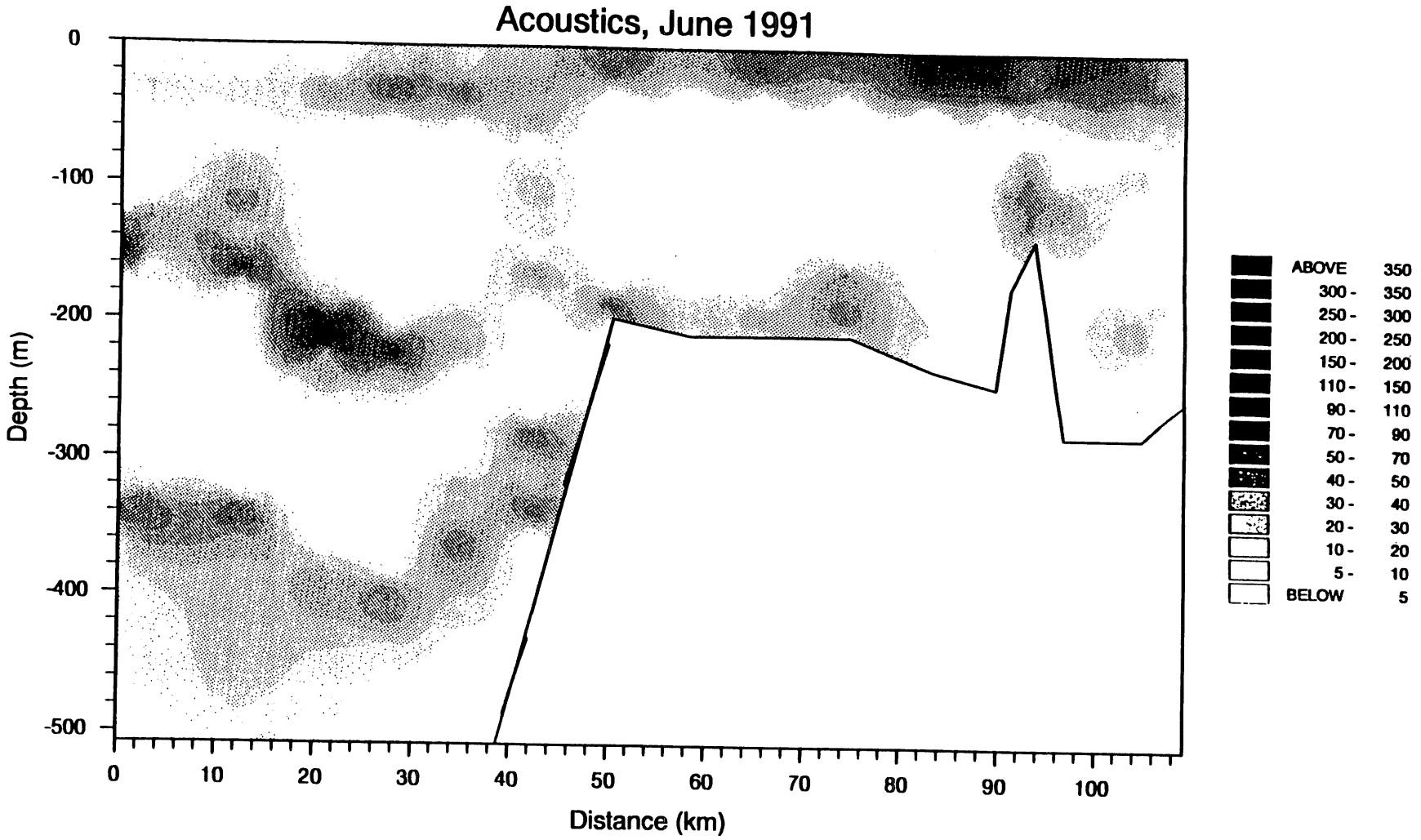


Figure 5. Total echo integrator values ($m^2/nm^2$) showing acoustic scattering layers from Storfjorden to the eastern part of the Norwegian Sea during June 1991.

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Annex VII

## Provisional list of sampling gear and instrumentation to be included in the seagoing workshop in Norway.

| | | |
|---|---|---|
| WATER BOTTLE | 30 l | (Alcaraz ?) |
| PUMPS | "Hufsa" | IMR |
| VERTICAL NETS | WP-2 50 µm | IOW/L. Postel (LP) |
| | WP-2 200 µm | |
| | LHPR 50 µm, 200 µm | S. Coombs/Plymouth |
| LARGE NETS | Bongo net | Coombs/IMR |
| | IKMT | |
| | MIK | IMR |
| | Calcofi-nett | W. Greve |
| MULTIPLE NETS | MOCNESS 1 $m^2$ | IMR |
| | 10 $m^2$ | IMR |
| | Multinet 0.25 $m^2$, 200 µm | IOW/IMR |
| | BIONESS | Eastern Marine Marsh/Canada |
| HIGH-SPEED | Gulf III | IMR |
| | Gulf/Aberdeen | S. Hay |
| | CPR | |
| TRAWLES | Pel. trawl | IMR |
| | Plankton trawl | IMR |
| OPTICAL SYSTEMS | IPR | J. Lenz |
| | Video-Profiler | French |
| | OPC | Germany?/Canada? |
| ACOUSTIC | Split beam, hull-borne 4 freq. 18, 38, 120 and 200 kHz | IMR |
| | | SIMRAD/IMR |
| | Mesotech 2Mhz Scanning sonar | SIMRAD/IMR |
| | Transportable 120 kHz splitbeam transducer with 200m conducting cable. | IMR |
| | Towed split beam 38 kHz transducer with 800m conducting cable. | IMR |

IOW=Institute für Ostseeforschung, Warnemünde,Germany
IMR=Institute of Marine Research, Bergen, Norway

Contn.

# Provisional list of participants to the seagoing workshop in Norway

## Countries

| | |
|---|---|
| ICELAND: | Astthorsson<br>Gislason<br>2 technicians |
| GERMANY: | Lutz Postel<br>Kai Wieland<br>1-2 technicians<br>Uwe Kils?, Wulf Greve<br>1 engineer CTD<br>1 technician Multinet<br>3 technicians |
| U.K.: | Graeme Hays (CPR)<br>Steve Cooms<br>John Nichols<br>Aberdeen |
| USA: | Peter Wiebe<br>Van Holliday |
| CANADA: | Doug Sameoto? |
| NORWAY: | Tor Knutsen<br>Hein Rune Skjoldal<br>Herman Bjørke<br>Trygve Gytre<br>Stein Kaartvedt<br>Gunnar Pedersen<br>-4 technicians |
| SPAIN: | Santiago Hernández-Léon<br>Alcaraz |

## Companies

| | |
|---|---|
| SIMRAD | 1 person? |
| SCANMAR | Trevor Ward |
| FOCAL TECHNOLOGIES Inc. | ? |
| Eastern Marine-Marsh LTD. | Dan Wellwood |

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Annex VIII

# TABLE OF CONTENT OF THE ZOOPLANKTON METHODOLOGY MANUAL

Annex IX

## ZOOPLANKTON METHODOLOGY MANUAL

**Provisional list of main and associate authors.**

| CHAPTER | | MAIN AUTHOR | ASSOCIATE AUTHORS |
|---|---|---|---|
| 0. | PREFACE | | |
| 1. | INTRODUCTION | | Huntley, Lenz. Skjoldal |
| 2. | SAMPLING AND EXPERIMENTAL DESIGN | **Skjoldal** | Wiebe |
| 3. | SAMPLING OF ZOOPLANKTON | **Wiebe** | Sameoto, Hamner, Båmstedt, Heath, Hernroth, Lutz Postel |
| 4. | BIOMASS AND ABUNDANCE | **Wiebe** | Schneider, Berman, Burkill (microplankton) |
| 5. | ACOUSTICAL METHODS | **van Holliday** | Stanton, Dalen, Simmonds, Greene |
| 6. | OPTICAL METHODS | **Schulze** | Herman, Kils, Davis, Berman, Lenz |
| 7. | FEEDING | **Conover** | Båmstedt, Huntley, Harris, Hirche, Schnack-Schiel, Daro, Mayzaud |
| 8. | GROWTH | **Kiørboe** | Runge, Bergeron, Tande, Miller, Fransz, Kimmerer, Hirche |
| 9. | METABOLISM | **Ikeda** | Schneider, Le Borgne, Hernández-Leon, Postel |
| 10. | BEHAVIOUR | **Paffenhöfer** | Poulet, Busky, Yen, Strickler, Tiselius, Alcarez, Kaartvedt |
| 11. | POPULATION DYNAMICS | **Aksnes** | Fransz, Davis, Durbin, Matthews |
| 12. | MODELLING | **Frost** | Evans, Vinogradov, Nival, Gurney, Giske, Slagstad, Cushing, Denman, Baretta |