ICES Sea-going Workshop on Zooplankton Sampling and Biomass Determination, Norway

2-13 June 1993

Plan and general description of study area

General description of study area

The Workshop will be carried out in the Storfjord at Møre, western Norway (62°30'N,05°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 profiler (VP) 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 VP 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 in situ 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 specefidally 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.

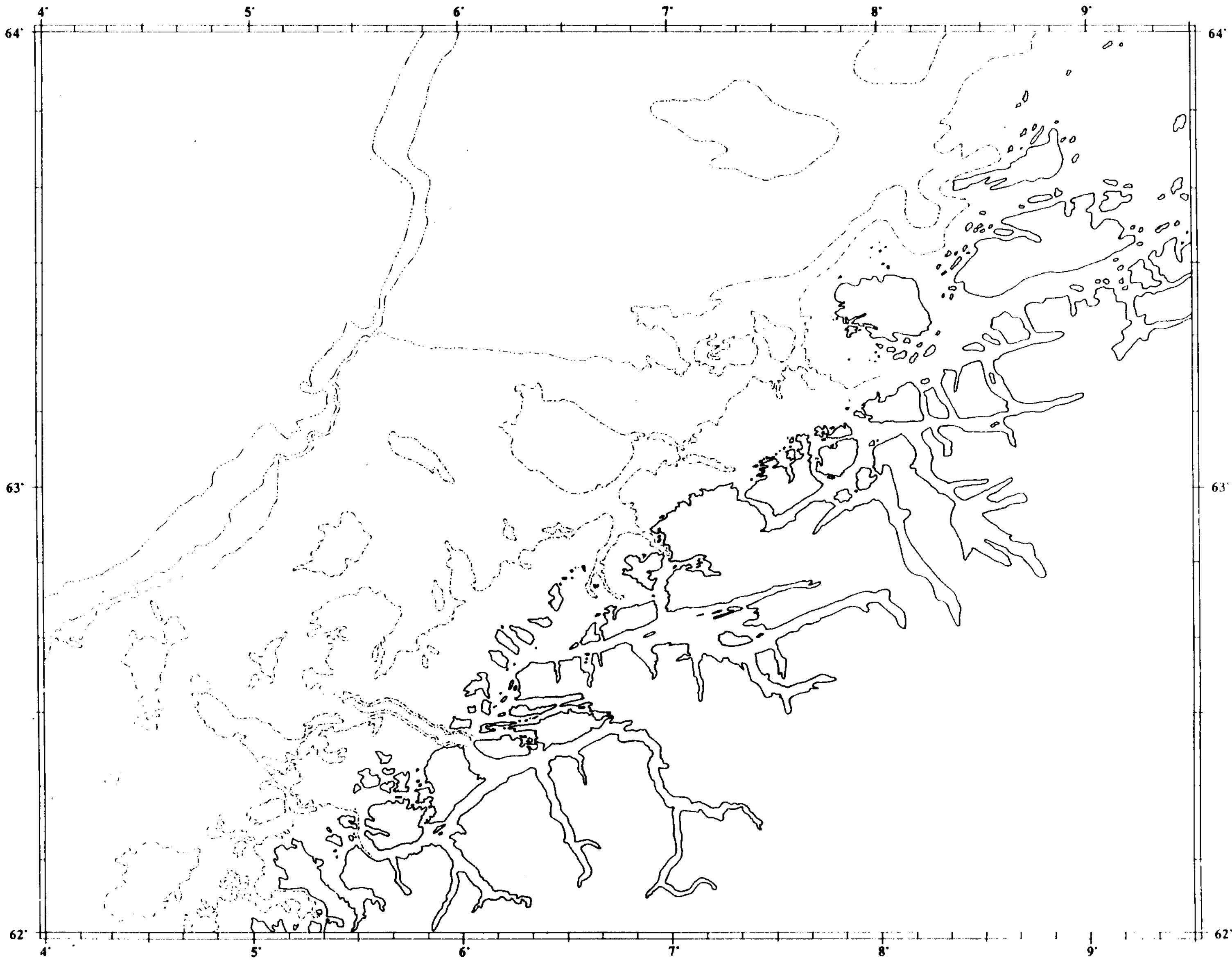

Figure 1. The Møre shelf, slope and fjord area with bottom contours. Dotted lines, represent 100m depth intervals.

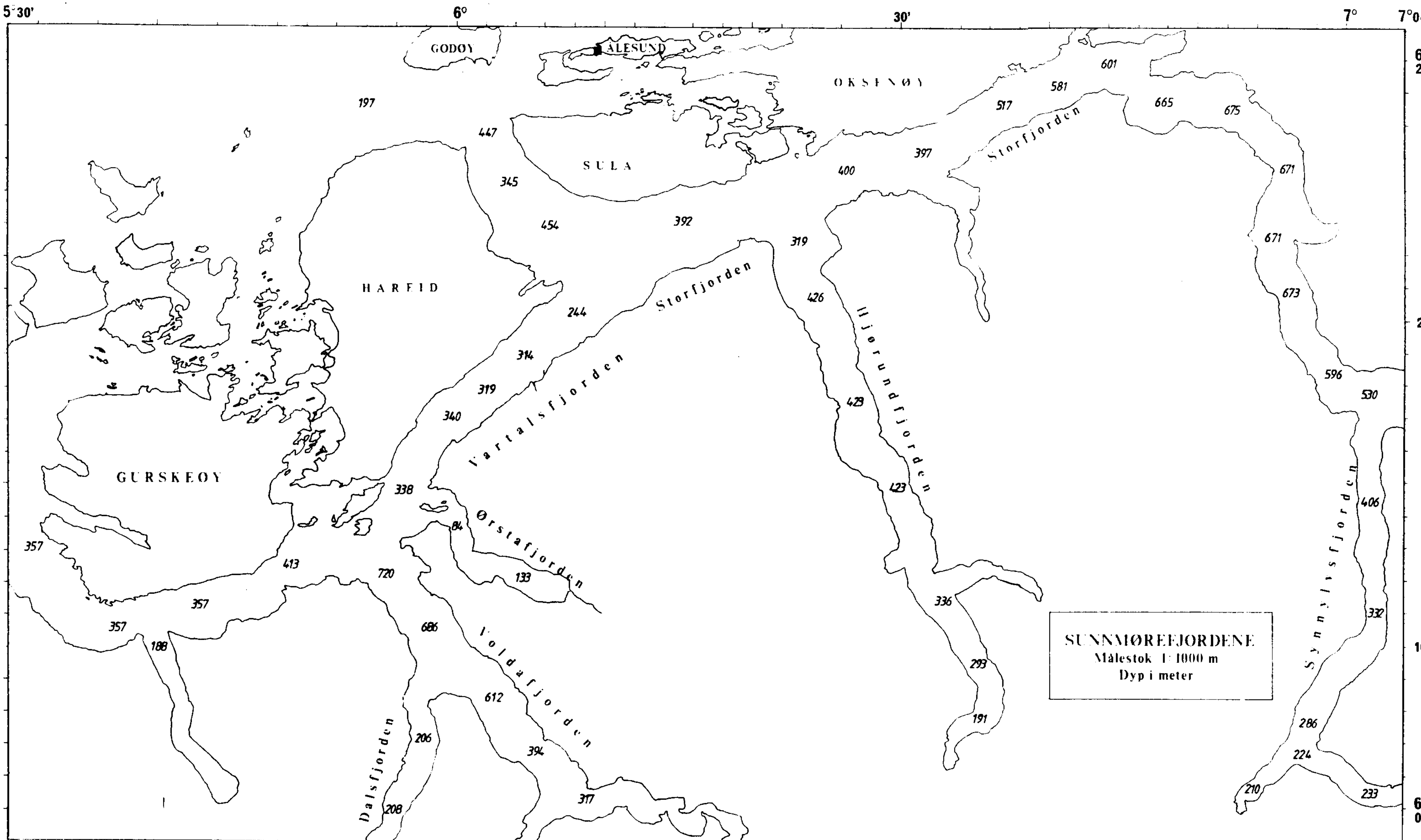

Figure 2. Storfjorden and adjacent fjords at Møre. Numbers represent depth in meters.

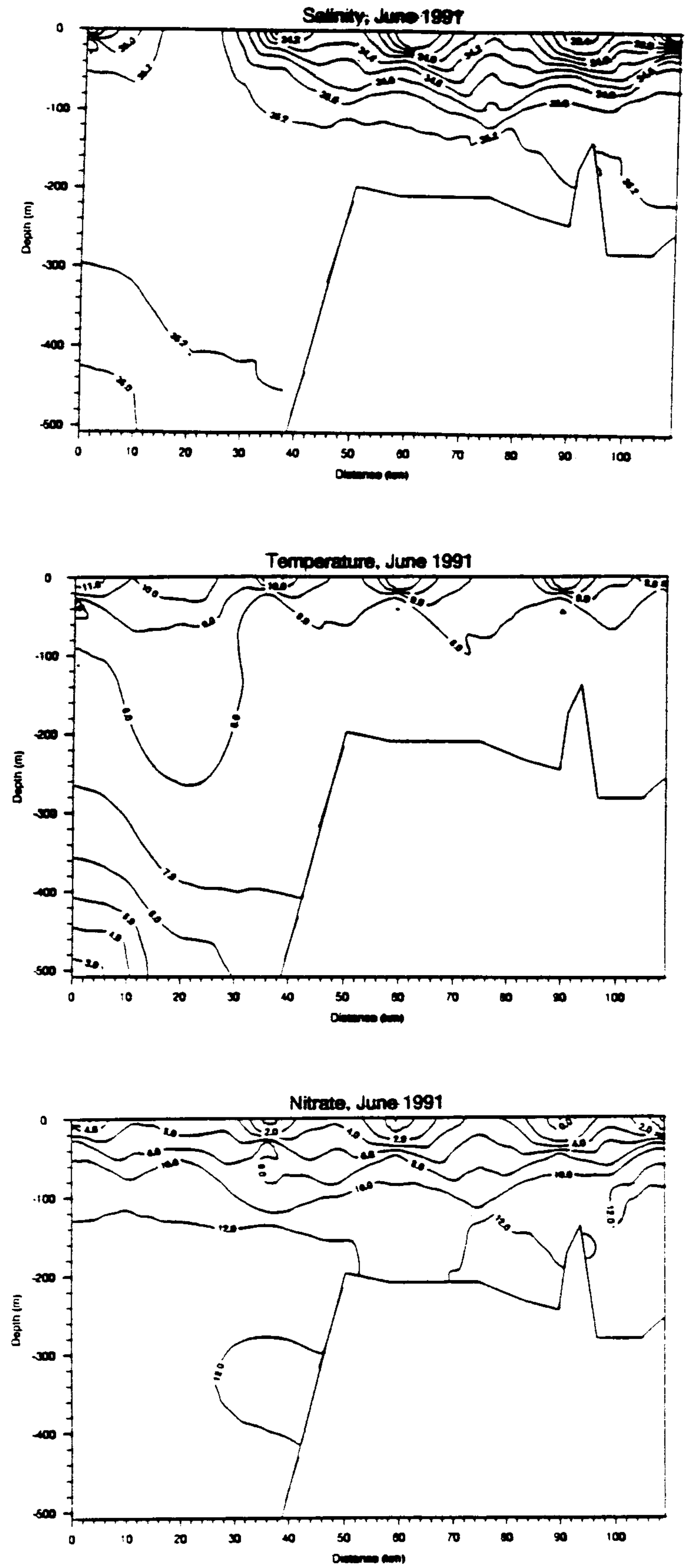

Figure 3. Salinity ($^0/_{00}$), temperature (^{0}C) and nitrate (µM) along a transect from Storfjorden to the eastern part of the Norwegian Sea during June 1991.

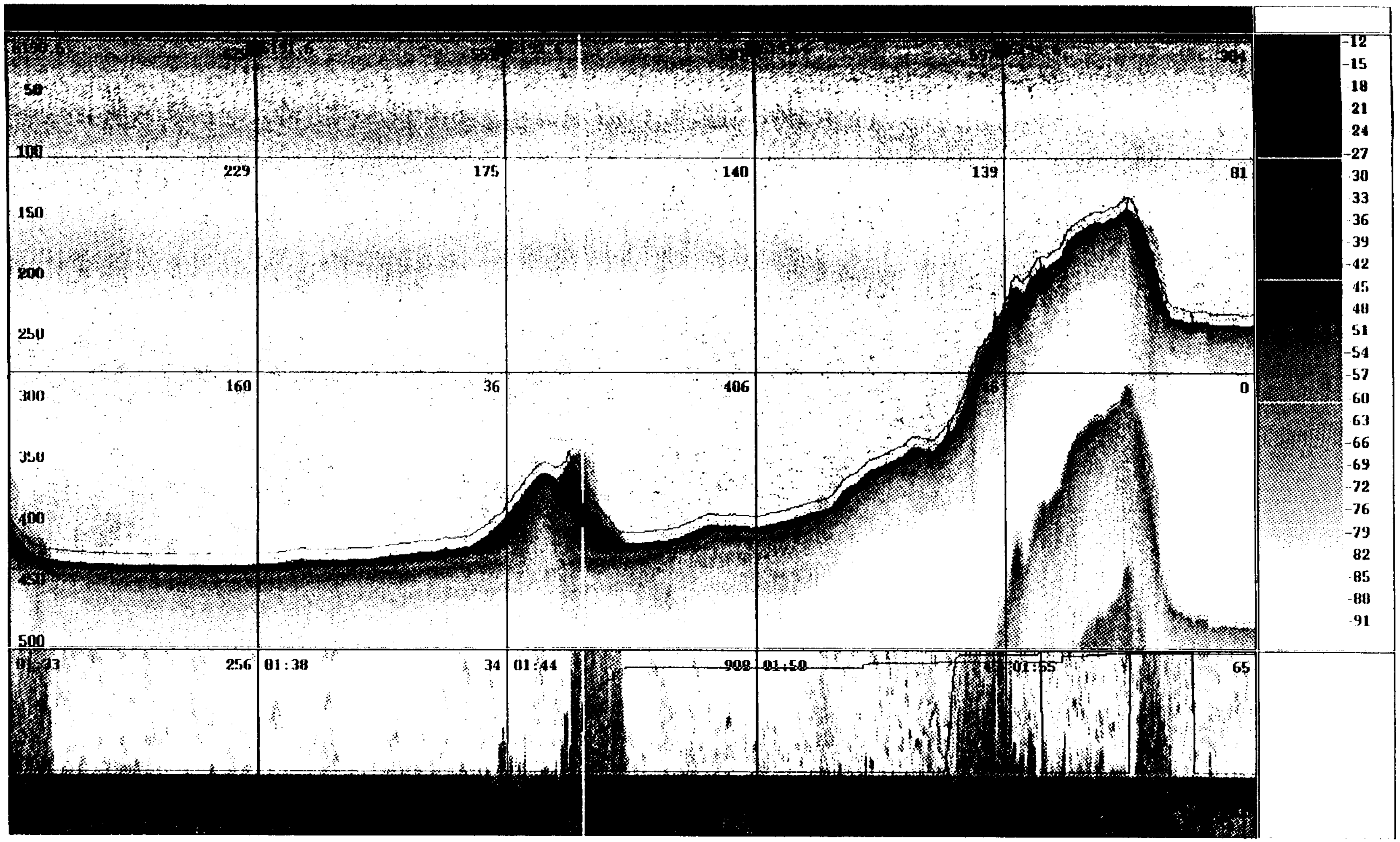

Figure 4. Night time acoustic scattering profile (5nm) from Storfjorden during June 1991 as detected by the SIMRAD EK 500 Scientific echosounder at 38 kHz.

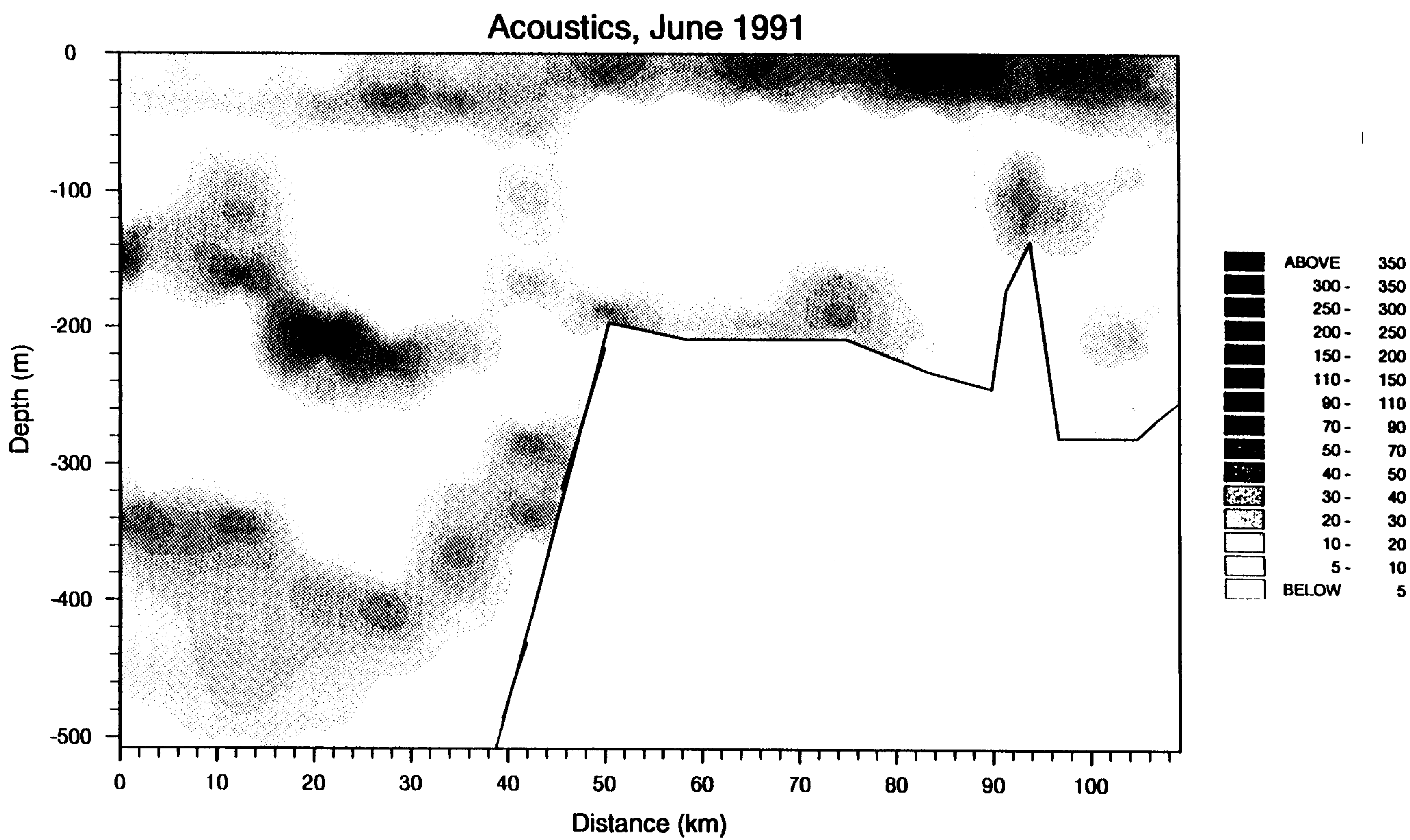

Figure 5. Total echo integrator values (m^2/nm^2) showing acoustic scattering layers from Storfjorden to the eastern part of the Norwegian Sea during June 1991.