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International Council for the
Exploration of the Sea

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Hydrography Committee

Report of the Working Group on Oceanic Hydrography

Aberdeen, 21 - 23 April 1993

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Report on the meeting of the ICES Working Group on Oceanic Hydrography Aberdeen 21 - 23 April 1993.

1.Opening

The chairman Erik Buch opened the meeting and welcomed all participants. He annonced a joint session with MDM on thursday afternoon. Hendrik van Aken was oppointed rapporteur.

2. Review of membership

No information on changes of membership have been received.

3. Remarks from the ICES Oceanography Secretary

Harry Dooley gave additonal comments on his written report to the working group handed out to the participants at the beginning of the meeting.

ICES is now involved in I-GLOBEC as a full partner. The ICES "Cod and Climate Change (CCC)" programme will be a sub-programme within GLOBEC. GLOBEC is a global programme in which CCC is a regional focus. The working group on CCC will meet in Lowestoft, June 1993 to review synopses, made by local experts, on the regionally varying environmental factors which may influence the cod stock. On a question about the scientific goals of GLOBEC, Bob Dickson stated that GLOBEC has to determine the environmental controls of the dynamics of zooplankton. It has not yet been established how ICES will realize its partnership in GLOBEC, a matter the ICES secretariat still has to determine.

The marine chemistry working group has reviewed some chapters of the WHP Observational Manual, but the chapter on nutrient analysis was not available in final form.

The archiving of the NANSEN and GSP data sets has been finished. Data from the second GSP field phase have not been discussed yet, but it may be submitted to ICES for archiving following the same procedures as used during the first field phase.

Whereas the Nansen data set is now finished, no comprehensive report on this research programme has been written. During the previous meeting of the WGOH John Gould had volunteered by telephone to coordinate such a report. It should have a format like the GSP - EOS report. The status of the report appeared to be unknown to the participants. Erik Buch promised to contact John Gould on this matter.

(John Gould has during a phone call after the meeting promised to carry on with the report and he he will highly acknowledge the help of Bogi Hansen and Svein Østerhus who during the meeting offered their assistance).

Harry Dooley reported that the Data Archeology Project is still a difficult task. On a question posed by Hendrik van Aken, Harry Dooley explained that till the late 1960's ICES was the formal recipient of oceanographic data, dealing directly with the responsible scientists. Since the National Data Centers have taken over that role, the data flow towards the ICES archives have deteriorated.

Harry Dooley was worried that ICES was not involved in the Global Ocean Observing Systen (GOOS) since he felt that the activities of ICES are parallel to those planned for GOOS. The participants agreed with Harry and it was decided to recommend to the Hydrography Committee to work for an involvement of ICES in GOOS.

Harry Dooley reminded the participant that the closing day for submission of contributions to the next Statutory Meeting is the first of May. Till now only a few submissions have been received.

Erik Buch considered the recommendation of last years meeting that ships of opportunity should also measure the sea surface salinity (SSS). According to Gert Becker and Savi Narayanan, no reliable sensor systems are yet available, but it is expected that they may become available within one or two years. Some navy authorities have large amounts of SSS data, but the status of these data is in general confidential.

4. Establishment of a net of standard stations and sections

The lists of standard stations and standard sections, prepared by Erik Buch, was discussed. It was decided to add all (former) weather ship positions to the list of stations. No response with regard to the sections was received from Russia, France and Portugal. The question was posed how to promote the occupation of the standard stations and the survey of the standard sections. Robert Gelfeld remarked that the CD-ROM with hydrographic time series of stations and sections, which will be available from WDC-A this year, may make the oceanographic community aware of the importance to maintain oceanographic time series.

The question whether the working group has to determine which parameters should be measured was discussed. The general feeling was that a list of obliged parameters only will discourage people to get involved in the work on standard stations and sections.

Results from the time series programme should be published in special topic sessions like the one in Mariehamm. The existence of time series of standard stations and sections can be advertised by means of bulletin boards and the electronic information center of the University of Delaware (J.Crease).

Any remaining changes and additions to the lists of stations and sections should be sent to Erik Buch.

5. Results from standard sections

Recent surveys of standard sections near the Faroe Islands, Iceland, from the Norwegian Sea, the Barents Sea, the Rockall Channel, the Davis Strait and the Labrador Sea were presented by several participants. Also a large number of VOS-XBT sections across the N.Atlantic and time series from OWS M were presented. In the discussion of these presentations the importance of these time series for questions on the relations between Cod and Climate was stressed. All participants who presented time series were asked to send a small report (1 A4 page) together with copies of their figures to Erik Buch before 15 May. This material will in a edited form be added to the report of the WGOH-Meeting.

6.Report from the ad hoc group on the 1990 - 91 high salinity anomaly

On behalf of the ad hoc group Gert Becker presented the available evidence for a high salinity event in the N.E.Atlantic and the North Sea in 1990 - 1991. The origin of the anomalous salty water seems to be near the Iberian peninsula. Unexplained is the amplification of the anomaly when entering the North Sea, both in the Southern Bight and in the northern North Sea. The report of the ad hoc group is added as an appendix to this report (Appendix VIII).

7. Oceanagraphic data quality and data processing

David Ellett stressed the importance of collecting an overview of unpublished manuscripts on methods for the determination of the salinity and the related data quality for the study of historical time series. After some discussion it was concluded that also the methods for temperature measurements should be included. David Ellett volunteered to proceed with this matter.

Recent experiences with SBE CTD's were presented. These were in general very positive. EG&G has stopped the production of MK V CTDs and has transferred the MK III to General Oceanics. The CTD from FSI seems to be operational although some technical problems still have to be settled.

Problems with the General Oceanics rosette sampler were discussed extensively. The quality of this instrument seems to become less. Failure of bottle firing as well as double firings occur regularly. This causes large problems in identifying samples. Some institutes apply large modifications of the GO rosette sampler before a new sampler becomes operational.

Savi Narayanan and Johan Blindheim reported positive experiences with the Guildline portable salinometer. The accuracy is comparable with the Guildline Autosal, while the operations are faster due to faster flushing of the cell.

Hendrik van Aken reported that John Gould and Raymond Pollard had informed him about doubts on the quality of standard water batch P115. However OSI, which produces this water, has not yet published any warning with regard to the quality of this batch.

Eberhard Hagen mentioned problems with the quality and calibration of meteorological sensors on board researd vessels. Observations with these sensors are important for the corrections for IR-RS skin temperature effects. It was the general feeling of most participants that calibration of meteorological sensors was not within the scope of the working group.

Problems with the quality control of surface drifters related to the loss of drogues was shortly discussed. Bob Dickson mentioned that Dr. L.Merlivat from France has developed a pCO_2 sensor to be mounted on surface drifters.

Chapters (Standards and Laboratory Calibration, Salinity Measarements, Underway Measurements and CTD Methods) from the WHP Manual on Operations and Methods (WHPO91-1) were discussed and reviewed as a guideline for hydrographic observations by WOCE members.

With regard to the chapter on standards and laboratory calibration it was remarked that SeaBird Electronics (SBE) has a calibration facility which carries out fast and accurate calibrations of SBE CTD sensors.

The use of digital reversing thermometers and pressure sensors was discussed. The feeling was that if enough care is given to these instruments, they are accurate enough for CTD-calibrations for most research programmes. Laboratory calibration however gives an indepedent check and forms a sort of double insurance.

In the chapter on salinity determinations most participants missed an extensive discussion on the preparation and cleaning of the sample bottles.

With regard to the CTD oxygen sensors it was remarked that at present these sensors require regular (each cast) calibrations and are not very reliable. The following discussion however did not give new insights.

The required accuracies for meteorological observations from research ships were considered to be too ambitious for standard ship observations and sometimes not realistic.

It was the general feeling of the participarts that the manual was clearly written and contains valuable information on methods and procedures needed to meet the accuracy requirements for the WHP one-time hydrographic surveys. They were well aware that such accuracies are not always required for hydrographic work in ICES, but even in such cases the manual may be used as a guideline. Therefore it was decided to recommend to the Hydrography Committee to use the reviewed chapters as a guideline for the hydrographic working procedures for ICES.

8. Progress in the studies of cod recruitment in relation to climate variability

Harald Loeng presented evidence for a relation between the temparature in the Barents Sea and cod recruitment. With low temperatures less food is available (copepods) for the young cod and therefore less recruitment will take place. Empirical evidence confirms low recruitment at low temperatures. At higher temperatures the recruitment can be larger, but low recruitment occasionally occurs at higher temperatures. This indicates that available food and temperature are limiting factors for recruitment but they are not the only regulating factors.

Theoretical considerations suggests that high turbulence and therefore strong winds will increase the contact ratio for cod larvae with its prey (copepods). Therefore strong winds in the period after hatching can promote the recruitment af cod. Since low stratification due to strong winds appear to be disadvanteous for the recruitment of haddock larvae, the relative success of cod and haddock recruitment can be used to test this theoretical model.

At the June meeting in Lowestoft of the Cod and Climate Change Working Group questions will be posed which will require modelling efforts for an answer. In the view of Bob Dickson extreme situations can probably be modelled with some success. Johan Blindheim points to the possible relation between long term and large scale hydrographic trends and the long term decline of the cod. However model studies on long term trends are probably less successful than studies on extreme hydrographic situations. Also the normal inter annual changes are assumed to be difficult to model.

Hendrik van Aken stated that with regard to the relations between hydrography and cod explicit hypotheses must be stated. Only then model studies can be used to test these hypotheses.

9. The role of ICES in planned experiments etc.

Hendrik van Aken gave a summary of a proposal, made by John Gould for the WOCE Scientific Steering Group. This proposal is concerned with the study of Variability of Ocean Circulation in the Atlantic (VOCAL) and is meant as a follow-up of WOCE CP3 which appears to be too under-resourced to meet its objectives. After some discussion the participants decided that in principle the proposal was in line with current concerns of ICES on Atlantic variability and its relations with fish stocks, as well as with climate change. The working group will wait for further proposals from John Gould.

Eberhard Hagen presented information of the research carried out by the Wardemünde group in the Gulf of Cadiz and west of Portugal. This was followed by an extensive discussion on the probable origin of high salinity surface water in the poleward Eastern Boundary Current. It was concluded that if the high surface salinity was caused by mixing with Mediterranean water, slope processes have to be involved.

After Eberhard Hagens presentation of his research in the eastern Atlantic boundary earlier discussions on the poleward Eastern Boundary Current where brought up. Robin Pingree and Yves Camus seem to have a lot of current meter data from the eastern Atlantic Boundary. The planned British and Dutch programmes will add to the existing knowledge. Therefore it was concluded that within a few years more definitive answers can be given on the questions, posed earlier by the blue whiting group.

Bob Dickson handed out copies of a letter from SIO and LDGO with regard to future plans for a research programme on the thermohaline circulation of the North Atlantic (Appendix IX).

10. WOCE

Hendrik van Aken reviewed the status of the WOCE Hydrographic programme in the North Atlantic. The one time surveys will be concentrated mainly in the period 1994 to 1997. The repeat hydrography appears to be well underway since 1990. However not all repeat sections and repeat areas will be surveyed at the intended rate or will not be surveyed at all.

Bob Dickson presented information of his WOCE study on the kinetic energy distribution in the world ocean. He invited all participant to stimulate the submission of long term current observations (>6 months) from deep water (>500m). Additional to this presentation Dickson also presented an overview of transport measurements of the overflow from the Nordic Sea into the Atlantic Ocean.

11.The ICES Hydrographic Inventory

Copies of the hydrographic inventory were handed out. The participants were invited to send amendments to the Oceanography Secretary.

12. Any other Business

Svend Aage Malmberg brought the possible radioactive contamination of the Lofoten Basin and the Kara Sea under attention. After an extensive discussion it was concluded that monitoring of the radio-active doses is already carried out. It was decided to discuss possible transport and dispersion of radio-active contamination in these areas during next years meeting of the WGOH.

Possible special topic sessions and special theme sessions for future Statutory Meetings were discussed on request from Hendrik van Aken. Because of its importance to questions on hydrographic variability of the North Atlantic and related chemical and biological changes it was decided to recommend to have a special topic session on the WHP repeat surveys of the North Atlantic in 1995. A special theme session on the JGOFS North Atlantic Pilot Programme was considered to be inappropriate, given the recent publication of a special theme volume of Deep-Sea Research, devoted to this subject. Because of the possible importance of ocean circulation models to studies on the relation between ocean circulation and cod recruitment combined with the advanced modelling possibilities, it was decided to recommend to have a special theme session in 1995 on ocean modelling focussing on questions to be raised during the Cod and Climate Change meetings in 1993. Jan Backhaus was proposed convener of this session.

Eberhard Hagen and Peter Lundberg proposed a special topic session on the ocean remote sensing by new satellites like ERS1 and Topex-Poseidon. After some discussion it was decided to postpone a decision on this proposal to the 1994 meeting of the WGOH.

The Mariehamm symposium on ocean variability was reviewed. The general feeling was that this meeting formed a good successor for the annual reviews of the hydrographic situation in the Annales Biologiques. Its has been already decided that in principle such symposia are held at decadal intervals. The Working Group therefore noted the need to put forward a relevant recommendation at the appropiate time (ca. 1998).

13. Place, data and topics of next meeting

As topics for the next meeting the following subjects were proposed:

- Spreading of radio-activity from the Northern Seas
- Standard Sections and Stations
- Follow-up on questions relating to Cod and Climate and process modelling
- Review of the WOCE Hydrographic Programme and other national and international projects in the North Atlantic.
- The Nansen summary paper
- The 1990-1991 positive salinity anomaly
- Data archeology
- Presentations on different new pCO2 systems
- Standardisation of North Atlantic water mass terminology
- Meta-data

It was suggested to meet next year in Bergen from 18 to 20 April.

APPENDIX I

List of participants.

Name	Institute	Adress
Harry Dooley	ICES	Copenhagen, Denmark
Robert Gelfeld*	U.S.NODC	Wasington, DC
Nigel Rees	PML	Plymouth, UK
Bill Turrell	MLA	Aberdeen, Scotland
Svend-Aage Malmberg	MRI-R	Reykjavik
Bob Dickson	MAFF	Lowestoft, UK
Gerd Becker	BSH	Hamburg, Germany
Janice Atkinson*	HO	Taunton, Somerset, UK
Johan Blindheim	IMR	Bergen, Norway
Harald Loeng	IMR	- do -
Bogi Hansen	FRS	Torshavn, Faroe Islands
Erik Buch	FRV	Copenhagen K, Denmark
Hendrik van Aken	NIOZ	Texel, Netherlands
D.J.Ellett	Dunst.Mar.Lab.	Oban, Scotland
Eberhard Hagen	IBSR	Warnemunde, Germany
Lesley Richards*	BODC	Bidston, UK
Svein Østerhus	GI	Bergen, Norway
Peter Lundberg	OI	Gothenborg, Sweden
Savi Narayanan	NAFC	St.Johns, Canada

* Members of the Marine Datamanagement W.G. attending the meeting the first day.

APPENDIX II

ICES WORKING GROUP
ON
OCEANIC HYDROGRAPHY

ABERDEEN 21 - 23 APRIL 1993

Terms of reference:

a. Review the updated list of, and results from, standard stations and sections.
b. Assess the state of oceanographic data quality and data processing, taking into account the present performance of instrumentation.
c. Prepare an overview of WOCE North Atlantic Hydrography Workshop, and review relevant ongoing hydrographic activities.
d. Syntesize the findings of an ad hoc group on the 1989-1991 high salinity anomaly.
e. Review progress on studies relating cod recruitment and climatic variations.
f. Consider the ICES role in planned experiments in the eastern Boundary Current, and the North Atlantic Gyre Experiment.
g. Review the relevant sections of the WHP manaul as a guide for hydrographic procedures in the ICES area.

AGENDA

1. Opening
2. Review of membership
3. Remarks from the ICES Hydrographer
4. Establishment of a net of standard stations and sections
5. Results from standard sections
6. Report from the ad hoc group on the 1989-91 high salinity anomaly
7. Oceanographic data quality and data processing, taking into account the present performance of instrumentation
8. Progress in the studies of cod recruitment in relation to climate variability
9. The role of ICES in planned experiments in the Eastern Boundary Current and the North Atlantic Gyre Experiment.
10. WOCE
    a. North Atlantic Hydrography Workshop
    b. Ongoing activities.
11. The ICES Hydrographic Inventory
12. Any other business
13. Place, date and topics of next meeting

APPENDIX III

Report from the joint meeting between the Oceanic Hydrography and Marine Data Management Working Groups.
(prepared by Lesley Richards).

Several topics of interest to both groups were discussed during the joint session. R. Gelfeld described the data archaeology work currently being undertaken at the US NODC and WDC-A(Oceanography). This led on to a discussion of calibrations, quality control and information accompanying data.

Data archaeology began at the US NODC/WDC-A several years ago; the work so far has concentrated on physical oceanography, locating data sets which have not been sent to national oceanographic data centres and which may be in manuscript form or kept by individual scientists. Within the US NODC the archives have been searched, station location plots have been produced and the NODC has worked with scientists to identify gaps and to fill them.

The project now has international status with the backing of IOC and is known as the GODAR (Global Oceanographic Data Archaeology and Rescue) project. ICES is actively involved with this work and a close relationship is maintained between the NODC/WDC-A and ICES. Copies of the archaeology data set are kept at both ICES and WDC-A for security. The cost of adding data to the archive has been about 3 man years for 30000 stations. This includes not only digitising the data but also the quality control, which is time consuming. It is also important to check that data have not already been digitised to avoid duplication. The data from this project are freely available. Meetings such as the present one were valuable for exchange of ideas and to help track down data.

In response to a question from D. Ellett about metadata, R. Gelfeld said that WDC-A tries to recover as much information as possible. He asked if anyone knew of any large data sets, which may be at risk. G. Becker said that large volumes of data were collected by Germany prior to the formation of DOD, which were only partly at the data centre. R. Dickson volunteered to search for a data set which he remembered, but no longer knew the whereabouts of; this was a series of surface salinity values on a 5 degree grid for the North Atlantic (the data were derived from the continuous plankton recorder).

In reply to questions about restrictions on the data, H. Dooley said that data at ICES could be restricted, (i.e. data could be sent to ICES and no further). In addition, scientists were informed of any requests for data up to ten years old. Over the last few years interest in the high salinity anomaly (1989/90) meant that scientists were interested in comparing with data collected in past decades. Searches at ICES and WDC-A revealed many gaps in the data record which need to be filled.

Concern was expressed by D. Ellett about the information accompanying data, and he volunteered to search for copies of (old) papers with information about calibrations, intercalibrations and methods. The Working Groups agreed that this would be valuable but recognised that it is often hard tracking down the data sets, the metadata is even more difficult and harder to check. ICES does not store metadata with the data themselves, but includes comments in the ROSCOP database. J. Blindheim recalled how in the past standard reporting forms were used, but this seemed to have fallen into disuse. S. Narayanan reported that in Canada each laboratory or scientist had had their own system, but now they had all decided on a standard form to be included in the header.

Mention was also made of the WOCE procedures for hydrographic data. The data quality experts were provided with quite detailed cruises reports which were very useful and formed part of the quality control.

The WHP guidelines were thought to be useful and it was generally recommended that scientists should send information to accompany the data. In the USA, funding was often dependent on the appropriate documentation being produced. ICES recommended that documentation should be short and to the point. The use of the SCOR Working Group 51 Guidelines was encouraged. It was felt that part of the problem was that as people change jobs and move on their expertise often goes with them and guidelines for data submission and accompanying information would help to alleviate this.

H. van Aken was concerned about data submission to the WDC-A from ICES countries where NODCs did not function well. In cases like this, the data can be sent directly to WDC-A. There was also some discussion about how data should be sent to ICES. Some years ago the MDM Working Group had produced guidelines for sending reduced resolution data to ICES; however ICES will accept high resolution data (1 or 2 dbar interval). Data sent to ICES are carefully quality controlled and any problems sorted out with data originators. Data quality control guidelines need to be set up and this is an important part of the processing. For the GTSPP an essential element is the quality control; however this is carried out by a panel, and the data originators are not consulted. It was felt that it would be a better approach if the data centres remained in close contact with the data originators when carrying out their quality control and reported back any problems.

H. van Aken briefly asked about ways of organising CTD data on a PC. There was brief discussion of the value of relational databases, which can be very useful and easy to access, but can cause problems in the longer term when the database systems are updated or become obsolete - then access to the data can be very difficult. However, they are very useful as working databases. Following on from the discussion at last years joint meeting L. Rickards briefly described a software package, developed by the University of Hawaii for processing, quality control, display and storage of shipborne ADCP data. This package is available for Unix systems and IBM PCs. It has mostly been written in-house, but does use a commercial package (Matlab) for some functions. The University of Hawaii were keen let others try out the package and obtain feedback. Further details can be obtained from L. Rickards. She has a copy of the software package and manual, but has not yet had the opportunity to test it out.

APPENDIX IV

Recommendations

1) The Working Group on Oceanic Hydrography recommends that the Hydrography Committee should promote an involvement of ICES in the Global Ocean Observing System (GOOS).

2) The Working Group on Oceanic Hydrography recommends that the Hydrography Committee during the 1995 Statutory Meeting organize:

- A Special Topic session on WOCE Hydrographic Programme repeat surveys of the North Atlantic.

- A Theme Session on ocean modelling focussing on questions to be raised during the Cod and Climate meetings in 1993.
Convener: Jan Backhaus.

3) The Working Group on Oceanic Hydrography recommends that the WHP Manual on Operations and Methods be used as a guideline for the hydrographic working procedures within the ICES community.

4) The Working Group on Oceanic Hydrography (Chairman: Dr E. Buch, Denmark) will meet in Bergen, Norway from 18-20 April 1994 to:

a) assess the potential impact of the radioactive contamination of the Nordic Seas arising from possible sources off northern Norway and Russia.

b) assess progress in the understanding of the role of climatic variability and long-term change on pan-atlantic cod populations.

c) update and review the results of Standard Sections and Stations, including relevant data from the ICES Data Bank.

d) review progress in the WOCE Hydrographic Programme, and other oceanographic projects in the North Atlantic.

e) finalize the report on the ICES NANSEN Project.

f) provide input to the Working Group on Marine Data Management on matters related to the IOC/ICES GODAR Project.

g) assess and evaluate new intrumentation for the measurement of oceanic parameters.

h) evaluate proposals for standard names for North Atlantic water masses.

APPENDIX V

ICES STANDARD STATIONS

Location	Position	Depth
Greenland Sea	75°00N 05°00W 71°00N 04°00E	
West Greenland	63°53N 53°22W	1300
Norwegian Sea	64°30N 06°00W	
Iceland Basin	60°00N 20°00W	
Faroe-Shetland Channel	61°28N 03°42E	
Faroe Bank Channel	61°16N 08°00E	
Porcupine Abyssal Plain	50°00N 17°00W	
Weathership A Weathership B Weathership C Weathership D Weathership E Weathership H Weathership I Weathership J Weathership K Weathership L Weathership M Weathership R	62°00N 33°00W 55°47N 51°53W 52°45N 35°30W 44°00N 41°00W 35°00N 48°00W 38°00N 71°00W 59°00N 19°00W 52°30N 20°00W 45°00N 16°00W 57°00N 20°00W 66°00N 02°00E 47°00N 17°00W	
Canadian Eastcoast Prince 5 Station 27	 44°57N 66°49W 47°33N 52°35W	

APPENDIX VI

LIST OF STANDARD SECTIONS IN THE NORTH ATLANTIC.

COUNTRY/NAME	STARTPOINT	ENDPOINT	OCC/YEAR	START	PARAMETER
CANADA					
Flemish Cap	47°00N 52°02W	47°00N 42°00W	1		
Bonavista	48°44N 52°58W	50°00N 49°00W	1		
White Bay	50°40N 55°00W	52°07N 49°45W	1		
Seal Island	53°14N 55°39W	59°38N 44°09W	1		
DENMARK					
C. Farewell	59°38N 44°09W	58°46N 45°50W	1	1950	T,S
C. Desolation	60°50N 48°45W	60°02N 51°27W	1	1950	T,S
Frederikshaab	61°57N 50°00W	61°34N 52°30W	1	1950	T,S
Fylla Bank	63°57N 52°22W	63°48N 53°56W	1	1950	T,S
Sukkertop	65°06N 52°55W	65°06N 54°58W	1	1950	T,S
Holsteinsborg	66°53N 54°10W	66°41N 56°38W	1	1950	T,S
FAROES					
Northern Section	62°20N 06°05W	64°30N 06°05W	4	1988	T,S
Nolsey-Shetland	62°00N 06°12W	61°01N 01°36W	4	1988	T,S
Troellhoevdi - Faro Bank	61°50N 07°00W	60°28N 09°20W	4	1988	T,S
GERMANY					
Dohrn Bank I	65°27N 28°38W	65°53N 30°53W	1	1981	T,S
Dohrn Bank II	65°58N 29°24W	65°21N 30°06W	1	1981	T,S
Gauss Bank	65°22N 34°30W	64°50N 33°33W	1	1981	T,S
Heimland Ridge	64°09N 37°12W	63°33N 36°33W	1	1981	T,S
Cape Moesting	63°38N 40°05W	63°04N 39°12W	1	1981	T,S
Cape Bille	62°10N 41°24W	61°56N 40°27W	1	1981	T,S
Discord Bank	60°57N 42°17W	60°48N 40°18W	1	1981	T,S
ICELAND					
Faxafloi	64°20N 22°25W	64°20N 28°00W	4	1950	T,S,O,N,P,Si
Latrabjerg	65°30N 24°34W	66°09N 27°15W	4	1950	T,S,O,N,P,Si
Kogur	66°30N 23°00W	67°20N 23°40W	4	1950	T,S,O,N,P,Si
Siglunes	66°16N 18°50W	68°00N 18°50W	4	1950	T,S,O,N,P,Si
Langan N	66°37N 14°16W	68°00N 12°40W	4	1950	T,S,O,N,P,Si
Langan A	66°22N 14°22W	66°22N 09°00W	4	1950	T,S,O,N,P,Si
Krossan	65°00N 13°30W	65°00N 09°00W	4	1950	T,S,O,N,P,Si
Stokksn	64°12N 14.50W	63°40N 13°40W	4	1950	T,S,O,N,P,Si
Selv.B.	63°41N 20°41W	63°00N 21°28W	4	1950	T,S,O,N,P,Si
Iceland Sea	68°15N 16°32W	70°35N 13°25W	1	1987	T,S,O,N,P,Si
NORWAY					
Torungen	58°24N 08°46E	57°38N 09°52E	10	1953	T,S
Oksø	58°03N 08°05E	74°14N 08°33E	2	1959	T,S
Hansth.-Aberdeen	57°00N 07°57E	57°00N 01°28W	2	1967	T,S
Utsira	59°17N 05°02E	59°17N 02°14W	2	1947	T,S
Feie	60°45N 04°37E	60°45N 00°40W	2	1967	T,S
Svinøy	62°22N 05°12E	64°40N 00°00E	2	1978	T,S
Gimsøy	68°24N 14°05E	70°24N 08°12E	2	1978	T,S
Bjørnøy	70°30N 20°00E	74°15N 19°10E	6	1965	T,S
Vardø	70°30N 31°13E	76°30N 31°13E	2	1955	T,S
Sem Islands	69°05N 37°20E	76°30N 37°20E	1	1956	T,S
Bjørnøya-W	74°30N 18°30E	74°30N 07°00E	1	1947	T,S
SCOTLAND					
FIM	60°10N 03°44W	61°12N 06°22W	1	1927	T,S,Si
FS	62°00N 06°12W	60°56N 01°00W	1	1934	T,S,Si
MR	56°40W 06°08W	57°35N 13°38W	1 - 5	1975	T,S
JONSIS	59°17N 05°02E	59°17N 02°14W	2	1970	T,S,O,N,P,Si
SPAIN					
Vigo					
La Coruna					
Santander					

APPENDIX VII

RESULTS FROM STANDARD SECTIONS AND STATIONS

In the light of a growing recognition of the importance of the variability of the physical environment to changes in fish stocks (reproduction, growth, migration etc) the Oceanic Hydrography Working Group has established a net of standard sections and stations, see Appendix VI and VII. At each meeting observational results from this network of sections and stations will be presented and discussed. A summary of these presentations will be given as an appendix to the working group report with the purpose of giving an annual review of the hydrographical conditions in the northern North Atlantic which hopefully can be used in a wider perspektive within the ICES community.

The following contains a short summary of the national reports on results from work on standard sections in 1992.

Scotland (David Ellett).

The Dunstaffnage Marine Laboratory is responsible for the occupation of the ICES standard section west of Scotland.

The standard section between Mull and Rockall was worked during 25-29 September 1992 and the shelf portion of the section was also sampled in March, May and August 1992. The deep-water part of the section (Fig.1) showed an unusually fresh layer (<35.24 psu) across the surface of the section. Fig.2 shows that surface salinity salinity in the Rackall Trough was at its lowest value since the "Great" salinity anomaly in 1975, at about 0.14psu below the 1961-70 monthly mean. This is all the more surprising as it follows a period of high salinity in late 1989 to early 1991, when salinities were at a level (ca. 0.06psu above the 1961-70 mean) not seen since 1967. At depth of 1600-1800m (Fig.3), in the Labrador Sea Water salinity minimum, salinity values had risen from the particularly low values in 1990.

A Seacat temperature - salinity logger and a termistor chain were moored at station "M" of the section at a depth of approximately 400 m in soundings of 2236 m from september 1992 to March 1993 to investigate winter mixing in the Rockall Trough.

Faroe Islands (Bogi Hansen).

The three Faroese standard sections shown on the map in Fig.4 are operated by the Fisheries Laboratory of the Faroes. Section E may extend all the way towards Shetland; but for the four occupations in 1992 this section only extended to mid-channel.

Figs. 5 - 8 show vertical sections of temperature (T), salinity (S) and fluorescence (F). Fluorescence is shown in relative units, but these units are the same for all the cruises in 1992 and in general skould be fairly close to chlorophyll-a concentrations in mg/m^3.

In the Faroe Bank Channel the homogeneous layers of Modified North Atlantic Water (MNAW) decreased during 1992 in both temperature and salinity as compared to the fairly stable values found since the mid-eighties until the beginning of the nineties. The same tendency was observed on the standard section north of the Faroes where the amount of MNAW has been decreasing since the end of the eighties.

Norway (Johan Blindheim and Harald Loeng).

The Norwegian Atlantic Current is the path way for heat transported from the Atlantic into the Nordic Seas while the East Icelandic Currents brings Arctic Waters into the area. The relation between the intensity in these two current systems is an important ecological factor. It is now known that important Norwegian commercial fish stocks have large growth and greatest success in reproduction when the Norwegian Atlantic Current carries much heat into the northern areas. Temperature and salinity are therefore monitored regularly at a number of standard sections as show in Fig.9 by the Institute of Marine Research in Bergen.

The trends in temperature and salinity since 1978 at the sections off

A: Sørkapp (West Spitsbergen)
B: Grimsøy (Lofoten)
C: Svinøy

as observed in July/August is shown in Fig.10. The values shown are averages between 50 and 200 m along the part of the sections that cover the core of the Atlantic Water. The warm periods around 1983 and 1990 were both associated with strong year classes in important fish stocks. After the latter warm period, which culminated in 1990 - 1991, condition are now characterized by decreasing temperatures. During the warm period around 1990 there was not a well established parallellity between temperature and salinity trends, and the warm anomaly was more outstanding in the northern part of the area (Sørkapp) than in the south. This indicates that local temperature exchange with the atmosphere may have been of importance in addition to the advective effects.

Similar local effects were also active in the Barents Sea as indicated in Fig.11 showing trends in temperature and salinity as observed in August at the sections:

A: Fugløya - Bear Island
B: Vardø-N
C: Sem Islands-N

The temperatures have culminated after a maximum in 1990 - 1991, but the decline is not yet considerable. Salinities have culminated in the western Barents Sea while they were still high in the eastern part.

Recent considerable warming was also observed in coastal waters on the Skagerak coast. Sea surface temperature trends since 1870 at Torungen Light House for the quarters January - March and July - September are given in Fig.12. For the first quarter temperatures were by far the highest on record.

Iceland (Svend Aage Malmberg).

The hydrographic conditions in the Icelandic waters are monitored seasonally on 10 - 12 standard sections by the Marine Research Institute in Reykjavik.

The 1992 results reveal near normal conditions in the warm waters south and west of Iceland. The inflow of the relatively warm and saline Atlantic Water of the Irminger Current into the North Icelandic waters was also present as in 1991, whereas it was absent in 1988 - 1990, Fig. 13. Despite this inflow in 1991 and 1992 only small year classes of cod appeared, but the capelin stock increased again in 1991 - 1992 after the decline in 1989 - 1990. The last strong year classes of cod was experienced as far back as in 1983 and 1984.

East Greenland (Manfred Stein).

The standard sections along Southeast Greenland are worked once a year in October - November by the Institute für Seefisherei, Hamburg. In 1992, however, only the Gauss Bank section was observed due to technical problems with the ship.

The Gauss Bank observations are shown in Fig. 14 and some statistics are given in Tabel 1.

West Greenland (Erik Buch).

The standard sections along the southwest coast of Greenland are worked once a year in June - July by the Royal Danish Administration of Navigation and Hydrography.

Atmospheric conditions.

The climatic conditions over West Greenland has been rather cold during recent years, Fig.15.

After the extremely cold period at the beginning of the decade (1982-84) the climatic conditions normalized; after 1989 the air temperatures have again shown negative anomalies, especially during winter.

Studies of the meteorological circulations over the Greenland area show that the present cold climate is caused by a cold arctic airmass over the Davis Strait, i.e. the same phenomenon as in the early 1980'es.

The cold atmosphere has resulted in a cooling of the oceanic surface-layer along the entire West Greenland coastline which again has resulted in a greater than normal coverage of sea-ice in the Davis Strait during recent winters.

The Fylla Bank mid-June time series

The mean temperature on top of Fylla Bank (Fylla Bank Section St.2, 44 m) medio June has been measured since 1950. It has been taken as an indicator on the climatic conditions in the West Greenland area and used in that respect in fisheries assesment work. In Fig. 16 the time series of actual observations as well as a three year running mean of the temperature on top of Fylla Bank are shown. It is noticed that since 1989 the temperature conditions have been comparable to the conditions observed during the two previous cold periods, i.e. the cold years around 1970 and 1983.

Results from the 1992 cruise

The observed surface temperatures and salinities are shown in Fig. 17 - 18. Water of Atlantic origin (T > 3°C) is only observed off Southwest Greenland. The low temperature and salinity measured at st.5 at the northernmost section is due to the fact that this station was very close to the ice-edge at the time of observation.

Examples of the vertical distribution of temperature and salinity on the six sections is given in Fig. 19 - 20.

The surface layer at the southernmost sections is dominated by the front between the cold, relatively fresh polar water near the coast and the varm, saline Atlantic water further offshore. At the remaining sections the surface layer is relatively homogeneous as a consequence of the above mentioned atmospheric cooling while the core of the inflowing Polar water (T < 0 - 1°C) is situated at a depth of 75 - 150 m.

At greater depths, where water of Atlantic origin is found, the oceanographic conditions are close to normal, i.e. temperatures in the interval 3.5 - 4.5°C and salinities above 34.85. It shall however be noted that Irminger Water (S > 34.92) was observed in great quantities as far north as at the Sukkertop section which is unusual at this time of the year.

Canada (Savi Narayanan)

The Physical Oceanography Section of the Department of Fisheries and Ocean (DFO) at the Northwest Atlantic Fisheries Center (NACF) is responsible for the occupation of the ICES standard sections across the continental shelf off eastern Canada and the long-term monitoring station, Station 27. The St. Andrews Biological Station is responsible for the monitoring station, Prince 5.

Standard stations:

Prince 5:

This long-term monitoring station off St. Andrews, New Brunswick, Canada was monitored 1/month in 1992. This data indicate that well-mixed conditions prevailed through most of 1992, with the exception of the spring freshening and the summer heating. Furthermore, temperature and salinity anomalies at 0, 50 and 90 m were negative over the last approximately 2 years.

Station 27:

This station off St. Johns, Newfoundland was occupied on an opportunistic basis, to collect temperature and salinity profiles. The negative temperature anomaly established in 1990 is still continued, though the conditions improved slightly in 1992. Furthermore, the deep salinities in the last two years were fresher than they had been in the previous three.

Standard Sections:

All four sections were occupied in 1992 to collect temperature and salinity profiles. Area of the cold intermediate layer (defined as the subsurface layer at sub-zero temperatures) computed along each of these sections, show that the area has decreased by about 10% in 1992 compared to 1991, indicating a slight improvement in the severely cold conditions that exixted since 1990.

Conclusions.

From this short overview of the oceanographic conditions in the northern North Atlantic in 1992 it can be concluded that:

* The positive anomalies in temperature and salinity that has dominated the eastern Atlantic in recent years seem to have culminated although high positive anomalies still can be observed in the northeastern part of the Nordic Seas.

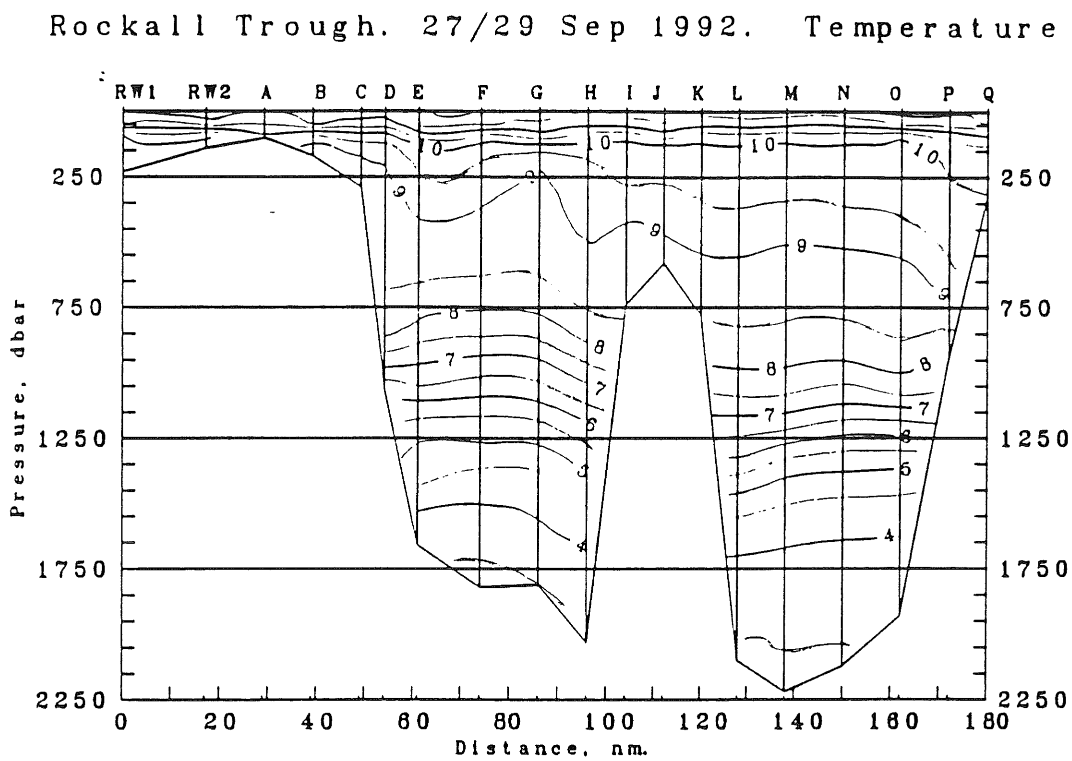
* In the central part conditions seem normal.

* The western part of the North Atlantic experience extreme negative anomalies in temperature and salinity which do not yet seem to have culminated.

Table 1. Gauss Bank Section statistics.

GAUSS BANK							Anomaly			
S5	830930	860906	880914	920919	Mean		830930	860906	880914	920919
	1983	1986	1988	1992			1983	1986	1988	1992
0	7,35	8,712	8,092	7,362	7,88	0	-0,53	0,83	0,21	-0,52
10	7,35	8,701	8,088	7,357	7,87	10	-0,52	0,83	0,21	-0,52
20	7,35	8,666	8,087	7,358	7,87	20	-0,52	0,80	0,22	-0,51
30	7,36	8,492	8,082	7,356	7,82	30	-0,46	0,67	0,26	-0,47
50	7,34	7,77	8,031	7,361	7,63	50	-0,29	0,14	0,41	-0,26
75	7,22	6,867	7,459	7,329	7,22	75	0,00	-0,35	0,24	0,11
100	7,09	6,471	6,886	6,535	6,75	100	0,34	-0,27	0,14	-0,21
150	6,48	6,453	6,758	6,441	6,53	150	-0,05	-0,08	0,22	-0,09
200	6,32	6,405	6,688	6,139	6,39	200	-0,07	0,02	0,30	-0,25
250	6,23	6,163	6,422	6,002	6,20	250	0,03	-0,04	0,22	-0,20
300	6,06	5,92	6,218	5,848	6,01	300	0,05	-0,09	0,21	-0,16
400	5,18	5,471	5,626	5,64	5,48	400	-0,30	-0,01	0,15	0,16
500	5,03	5,069	5,253	5,199	5,14	500	-0,11	-0,07	0,12	0,06
600	4,89	4,748	4,791	4,916	4,84	600	0,05	-0,09	-0,05	0,08
800	3,96	4,099	3,915	4,533	4,13	800	-0,17	-0,03	-0,21	0,41
1000	3,19	3,758	3,481	3,853	3,57	1000	-0,38	0,19	-0,09	0,28
1200	2,27	3,274	1,736	2,779	2,51	1200	-0,24	0,76	-0,78	0,26

GAUSS BANK							Anomaly			
S4	830930	860906	880914	920919	Mean		830930	860906	880914	920919
	1983	1986	1988	1992			1983	1986	1988	1992
0	6,81	4,406	8,204	7,219	6,66	0	0,15	-2,25	1,54	0,56
10	6,84	4,586	8,21	7,228	6,72	10	0,12	-2,13	1,49	0,51
20	6,82	5,485	8,2	7,229	6,93	20	-0,11	-1,45	1,27	0,30
30	6,83	6,661	8,185	7,23	7,23	30	-0,40	-0,57	0,96	0,00
50	6,84	6,934	8,118	7,232	7,28	50	-0,44	-0,35	0,84	-0,05
75	7,17	6,763	7,033	7,176	7,04	75	0,13	-0,27	-0,00	0,14
100	6,87	6,729	6,81	6,523	6,73	100	0,14	-0,00	0,08	-0,21
150	6,66	6,609	6,744	6,307	6,58	150	0,08	0,03	0,16	-0,27
200	6,51	6,539	6,426	6,267	6,44	200	0,07	0,10	-0,01	-0,17
250	6,38	6,444	6,066	6,054	6,24	250	0,14	0,21	-0,17	-0,18
300	6,05	6,247	5,929	5,838	6,02	300	0,03	0,23	-0,09	-0,18
400	5,22	5,821	5,28	5,328	5,41	400	-0,19	0,41	-0,13	-0,08
500	4,72	5,196	4,67	4,806	4,85	500	-0,13	0,35	-0,18	-0,04
600	4,32	4,841	4,39	4,336	4,47	600	-0,15	0,37	-0,08	-0,14
800	3,61	4,245	3,635	3,489	3,74	800	-0,13	0,50	-0,11	-0,26



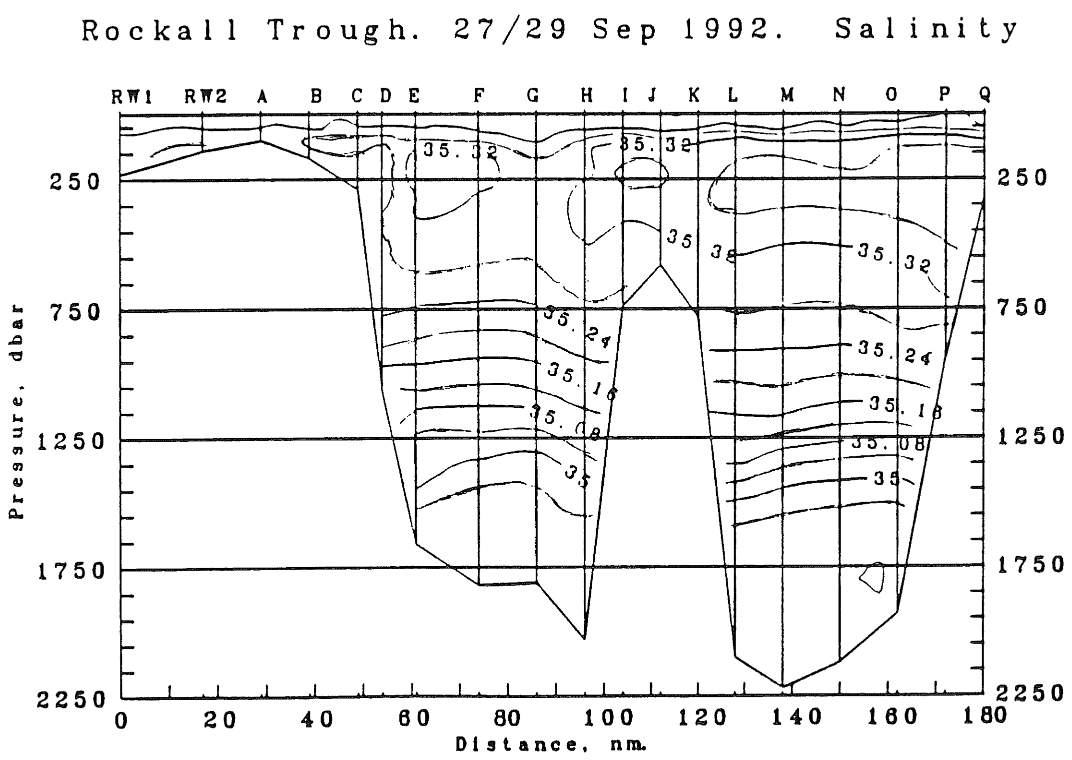


Figure 1. CTD section across the Rockall Trough (ca. 57oN), 27-29 Sept. 1992.

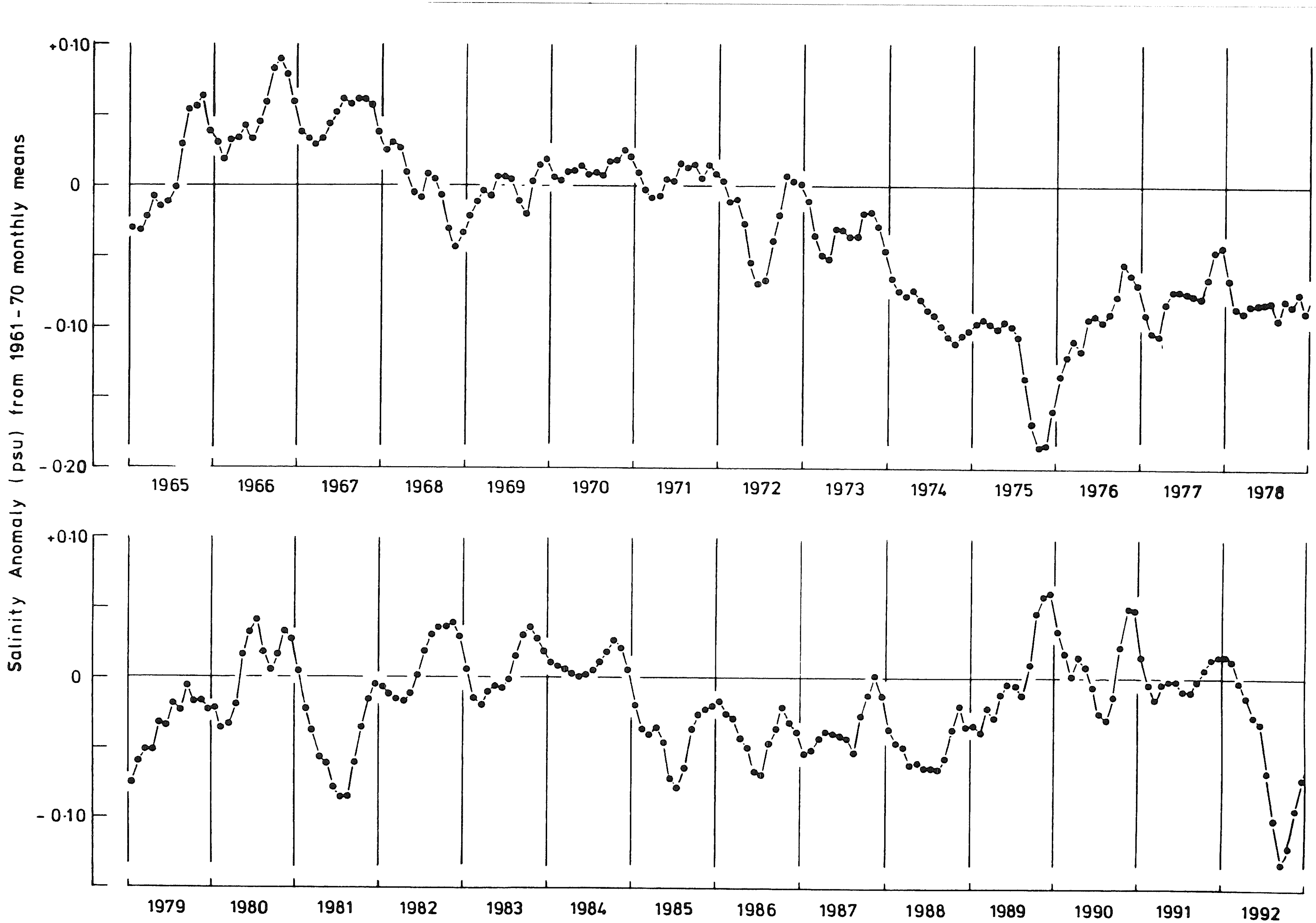


Figure 2. 3-month running means of monthly surface salinity anomalies in the central Rockall Trough from 1961-70 monthly means.

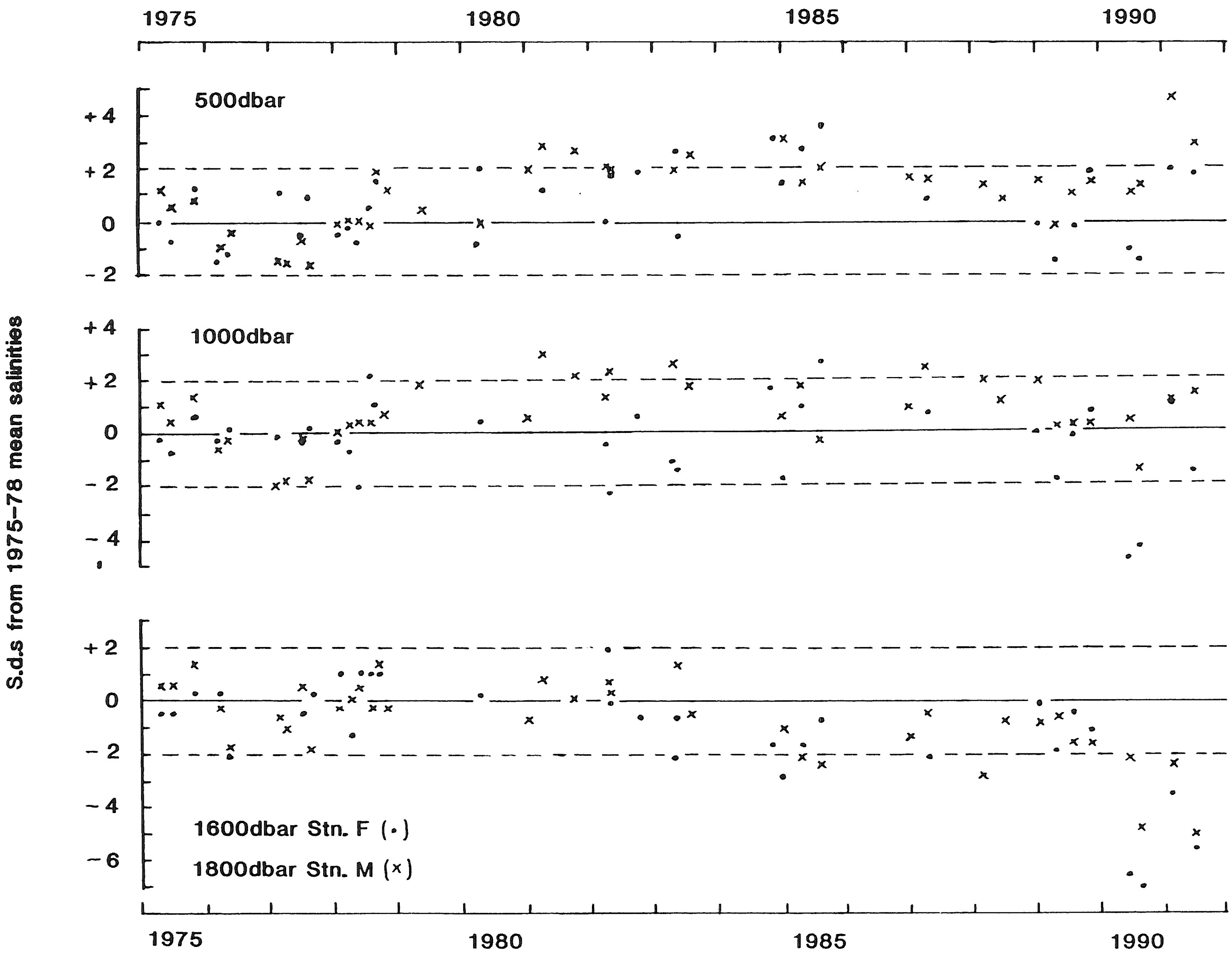


Figure 3. Standard deviations of salinity from 1975-78 means at three levels for stations F and M in the central Rockall Trough.

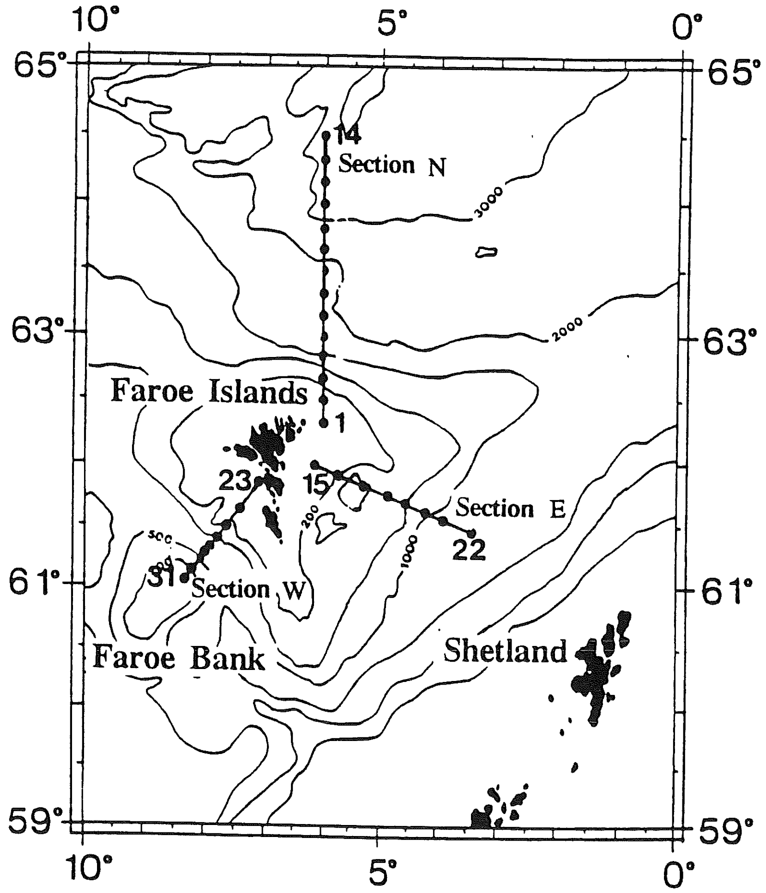


Fig. 4 Map showing bottom topography and the three Faroese standard sections

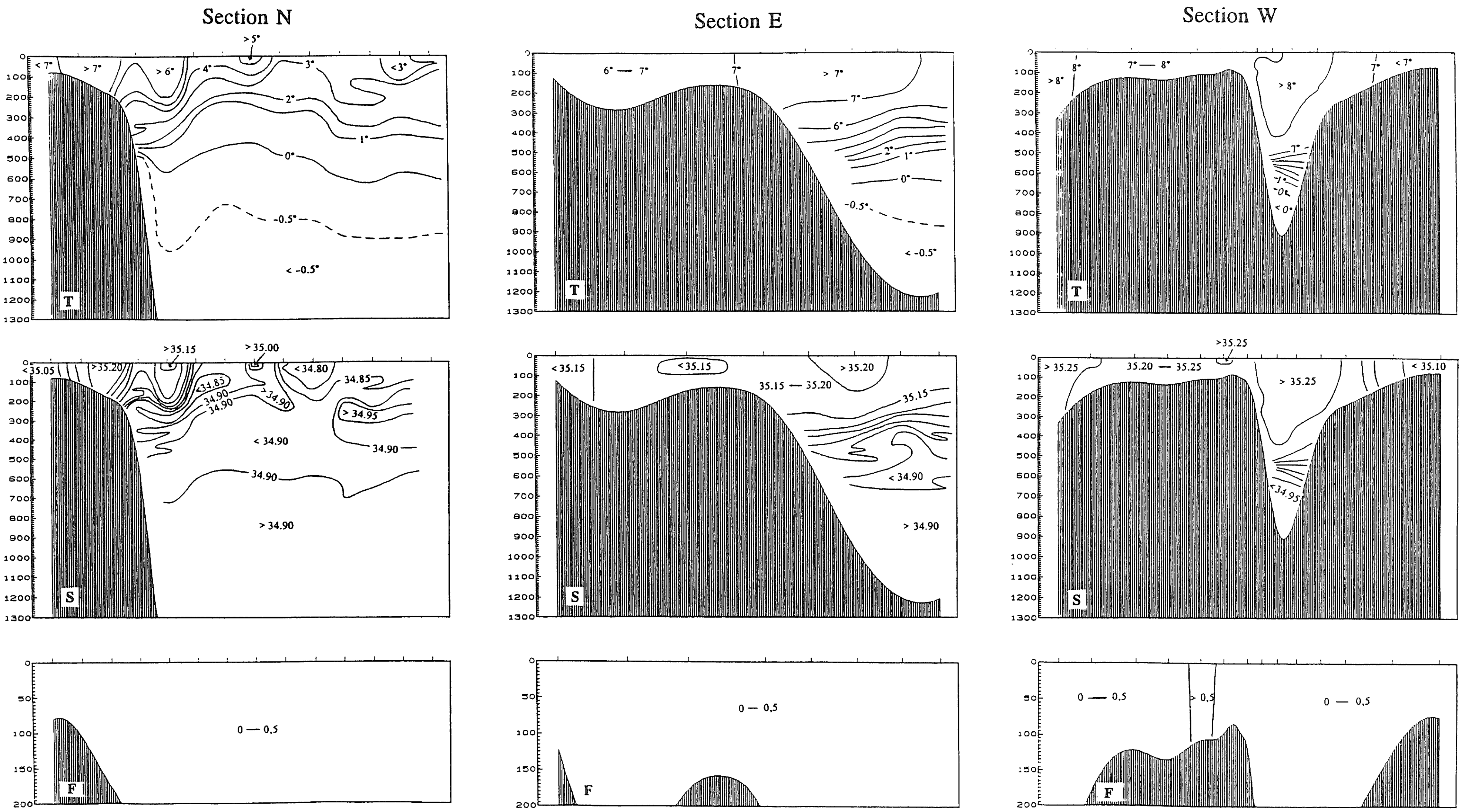


Fig. 5 6.March - 15.March 1992

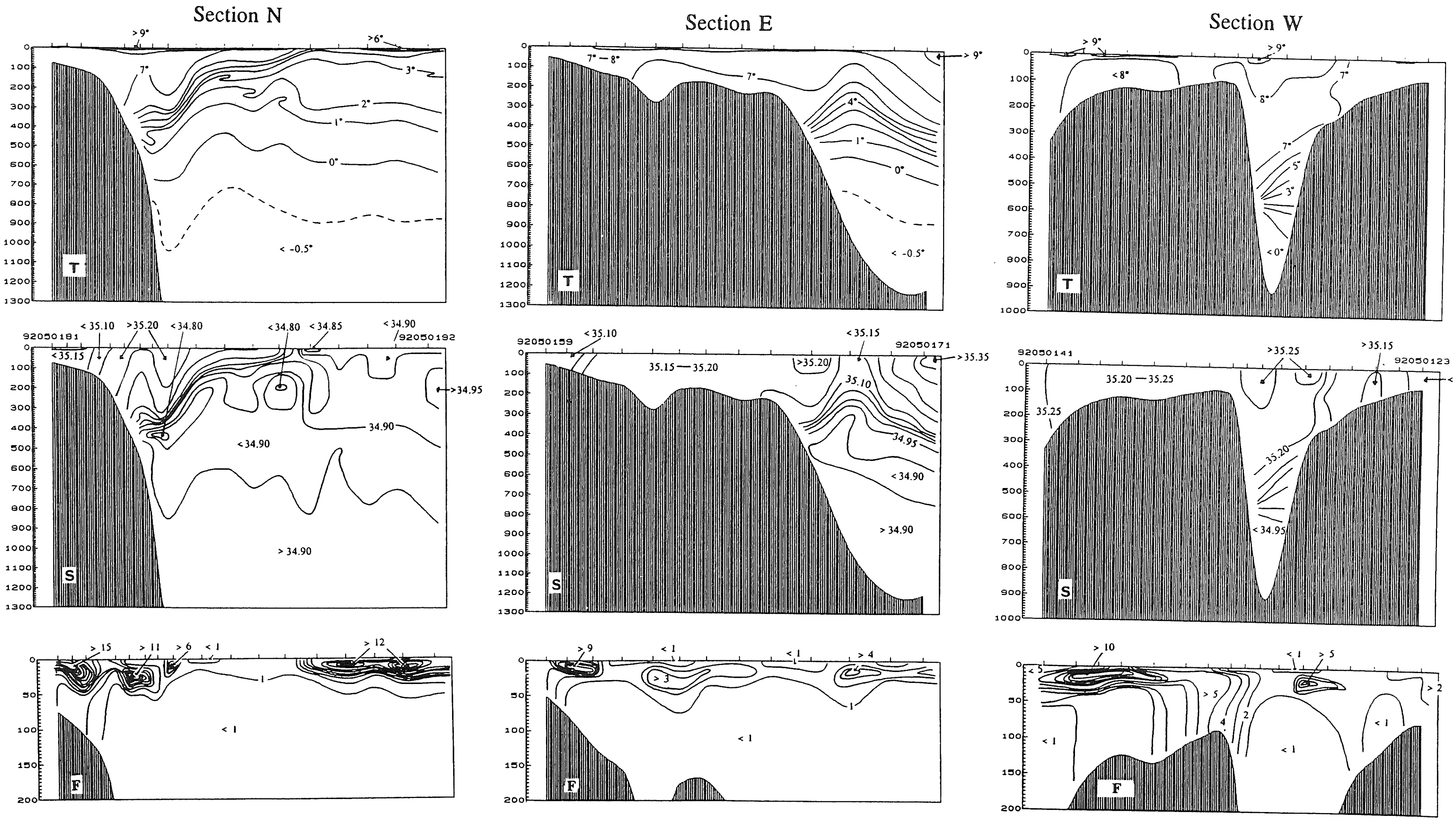


Fig. 6 22.May - 2.June 1992

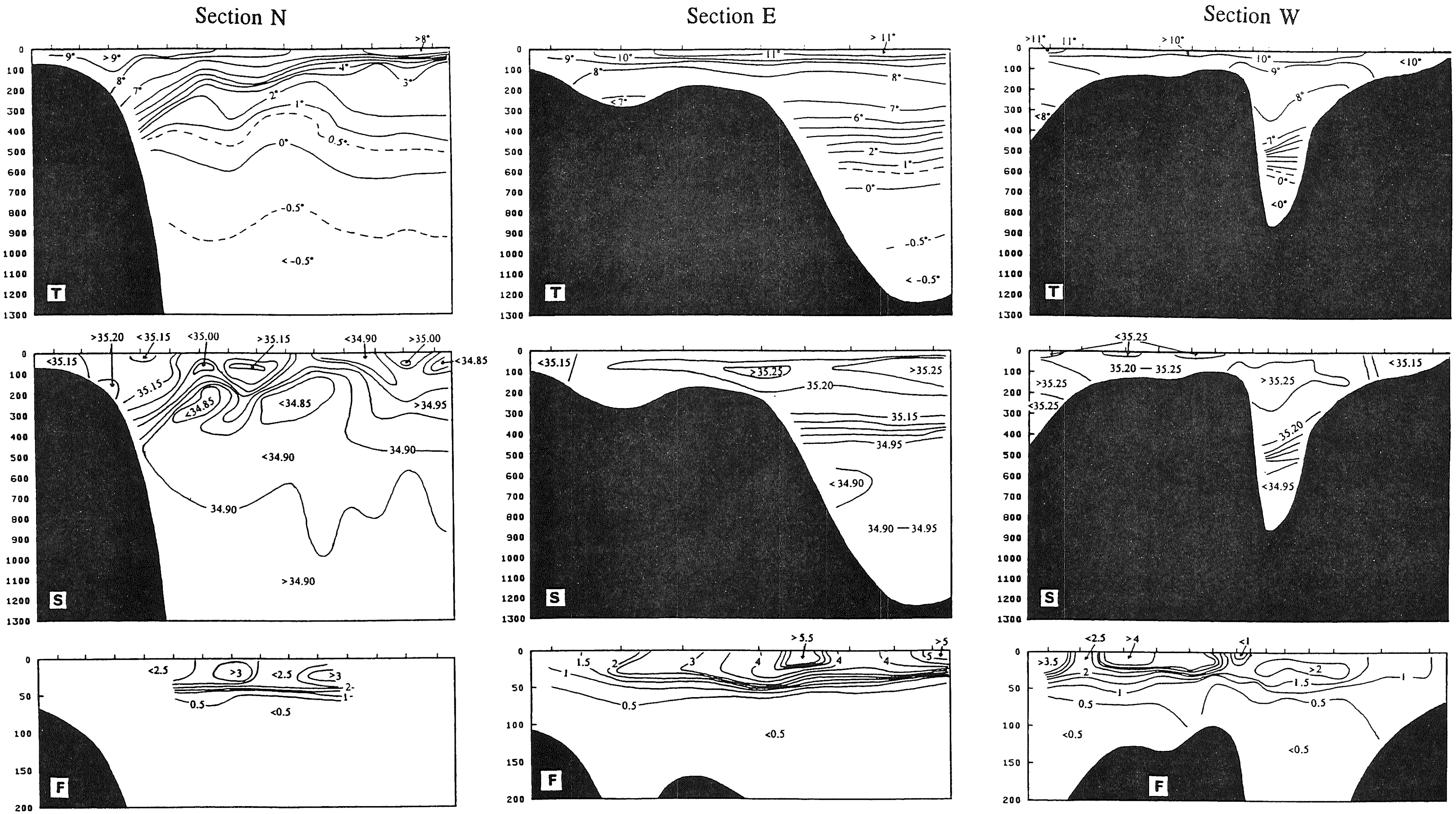


Fig. 7 13.July - 26.July 1992

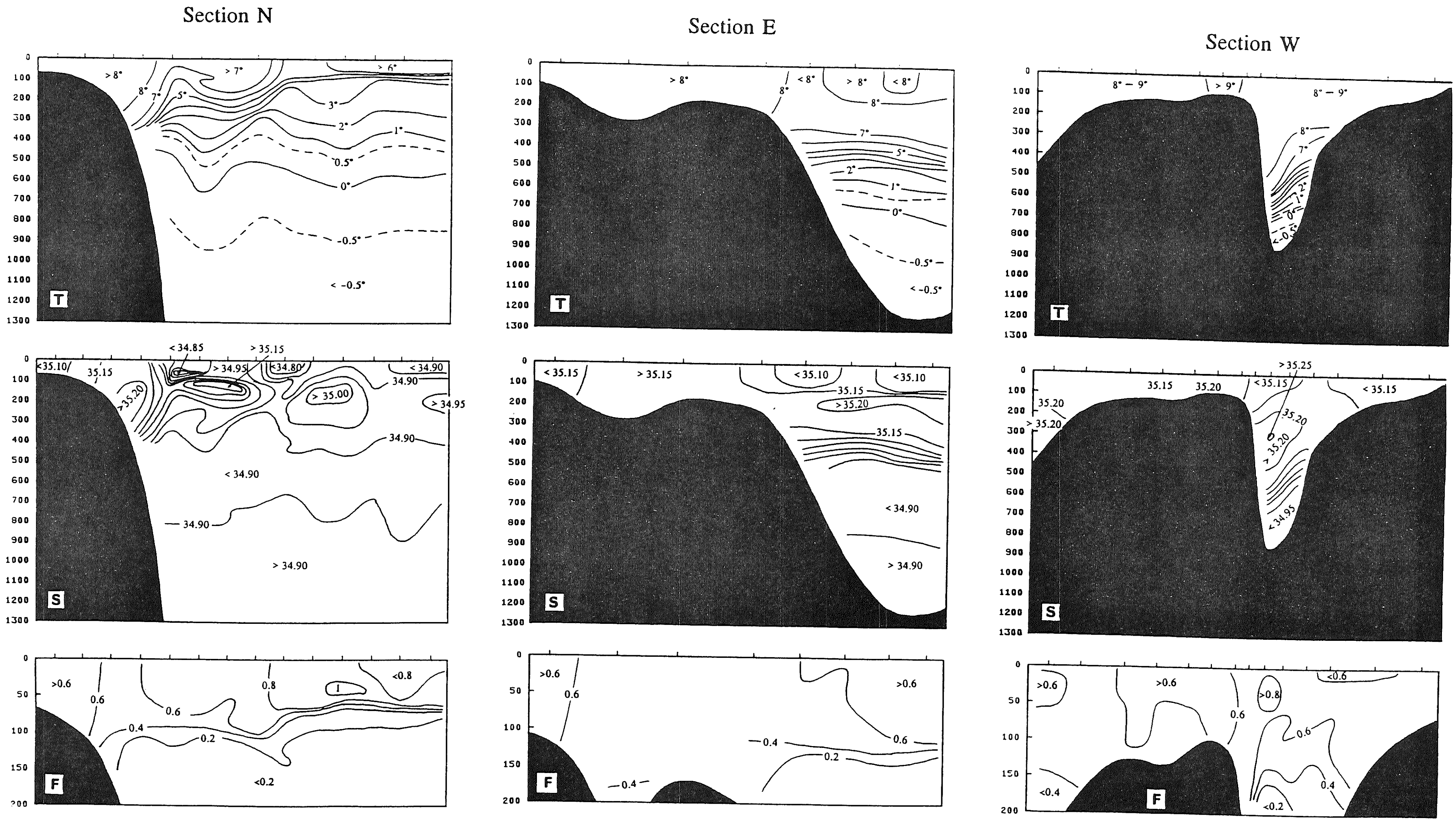


Fig. 8 29.Oct - 4.Nov 1992

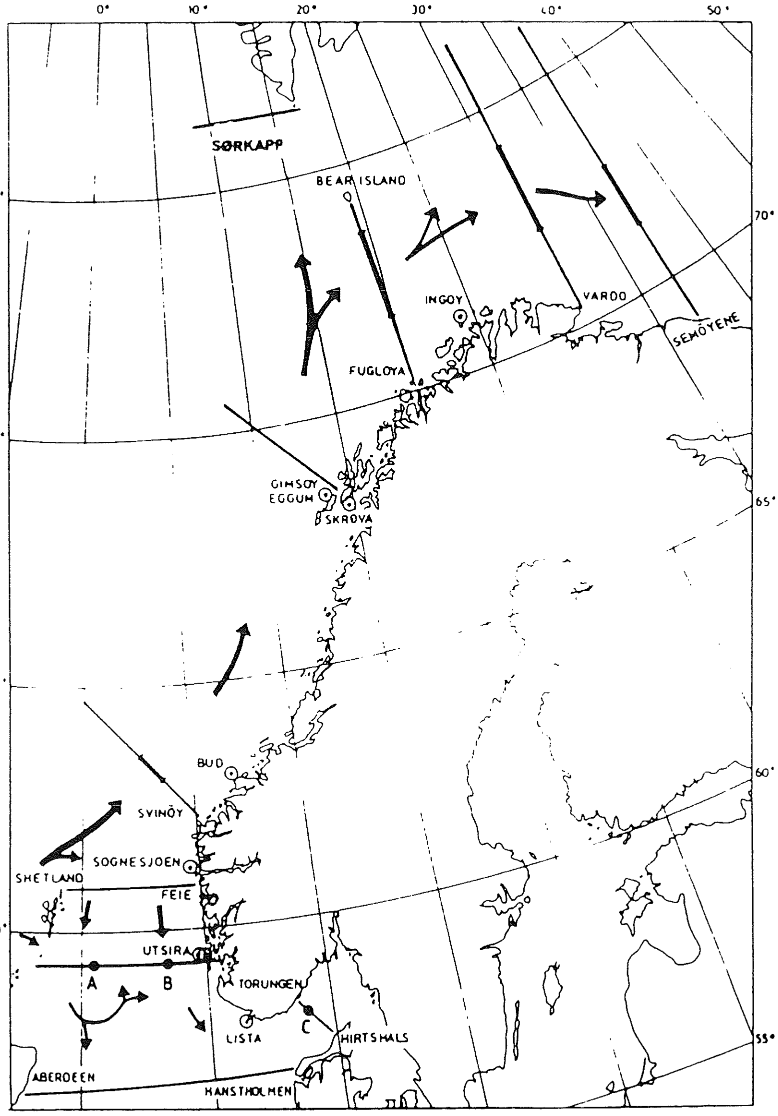


Fig. 9 Standard sections and stations ( ) together with a schematic flow-pattern for Atlantic water.

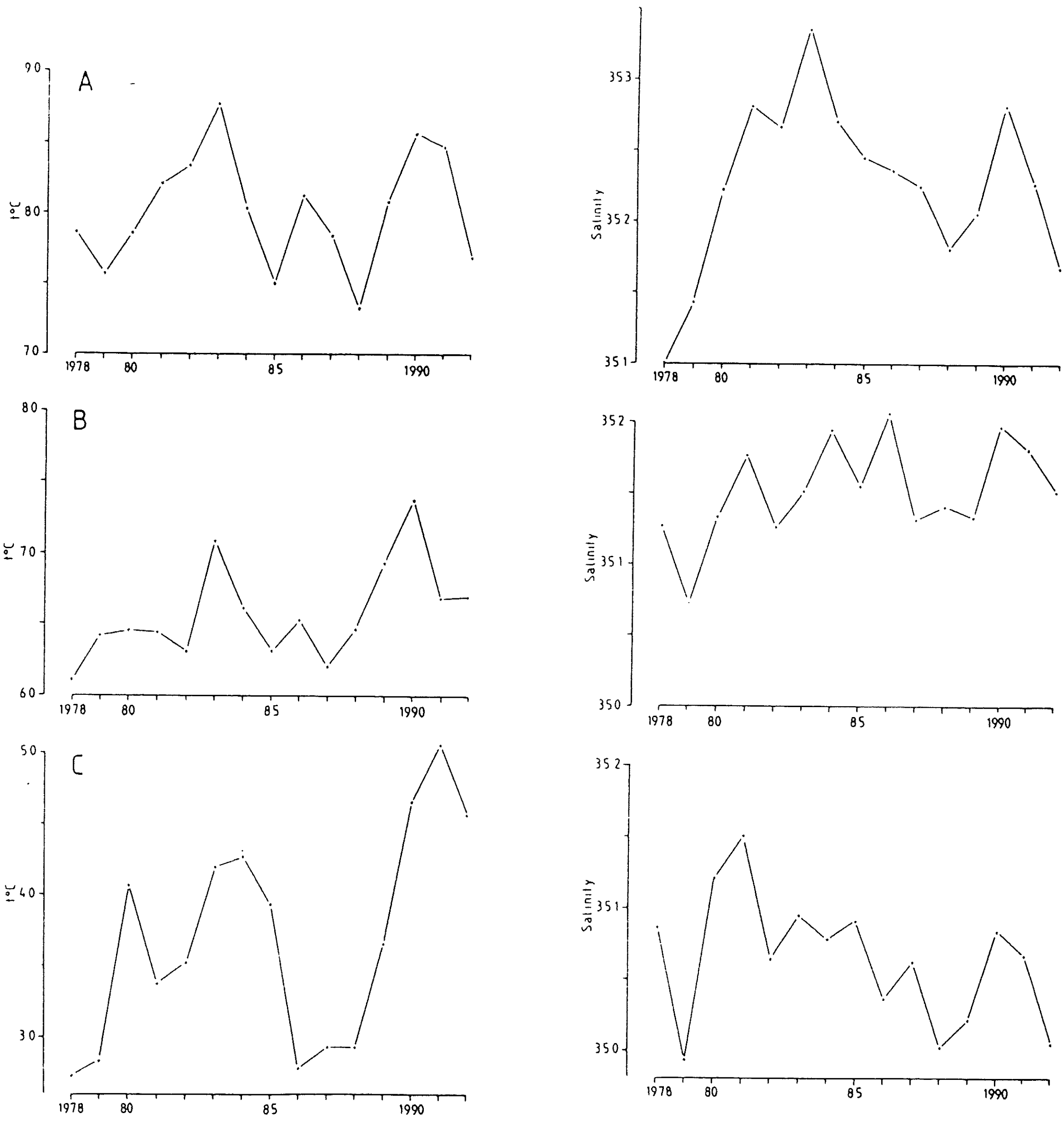


Fig.10 Trends in temperature and salinity (July/August) since 1978 at the sections off
A: Sørkapp (West Spitsbergen)
B: Grimsøy (Lofoten)
C: Svinøy

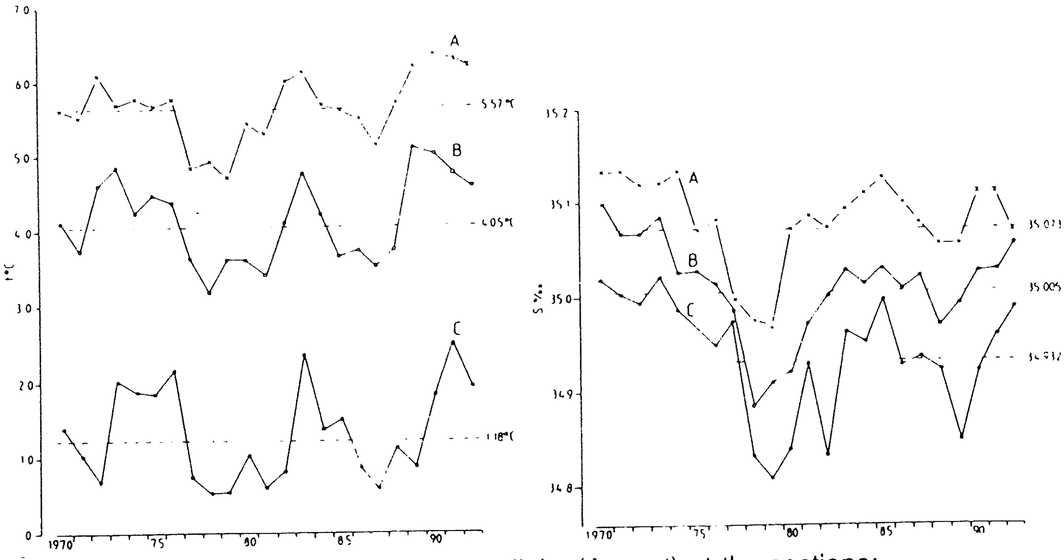


Fig.11 Trends in temperature and salinity (August) at the sections:
A: Fugløya - Bear Island
B: Vardø-N
C: Sem Islands-N
The mean value for the period 1970-1989 is indicated for each section

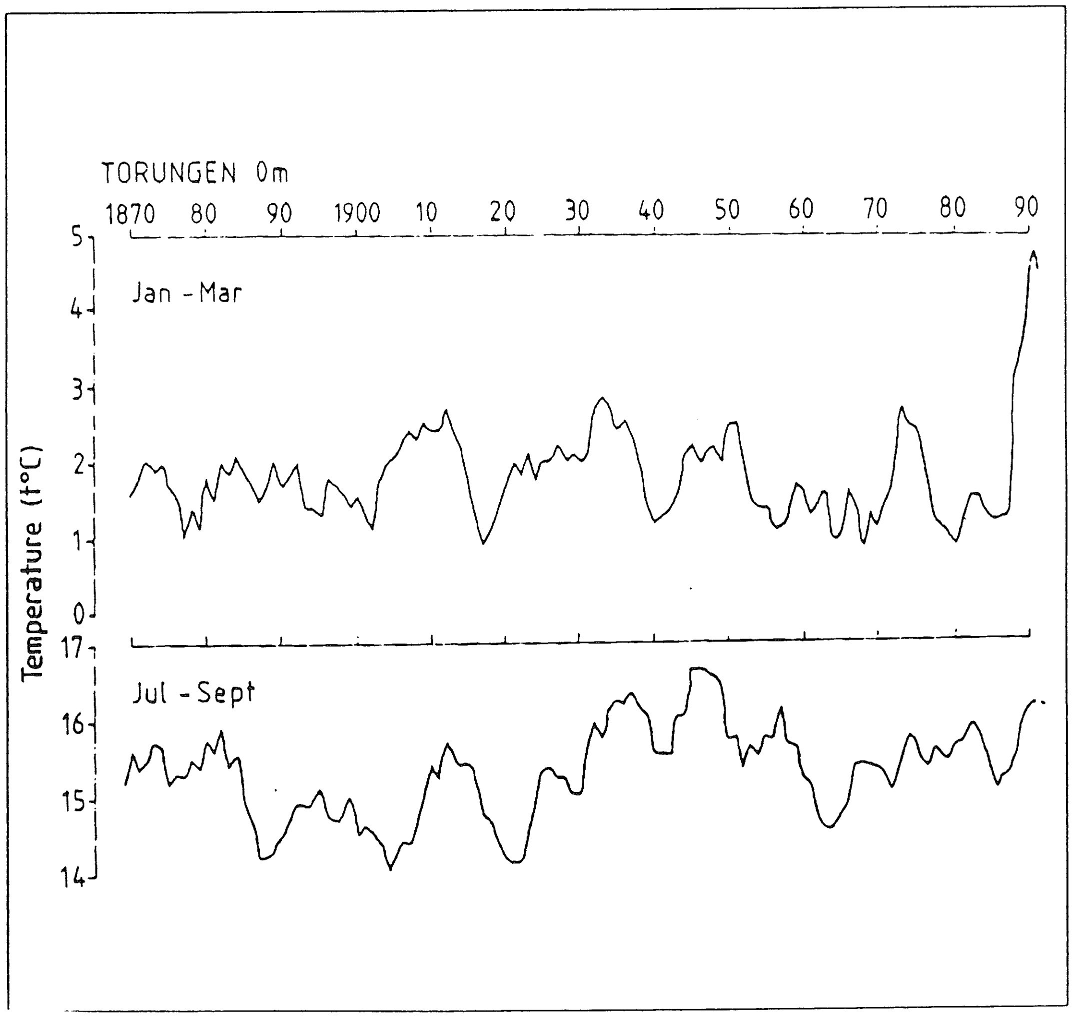


Fig.12 Surface variations (5 years running mean) at Torungen Lighthouse 1870 - 1990

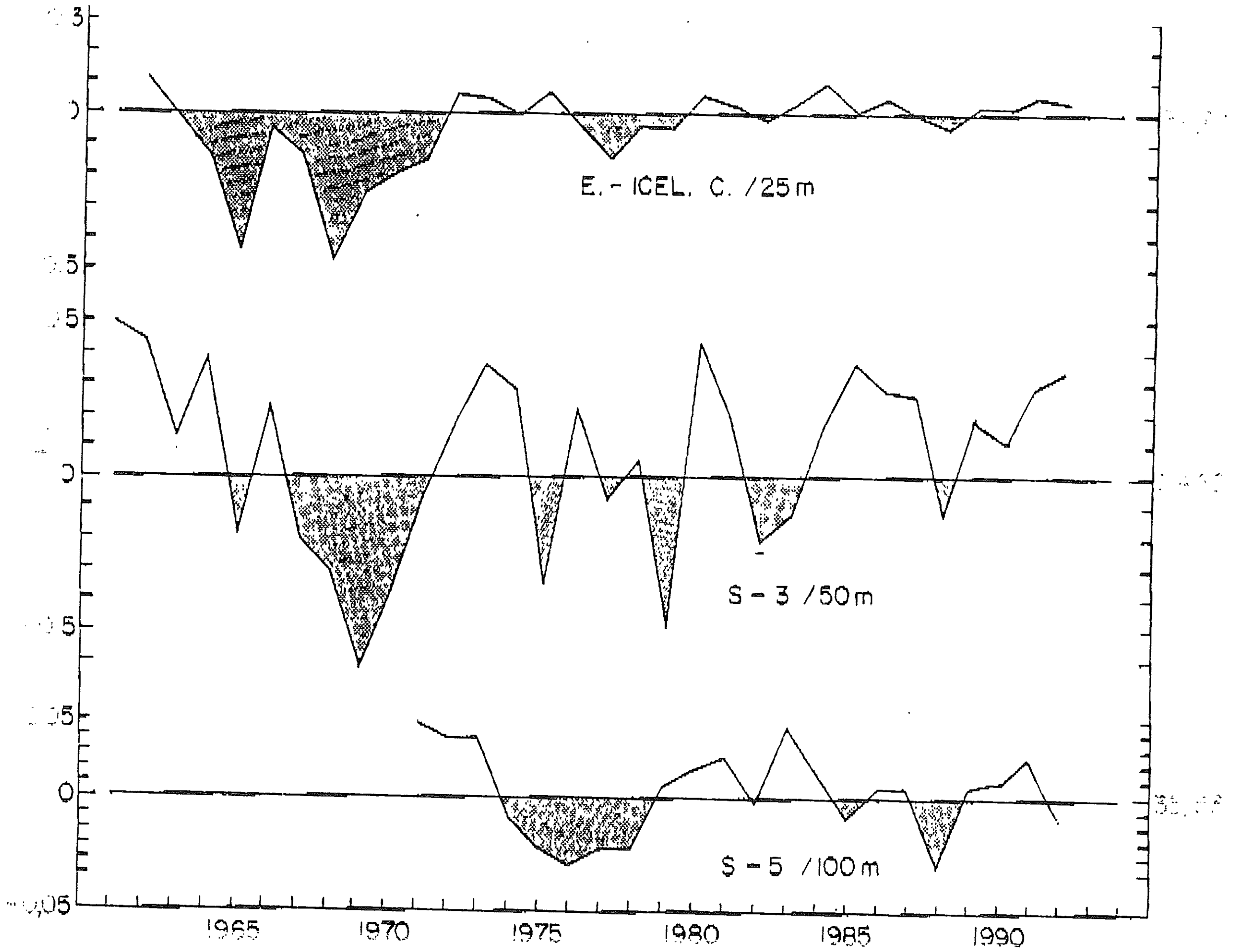
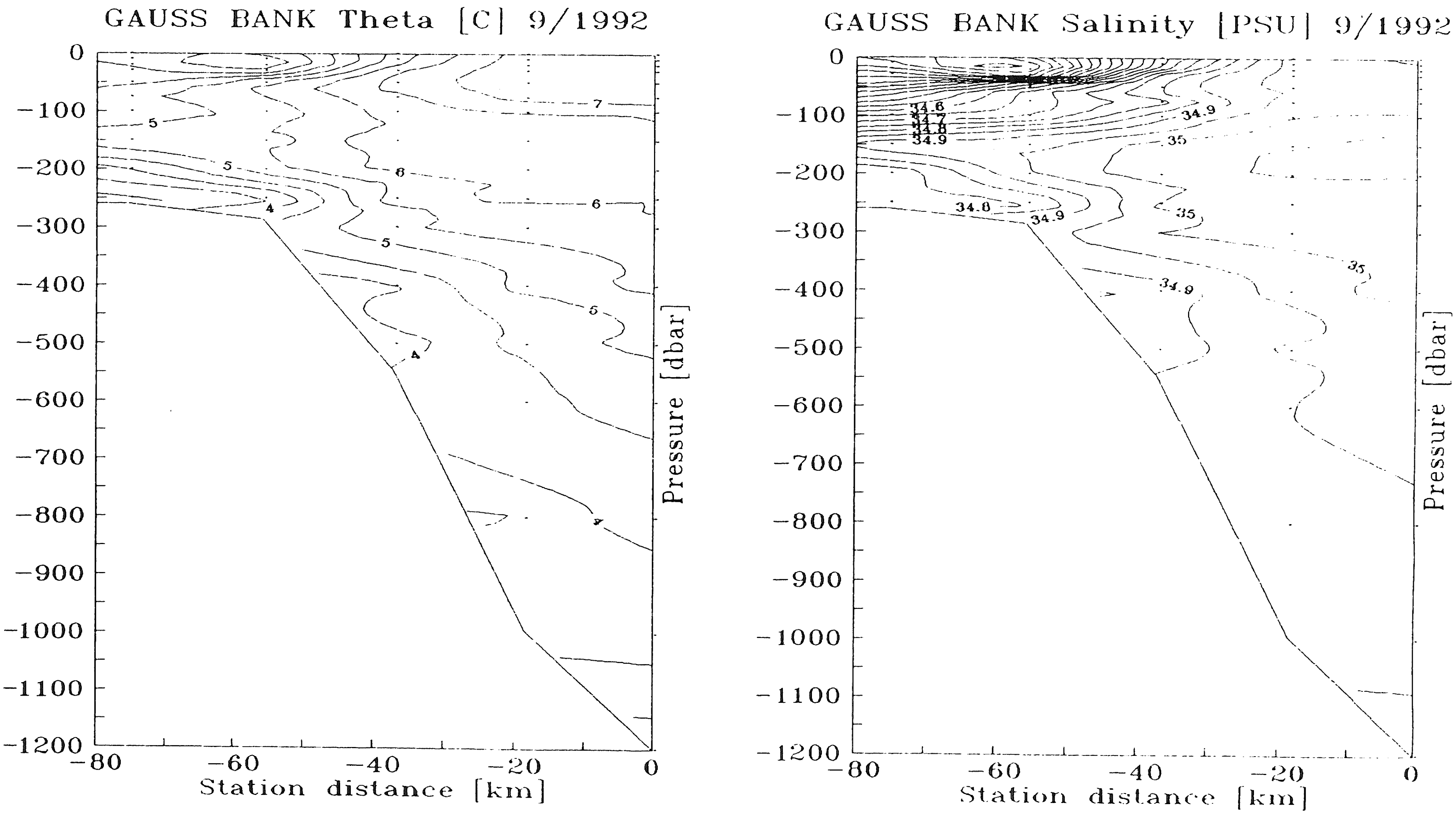


Fig.13 Salinity in the East Greenland Current (25m), North Icelandic shelf waters (50m) and South Icelandic shelf water (100m).

Fig.14


GAUSS BANK Theta [C] 9/1992
Pressure [dbar]
Station distance [km]
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
-1100
-1200
-80
-60
-40
-20
0
GAUSS BANK Salinity [PSU] 9/1992
Pressure [dbar]
Station distance [km]
34.6
34.7
34.8
34.9
35

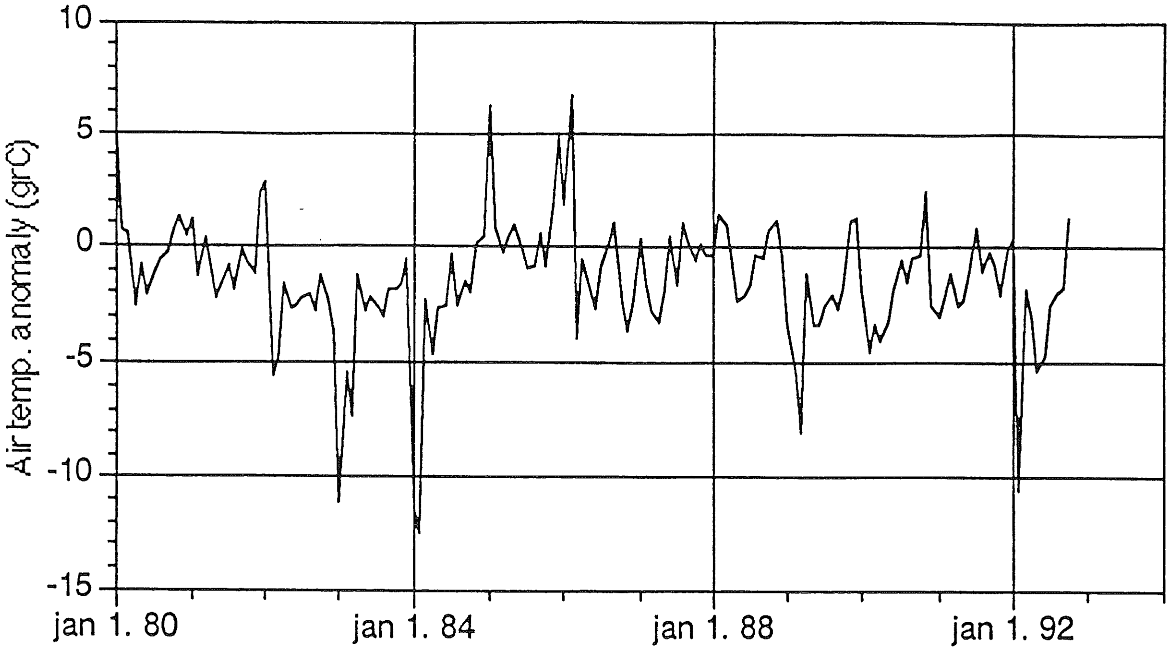


Fig.15 Monthly mean air temperature anomalies from Nuuk/ Godthaab, 1980 - 1992.

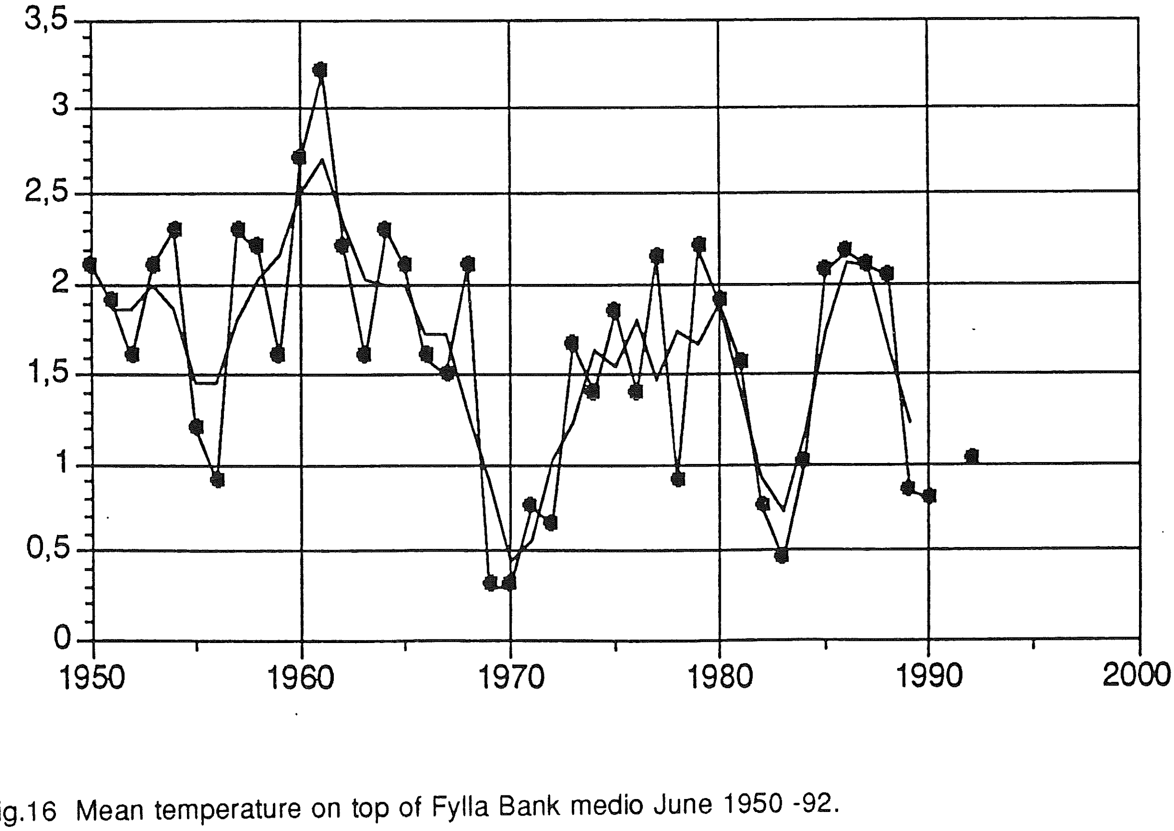


Fig.16 Mean temperature on top of Fylla Bank medio June 1950 -92.

---- Observed values

—— 3 years running mean

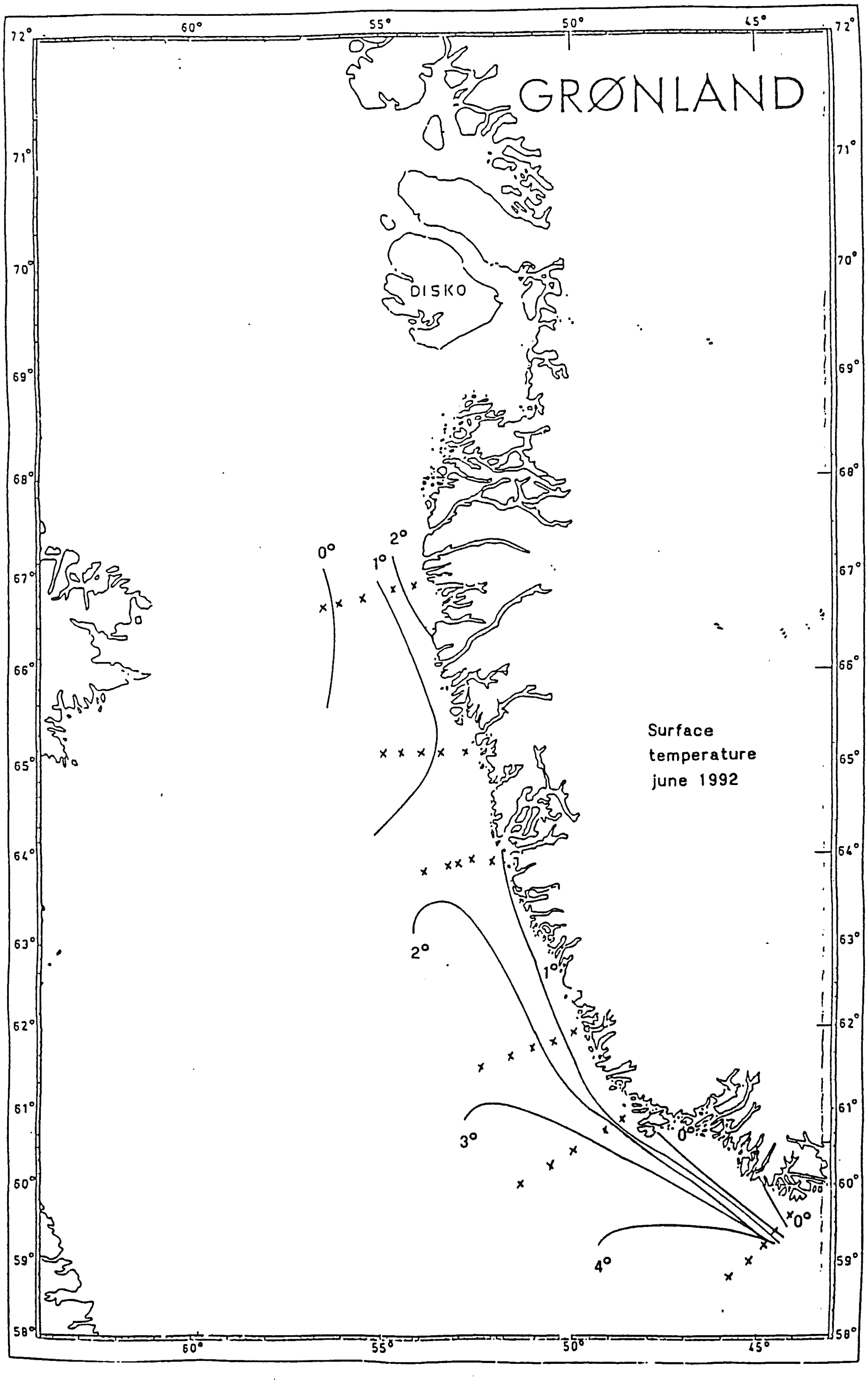


Fig.17 Surface temperatures, June 1992.

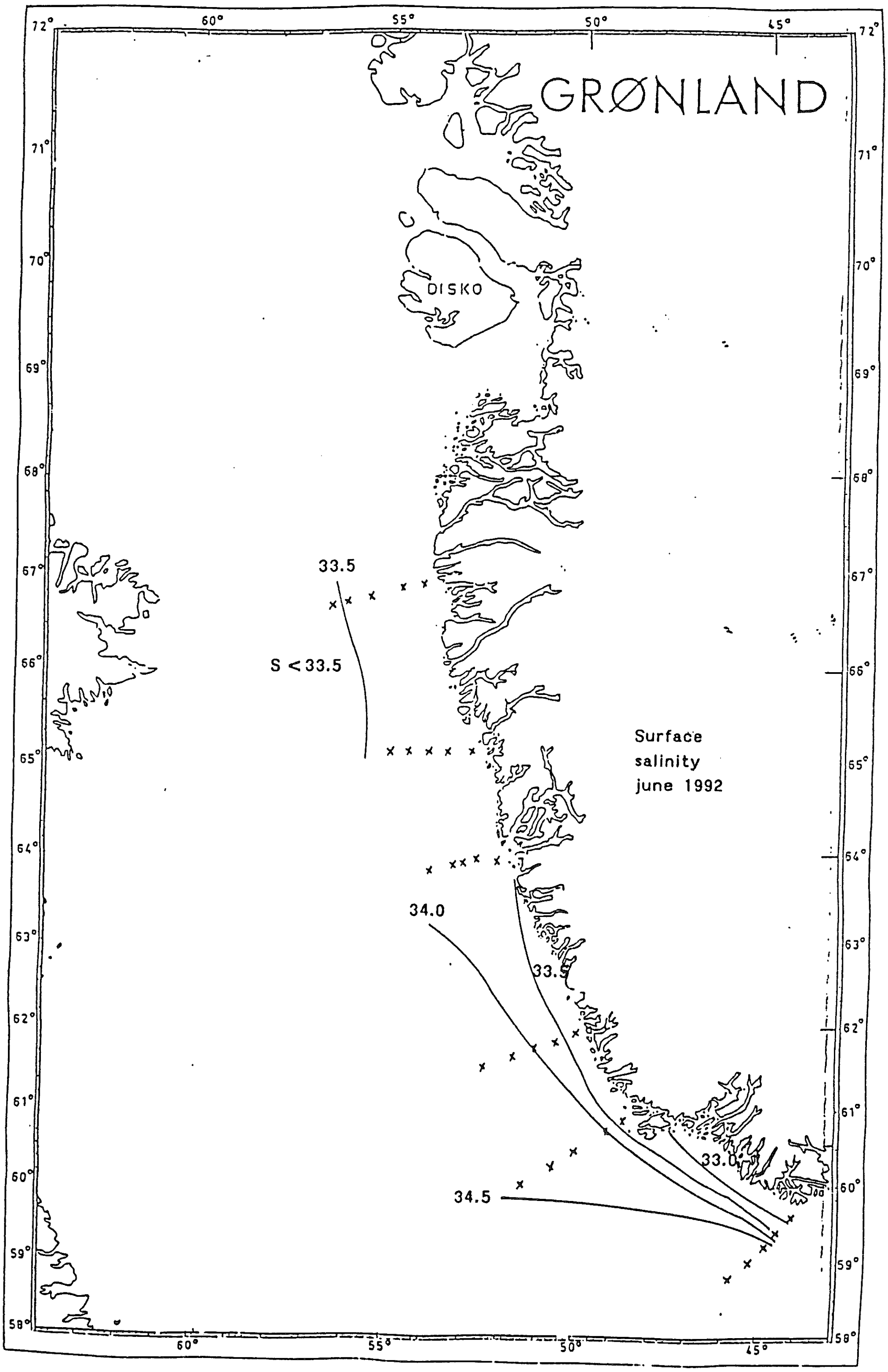


Fig.18 Surface salinities, June 1992.

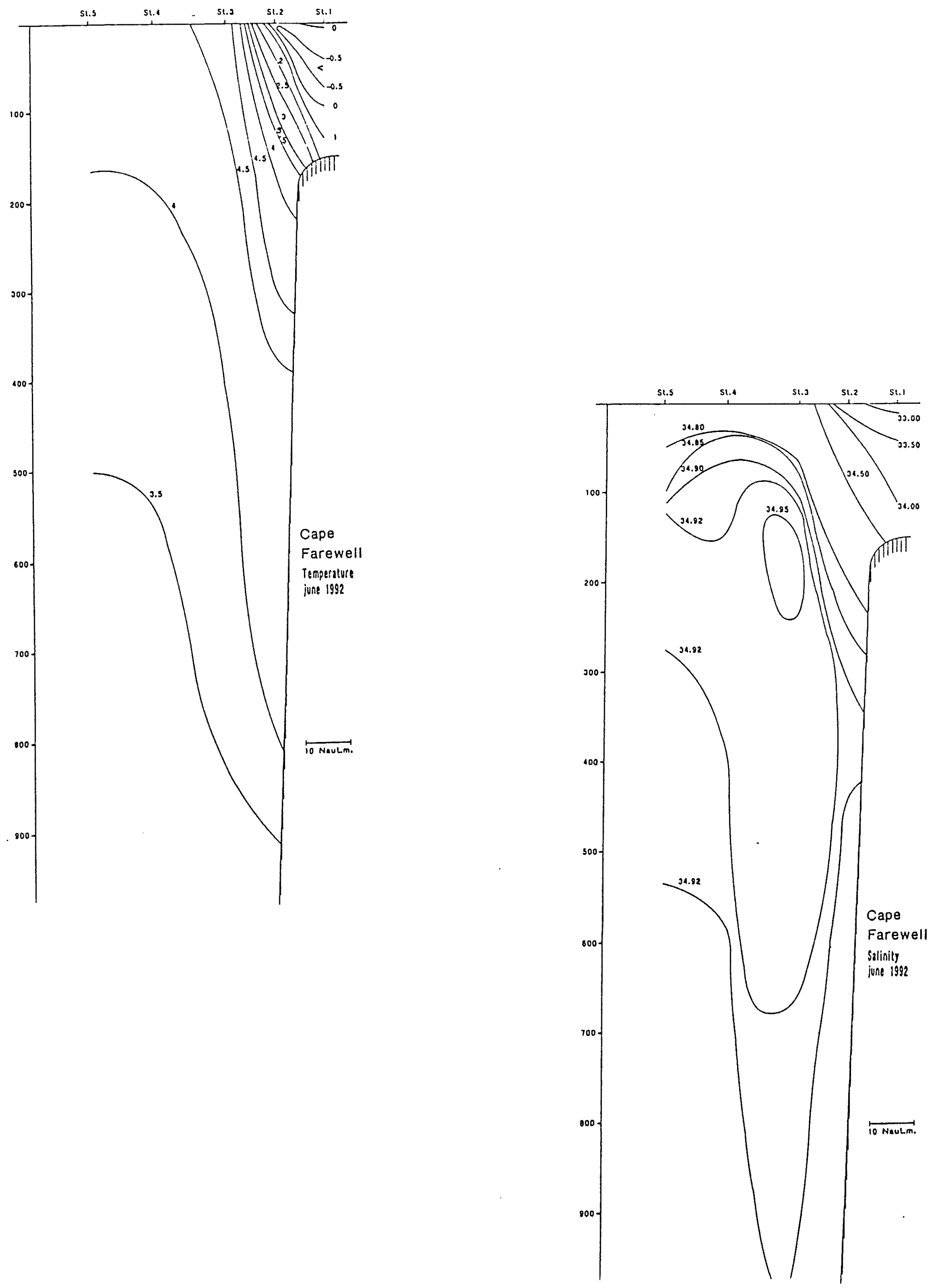
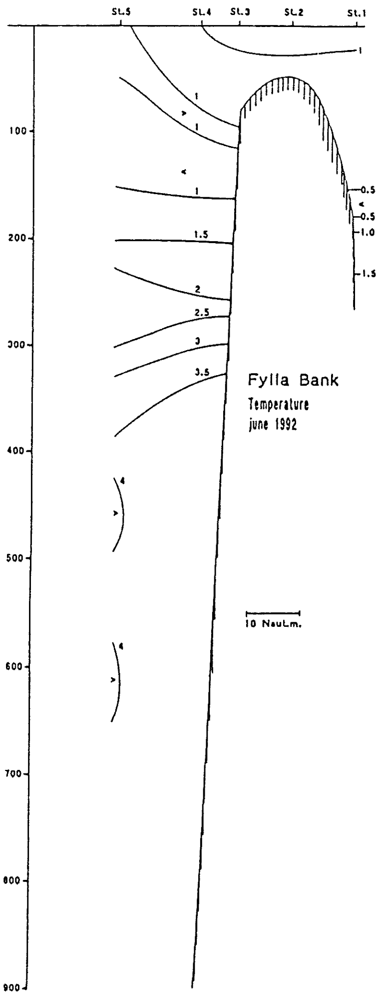


Fig.19 Vertical distribution of temperature and salinity at the Cape Farewell section, June 1992.



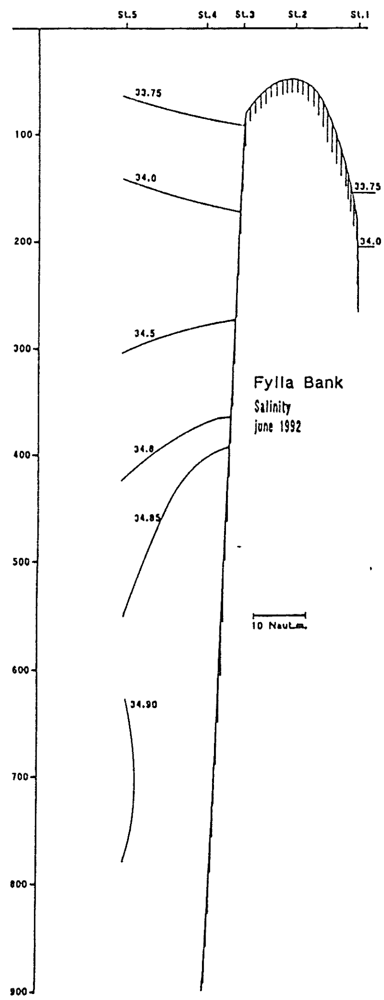


Fig.20 Vertical distribution of temperature and salinity at the Fylla Bank section, June 1992.

APPENDIX VIII

<u>Report of the *ad hoc* group on the 1989-91 high salinity anomaly</u>

G. Becker, H.D. Dooley, W.R. Turrell and D.J. Ellett.

A high salinity anomaly of magnitude approaching that of the 1970's low-salinity anomaly was observed in the ICES region between the English Channel (Fig. 1) and the northern North Sea in the years 1989 to 1991 (Fig. 2). The effects of the anomaly differed between the English Channel and the northern North Sea; in the first area, the amplitude of the signal increased towards the east and into the Southern Bight; along the slope zone west and north of Britain the amplitude gradually decreased. In the Southern Bight salinity values reached 35.6 psu during winter and spring 1990 and in winter 1991. In the Rockall Channel, a surface anomaly of ca. 0.06 psu was found in both winters, but upper water of lower salinity masked the high salinity water during the intervening period. In the northern North Sea, surface values of up to 35.485 psu were reported in January 1990. This exceptionally saline water appears to have been very patchy; a series of ten sections across the Rockall Channel and Faroe-Shetland Channel during November 1988 to September 1991 observed little water exceeding 35.4 psu although substantial subsurface cores of 35.40 to 35.45 psu were found. In October 1989, anomalies on the Fair Isle-Munken section (Fig. 3) showed that salinity was higher to a greater depth than usual. Salinity in the Modified North Atlantic water to the northwest of this section also had salinity somewhat above normal levels. The 1990 SST winter observations (Fig. 4) in the Skagerak were the highest since the time series started in 1870.

Nutrient levels in the anomalous water of the eastern English Channel were the lowest winter levels of ICES records. In the northern North Sea, salinity/nitrate ratios measured before 24th January 1990 were high, though notably lower subsequently. Unusual plankton species were observed in the German Bight and CPR records from the northern North Sea (Fig. 5) showed a remarkable increase which parallels a similar increase of temperature observed off the south Norwegian coast. Horse mackerel in large quantities were also abundant in the North Sea at this period.

No clear and obvious explanation for the anomaly can be suggested at present, although several contributory factors may be advanced. The anomaly occurred during a series of mild winters in shelf waters which coincided with the highest NAO winter index (Fig. 6) of the century in 1989, indicating a strengthening of westerly winds over the Atlantic Current. Because water of sufficiently high salinity is available over the deep water west of Ushant, a shift of position of the subtropical gyre by some 80 n. ml. could be enough to bring this water to the shelf-edge. In addition, the increasing eastward amplitude of the anomaly in the English Channel suggests that the evaporation/precipitation balance may have been upset by recent dry winters over southeastern Britain. The penetration of high salinity water well into the Southern Bight may indicate stronger transport through the Channel.

Such factors can only be further investigated by assembling all available data from cruises during the period, and members of the working group are urged to make all relevant cruise data available to ICES to enable the best possible distributions to be compiled. Rainfall and run-off data should be obtained for bordering land regions. Further detailed examination of this event may be as useful in advancing our knowledge of the European seas as the earlier studies of the 1970s salinity anomaly.

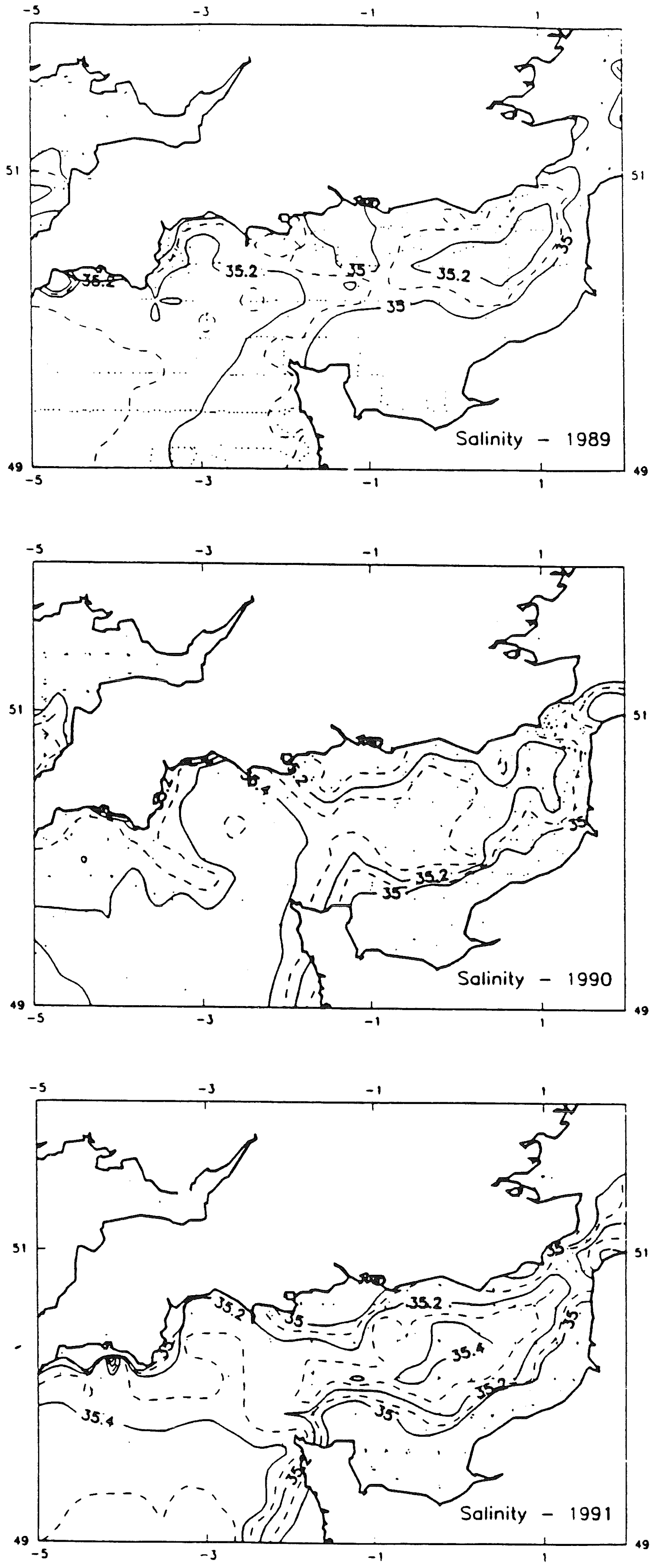
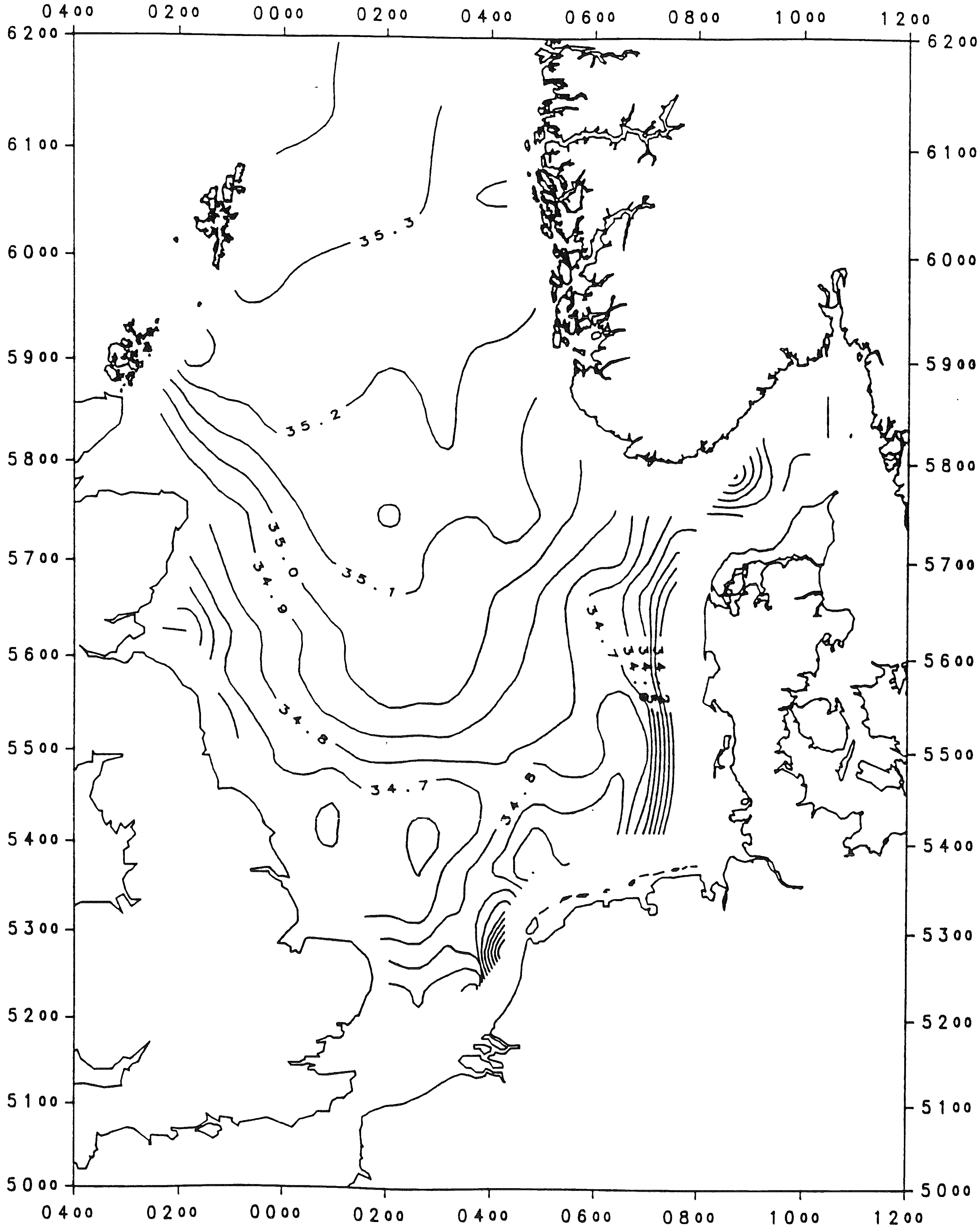


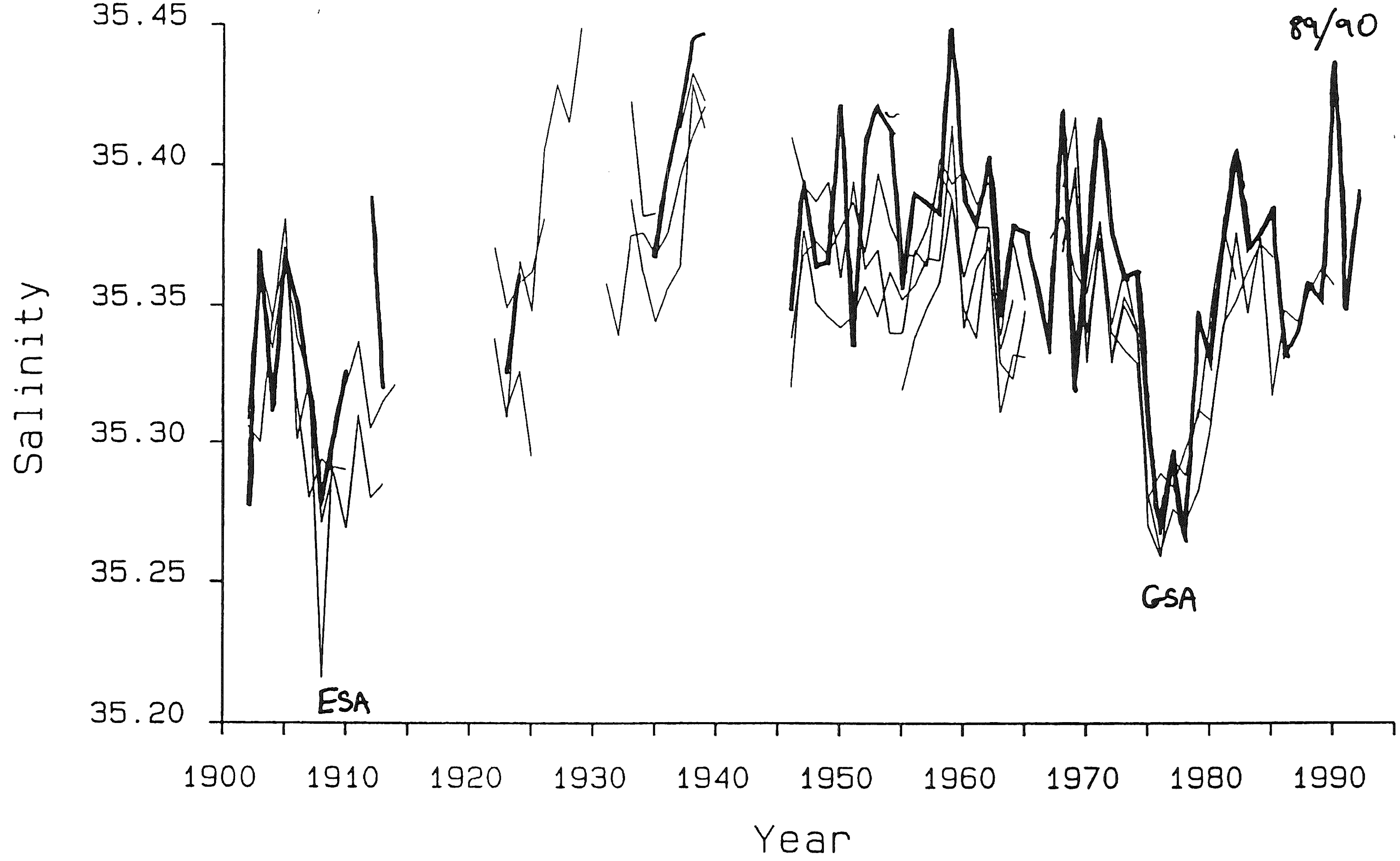
Figure 1 Salinity Distributions in English Channel, 1989-1991



IYFS 1990

Bottom salinity (February)

Figur 2



35.45
35.40
35.35
35.30
35.25
35.20
Salinity
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Year
ESA
GSA
89/90

1

Figure 3

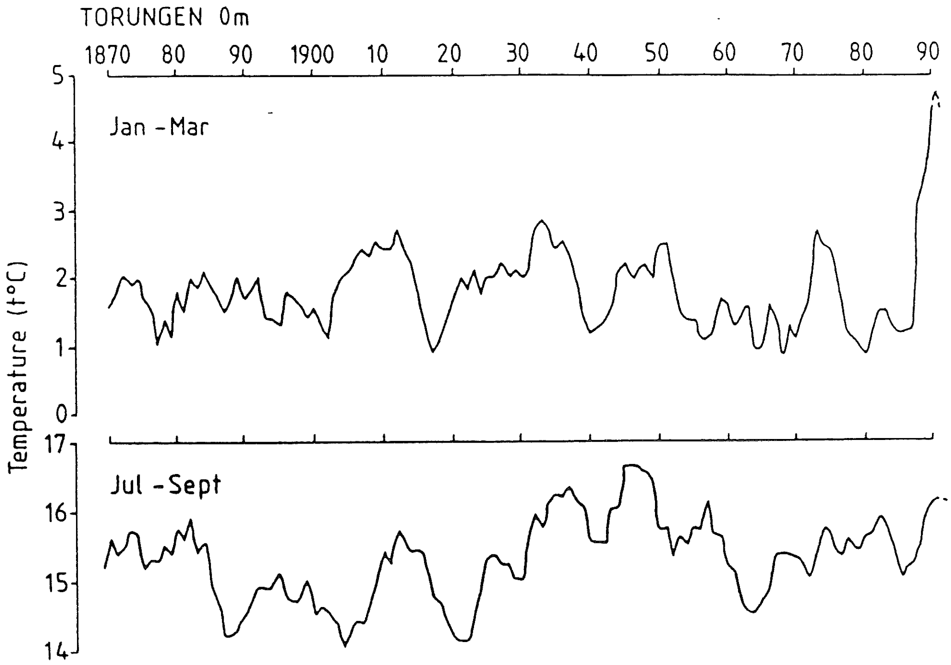
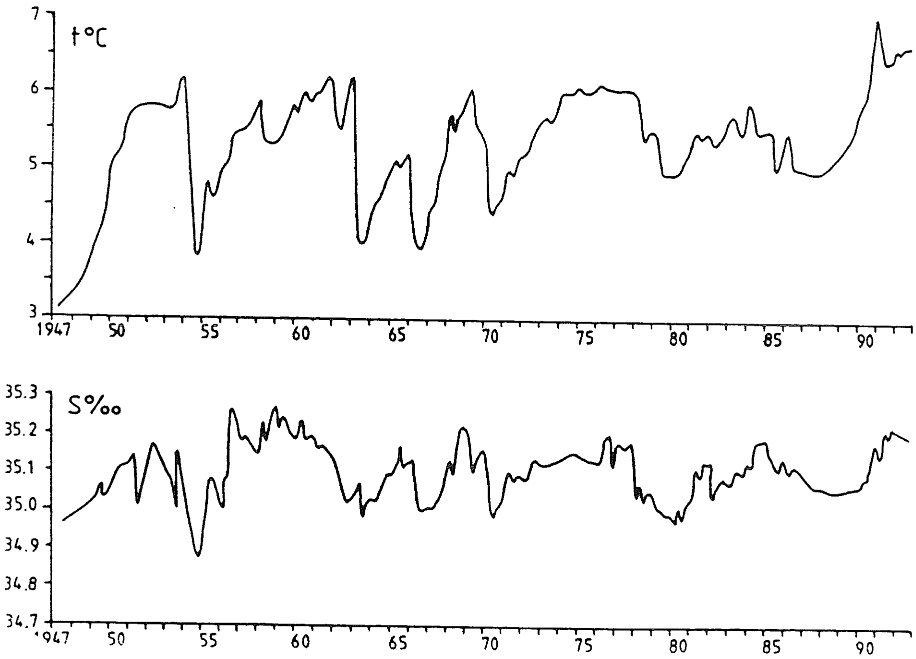

TORUNGEN 0m
1870 80 90 1900 10 20 30 40 50 60 70 80 90
Jan - Mar
Jul - Sept
Temperature (t°C)
5 4 3 2 1 0
17 16 15 14

Fig 4


t°C
7 6 5 4 3
1947 50 55 60 65 70 75 80 85 90
S‰
35.3 35.2 35.1 35.0 34.9 34.8 34.7
1947 50 55 60 65 70 75 80 85 90

C

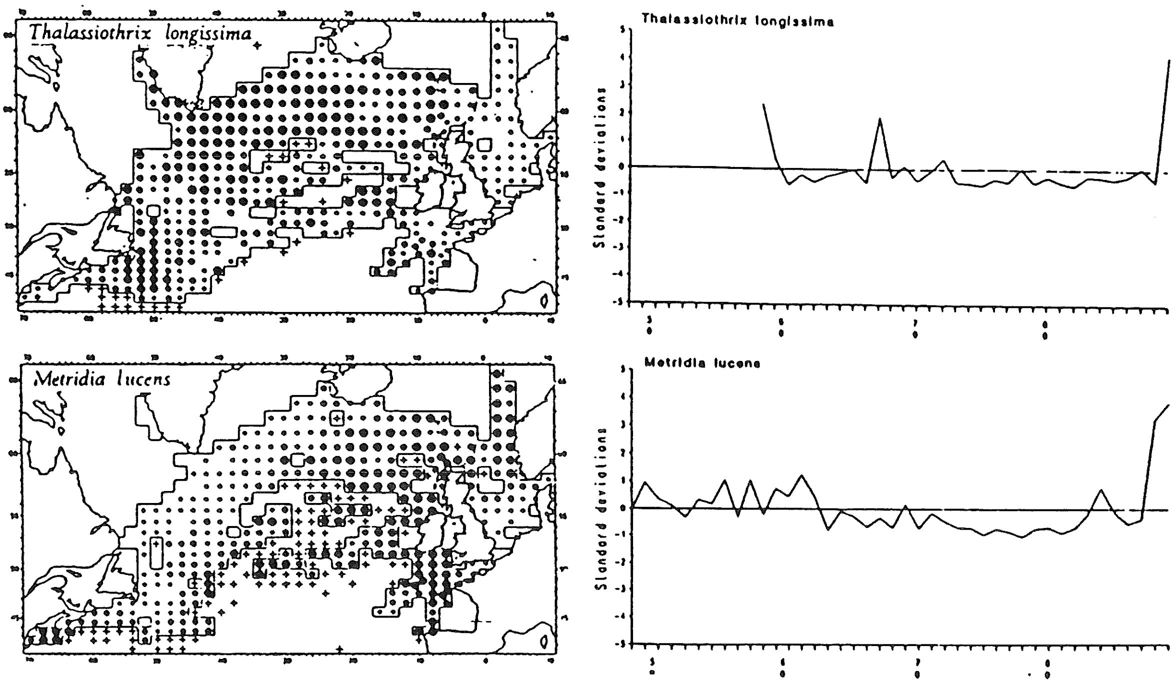
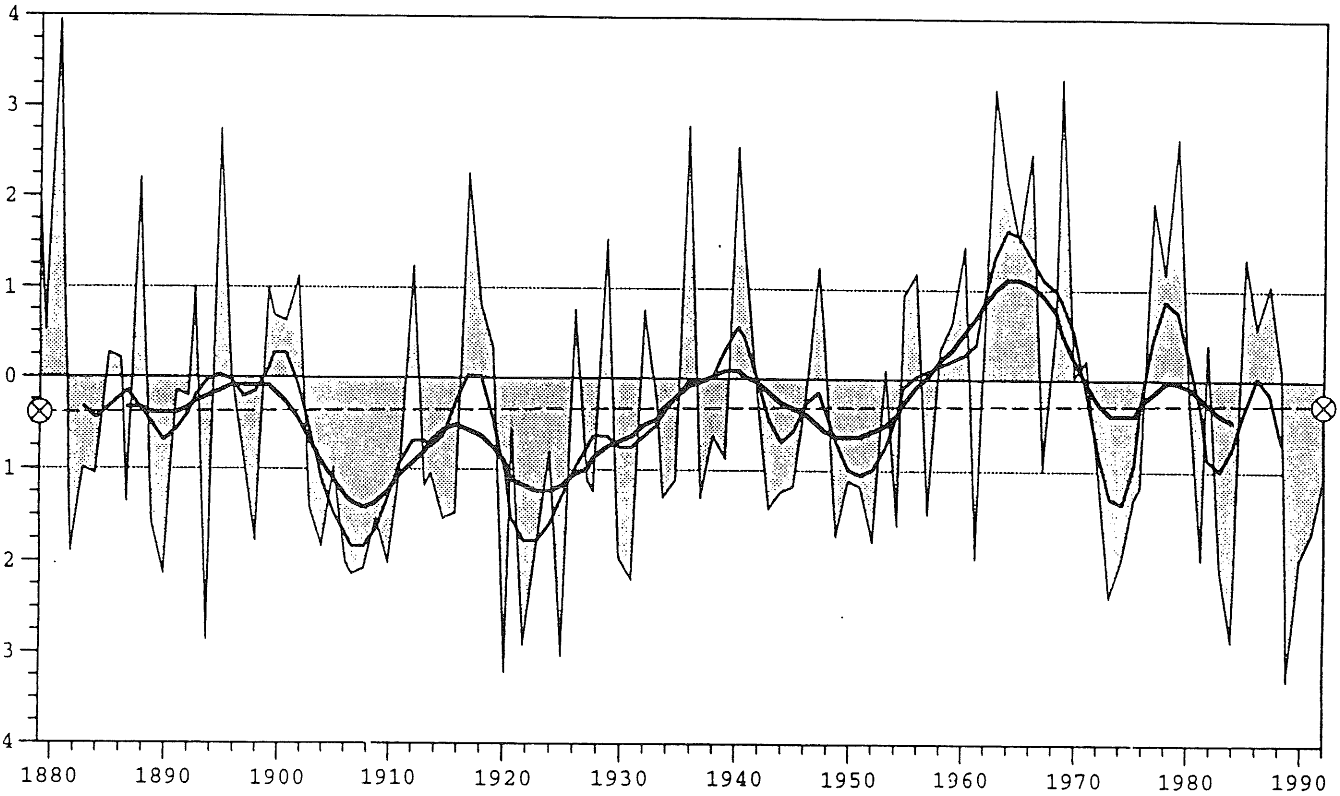

Thalassiothrix longissima
Metridia lucens
Thalassiothrix longissima
Standard deviations
Metridia lucens
Standard deviations

Fig 5


4
3
2
1
0
1
2
3
4
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990

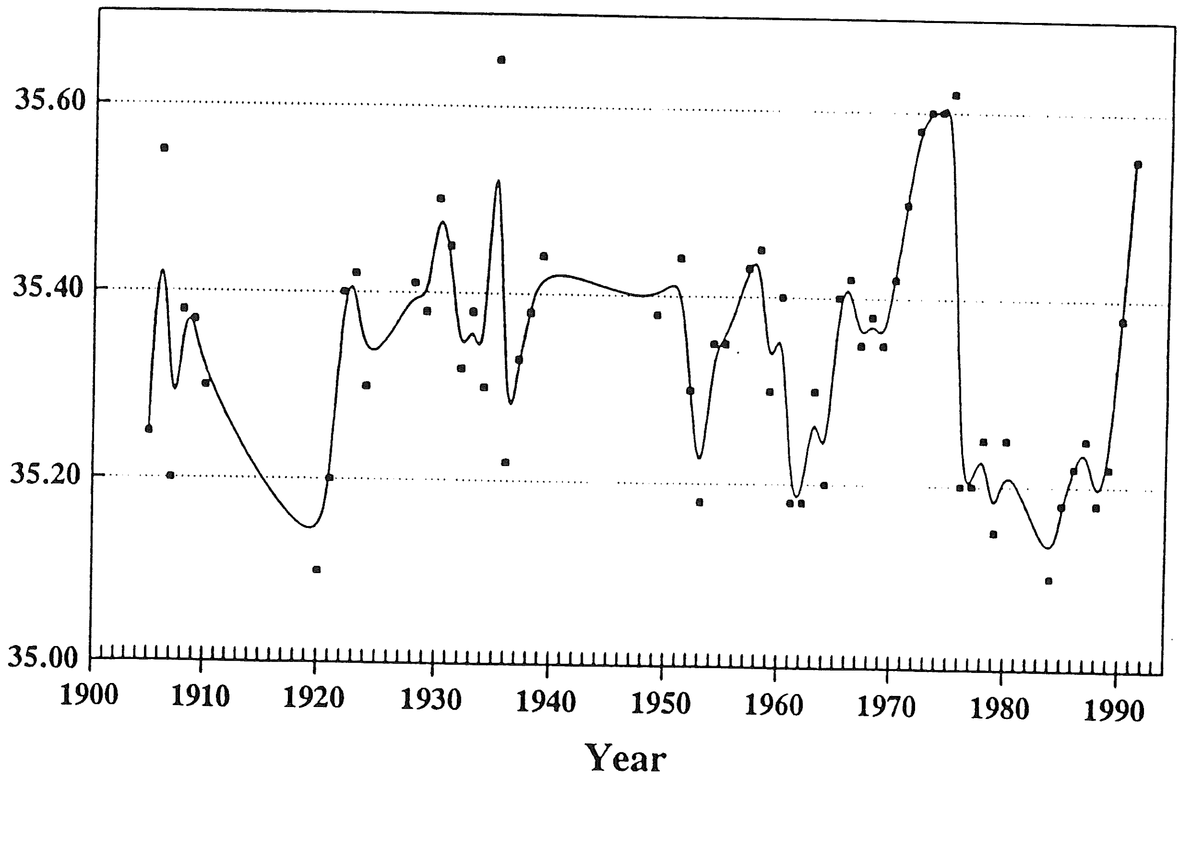

35.60
35.40
35.20
35.00
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Year

Fig. 6

APPENDIX IX

UNIVERSITY OF CALIFORNIA, SAN DIEGO UCSD

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April 7, 1993

Dr. Robert Dickson
Fisheries Lab
Lowestoft
Suffolk NR 33 0 HT
United Kingdom

Dear ~~Dr. Dickson~~ Bob,

Scripps and Lamont-Doherty are organizing a program addressing the ocean's role in climate change on the decade to century time scale. The program will include study of past climate changes as recorded in the geological/geochemical record and examination of the processes of the present thermohaline and overturning circulation. Both of these threads will involve field observations, modeling and analysis of existing observations. We hope to fashion a coordinated program under the auspices of the NOAA Office of Global Programs. It will involve SIO and LDEO along with scientists from the broader academic community including NOAA laboratories. We intend to develop our plans sufficiently to submit a substantial proposal to NOAA this July.

Two science planning meetings will be held to develop focused sub-programs in the two areas, the paleo record and processes in the present climate. LDEO is hosting a meeting for the paleo sub-program and we are here inviting you to attend the planning meeting for the modern climate sub-program. The latter meeting will be held on 17-18 May in San Diego. We can provide limited support for your travel and subsistence while at the meeting.

At this point we see the modern climate activities focusing on a combination of closely related topics. The challenge for the meeting will be to put together a coherent attack that will address the most scientifically important aspects. The topics we are thinking about for the San Diego meeting are:

Thermohaline Circulation of the North Atlantic. The importance of the overturning circulation of the North Atlantic to climate is evidenced in models and in the paleo record. Abrupt and large changes in the past are known and smaller changes are evident in the instrumental record. Is there a scientific basis for stating the likelihood of future significant changes or predicting the factors that will lead to such changes? Would we know if it were happening now? We suspect that progress here will come by developing models that incorporate the best physics as verified by large-scale observations. What parts of the present circulation they must get right? Do we know the right answers well enough to identify inadequate models? Will we learn more by better understanding rate processes in the present circulation or defining changes? Do we need to know more about the surface transports into the Nordic Seas or just what comes out?

Overturning Circulation in the Southern Ocean. Models suggest that bottom water formation in the Southern Ocean is a bi-stable process. There are no instrumental observations of climatically relevant changes in the Southern Ocean and the paleo-record is less clear than in the North Atlantic. Are there changes like we have seen in the North Atlantic? The climatically important overturning circulation in the Southern Ocean also involves strongly wind-driven transports, ice formation and melting and very vigorous air-sea interaction, all of which determine the properties of shallow Southern Ocean waters. These waters influence both deep convection and the character of intermediate waters which invade each of the temperate-latitude oceans. Thus atmospheric forcing must influence stratification in all oceans. How? What governs the rate of deep and intermediate water formation? Atmospheric conditions, rate limiting steps in the deep ocean, ice dynamics, or the near-surface process removing fresh, low-density water from the Antarctic coast?

Climate Processes. Models and comparative descriptive work show the critical role that surface-layer salinity plays in regulating thermohaline processes in both hemispheres. What can be learned about the mean water cycle and its climatically relevant variations? Ultimately much of the ocean's role in climate is manifested in its transport of heat. What is needed to better understand not only heat transport, but its variations? Similarly, deep-water formation subducts other climatically important properties like CO_2. These processes need to be properly modeled and their rates learned. Perhaps most basic, yet most important, of all: What is the overturning circulation? Do we need to know this or can we trust models to describe variations of a climate it cannot describe?

Future Observing Systems and Models. Investigations on decadal time scales must involve substantial modeling. No other approach is feasible. At the same we must know how the real climate is changing and what processes are responsible. The marine observations south of 35°S are frighteningly sparse. How do we make progress toward developing the models and observing systems needed without demanding unreasonable resources?

I think that this gives you an idea of what we are thinking about and I hope that it sounds interesting. We plan to have a group of about 20 scientists in San Diego to carry planning forward. This will represent a core of leaders but others will also participate. Peter Niiler and Peter Schlosser are putting together a "white paper" that is intended to serve as the outline for the "modern climate" part of the program and you should receive that by the end of April. We will also forward specifics on travel separately. I hope you will be able to join us and that we can fashion a program which both meets the nation's needs and advances science.

Yours sincerely,

Russ E. Davis

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