INSTITUTE OF MARINE RESEARCH
BERGEN, NORWAY

CRUISE REPORT

CRUISE NUMBER: JH1998210

VESSEL: R/V "JOHAN HJORT"

DEPARTURE: Tromsø, Norway , August 1, 1998

ARRIVAL: Tromsø, Norway , August 23, 1998

PORT OF CALL: Tromsø, Norway on August 11, 1998

PARTICIPANTS:

Name	Affiliation	Responsability
Francisco Rey	Institute of Marine Research, Bergen	Chief scientist
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Jarle Kristiansen	Institute of Marine Research, Bergen	Instrument operator
Marianne Holm	Institute of Marine Research, Bergen	Salmon investigations
Lisa Miller	Institute of Marine Research, Bergen	Thorium investigations
Sean Chamberlin	Fullerton College, California, USA	Fluorometry
Fred Menzia	NOAA-PME , USA	CFC
Ken Eriksson	Brookhaven National Laboratory, USA	CFC
Leif Anderson	Univ. of Gøteborg, Sweden	CO_2
Agneta Fransson	Univ. of Gøteborg, Sweden	CO_2

SCIENTIFIC OBJECTIVES

The cruise had several major objectives:

1) To carry out physical, chemical and biological investigations in the Greenland Sea and northern Norwegian Sea in connection with the following research projects:

• "Mixed layer dynamics, nutrient supply and primary production in the Nordic Seas". The project is supported by a grant from the Norwegian Research Council and is part of IMR´s research program "Mare Cognitum".

• " Biogenic carbon production in the upper layers of the Greenland Sea as a function of vertical nutrient fluxes". The project is supported by a grant from the European Commission through its MAST-III program MAS3-CT95-0015 " European Subpolar Ocean Programme-2: The thermohaline circulation in the Greenland Sea" and it is also part of IMR´s research program "Mare Cognitum".

2) To carry out studies on the inorganic carbon system in the Greenland Sea. This work is also a main component of the " European Subpolar Ocean Programme-2: Thermohaline circulation in the Greenland Sea" financially supported by the European Union (MAS3-CT95-0015)

3) To carry out hydrographical, chemical and biological oceanographical observations at the standard Norwegian section Gimsøy-NW as part of IMR`s own monitoring activities.

4) To collect samples for chlorofluorcarbons (CFC) and transient tracers at selected stations in the Norwegian and Greenland Seas as part of a routine cooperative observation program between IMR and Brookhaven National Laboratory, USA.

5) To collect water samples for Thorium-234 investigations (IMR).

6) To map the distribution of salmon in the northern Norwegian Sea (IMR).

CRUISE TRACK

Figure 1 shows the cruise track and the positions of the stations where sampling was carried out. The western limits of the cruise track were extended until the ice edge at all east-west sections .

SAMPLING METHODOLOGY

HYDROGRAPHY

The hydrographic work was carried out with two independent CTD-water sampling packages from SeaBird Inc. with data being collected both during up- and downcast. The first package consisted of a SBE 911plus CTD with a 12 position SBE 32 Caroussel (CTD-12) equipped with 10 liter Niskin bottles and was used preferentially for deep water work. The conductivity sensor of this package failed at station number 508 and was replaced by a new one at station 509. At this station water samples for conductivity analyses were obtained at all sample levels. The other package consisted of a SBE 19 Seacat with a 24 position SBE 32 Caroussel (CTD-24) equipped with 23 pcs. 2.5 liters Niskin water samplers and was used for shallow water work. In the remaining place of the 24 positions Caroussel, a Biospherical QSP-200L irradiance meter was mounted. A SeaTech fluorometer was also attached to the system. Both the irradiance meter and the fluorometer were coupled to the SBE 19 for powering and data transmission. At all stations water samples were collected from the deepest sampling level from both CTD packs for calibration of the conductivity sensors.

CHEMISTRY

• Oxygen

Oxygen concentration was measured using the Winkler method with visual determination of the titration end-point. Titration was done on whole samples (about 120 ml) using a 1 ml automatic burette (Metrohn) with a dispensing precision of 0.001 ml. Calibration of the thiosulfate solution (about 0.1 N) was as done on each run. The reproducibility of the method estimated as the standard deviation of ten replicates drawn from one 10 l Niskin bottle was 0.010 ml l^{-1} at an oxygen concentration of about 7 ml l^{-1}. Sampling procedures, reagents preparation and analyses were done

following WOCE recommendations as stated in Culberson (1991). Conversion of volumetric to weight concentrations were done as recommended by WOCE using potential temperature from the CTD bottle file

• Nutrients

Seawater samples for the analysis of nitrate, nitrite, phosphate and silicic acid were collected just after the sampling for trace gases and oxygen. After rinsing three times, samples were drawn into 15 ml high-density polyethylene test tubes with pressure caps and kept dark and refrigerated at 4 %C without preservative. All samples were analyzed within 24 hours after sampling. Tests done for effects of the delay in analysis showed variations for all nutrients not significantly different to the precision obtained for each parameter.

The nutrient analyses were performed using a system build up by the following items:

- Pump system from Ismatec, Switzerland.
- Reaction units of own fabrication
- Autosampling , detection and computing units from SAN^{plus} Segmented Flow Analyzer, Skalar Analytical B.V., The Netherlands.

The methods used were adaptations of standard methods (Strickland and Parsons, 1972) slightly modified to the autoanalyzer system (Føyn et al., 1981). The precision for the different analyses (ten samples drawn from the same Niskin sampler) at full scale was less than 0.2% for nitrite, nitrate and silicic acid and less than 2 % for phosphate. The reproducibility during the whole cruise, tested by analyzing a control solution during each run, was less than 1% for nitrite, nitrate and silicic acid and less than 3% for phosphate.

• Chlorofluorocarbons. CFC-11, CFC-12, CFC-113, CH3CCL3, and CCl4 (Fred Menzia and Ken Eriksson)

Sample Collection

All samples were collected using 10 liter water sampling bottles. Aliquots of seawater were transfered to 100 cm^{-3} precision ground-glass syringes for the CFC analysis. All the 12 bottles in use remained on the frame in the water sampling room between stations. None of them showed a CFC contamination problem during the cruise.

Equipment and Technique

Chlorofluorocarbons CFC-11, CFC-12 , CFC-113, CH3CCl3 and CCl4 were measured at most stations. The analytical technique is described in Wallace et. al. (1994) and more completely in Happell et. al. (1996). Trapping was achieved using a length of 1/8 in. o.d. ss tubing packed with Porapak N cooled to -20 °C. Subsequent desorption was done by electrically heating the trap to 125 °C and injecting the contents of the trap onto a megabore DB-624 precolum and column housed in a Varian ECD-GC. Water samples for analysis were drawn first from the bottles and then stored under clean sea water. The analysis was usually completed within 12 hours of the samples coming on board. Air samples were run periodically from an air intake high up on the foremast. Air was pumped from this location through a length of Dekoron tubing.

Calibration

Calibration curves used for determining CFC concentrations in air and water samples are generated by injections of known volumes of standard gas. The calibration curves spaned the range of CFC levels in the air and water analyses. The standard was contained in a Scott Aculife cylinder as recommended in WHPO 91-1. The gas standard was prepared and calibrated at Brookhaven National Laboratory using methods described in Happell and Wallace (in press).

• **Transient tracers** (Fred Menzia and Ken Eriksson)

Samples for Helium and Tritium were collected following closely the recomendations given by WOCE (Bullister, 1991; Jenkins et al., 1991). All samples will be analyzed ashore.

• **Carbonate system** (Leif Anderson and Agnetha Franson)

The carbonate system was determined by analysing water samples from the rosette for total alkalinity, AT, total dissolved inorganic carbon, CT, and the total hydrogen ion concentration, pH. These parameters are defined as

$CT = [CO_2] + [H_2CO_3] + [HCO_3^-] + [CO_3^{2-}]$

$AT = [HCO_3^-] + 2[CO_3^{2-}] + [B(OH)_4^-]$

$pH = -\log[H^+]$

From two of these parameters any species of the carbonate system can be calculated. Measurements of CT was performed by extraction of carbon dioxide gas from an acidified seawater sample using nitrogen gas. The extracted CO_2 was then coulometrically titrated. AT was measured by potentiometric titration and pH was spectrophotometrically determined using the indicator m-cresolpurple. AT is mainly affected by formation and dissolution of metal carbonates, while CT and pH is affected by air-sea exchange of CO_2 and by photosynthesis and microbial decay of organic matter as well.

BIOLOGY

• **Water sampling.** Samples for biological analyses were obtained from the Niskin bottles on the caroussels

• **Biomass (BIOM)**

• **Chlorophyll**

Samples for chlorophyll analyses were collected in 263 ml plastic bottles and filtered through glassfiber type F filters. The filters were inmediately frozen and kept until their analyses ashore. In the laboratory the pigments were extracted during overnitgh with 90% acetone at 4°C and in the dark. Thereafter the extracts were centrifuged at 500 g and measured fluorometrically with a Turner Designs AU-10 filter fluorometer both before and after the addition of 5% v/v hydrochloric acid.The fluorometer was calibrated against commercial chlorophyll *a* (Sigma Inc.).

• **Particulate organic carbon and nitrogen.**

Samples were collected in 529 ml plastic bottles and filtered through pre-combusted glassfiber filters of type F. The filters were frozen inmediately after filtration and will be analyzed in the laboratory ashore using a Carlo Erba model 106 Elemental analyzer.

• **Particulate biogenic silica.**

Water samples were collected in 529 ml plastic bottles and filtered through polycarbonate filters with 0.6 &m pore size. The filters were then inmediately frozen and will be analyzed ashore.

• Phytoplankton taxonomy

Samples for quantitative analysis of phytoplankton were drawn from the Niskin bottles into 100 ml brown glass bottles and hexamine neutralized-formaldehyde was added for conservation..

• Primary productivity

• Radioactive carbon uptake (14C)

Uptake of radioactive carbon by phytoplankton was done by means of two incubation schemes. The first with a P vs E incubator equipped with a metal halide daylight lamp (OSRAM HQI-T 400/DH) providing 16 different irradiances from 0 to about 700 μmol m^{-2} s^{-1} by means of neutral filters. The incubator was cooled with subsurface seawater (about 5 meter deep) from the ship´s water intake. Samples aliquots from a 500 ml sample collected in a dark glass bottle were used to rinse the 25 ml incubation glass bottles. These had previously been thouroghly washed with diluted hydrochloric acid and rinsed three times with distilled water. To the remaining water sample 40 μCi $Na_2H^{14}CO_3$ was added . After thourogh mixing 20 ml of the radioactive sample were dispensed on each of the 16 incubation bottles and placed inmediately in the incubator. A 200 μl aliquot, in triplicate, was also dispensed into 1 ml of phenethylamine in order to determine the actual activity in the sample. Incubation time lasted about 2 hours. After incubation the samples were inmediately filtered through glassfiber filters of type F and frozen for later analysis ashore. This scheme was applied to samples from two depths, usually above and below the pycnocline, from selected stations. The second scheme was based on short time *in situ* incubations .Paralell samples and one dark sample of 60 ml were taken from different depth levels in the euphotic zone into polycarbonate culturing flasks and added 10 μCi $Na_2H^{14}CO_3$. The incubations were carried out at the same time as the profiling work with the PNF and FRRF fluorometers.. After incubation the samples were inmediately filtered through glassfiber filters of type F and frozen for later analysis ashore. For all incubations comercially available radioactive carbon was used (DuPont NEN Sodium bicarbonate NEC-086S, 20 μCi)

• *In situ* phytoplankton photosynthesis

In situ phytoplankton photosynthetic rate was estimated by means of a PNF-300 Profiling Natural Fluorometer (Biospherical Instruments Inc., USA) . In addition the instrument records depth profiles of irradiance, natural fluorescence, cholorophyll concentration and temperature. A FRRF fluorometer from Chelsea Instruments Ltd. (Fasttracka) was also deployed simultaneously with the PNF-300 in order to obtain rapid, real-time *in situ* measurements of the photosynthetic characteristics of phytoplankton. Since the main aim of this work was to evaluate the capability of both the PNF and FRRF to estimate phytoplankton photosynthesis, most of the work was done recording this type of information over 10-15 minutes periods at the same depth levels at which the *in situ* incubation work was carried out.

• Zooplankton

Samples for zooplankton biomass and species composition were obtained by vertical tows at selected depth intervals by means of a 56 cm opening WP-2 plankton net with a 180 μm mesh size. The samples were split into two, one part being preserved with formaldehyde for later determination of species composition. The other part was passed through three different meshsize nets, 2000, 1000 and 180 μm, and the fractions collected into preweighted aluminium containers, dried at 60 °C and then frozen, for later determination of dried weight ashore. The same procedure was applied to the samples collected with the MOCNESS net, which was obliquely towed at two knots through the water column from about 700 meters depth or close to the bottom andup to the surface.For grazing

studies zooplankton specimens were collected with the WP-2 net provided with a closed bottom end. The grazing rates were estimated using a method based on the production of fecal pellets.

UNDERWAY MEASUREMENTS

Chlorophyll *in vivo* fluorescence (WebStar Mini fluorometer), temperature and salinity (SBE 21 Thermosalinograph, Seabird Inc.) were continously monitored on water from the ship's water intake at 5 meters depth. Incoming irradiance (Li-Cor PAR cosine sensor) was continously logged during the whole cruise.

SUMMARY OF STATION WORK

Table 1 shows an overview of the work carried out at each oceanographic station. Fig. 1 shows the cruise track and stations positions.

PRELIMINARY RESULTS

The general hydrographical situation in the central Greenland Sea during the study period is despicted in Fig.2 where the vertical distribution of temperature and salinity along the 74° N is shown. From the eastern end of the section and extending out to about 50 nautical miles to the west , the upper 400 meters were dominated by Atlantic water (> 35 PSU, temperature above ca. 2° C). A transition zone from Atlantic to proper Greenland Sea water (> 34.9 PSU, temperature above 0 ° C) was also observed. The central part of the section was characterized by water masses with salinities below 34.9 PSU and temperatures below 0°C, representing Greenland Sea water. Towards the western end of the section a gradual transition to the Polar waters of the East Greenland current was observed. No indication of winter mixing deeper than about 1500 meters was observed at this section or the other two sections covered.

The biological conditions in the upper layers of the Central Greenland Sea were typical of a late summer situation with extremely low nutrient concentrations (Fig.3) and small phytoplankton and zooplankton biomass over the whole section. Fig. 4 and 5 shows screen dumps of uncorrected data from the SBE 19 CTD-package from one station in Atlantic waters (Station 498) and another close to the ice edge (Station 487). The vertical distribution of salinity, temperature and chlorophyll *in vivo* fluorescence observed at these stations were typical from most of the stations covered in the central Greenland Sea, with the subsurface chlorophyll *in vivo* fluorescence maximum being more marked at the stations with low surface salinity close to the ice edge.

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Bergen, December 16, 1998

Francisco Rey
Chief Scientist

TABLE 1. OVERVIEW OF THE STATION WORK

ABREVIATIONS

CTD-12	SeaBird 911+ CTD with SBE 32 Caroussel with 12 * 10 liters Niskin bottles.
CTD-24	SeaBird 19 CTD with SBE 32 Caroussel with 24* 2,5 liters Niskin bottles.
WP-2	Zooplankton Net, 58 cm opening, 180 μm mesh size.
N-30	Niskin bottle 30 liters. Used for collecting zooplankton fecal pellets.
PNF/FRRF	Biospherical Profiling Natural Fluorometer PNF-300 and Chelsea`s Fast Repetition Rate Fluorometer (Fasttracka)
BOTTOM	Bottom depth determined acoustically with Simrad EK-500, 18 kHz.
WIND Dir	Wind direction in 10 degrees intervals (34=340 °)
WIND Speed	In knots
AIR Temp	Air temperature in degrees Celsius
W	Weather meteorological code
C	Cloudiness meteorological code
SEA	State of the sea; meteorological code
ICE	Presence of ice; meteorological code
NS	Water sampling for nutrient analyses
CO2	Water sampling for inorganic carbon system
14C	Productivity experiments
O2	Water sampling for oxygen analyses
CFC	Water sampling for chlorofluorocarbons
SF6	Water sampling for tracer Hexafluorosulfur
BIOM	Water sampling for phytoplankton biomass
Others	Thorium: water sampling Thorium 234 analysis Radionuclides: 137 Cs, Iodine, Technecium Tracers: Helium and Tritium

STN	POSITION						DATE	TIME	BOTTOM	WIND		Air	W	C	SEA	ICE	OPERATION	CAST	SAMPLING	PARAMETERS						
NBR	LATITUDE			LONGITUDE				(UTC)	DEPTH	Dir	Speed	Temp						NBR	RANGE	NS	CO2	14C	O2	CFC	SF6	BIOM	Others
									(m)										(dbars)								
485	66	0.08	N	2	0.03	E	04-08-98	11.14	2082	21	14	2	2	8	4	0	CTD-12	1	0-2035	X	X		X	X	X		
485	66	0.58	N	2	0.56	E	04-08-98	13.40	2058	21	14	2	2	8	4	0	CTD-12	2	0-502	X	X		X	X	X	X	
485	66	0.58	N	2	0.56	E	04-08-98	14.15	2058	21	14	2	2	8	4	0	CTD-12	3	10								Thorium
486	71	10.79	N	7	40.53	W	06-08-98	5.02	2060	8	11	7	2	8	4	0	CTD-12	1	0-1998	X	X		X	X	X		
486	71	10.75	N	7	42.10	W	06-08-98	7.08	2060	8	11	7	2	8	4	0	CTD-12	2	0-502	X	X		X	X	X	X	
487	73	0.06	N	15	25.75	W	07-08-98	1.51	2192	35	17	3	2	8	2	7	CTD-12	1	0-2161	X	X			X	X		Radionuclides
487	73	0.09	N	15	25.57	W	07-08-98	3.47	2193	35	17	3	2	8	2	7	CTD-12	2	0-503	X	X			X	X		
488	73	0.19	N	13	1.26	W	07-08-98	9.30	2634	10	11	5	2	8	2	7	CTD-12	1	0-2602	X	X						Thorium
488	73	0.00	N	13	3.72	W	07-08-98	11.08	2634	10	11	5	2	8	2	7	CTD-24	1	0-200	X		X				X	
488	73	0.00	N	13	3.72	W	07-08-98	11.50	2634	10	11	5	2	8	2	7	N-30	1	50-0								
488	73	0.00	N	13	3.72	W	07-08-98	12.00	2634	10	11	5	2	8	2	7	WP-2	1	100-0								
488	73	0.00	N	13	3.72	W	07-08-98	12.21	2634	10	11	5	2	8	2	7	PNF/FRRF	1	0-75								
489	72	59.92	N	10	59.74	W	07-08-98	19.47	2760	15	13	5	2	8	2	7	CTD-12	1	0-2749	X	X		X	X		X	
489	73	0.46	N	11	1.41	W	07-08-98	22.20	2768	15	13	5	2	8	2	7	CTD-12	2	0-501	X	X		X	X			
490	73	0.07	N	9	0.02	W	08-08-98	2.06	2734	11	14	6	2	8	2	7	CTD-12	1	0-2703	X							
491	73	0.00	N	7	1.87	W	08-08-98	8.23	2597	8	10	7	2	8	2	7	CTD-24	1	0-200	X		X				X	
491	73	0.28	N	7	2.70	W	08-08-98	8.50	2514	8	10	7	2	8	2	7	CTD-12	1	0-2506	X	X		X	X			
491	73	1.32	N	7	6.79	W	08-08-98	10.30	2556	8	10	7	2	8	2	7	PNF/FRRF	1	0-75								
491	73	1.32	N	7	6.79	W	08-08-98	11.07	2556	8	10	7	2	8	2	7	CTD-12	2	0-500	X	X		X	X			
491	73	1.32	N	7	6.79	W	08-08-98	12.25	2556	8	10	7	2	8	2	7	WP-2	1	100-0								
491	73	1.32	N	7	6.79	W	08-08-98	12.40	2556	8	10	7	2	8	2	7	N-30	1	0-50								
492	72	59.98	N	4	59.79	W	08-08-98	17.43	2830	13	9	8	2	8	2	7	CTD-12	1	0-2752	X							
493	73	0.10	N	3	0.21	W	08-08-98	22.51	2958	1	5	7	2	8	4	0	CTD-12	1	0-2929	X	X		X	X			
493	73	0.58	N	2	59.35	W	09-08-98	1.20	2944	1	5	7	2	8	4	0	CTD-12	2	0-505	X	X		X	X			
494	73	0.03	N	0	59.35	W	09-08-98	4.53	2760	34	5	7	2	8	4	0	CTD-12	1	0-2852	X							
495	72	59.50	N	0	59.89	E	09-08-98	12.06	2975	33	11	8	2	8	3	0	CTD-24	1	0-200	X		X				X	
495	72	59.04	N	1	0.04	E	09-08-98	12.36	2716	33	11	8	2	8	3	0	CTD-12	1	0-2682	X	X		X	X			Thorium

STN	POSITION						DATE	TIME	BOTTOM	WIND		Air	W	C	SEA	ICE	OPERATION	CAST	SAMPLING	PARAMETERS							
NBR	LATITUDE			LONGITUDE				(UTC)	DEPTH	Dir	Speed	Temp						NBR	RANGE	NS	CO2	14C	O2	CFC	SF6	BIOM	Others
									(m)										(dbars)								
495	72	59.04	N	1	0.04	E	09-08-98	12.40	2716	33	11	8	2	8	3	0	PNF/FRRF	1	0-75								
495	72	59.04	N	1	0.04	E	09-08-98	13.00	2716	33	11	8	2	8	3	0	WP-2	1	100-0								
495	72	59.04	N	1	0.04	E	09-08-98	13.15	2716	33	11	8	2	8	3	0	N-30	1	0-50								
495	72	57.82	N	0	59.95	E	09-08-98	14.55	2539	33	11	8	2	8	3	0	CTD-12	2	0-501	X	X		X	X			
496	73	0.13	N	3	1.57	E	09-08-98	19.23	2432	1	9	9	2	8	3	0	CTD-12	1	0-2401	X							
497	72	59.96	N	5	0.17	E	10-08-98	0.04	2991	2	4	9	2	8	3	0	CTD-12	1	0-2962	X	X		X	X			
497	72	59.96	N	4	59.26	E	10-08-98	2.30	2986	2	4	9	2	8	3	0	CTD-12	2	0-502	X	X		X	X			
498	73	0.00	N	10	57.51	E	12-08-98	15.45	2014	9	14	9	2	8	3	0	WP-2	1	100-0								
498	73	0.00	N	10	57.51	E	12-08-98	16.00	2014	9	14	9	2	8	3	0	PNF/FRRF	1	0-75								
498	73	0.00	N	10	57.51	E	12-08-98	16.00	2014	9	14	9	2	8	3	0	N-30	1	0-50								
498	73	0.00	N	10	57.51	E	12-08-98	16.07	2014	9	14	9	2	8	3	0	CTD-24	1	0-200	X	X	X				X	
498	73	6.68	N	10	55.23	E	12-08-98	17.23	2014	9	14	9	2	8	3	0	CTD-12	1	0-1982	X	X		X	X			
498	73	6.76	N	10	50.48	E	12-08-98	19.51	2014	9	14	9	2	8	3	0	CTD-12	2	0-500	X	X		X	X			
498	73	0.00	N	10	49.66	E	12-08-98	20.00	2014	9	14	9	2	8	3	0	PNF/FRRF	2	0-75								
498	73	0.00	N	10	49.66	E	12-08-98	20.17	2014	9	14	9	2	8	3	0	CTD-24	2	0-200	X	X	X				X	
498	73	0.00	N	10	49.66	E	12-08-98	21.45	2014	9	14	9	2	8	3	0	WP-2	2	100-0								
498	73	0.00	N	10	41.43	E	13-08-98	0.00	2072	9	14	9	2	8	3	0	PNF/FRRF	3	0-75								
498	73	0.00	N	10	41.43	E	13-08-98	0.04	2072	9	14	9	2	8	3	0	CTD-24	3	0-200	X	X	X				X	
498	73	0.00	N	10	41.43	E	13-08-98	1.15	2072	9	14	9	2	8	3	0	WP-2	3	100-0								
498	73	0.00	N	10	40.87	E	13-08-98	3.45	2014	9	14	9	2	8	3	0	WP-2	4	100-0								
498	73	0.00	N	10	40.87	E	13-08-98	4.00	2014	9	14	9	2	8	3	0	N-30	2	0-50								
498	73	0.00	N	10	40.87	E	13-08-98	4.06	2014	9	14	9	2	8	3	0	CTD-24	4	0-200	X	X	X				X	
498	73	0.00	N	10	40.87	E	13-08-98	4.30	2014	9	14	9	2	8	3	0	PNF/FRRF	4	0-75								
498	73	0.00	N	10	37.28	E	13-08-98	9.00	2014	10	20	9	2	8	3	0	CTD-24	5	0-200	X		X				X	
498	73	0.00	N	10	37.28	E	13-08-98	9.45	2014	10	20	9	2	8	3	0	WP-2	5	100-0								
498	73	0.00	N	10	37.28	E	13-08-98	9.55	2014	10	20	9	2	8	3	0	N-30	3	0-50								
498	73	0.00	N	10	37.28	E	13-08-98	10.00	2014	10	20	9	2	8	3	0	PNF/FRRF	5	0-75								
498	73	0.00	N	10	37.28	E	13-08-98	10.45	2014	10	20	9	2	8	3	0	CTD-12	4	1500								Thorium
498	73	10.00	N	10	27.61	E	13-08-98	11.56	2125	10	20	9	2	8	3	0	CTD-24	6	0-200	X	X	X				X	
498	73	10.00	N	10	27.61	E	13-08-98	12.00	2125	10	20	9	2	8	3	0	PNF/FRRF	6	0-75								
498	73	10.00	N	10	27.61	E	13-08-98	12.50	2125	10	20	9	2	8	3	0	CTD-12	5	1500								Thorium
498	73	12.52	N	10	17.85	E	13-08-98	16.01	2150	10	20	9	2	8	3	0	CTD-24	7	0-200	X		X				X	
498	73	12.52	N	10	17.85	E	13-08-98	16.15	2150	10	20	9	2	8	3	0	PNF/FRRF	7	0-75								
498	73	12.52	N	10	17.85	E	13-08-98	17.00	2150	10	20	9	2	8	3	0	WP-2	6	100-0								
498	73	6.76	N	10	50.48	E	13-08-98	20.10	2014	9	14	9	2	8	3	0	CTD-12	3	75								Thorium

STN	POSITION						DATE	TIME	BOTTOM	WIND		Air	W	C	SEA	ICE	OPERATION	CAST	SAMPLING	PARAMETERS							
NBR	LATITUDE			LONGITUDE				(UTC)	DEPTH	Dir	Speed	Temp						NBR	RANGE	NS	CO2	14C	O2	CFC	SF6	BIOM	Others
									(m)										(dbars)								
499	74	0.07	N	8	59.87	E	13-08-98	22.12	2726	10	16	10	2	8	3	0	CTD-12	1	0-2704	X	X		X	X			
499	74	1.63	N	8	58.24	E	14-08-98	0.33	2795	10	16	10	2	8	3	0	CTD-12	2	0-502	X	X		X	X			
500	74	0.00	N	4	59.82	E	14-08-98	7.42	3076	12	23	10	2	8	3	0	CTD-24	1	0-200	X		X				X	
500	74	0.00	N	4	59.82	E	14-08-98	8.00	3076	12	23	10	2	8	3	0	PNF/FRRF	1	0-75								
500	74	0.71	N	4	56.61	E	14-08-98	8.49	3250	12	23	0	2	8	3	0	CTD-12	1	0-3041	X	X		X	X			Thorium
500	74	0.71	N	4	56.61	E	14-08-98	9.45	3250	12	23	0	2	8	3	0	WP-2	1	100-0								
500	74	0.71	N	4	56.61	E	14-08-98	10.00	3250	12	23	0	2	8	3	0	N-30	1	0-50								
500	74	1.63	N	4	48.26	E	14-08-98	11.23	3260	12	23	10	2	8	3	0	CTD-12	2	0-501	X	X		X	X		X	
501	74	0.04	N	1	0.04	E	14-08-98	17.25	3090	12	22	9	2	8	3	0	CTD-12	1	0-3002	X	X		X	X			
501	74	0.16	N	1	5.21	E	14-08-98	20.11	3125	12	22	9	2	8	3	0	CTD-12	2	0-503	X	X		X	X		X	
502	73	59.96	N	2	59.68	W	15-08-98	3.31	3505	12	22	8	2	8	4	0	CTD-12	1	0-3454	X	X		X	X			
502	74	0.10	N	2	56.00	W	15-08-98	6.19	3504	12	22	8	2	8	4	0	CTD-12	2	0-505	X	X		X	X		X	
503	73	59.99	N	7	0.11	W	15-08-98	12.40	3320	10	19	8	2	8	4	0	CTD-24	1	0-200	X		X				X	Thorium
503	73	59.99	N	7	0.11	W	15-08-98	13.00	3320	10	19	8	2	8	4	0	PNF/FRRF	1	0-75								
503	74	0.52	N	7	2.50	W	15-08-98	13.41	3306	10	19	8	2	8	4	0	CTD-12	1	0-3274	X	X		X	X	X		
503	74	0.52	N	7	2.50	W	15-08-98	15.00	3306	10	19	8	2	8	4	0	WP-2	1	100-0								
503	74	0.52	N	7	2.50	W	15-08-98	15.15	3306	10	19	8	2	8	4	0	N-30	1	50-0								
503	74	1.99	N	7	7.70	W	15-08-98	16.37	3313	10	19	8	2	8	4	0	CTD-12	2	0-500	X	X		X	X	X		
504	74	0.04	N	10	59.92	W	15-08-98	23.45	3026	9	9	6	4	9	3	0	CTD-12	1	0-3003	X	X		X	X			
504	74	0.64	N	11	2.89	W	16-08-98	2.08	3001	9	9	6	4	9	3	0	CTD-12	2	0-503	X	X		X	X		X	
505	73	59.76	N	15	21.46	W	16-08-98	8.49	902	1	28	1	4	9	3	0	CTD-12	1	0-881	X	X		X	X			
505	73	59.82	N	15	21.74	W	16-08-98	10.56	881	1	28	1	4	9	3	0	CTD-12	2	0-303	X	X		X	X		X	Thorium
506	74	59.71	N	13	43.00	W	16-08-98	20.46	197	4	13	2	4	9	3	0	CTD-24	1	0-200	X		X				X	
506	74	59.71	N	13	43.00	W	16-08-98	20.53	197	4	13	2	4	9	3	0	PNF/FRRF	1	0-75								
506	74	59.68	N	13	43.29	W	16-08-98	21.11	196	4	13	2	4	9	3	0	CTD-12	1	0-180	X	X		X	X	X		
506	74	59.68	N	13	43.29	W	16-08-98	21.55	196	4	13	2	4	9	3	0	WP-2	1	100-0								
506	74	59.68	N	13	43.29	W	16-08-98	22.10	196	4	13	2	4	9	3	0	N-30	1	0-50								
507	74	59.92	N	12	7.08	W	17-08-98	2.53	1533	3	17	3	4	9	3	0	CTD-12	1	0-1502	X	X		X	X	X		
507	74	59.39	N	12	15.68	W	17-08-98	4.31	1360	3	17	3	4	9	3	0	CTD-12	2	0-299	X	X		X	X	X	X	

STN	POSITION						DATE	TIME	BOTTOM	WIND		Air	W	C	SEA	ICE	OPERATION	CAST	SAMPLING	PARAMETERS							
NBR	LATITUDE			LONGITUDE				(UTC)	DEPTH	Dir	Speed	Temp						NBR	RANGE	NS	CO2	14C	O2	CFC	SF6	BIOM	Others
									(m)										(dbars)								
508	75	0.04	N	7	59.93	W	17-08-98	12.12	3345	11	18	7	4	9	4	0	CTD-12	1	0-3301	X	X		X	X	X		He, Trit
508	75	0.46	N	7	58.39	W	17-08-98	15.06	3342	11	18	7	4	9	4	0	CTD-12	2	0-502	X	X		X	X	X	X	He, Trit
509	74	59.92	N	4	59.68	W	17-08-98	19.51	3536	14	15	7	4	9	4	0	CTD-12	1	0-3481	X	X		X	X			He, Trit
509	75	0.25	N	5	0.50	W	17-08-98	23.33	3540	14	15	7	4	9	4	0	CTD-12	2	0-500	X	X		X	X		X	He, Trit
510	75	0.00	N	2	0.06	W	18-08-98	4.20	3575	14	11	7	4	9	4	0	CTD-24	1	0-200	X		X			X	X	
510	75	0.00	N	2	0.06	W	18-08-98	4.45	3575	14	11	7	4	9	4	0	PNF/FRRF	1	0-75								
510	75	0.17	N	2	2.58	W	18-08-98	6.00	3570	14	11	7	4	9	4	0	WP-2	1	100-0								
510	75	0.17	N	2	2.58	W	18-08-98	6.03	3570	14	11	7	4	9	4	0	CTD-12	1	0-3500	X	X		X	X	X		He, Trit, Thorium
510	75	0.17	N	2	2.58	W	18-08-98	6.15	3570	14	11	7	4	9	4	0	N-30	1	0-50								
510	75	0.87	N	2	8.93	W	18-08-98	9.36	3476	14	11	7	4	9	4	0	CTD-12	2	0-500	X	X		X	X	X	X	He, Trit
511	74	59.99	N	0	59.96	E	18-08-98	14.32	3713	3	9	7	4	9	3	0	CTD-12	1	0-3684	X	X		X	X	X		
511	75	0.52	N	0	51.78	E	18-08-98	17.37	3713	3	9	7	4	9	3	0	CTD-12	2	0-750	X	X		X	X	X	X	
512	75	0.07	N	4	0.10	E	18-08-98	22.37	3067	10	13	8	4	9	3	0	CTD-12	1	0-3003	X	X		X	X			
512	75	0.00	N	3	59.92	E	19-08-98	1.31	3015	10	13	8	4	9	3	0	CTD-12	2	0-502	X	X		X	X		X	
513	75	0.00	N	7	0.13	E	19-08-98	6.20	1689	13	20	9	4	9	3	0	CTD-24	1	0-200	X		X				X	Thorium
513	75	1.08	N	6	57.61	E	19-08-98	7.00	1657	13	20	9	4	9	3	0	WP-2	1	100-0								
513	75	1.08	N	6	57.61	E	19-08-98	7.15	1657	13	20	9	4	9	3	0	N-30	1	0-50								
513	75	1.08	N	6	57.61	E	19-08-98	7.33	1657	13	20	9	4	9	3	0	CTD-12	1	0-1561	X	X		X	X			
513	75	0.00	N	7	0.13	E	19-08-98	7.50	1689	13	20	9	4	9	3	0	PNF/FRRF	1	0-75								
513	75	1.95	N	6	54.71	E	19-08-98	9.18	1665	13	20	9	4	9	3	0	CTD-12	2	0-300	X	X		X	X			
514	76	0.41	N	4	58.85	E	19-08-98	16.24	2598	12	13	9	4	9	3	0	CTD-12	1	0-2451	X	X		X	X			
514	76	1.38	N	4	55.50	E	19-08-98	19.26	2704	12	13	9	4	9	3	0	CTD-12	2	0-500	X	X		X	X		X	
515	76	0.02	N	1	0.21	E	20-08-98	0.55	3015	10	10	8	2	8	3	0	CTD-12	1	0-2993	X	X		X	X			
515	76	0.74	N	0	57.26	E	20-08-98	3.19	3007	10	10	8	2	8	3	0	CTD-12	2	0-502	X	X		X	X		X	
516	75	59.97	N	3	0.74	W	20-08-98	8.42	3635	2	11	7	2	8	3	0	CTD-24	1	0-200	X		X				X	
516	75	59.97	N	3	0.74	W	20-08-98	8.50	3635	2	11	7	2	8	3	0	PNF/FRRF	1	0-75								
516	75	59.93	N	3	1.85	W	20-08-98	9.12	3625	2	11	7	2	8	3	0	CTD-12	1	0-3592	X	X		X	X	X		
516	75	59.93	N	3	1.85	W	20-08-98	10.45	3625	2	11	7	2	8	3	0	WP-2	1	100-0								
516	75	59.93	N	3	1.85	W	20-08-98	11.00	3625	2	11	7	2	8	3	0	N-30	1	50-0								

STN	POSITION						DATE	TIME	BOTTOM	WIND		Air	W	C	SEA	ICE	OPERATION	CAST	SAMPLING	PARAMETERS							
NBR	LATITUDE			LONGITUDE				(UTC)	DEPTH	Dir	Speed	Temp						NBR	RANGE	NS	CO2	14C	O2	CFC	SF6	BIOM	Others
									(m)										(dbars)								
516	75	59.60	N	3	10.24	W	20-08-98	12.22	3612	2	11	7	2	8	3	0	CTD-12	2	0-501	X	X		X	X	X	X	He,Trit.
517	69	56.9	N	9	34.6	E	22-08-98	2.00	2879	6	13	2	8	8	3	0	WP-2	1	200-0								
517	69	56.9	N	9	34.6	E	22-08-98	2.09	2879	6	13	2	8	8	3	0	CTD-12	1	0-1503	X						X	
518	69	42.3	N	10	16.5	E	22-08-98	5.16	2926	6	21	3	8	8	3	0	CTD-12	1	0-1500	X						X	
518	69	42.3	N	10	16.5	E	22-08-98	6.30	2926	6	21	3	8	8	3	0	WP-2	1	200-0								
518	69	42.3	N	10	16.5	E	22-08-98	6.45	2926	6	21	3	8	8	3	0	MOCNESS	1	700-0								
519	69	29.1	N	10	57	E	22-08-98	9.39	2948	5	21	3	8	8	3	0	CTD-12	1	0-1500	X						X	
519	69	29.1	N	10	57	E	22-08-98	10.30	2948	5	21	3	8	8	3	0	WP-2	1	200-0								
520	69	14	N	11	37.8	E	22-08-98	12.32	2928	4	27	3	8	8	4	0	CTD-12	1	0-1502	X						X	
520	69	14	N	11	37.8	E	22-08-98	13.30	2928	4	27	3	8	8	4	0	WP-2	1	200-0								
521	69	1.96	N	12	17	E	22-08-98	15.06	2682	3	22	3	2	8	4	0	CTD-12	1	0-1502	X						X	
521	69	1.96	N	12	17	E	22-08-98	16.00	2682	3	22	3	2	8	4	0	WP-2	1	200-0								
521	69	1.96	N	12	17	E	22-08-98	16.45	2682	3	22	3	2	8	4	0	MOCNESS	1	700-0								
522	68	51.2	N	12	48.2	E	22-08-98	18.50	691	4	23	3	2	8	4	0	CTD-12	1	0-1503	X						X	
522	68	51.2	N	12	48.2	E	22-08-98	19.20	691	4	23	3	2	8	4	0	WP-2	1	200-0								
523	68	44	N	13	10.2	E	22-08-98	20.35	116	4	24	3	2	8	4	0	CTD-12	1	0-651	X						X	
523	68	44	N	13	10.2	E	22-08-98	20.50	116	4	24	3	2	8	4	0	WP-2	1	100-0								
524	68	34.8	N	13	35.3	E	22-08-98	22.05	134	3	24	3	2	8	4	0	CTD-12	1	0-106	X						X	
524	68	34.8	N	13	35.3	E	22-08-98	22.20	134	3	24	3	2	8	4	0	WP-2	1	125-0								
525	68	30.7	N	13	47.4	E	22-08-98	22.56	145	3	23	3	2	8	4	0	CTD-12	1	0-123	X						X	
525	68	30.7	N	13	47.4	E	22-08-98	23.05	145	3	23	3	2	8	4	0	WP-2	1	135-0								
525	68	30.7	N	13	47.4	E	22-08-98	23.20	145	3	23	3	2	8	4	0	MOCNESS	1	100-0								
526	68	25.8	N	14	0.87	E	23-08-98	0.04	112	4	21	3	2	8	3	0	CTD-12	1	0-133	X						X	
526	68	25.8	N	14	0.87	E	23-08-98	0.06	112	4	21	3	2	8	3	0	WP-2	1	100-0								

TABLE 2. OVERVIEW OF TRAWL STATIONS

ABREVIATIONS : see Table 1.

STN	POSITION						DATE	TIME	WIND		Air	W	C	SEA	ICE	TYPE
NBR	LATITUDE			LONGITUDE				(UTC)	Dir	Speed	Temp					
316	66	47.2	N	7	58.7	E	03-08-98	8.3	20	14	12.7	9	9	9	9	Pelagic Trawl
317	66	9.5	N	4	58.3	E	03-08-98	17.36	15	24	12.8	9	9	9	9	Pelagic Trawl
318	65	35.3	N	0	36.7	E	04-08-98	1.42	12	15	12.5	9	9	9	9	Pelagic Trawl
319	66	0	N	1	54.5	E	04-08-98	15.44	22	17	11.3	2	8	4	0	Pelagic Trawl
320	67	42.1	N	1	0.5	W	05-08-98	3.35	20	12	10.2	2	8	4	0	Pelagic Trawl
321	69	20.9	N	4	1.9	W	05-08-98	15.18	14	6	10.9	2	8	4	0	Pelagic Trawl
322	71	11.6	N	7	43	W	06-08-98	7.58	9	17	7	2	8	4	0	Pelagic Trawl
323	73	0.3	N	13	2.7	W	07-08-98	15.28	12	10	5.1	2	8	2	7	Pelagic Trawl
324	73	2	N	7	4.6	W	08-08-98	13.28	10	8	6.8	2	8	2	7	Pelagic Trawl
325	73	0.3	N	0	58	W	09-08-98	6.43	35	8	7.4	2	8	4	0	Pelagic Trawl
326	72	59.8	N	5	2.8	E	10-08-98	3.14	32	4	9	2	8	3	0	Pelagic Trawl
327	71	33.8	N	14	14.3	E	12-08-98	6.39	5	12	10.6	2	8	3	0	Pelagic Trawl
328	73	8.1	N	10	41.5	E	13-08-98	1.41	12	15	7.9	2	8	3	0	Pelagic Trawl
329	73	7.3	N	10	34.5	E	13-08-98	7.58	9	18	8.6	2	8	3	0	Pelagic Trawl
330	74	1.8	N	8	53.5	E	14-08-98	1.13	11	19	9.6	2	8	3	0	Pelagic Trawl
331	74	1	N	1	5.5	E	14-08-98	20.55	12	24	9.1	2	8	3	0	Pelagic Trawl
332	74	1.9	N	7	3.4	W	15-08-98	17.18	11	19	7	2	8	4	0	Pelagic Trawl
333	73	59.9	N	15	21.8	W	16-08-98	9.48	0	25	0.9	4	9	3	0	Pelagic Trawl
334	75	0.5	N	4	1.3	E	19-08-98	0.33	7	9	8.1	4	9	3	0	Pelagic Trawl
335	75	3.4	N	6	56	E	19-08-98	10.04	12	16	9.4	4	9	3	0	Pelagic Trawl
336	76	2.5	N	4	55.4	E	19-08-98	18.18	11	14	8.5	4	9	3	0	Pelagic Trawl
337	71	50.1	N	6	4	E	21-08-98	13.23	2	25	8.7	2	8	3	0	Pelagic Trawl
338	70	39.7	N	8	16.5	E	21-08-98	21.07	5	19	11.2	2	8	3	0	Pelagic Trawl

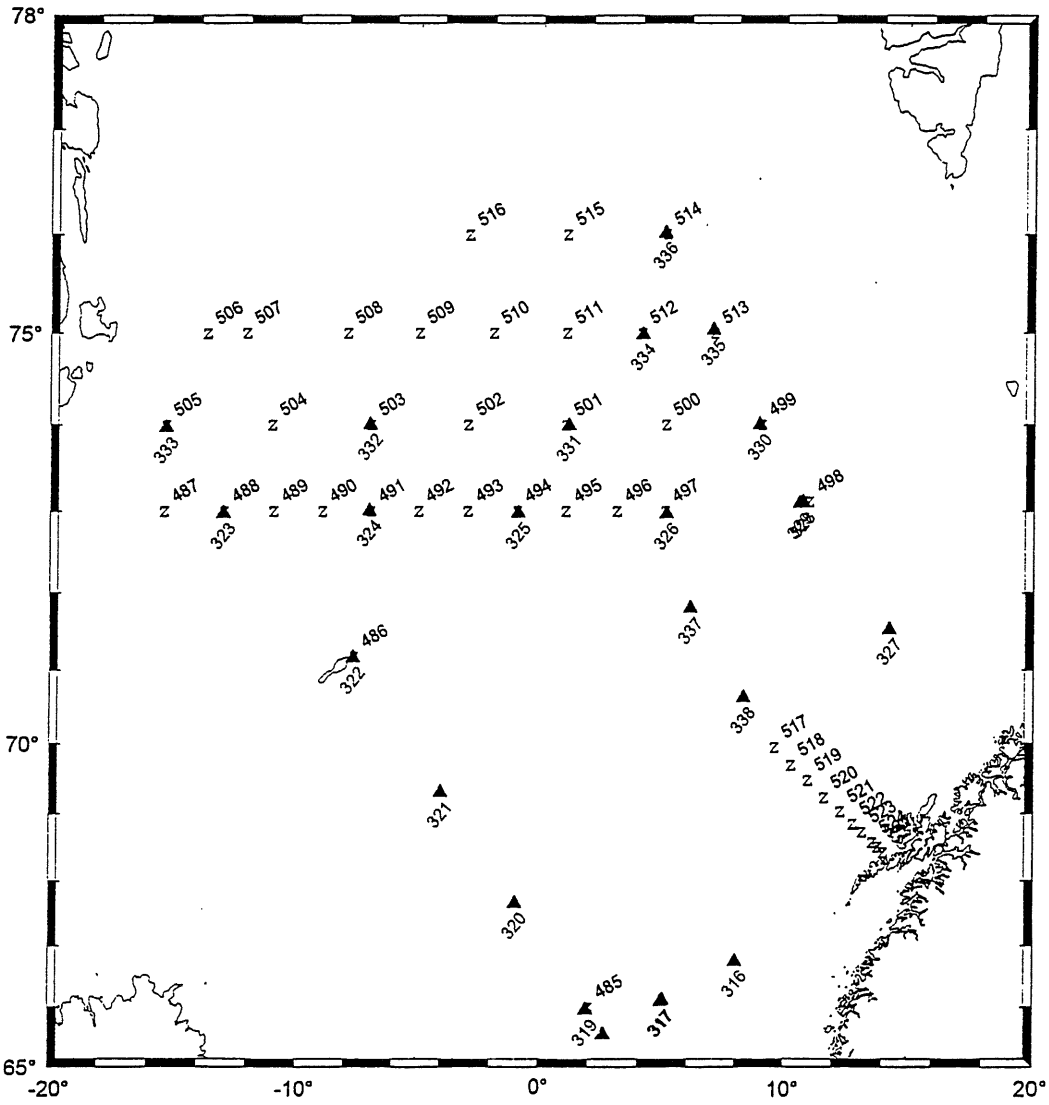

Figure 1. Cruise track and station locations for R/V "Johan Hjort" cruise JH1998210, 1 to 23 August,1998. (z= oceanographic stations; ▲= trawl stations).

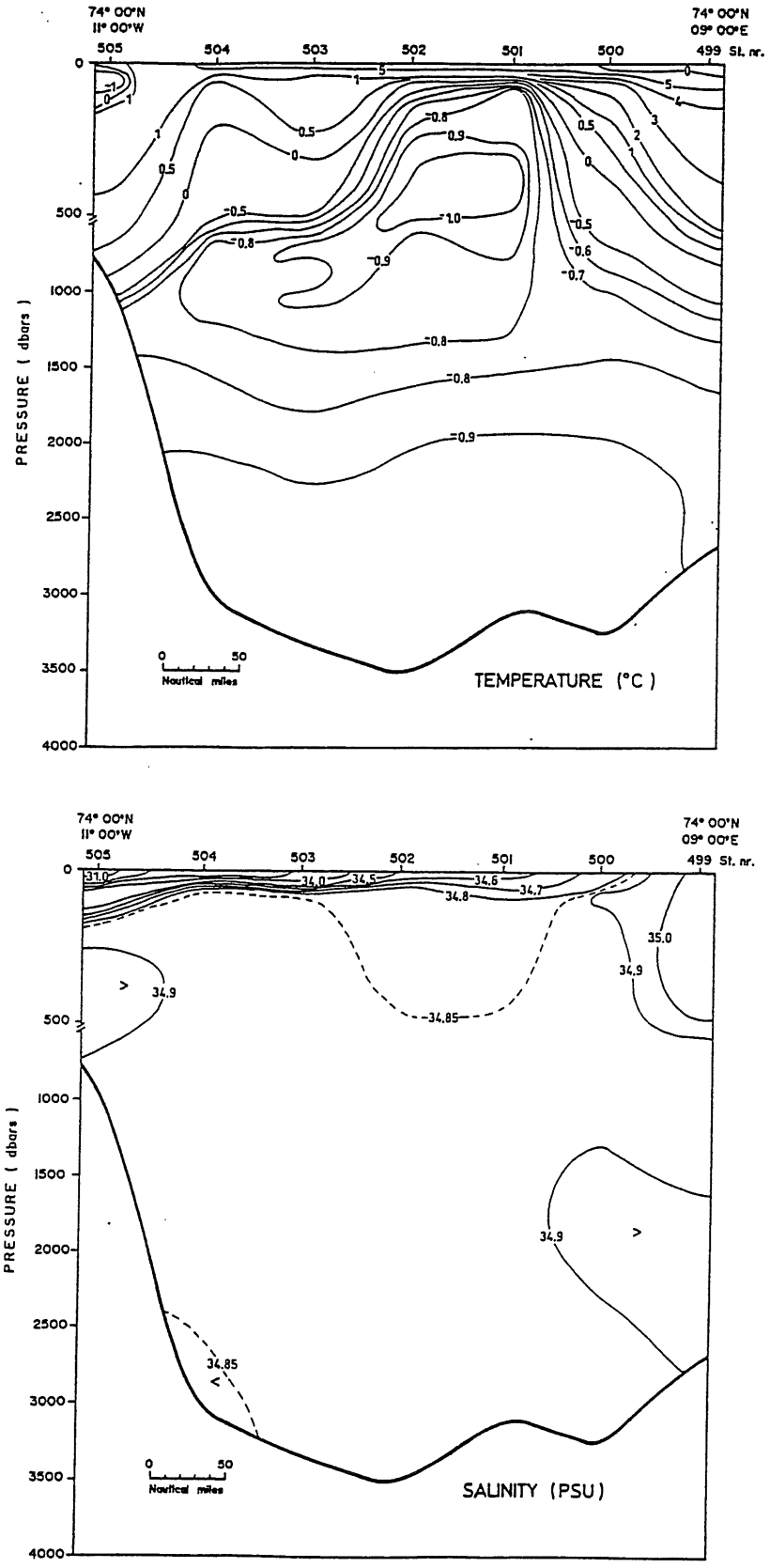

Figure 2. Vertical distribution of temperature (upper panel) and salinity (lower panel) at the section along 74°N in the central Greenland Sea.

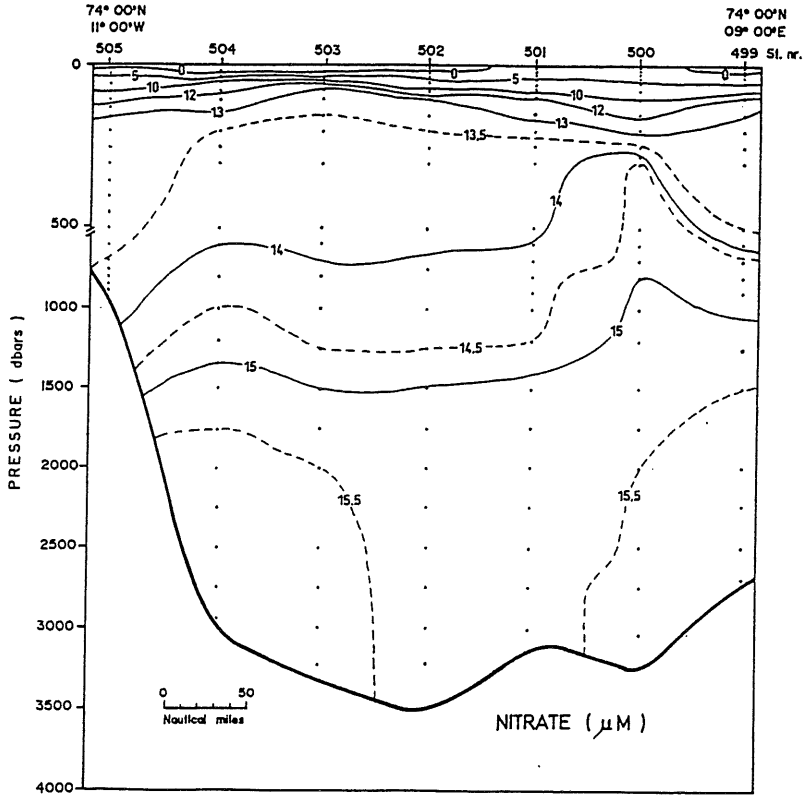

Figure 3. Vertical distribution of nitrate at the section along 74°N in the central Greenland Sea.

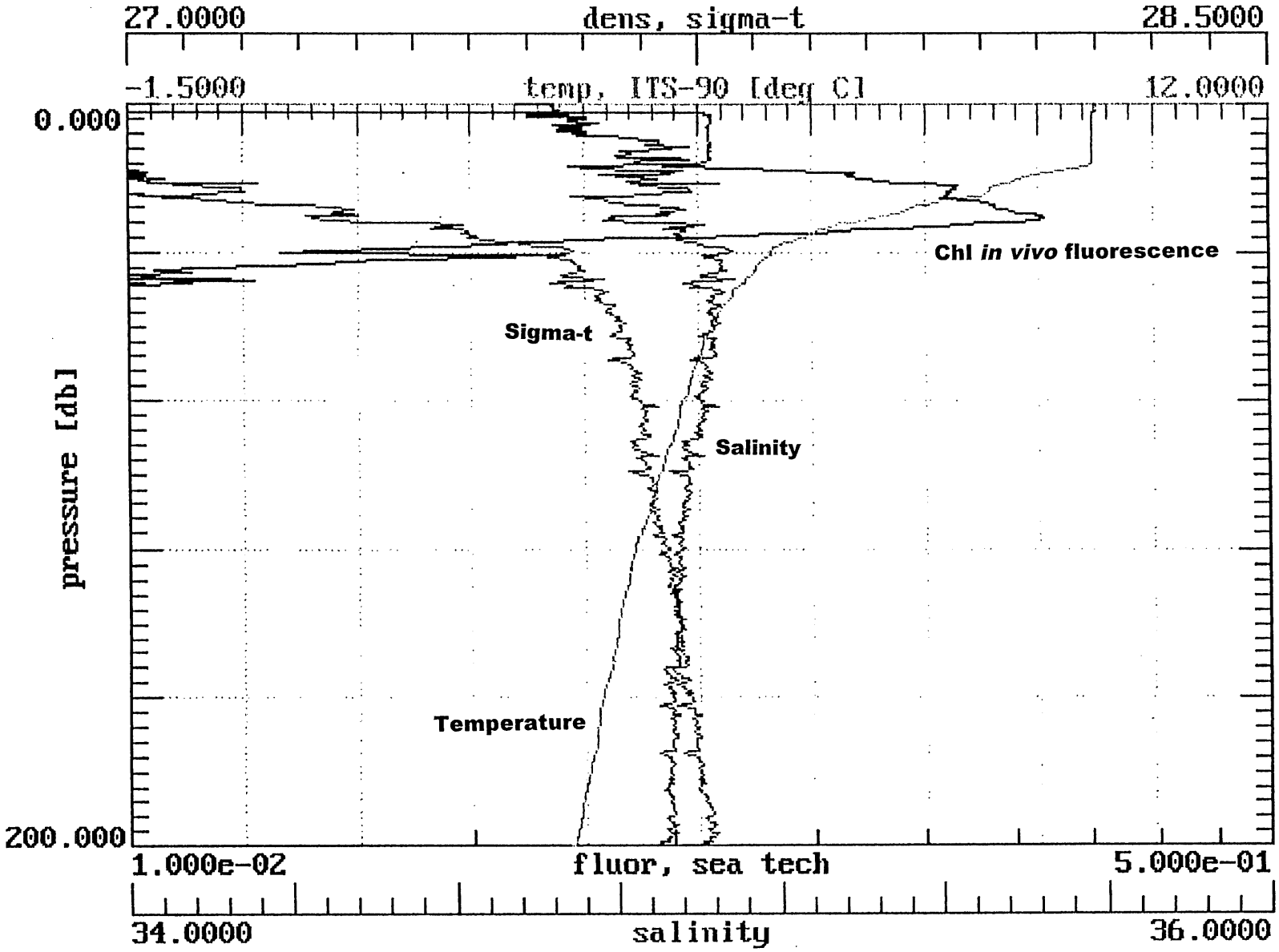

Figure 4. Vertical distribution of salinity (PSU), temperature (° C), sigma-t and chlorophyll *in vivo* fluorescence at station 498.

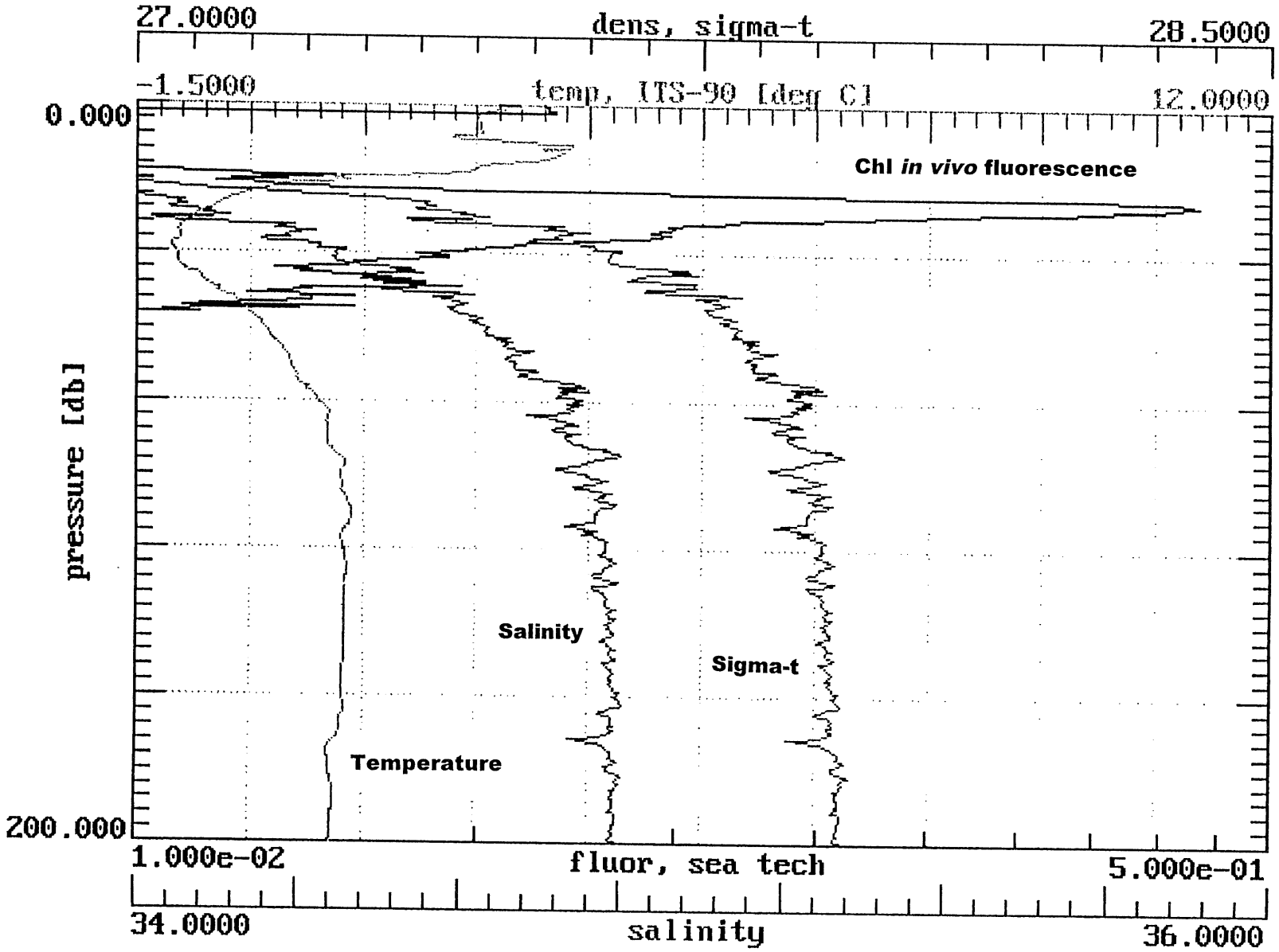

Figure 5. Vertical distribution of salinity (PSU), temperature (° C), sigma-t and chlorophyll *in vivo* fluorescence at station 488.