OMEX

Research Cruise

VALDIVIA 137

Celtic Shelf (Atlantic Ocean)
23/06 to 16/07/1993

Cruise Report
of the
Principal Scientific Officer
and the
Scientific Working Groups

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1. Research Program

One of the first cruises within the frame of the EEC project OMEX - 'Ocean Margin Exchange' - was performed with the German research vessel 'Valdivia' from 23/06 to 16/07/1993 on the Celtic Shelf of the Atlantic Ocean (see figure 1).
Participating scientists were biologists, chemists and biochemists from the Plymouth Marine Laboratory, the University of Kiel and the University of Hamburg.

At the beginning and the end of the cruise, the 'Valdivia' touched Plymouth boarding the scientists and the equipment of the PML.

General objective of the cruise was the analysis of biological, microbiological and biochemical processes at the ocean margin: Within the sampling area, the southwestern shelf-break of the Celtic Sea represents a border between the nutrient-rich water masses in deeper layers of the open ocean and the shallow shelf waters that are frequently depleted of nutrients. Thus, the development and productivity of planktic and bacterial species at the shelf break and in the shelf waters is dependent on occasionally upwelling. As a consequence of this, gradients of nutrients, as well as of biochemical substances like fatty acids and carbohydrates, were expected to be found in this area.

In order to study the situation during early summer, transects were performed *across* the shelf-break, sailing from shallow into deep water and vice versa. On the other hand, measurements were carried out *parallel* to the shelf-break, crossing a canyon that was expected to conduct water masses up or down the shelf.

At all stations vertical profiles of hydrographical data were recorded with a CTD probe. Water samples throughout the water column were taken either with 2.5-l Niskin bottles connected to the CTD probe, or with 30-l Niskin bottles attached to an extra rosette, employed in the euphotic zone in order to get a sufficient quantity of water.

More process related studies were performed by drifting experiments in nearly identical water bodies.

To achieve the mentioned goals, the cruise was divided into four parts:

1. During the first part of the cruise, the vessel performed a transect across the Goban Spur, the western shelf of the Celtic Sea (see figure 2). At five main stations proposed by OMEX groups (100, 200,...,500) and at four stations in-between (101,201,301,401), water samples were taken from definite depths. There were also taken sediment samples with a multicorer at selected stations. This first transect had lasted for four days.

2. Within a second transect, the Goban Spur was followed in reverse direction. Water samples were taken on the same five main stations (510, 410,...,110) as before. Every morning, just after pre-dawn sampling at one of the main stations, a drifting incubation rig was set out. Until the evening (08.00 p.m.), the vessel was staying close to the drifter, and water samples were taken from the euphotic zone every two hours (station numbers 511,512,...,515,411,412,...,415, etc.). Sediment samples had been taken on stations with shallow depths . The second transect took five days.

3. For the third part of the cruise, the vessel sailed about 100 nm in southern direction to the King Arthur Canyon. Within three days two transects across the canyon were carried out, each transect consisting of three stations. The first transect (stations 600, 610, 611, 620) lasted two days. At the station in the middle of the canyon, sampling was carried out twice (610 in the evening and 611 in the following morning). The second transect (stations 700, 710, 720) was located about 20 nm southwards of the first transect (see figure 2).
   During the first transect, the incubation rig was employed, as well as the multicorer at shallow stations for sediment samples.

4. At the end of the cruise, the 'Valdivia' sailed to the site of Meriadzek Terrace (station 800), the southern border of the Celtic Sea, where water samples in all depths were taken.
   The Meriadzek Terrace was meant to be a reference station, because other international scientific groups had already done some work at this site before.

In toto, on the cruise 'Valdivia 137' 684 water samples and 13 sediment samples had been taken at 47 stations.
At the stations, the following parameters were analysed aboard, or are going to be analysed in the laboratories ashore: temperature, salinity, turbidity, fluorescence, oxygen, pH, dry weight, 4π PAR irradiance, dissolved nutrients/carbohydrates, particulate carbon/ nitrogen/ phosphorus/carbohydrates, dissolved organic nitrogen/phosphorus, individual particulate fatty acids/ carbohydrates, microzooplankton, microzooplankton activity (grazing), heterotrophic/ mixotrophic protozoa, phytoplankton productivity (^{14}C-, ^{15}N-labelling) in (selected) water samples, and bacteria, bacterial production (^{3}H-thymidin incorporation), ecophysiological microbial potential (enzyme tests) in sediment samples.

Figure 1: OMEX research cruise Valdivia 137, 23/06 to 16/07/1993, operational area (hatched). Source: IOS, Wurmley, UK.

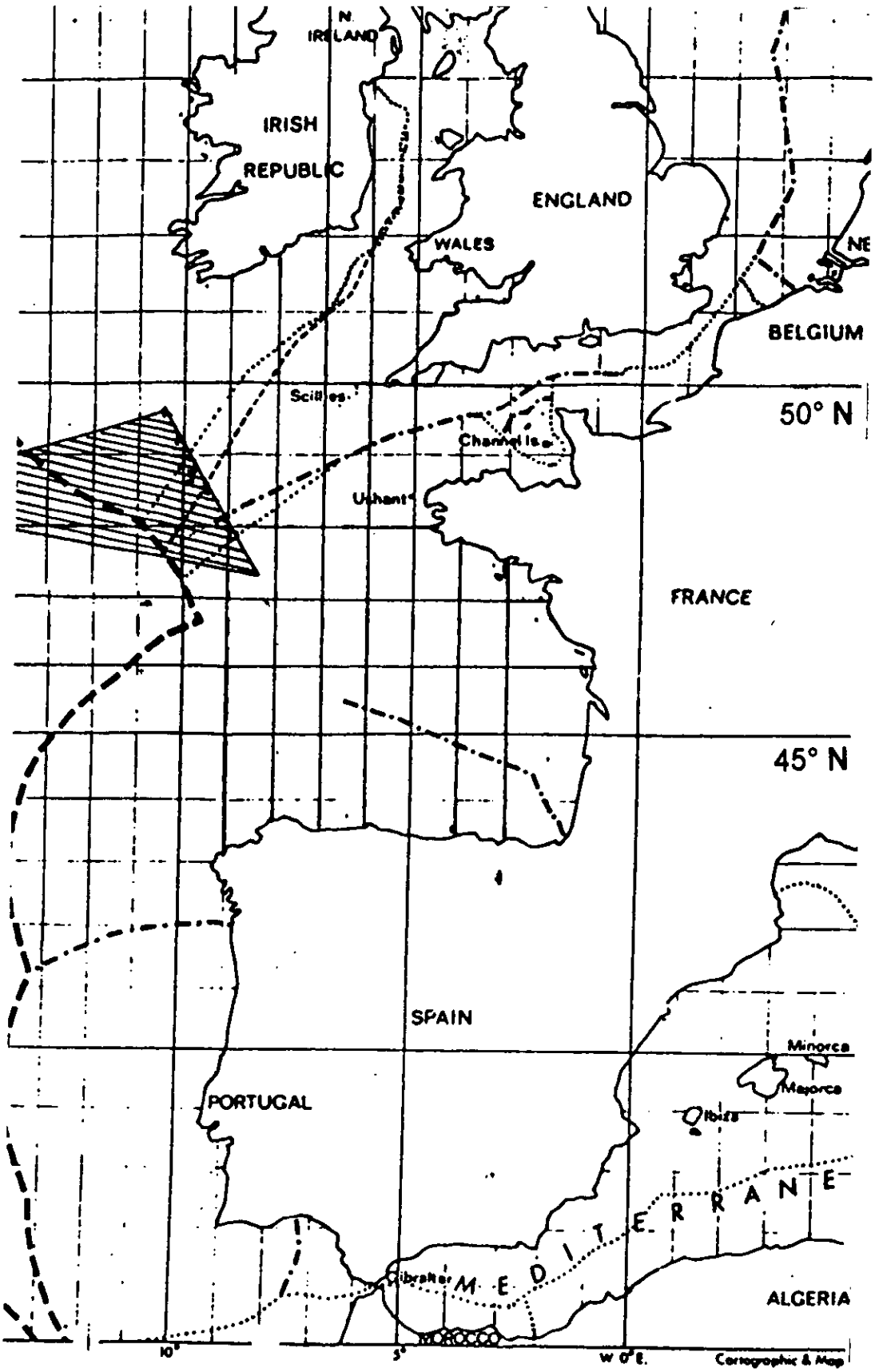
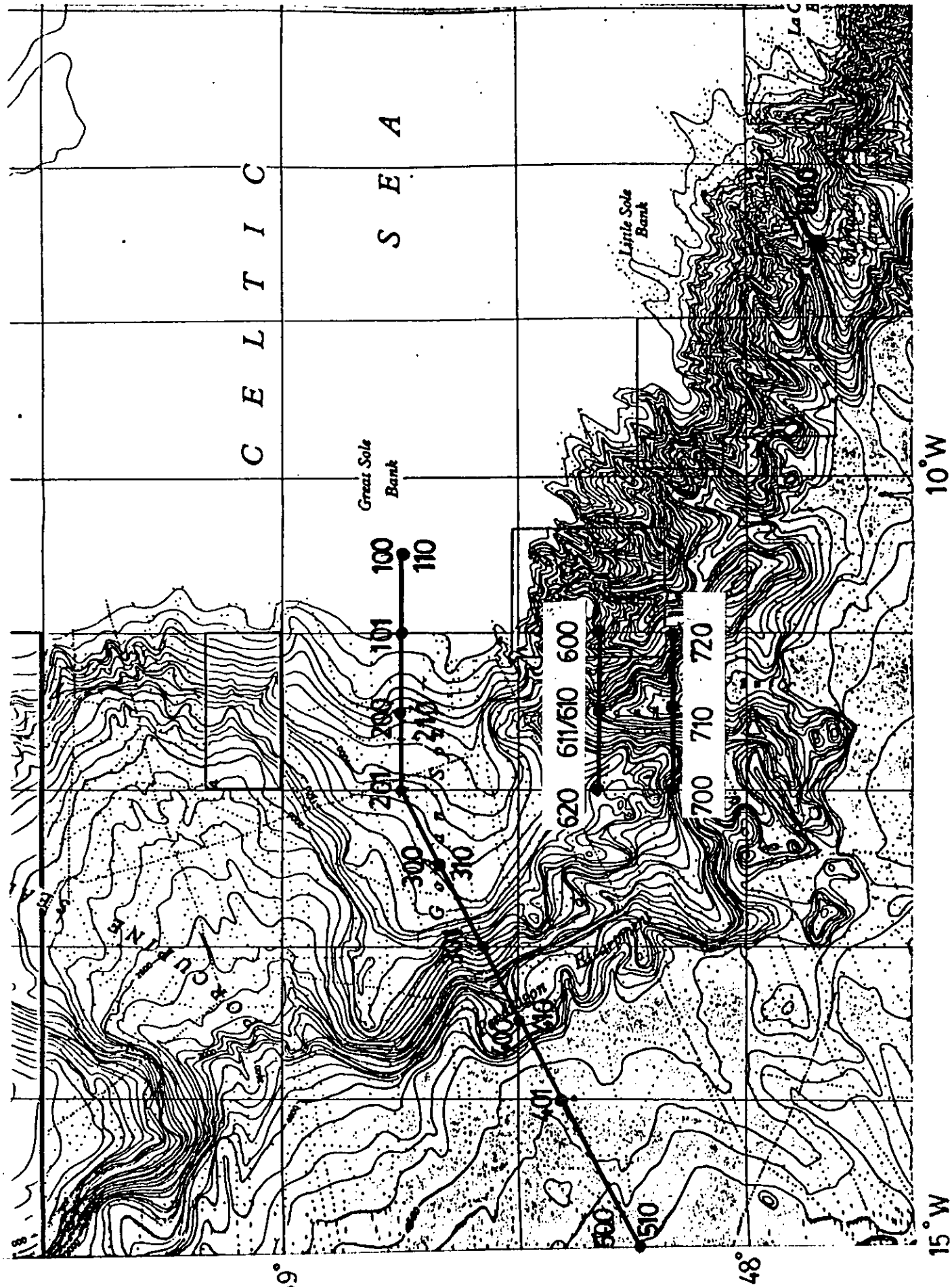


Figure 2: OMEX research cruise Valdivia 137, transects Goban Spur and King Arthur Canyon, sampling site Meriadzek Terrace.



2. Participating institutes and cruise personnel

Abbreviations:

PML	Plymouth Marine Laboratory, Plymouth
IfM	Institut für Meereskunde, Kiel
UHamb	Universität Hamburg
IBMC	Institut für Biogeochemie und Meereschemie, Hamburg
GBF	Gesellschaft für Biotechnologische Forschung, Braunschweig
CTD	Probe for measurements of conductivity, temperature and depth

Cruise personnel	**Institute**	**Research field**
Bloomer, Nicholas	PML	CTD, sampler rosette, engineer
Büns, Ise	IBMC	nutrients, organic substances
Edwards, Elaine	PML	microzooplankton
Eycke, Erhard	IBMC	CTD, sampler rosette, engineer
Jeskulke, Karen	IfM/UHamb	bacteria, bacterial productivity (^{3}H-Thy)
Pomroy, Alan	PML	phytoplankton productivity (^{14}C)
Poremba, Knut	IfM/UHamb	bacteria, bacterial productivity (^{3}H-Thy)
Raabe, Thomas	IBMC	cruise leading, CTD
Rees, Andy	PML	new production (^{15}N)
Schreiber, Ute	IBMC	fatty acids
Schütt, Monika	IBMC	nutrients, organic substances
Stelfox, Claire	PML	microzooplankton
Vahren, Wilfried	GBF/UHamb	ecophysiological microbial potential

3. Course of cruise

(Time is given as British Summertime, i.e. GMT + 1 h)

Wed, 23/06/93

18:30 Leaving Hamburg harbour.

Sat, 26/06/93

10:00 Reaching Plymouth harbour, loading PML equipment, installing the CTD.

Sun, 27/06/93

09:00 Leaving Plymouth.

15:00 First cast with CTD (for test use only) in the area out of the 12-nm zone, south of Cornwall.

Mon, 28/06/93

10:50 Reaching first station of Goban Spur Transect 1 (stat.no 100).
Beginning of the sampling:
First of all, CTD cast from surface to bottom without any stops, then, while heaving, taking water with 2.5-l Niskin samplers in the following depths:
(bottom-50), ...,3000,2000,1500,1000,900,800,700,600, 500,400,300,250,200,150,125 m.
In the euphotic zone, sampling was generally performed with 30-l Niskin samplers (depths: 100, 75, 50, 40 , 30, 20, 10, 5, 0 m), because a larger volume of water was required.
Whenever necessary, the big rosette sampler was also paid out to greater depths.
Since the CTD rosette sampler carried a maximum of 12 bottles, the CTD was driven down twice at the deeper stations.
The fluorometer connected to the CTD was only used down to maximum depths of 300 m, because the battery case was not resistant against high pressure and had to be taken off, before going down below 300 m.
On station 100 and 101 the fluorometer was not working properly, because there was a defect in the electrical cable.
At shallow stations not deeper than 2000 m, also the multicorer was paid out.
On selected stations Apstein net hauls were taken from depths between 50 and 75 m.

Wed, 30/06/93 In the morning telephone contact with RV 'Poseidon' (PSO Bodo von Bodungen). The 'Poseidon' was on an OMEX cruise, too, and mainly deployed sediment traps.

22:24 Receiving a fax from the 'Poseidon', providing information about temperatures and transmission data of some stations, lying close to the operational area of the 'Valdivia'.

Thu, 01/07/93

02:10 Ending the Goban Spur Transect 1.

Thu, 01/07/93

03:40 Beginning of the Goban Spur Transect 2 (stat.no. 510).
After a pre-dawn cast with the CTD combined with sampling in the euphotic zone, two incubation rigs connected to a buoy were set out.
Afterwards, sampling in the deeper layers was carried out.
From 12.00 a.m. to 08.00 p.m., there was regularly sampling every two hours in the euphotic zone (station numbers 511, 512, ...,515).
Between 8.00 and 9.00 p.m., the incubation rigs were taken aboard again.
This schedule was followed also the next days, on the stations 410 (, 411,..) , 310 (, 311,..), 210 (, 211,..) and 110 (, 111,..), respectively.
The multicorer again was employed at the shallow stations.
At station 510 the fluorometer broke down, because apparently it had not been resistant against the high water pressure. It was not possible to get it repaired aboard the vessel.

Mon, 05/07/93

20:50 Ending the Goban Spur Transect 2. The vessel was heading south for the King Arthur Canyon, then.

Wed, 07/07/93

04:50 Beginning of the King Arthur Canyon Transect 1. In the morning sampling and setting out of the incubation rigs was performed at station 600 as described before (see Goban Spur Transect 2).
After that the multicorer was employed.
This station was located at the upper margin of the canyon.
In the afternoon station 610, a deep station in the middle of the canyon, was sampled at.
Between 8 and 9 o' clock in the evening, the incubation rigs were taken aboard again at station 600.

Thu, 08/07/93

04:00 The sampling at the deep station, numbered as 611 (same location as 610) in the middle of the canyon, was carried out in the same way as in the morning of the day before, including the deployment of the incubation rigs.
On the way to the next station 620 at the western margin of the canyon, the multicorer was employed at a somewhat shallower position.
In the evening the incubation rigs were taken aboard.

20:40 Ending the Transect 1 at King Arthur Canyon.

Fri, 09/07/93

04:00 Beginning the King Arthur Canyon Transect 2.
At three stations, crossing the canyon, located about 20 nm south of the first Transect, vertical sampling profiles were taken.

Fri, 09/07/93

22:40 Ending the King Arthur Canyon Transect 2, then sailing south-east to Meriadzek Terrace.

Sat, 10/07/93

08:20 Reaching Meriadzek Terrace. Vertical sampling throughout the water column, using CTD and Niskin samplers.

12:06 Ending of the research program. Sailing back towards Plymouth.

Sun, 11/07/93

13:00 Reaching Plymouth harbour.

Mon, 12/07/93

Unloading for PML.

Tue, 13/07/93

08:30 Leaving Plymouth.

Fri, 16/07/93

00:00 Reaching Hamburg harbour.

08:00 Unloading.

4. Reports of the scientific working groups

All the results and conclusions presented on the following pages are based on first observations and analyses aboard the RV 'Valdivia'. These results do not claim to be absolutely complete and correct, and they should not be quoted before contacting the appropriate scientists.

4.1 Hydrography - N. Bloomer / E. Eycke / Th. Raabe

General course of cruise:

In the afternoon of Sunday 27th, a test cast was performed and some minor problems identified. These problems were soon overcome and the ship proceeded to its first station. In the first four casts the fluorometer did not seem to be working as expected, however, this was due to a problem with the harness, again quickly overcome. The casts then continued without incident until on cast 018 the fluorometer ceased to function. The cause was found to be the top plate which had deformed due to pressure. Unfortunately due to a misunderstanding, the instrument supplied was not as understood rated to 6000 metres. The case had not flooded and when tested, the instrument functioned. The casts then continued without the fluorometer. One other problem occurred; 5 out of the 7 thermometers supplied ceased to function, making only 2 readings possible. A light meter was rigged on

deck, and at four of the incubation sites a dipping light meter was used to take readings down to 20 metres. Since then everything continued well. The final cast was on Saturday 10th July, and afterwards the vessel sailed for Plymouth.

Methods:

Measurements had been carried out with a Neil Brown Mark II probe, where sensors for pressure, temperature and conductivity were installed. The probe, also including a software package for the recording of the data, was borrowed from the BAS (British Antarctic Survey), what should be mentioned as a very friendly gesture.
Furthermore, a Chelsea fluorometer was connected to the system.
In order to calibrate the conductivity sensor of the probe, water samples were taken at selected stations and analysed aboard using a salinometer .

First results:

Following the Goban Spur Transect 1, the water depth increased from 140 m (station 100) to 4800 m (station 500), then, on the way back, the depth decreased , respectively.

The transects at the site of King Arthur Canyon were performed across the canyon, where depths between 1300 and 2000 m at the margins were found, and the deepest points in the middle of the canyon lay between 3200 and 3800 m.

At all stations the salinity values had lain between 35.0 and 35.7 PSU. The higher values were normally found at the deeper stations below 1200 m.

The temperature lay about 15 to 16 °C in the upper layer (10 to 30 m) of the water column, and rapidly declined then down to 11/12 °C within the 100 m depth layer. Minimum values of 2 to 3 °C were found in the depths below 2500 m (see figure 3).

The fluorescence was measured solely during the first transect at the Goban Spur: At the surface relative values of 0.9 to 1.1 were recorded, reaching a maximum of 2.1 rel. units at a depth of 40 m and then, after this, steadily falling down to 0.5 rel. units at a depth of 100 m. This value remained relatively constant down to the depth limit of 300 m (see figure 4). These conditions were found at all stations of Goban Spur Transect 1.

Figure 3: CTD down-/upcast at station 301,
depth vs. parameters salinity, temperature, fluorescence (AD 1).

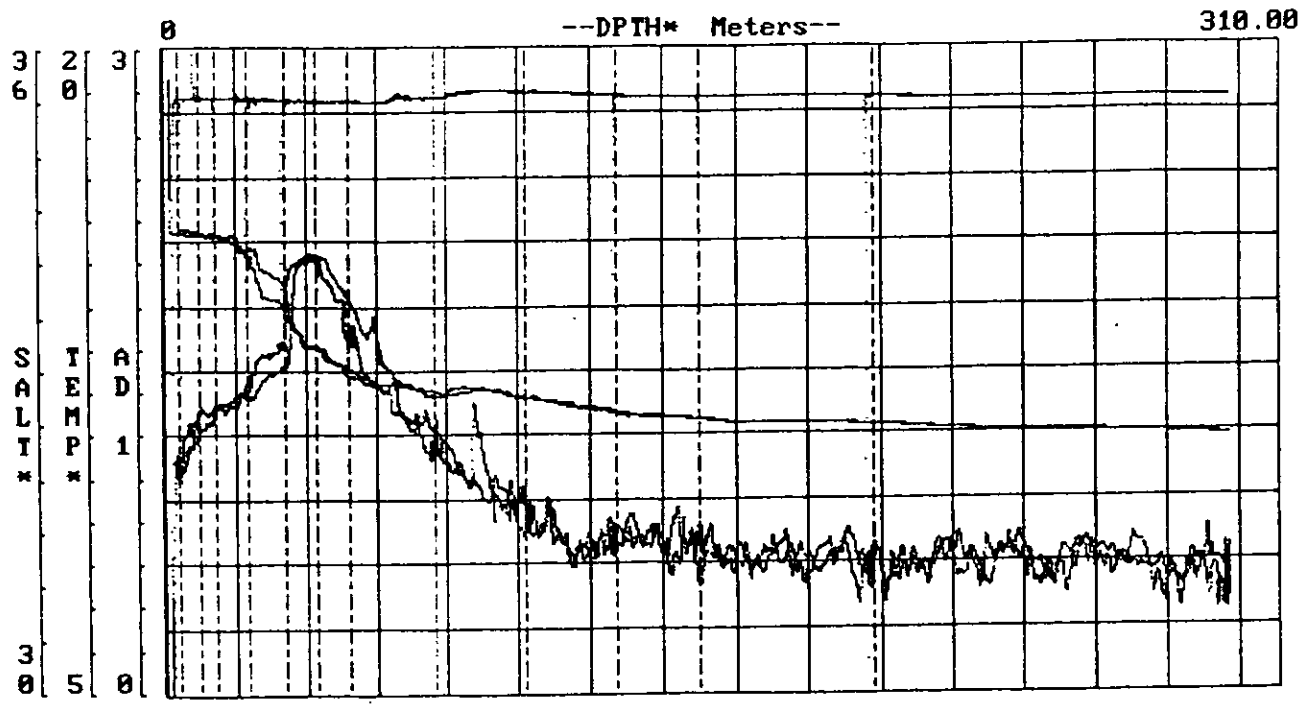
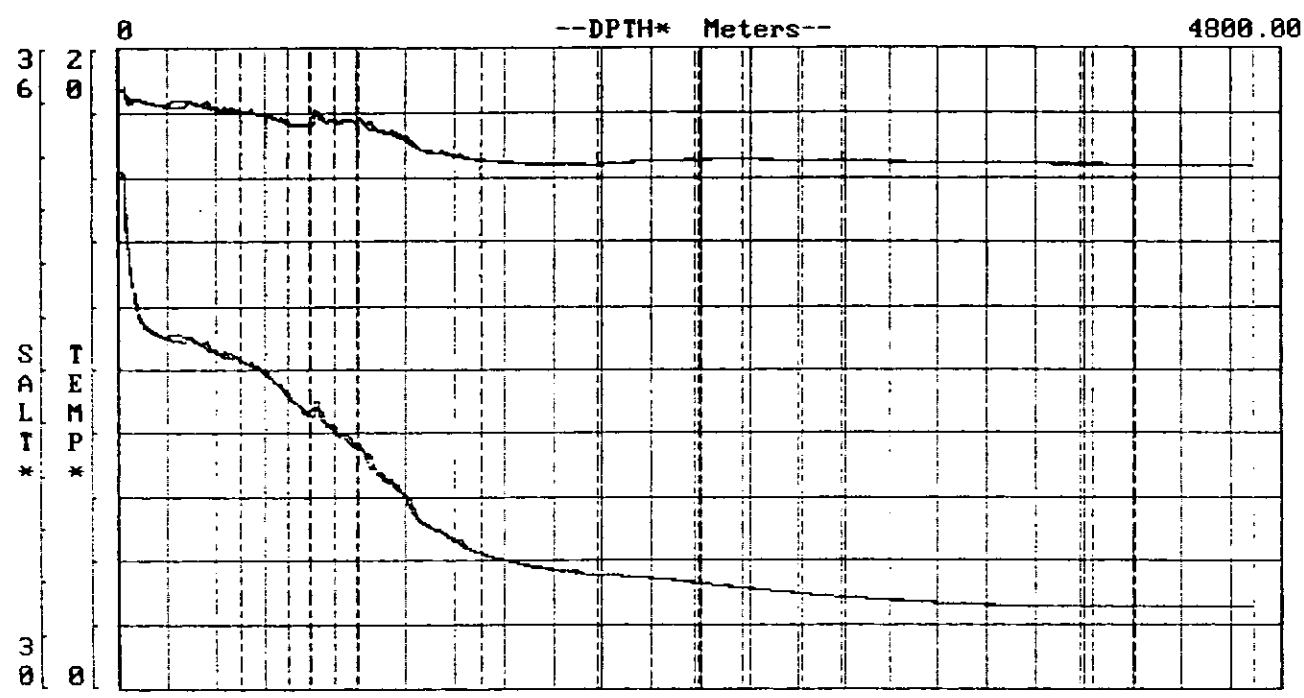


Figure 4: CTD down- and upcast at station 500, depth vs. parameters salinity, temperature



4.2. Microzooplankton - E. Edwards / C. Stelfox

MICROZOOPLANKTON HERBIVORY & COMMUNITY STRUCTURE

The overall objective of this research is to test the hypothesis that microheterotrophic activity is higher at the ocean margin (due to locally enhanced primary production from nutrient input), than in adjacent ocean and shelf waters. More specifically our main aims were to :
1) Quantify the concentration and species composition of microzooplankton (organisms <200µm in length) in the surface mixed waters of the ocean margin and adjacent shelf and ocean regions.
2) To determine microzooplankton standing stocks.
3) To quantify the herbivorous interactions between microzooplankton and phytoplankton in ocean margin surface waters.

METHOD

Microzooplankton Biomass Studies

Water samples were collected using a 30 l rosette sampler and were fixed as follows:
a) 1% acid lugols iodine for the subsequent determination of total microzooplankton biomass and species composition.
b) 2% hexamine buffered formaldehyde for the enumeration and identification of autotrophic components of the community.
c) 5% Bouin's solution for the subsequent determination of ciliate taxonomy by silver staining.
d) 0.3% glutaraldehyde for enumeration of autotrophic and heterotrophic nanoflagellates. Samples were stained with DAPI and proflavin filtered onto 0.4µm polycarbonate filters and frozen, to be analysed back in the lab.

Full detail of samples taken are shown in table 1 The above samples will be analysed in the lab using inverted microscopy and image analysis.
Apstein net hauls were carried out at all stations where possible, from depths down to 75m. The Apstein was fitted with a 20µm mesh net and allows qualitative assessment of the larger and less delicate of the microzooplankton such as the tintinnids and large heterotrophic dinoflagellates, together with larger phytoplankton cells. For each sample half was fixed in lugols iodine the rest were kept live for observation using an inverted microscope fitted with Nomarski Interference Contrast. A video was made of live cells including ciliates, dinoflagellates and other phytoplankton cells. This, together with numerous micrographs of different cells will help in future identification work.

In addition to the above biomass samples, 2 litres of water from 7 depths in the top 100m were filtered for subsequent analysis of pigment content by HPLC. This work will be carried out by Dr.R.Barlow at Plymouth Marine Laboratory.

Grazing cruises

Microzooplankton grazing cruises were carried out using the dilution technique of Landry & Hassett (1982). A total of 7 cruises were carried out in conjunction with primary production cruises, for further details see table 1. Water was collected from a depth of 10m, and pre-screened through a 200µm mesh net. Dilutions were made up in 2 litre polycarbonate cruiseal bottles, were incubated *in situ* and in a Gallenkamp incubator, for a period of 24 hours. Samples were taken for the determination of chlorophyll concentration, on two occasions they were size fractionated using polycarbonate membrane filters of pore sizes 0.2, 2 and 10µm. Water bottles were also sampled for species composition and biomass., fixing in lugols 1% and glutaraldehyde. We generally analyse the chlorophyll samples at sea, however, because of the intensity of our sampling schedule these samples were frozen and will be analysed immediately on return to the laboratory.

Fluorescently labelled algae (FLA): Qualitative analysis of microzooplankton grazing.

The objective of this research was to assess taxon specific protozooplankton herbivory. This was achieved using a tracer method to determine the uptake of fluorescently labelled phytoplankton (<10µm) by protozoa in natural water samples. Cultures of two species of algal flagellates of contrasting size, *Dunaliella tertiolecta* (approx. 10µm diameter) and *Chlorella stigmatophora* (4µm diameter), were stained with the fluorescent dye 5-(4,6-dichlorotriazin-2-yl) aminofluorescein (DTAF). Fluorescently labelled uptake cruises were carried out at a total of 14 stations, more details are given in table 1. Water samples obtained from a 30l rosette sampler from surface mixed waters , were inoculated with a known concentration of the stained algae and were incubated for 0, 5, 10, 20 and 60 minutes under ambient conditions. Samples were then fixed with 1% lugols iodine; they will be analysed back in the lab. the lugols will be cleared by the addition of sodium thiosulphate and analysis will be by inverted fluorescent microscopy. It is estimated that analysis of the majority of these samples will be complete by September 1993.

Table 1: Microzooplankton sampling schedule.

DATE	STATION	SAMPLING EVENT
28th June	100	Lugols 0-40m
		FLA- 10m
		Apstein net - 50m
	101	Lugols 0-150m
		DAPI 0-50m
		Bouins 10-20m
	200	Lugols 0-300m
		DAPI 0-50m
		FLA 5m
		Apstein net 50m
29th June	201	Lugols 5-1000m
		DAPI 5-50m
		FLA 10m & 40m
		Apstein net 75m
	301	Lugols 0-1800m
		DAPI 0-50m
		FLA 10m
		Apstein net 50m

30th June	400	Lugols 0-1000m DAPI 0-50m FLA 10m & 50m
	401	Lugols 0-1000m DAPI 0-50m
	500	Lugols 5-100m DAPI 5-50m FLA 10m
1st July	510	Lugols 0-100m DAPI 0-50m Bouins 10-50m Formaldehyde 0-50m HPLC 0-100m Dilution cruise 1 FLA 10m Apstein net 50m
2nd July	410	Lugols 0-100m DAPI 0-50m Bouins 10-50m Formaldehyde 0-50m HPLC 0-50m Dilution cruise 2 FLA 10m Apstein net 50m
3rd July	310	Lugols 0-100m DAPI 0-50m Bouins 0-50m Formaldehyde 0-50m HPLC 0-100m Dilution cruise 3 FLA 10m Apstein net 50m
4th July	210	Lugols 0-100m DAPI 0-50m Bouins 0-50m Formaldehyde 0-50m HPLC 0-100m Dilution cruise 4 FLA 10m Apstein net 50m
5th July	110	Lugols 0-100m DAPI 0-50m Bouins 0-50m Formaldehyde 0-50m HPLC 0-100m Dilution cruise 5 FLA 10m Apstein net 50m
7th July	600	Lugols 0-100m DAPI 0-50m Bouins 0-50m Formaldehyde 0-50m HPLC 0-100m Dilution cruise 6 FLA 10m Apstein net 50m
	610	Apstein net 50m

8th July	611	Lugols 0-100m DAPI 0-50m Bouins 0-50m Formaldehyde 0-50m HPLC 0-100m Dilution cruise 7 FLA 10m
	620	Apstein net 75m
9th July	700	Lugols 0-100m DAPI 0-50m Bouins 0-50m Formaldehyde 0-50m HPLC 0-100m FLA 10m & 40m
	710	Lugols 0-3650m DAPI 0-50m Bouins 0-50m Formaldehyde 0-50m Apstein 50m
	720	Lugols 0-1000m Bouins 0-50m Formaldehyde 0-50m Apstein net 50m
10th July	800	Lugols 0-2000m DAPI 0-50m Bouins 0-50m Formaldehyde 0-50m Apstein net 50m

RESULTS

A complete assessment of the results will be carried out in the laboratory. There is, however, some information available on the species composition of the Apstein net hauls. Tintinnid ciliates were numerous and varied in the net hauls, particularly along the Goban Spur transect (stations 200-500), no tintinnids were found at station 100/110.

The wide variety of species present at other stations included *Eutintinnus spp* , *Salpingella spp* , *Dadayiella spp.*, *Dictyocysta speciosa*, *Dictyocysta elegans*, *Codonellopsis sp.*, *Amphorides sp.*, *Xystonella flemingi*, *Ascambelliella ureolata*, *Rhabdonella*, *Acanthostomella norwegica*, *Climacocylis sp,* and *Parundella.*

As well as the tintinnids several rather large ciliates, namely *Euplotes sp*, *Peritromus* and *Lacrymaria* were commonly found. Commonly occuring phytoplankton included several species of *Gonyaulux, Ceratium furca, C.fusus, Oxytoxum scolopax, Oxytoxum tesselatum, Rhizosolenia styliformis, R. alata, Protoperidinium spp. Dinophysis rotundatum, Ptychodiscus noctiluca, Amphidoma, and Prorocentrum.*

Abundance of these species seemed to vary form station to station, for example, station 1 consisted predominantly of the diatom *Rhizosolenia* and the dinoflagellate *Ceratium spp, Phaeocystis* was also abundant as was the ciliate *Leegardiella sp.* Copepods and their nauplii, Acantharians and Foraminiferans were found in all samples.

This list is by no means complete, a more detailed species list will be available shortly. Hopefully from our successful video work many more species will be identified.

Finally we would like to express our gratitude to the Captain and crew of RS Valdivia without whose kind help and hospitality this work would not have been possible. We look forward to sailing with you all again.

References:

Landry M.R. & Hassett R.P. (1982) Estimating the grazing impact of marine microzooplankton. *Marine Biology*, **67,** 283-288.

Rublee P.A. & Gallegos C.L. (1989) Use of fluorescently labelled algae (FLA) to estimate microzooplankton grazing. *Marine Ecology Progress Series,* **51**, 211-227.

Sherr E.B., Sherr, B.F. & Mc Daniel J. (1991) Clearance rates of <6µm fluorescently labelled algae (FLA) by estuarine protozoa: potential grazing impact of flagellates and ciliates. *Marine Ecology Progress Series*, **69**, 81-92.

4.3. Primary Production - A. Pomroy and A. Rees

A total of nine incubations to determine the size-fractionated rates of uptake of ^{14}C bicarbonate and ^{15}N nitrate or ^{15}N ammonium were completed using either a free-floating in situ incubation system with 9 depths or a simulated in situ incubator on deck with bottles at 6 light intensities. In addition samples were also taken from the same water bottles as the production cruises for the following determinations:

1. Spectrophotometric analysis of chlorophyll.
2. Fluorometric analysis of size fractionated chlorophyll concentration.
3. Bacterial uptake of ^{3}H thymidine at in situ temperatures.
4. Bacterial uptake of ^{3}H leucine at in situ temperatures.
5. The enumeration of bacterial numbers by epifluorescence microscopy.
6. Samples preseved with Lugol's iodine for the identification and counting of phytoplankton species.
7. Samples preserved with glutaraldehyde for use in scanning electron microscopy for confirmation of phytoplankton identifications.

Station 201, 29 June 1993
Simulated in-situ primary production cruise.

Station 510, 1 July 1993
In-situ primary production cruise.

Station 410, 2 July 1993
In-situ primary production cruise.

Station 310, 3 July 1993
In-situ primary production cruise.

Station 210, 4 July 1993
In-situ primary production cruise.

Station 110, 5 July 1993
In-situ primary production cruise.

Station 600, 7 July 1993
In-situ primary production cruise.

Station 611, 8 July 1993
In-situ primary production cruise.

Station 700, 9 July 1993
Simulated in-situ primary production cruise.

4.4. Bacteria / Bacterial Productivity - K. Poremba / K. Jeskulke

For the collection of samples a total of 13 multicorer and 1 rosette sampler was used. Samples were taken at the stations 100, 200, 300 and 301 of the transect over the Goban Spur and in the King Arthur Canyon at station 701.
The microbial abundance (cell number and biomass) were studied with a direct cell count method (epifluorescence microscopy) and indirectly by DNA extraction and quantification.
There is no data available at this early stage, since both examination procedures will be completed at Kiel or Braunschweig, respectively.

Our measurements of the extra cellular microbial enzyme activity included the use of 5 ecological significant model substrates. These substrates were tested on sediment samples.
Preliminary data show that there is a preference for biological degradation of nitrogenous biopolymers like protein and chitin. The gathered data of cellulase- and amylase activities from the Goban Spur were, as expected, higher than data collected from deep sea sediments at 4500 m water depths. It is assumed, that the cluster of potential extra cellular enzyme activity is strongly associated to the quality of the available particular organic matter at the sample location in question. Furthermore, there is a correlation between water depth and enzymatic degradation potential, which is assumed to be related to the lesser extent of sedimentation rate of particular organic matter in the light saturated water layers. These findings must first be verified by further analysis in the Kiel laboratories. Presentation of precise data is not possible at the present time.

Measurements of the bacterial production rate from sediments and sediment contact water were done by the thymidin incorporation method. Preliminary data show that the secondary production potential declines with rising water depths and is therefore coherent with the extra cellular enzyme activity. Only station 300 (1250 m water depth) exhibited an unusually high thymidin incorporation rate in the sediment

contact water. It remains to be seen, however, if this finding can be confirmed by analysis of the sediment samples, which have not been investigated so far.

A physiological adaptation to increased hydrostatic pressure, compared to the surrounding *in situ* pressure of the samples, could not be shown in the cruises. Yet material from shallow water depths (>1600 m) displayed a barophobic reaction, indicating a large fraction of surface micro-organisms in the sediment micro-organism community. On the other hand it could be shown, that bacteria from 137 m water depth at 600 bar surrounding pressure (equivalent to 6000 m water depth) still exhibited 10 % of their *in situ* growth rate. This phenomenon was further investigated with cruises of the baro-tolerance of pelagic bacteria from 10, 150, 200 and 3650 m water depth. The cruises are not evaluated at the present time.

4.5. Ecophysiological Microbial Potential - W. Vahjen

Sediment samples were analysed from 137, 600, 1250 and 1680 m water depth. A soil DNA extraction protocol (Vahjen and Tebbe, Applied and environmental Microbiology; to be published in August 1993) was applied to extract DNA from deep sea sediments.

Quantification of deep sea DNA extracts
Each sediment sample was divided into segments of 1 cm depth, ranging from 0 to 10 cm.
Following the successful extraction of DNA from sediment of 137 m water depth, cruises were conducted to evaluate the stability of DNA quantity after freezing the sediments at - 20 C. No change in quantity could observed. Thus, all further cruises were carried out with previously frozen samples.
Comparison of the separate sediment segments showed the following results:

- the highest DNA quantities were found in the 0 - 1 cm segments, as expected;
- a gradual decline in quantity was observed in rising segment depths;
- the fragment size below 5 kb decreased with rising depth;

Comparison of sediment samples exhibited a strong decline in DNA quantity below water depths of 600 m. Further investigations for exact quantification via densitometric analysis will proceed in the Braunschweig laboratories.

Qualitative analysis of deep sea DNA extracts
DNA extracts from segments of 137 m water depth were investigated by restriction digest analysis. Although no distinct band clusters could be distinguished using four different restriction enzymes, there are significant differences in intensity and size of the restricted DNA samples from differing segment depths, indicating the presence of different organisms in deeper segment depths. Further cruises will be carried out at the Braunschweig laboratories.

Further investigations
Experiments with pressurised DNA samples showed fragmentation of DNA in the 40 - 30 kb region, when depths exceeded 1500 m, although the DNA quantity remained unchanged. This could, in part, explain the fragmentation, that was found in DNA extraction of sediment samples from 1680 m water depths.

DNAse activity was determined for all sediment sample depths. The cruises have shown high DNAse activities in all sediment samples, even at a incubation temperature of 4 C. Highest DNAse activities were observed in the 137 m sediment samples, lowest activities were found in the 1680 m sediment samples, indicating the decline of biological activity in deeper water depths.

4.6. Nutrients / Organic Compounds / Fatty Acids - I.Büns / M.Schütt / U.Schreiber / Th. Raabe

Main objectives of this investigation were transfer and transformation processes of nutrients and organic compounds in water masses passing the shelf break. On one hand, this research is based on results of sum parameter measurements. On the other hand, individual compounds will be analysed in order to refer concentration changes of these parameters more precisely to biogeochemical processes.

Methods:

At all stations water samples were vacuum filtrated over glass fibre filters (Whatman GFC) at low pressure (<0.2 bar). The filtrated volumes were adapted to the content of particulate matter. The filtrate, partly preserved with $HgCl_2$, was stored in glass and polyethylene bottles in a cooling chamber. Unless not done yet, the filtrate will be analysed for dissolved organic nitrogen/phosphorus/carbon, total carbohydrates.

The filters were stored in a freezer at -17 °C. From these filters dry weight, particulate carbon/nitrogen/phosphorus, carbohydrates and fatty acids will be determined.

The nutrients nitrate, nitrite, phosphate, silicate and ammonium, were directly measured out of the samples with a Technicon AutoAnalyzer System, provided that the content of particulate matter was not too high. Total dissolved nitrogen and phosphorus were analysed from filtrate, using a wet-chemical oxidation method followed by nitrate/ phosphate determination.

Furthermore, the parameters pH (WTW pH meter), fluorescence (Turner fluorometer) and turbidity (Turner nephelometer) were analysed immediately in every sample. Oxygen was determined by Winkler titration with a Metrohm titration stand.

First results:

During the whole cruise the nitrate concentrations were in a range between 0.05 to 20 µmol/l. The lowest values, not more than 0.2 µmol/l, were observed in the euphotic zone down to a depth of 20/30 m. From 30 to 100 m the concentrations

rose strongly up to 8 to 10 µmol/l, then slower increasing to maximum values of 20 µmol/l at depths below 1000 m. The very low concentrations in the upper layers were obviously due to uptake by phytoplankton.

In figure 5 vertical profiles of the nitrate concentrations, found at the Goban Spur Transect 1, are shown. The gradients observed on the remaining transects were nearly identical concerning concentration and shape.

For phosphate very similar distribution patterns were observed: Minimum values of less than 0.1 µmol/l were detected in the mixed layer from surface to 20 or 30 m, increasing to 1 µmol/l at 100 m depth, and at last reaching maximum values of 1.5 µmol/l in the depths below 1000 m. The vertical profiles of Goban Spur Transect 1 are given in figure 6. The respective plots for Goban Spur Transect 2 and the King Arthur Transects showed the same tendencies.

During the whole time of the cruise the concentrations of silicate in the euphotic zone were very low. Down to a depth of 50 m the silicate values were below 1 µmol/l; very often even not more than 0.5 µmol/l were found. In a water depth of 100 m the concentrations reached 3 µmol/l, and then increased steadily to a maximum of 40 µmol/l in 4000 m (at the deep stations). The vertical profiles of the different transects showed again very similar structures, so only the Goban Spur Transect 1 will be given as a representative plot (see figure 7).

Figure 5: Vertical profiles of nitrate concentrations on Goban Spur Transect 1.

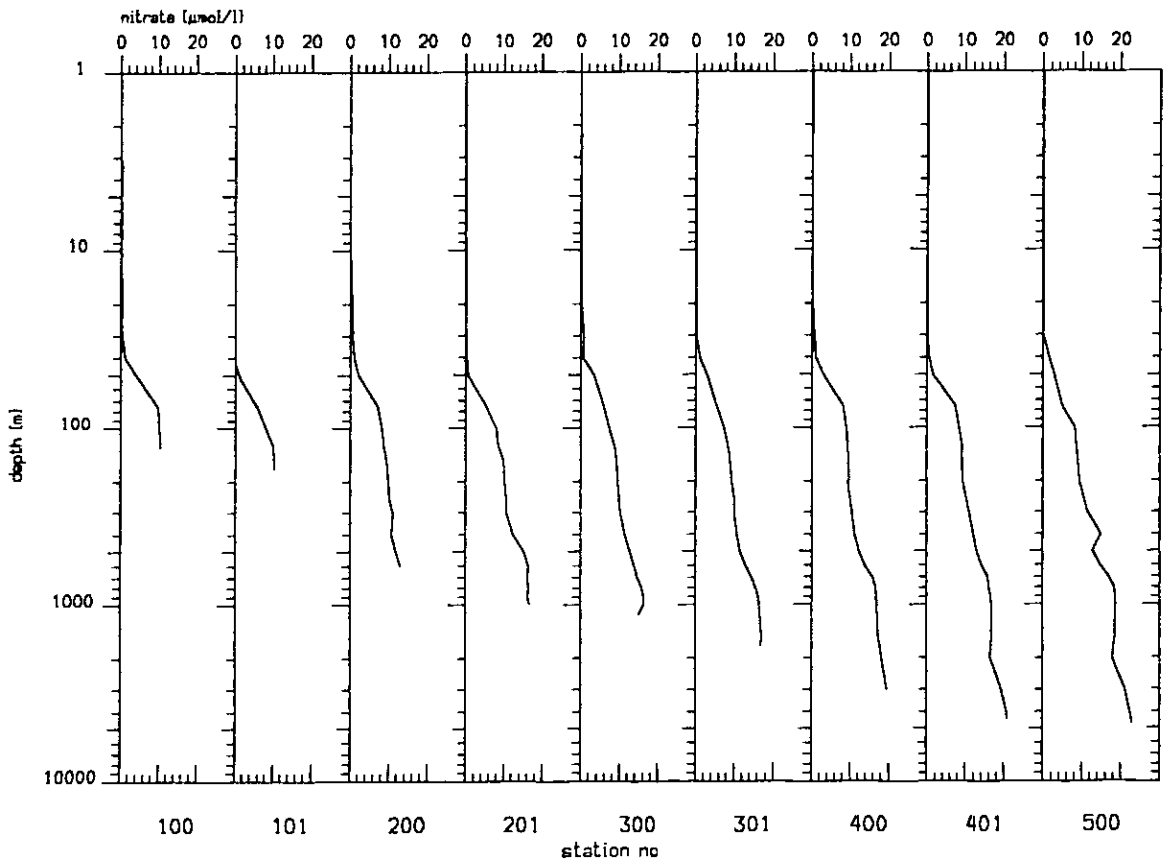


Figure 6: Vertical profiles of phosphate concentrations on Goban Spur Transect 1

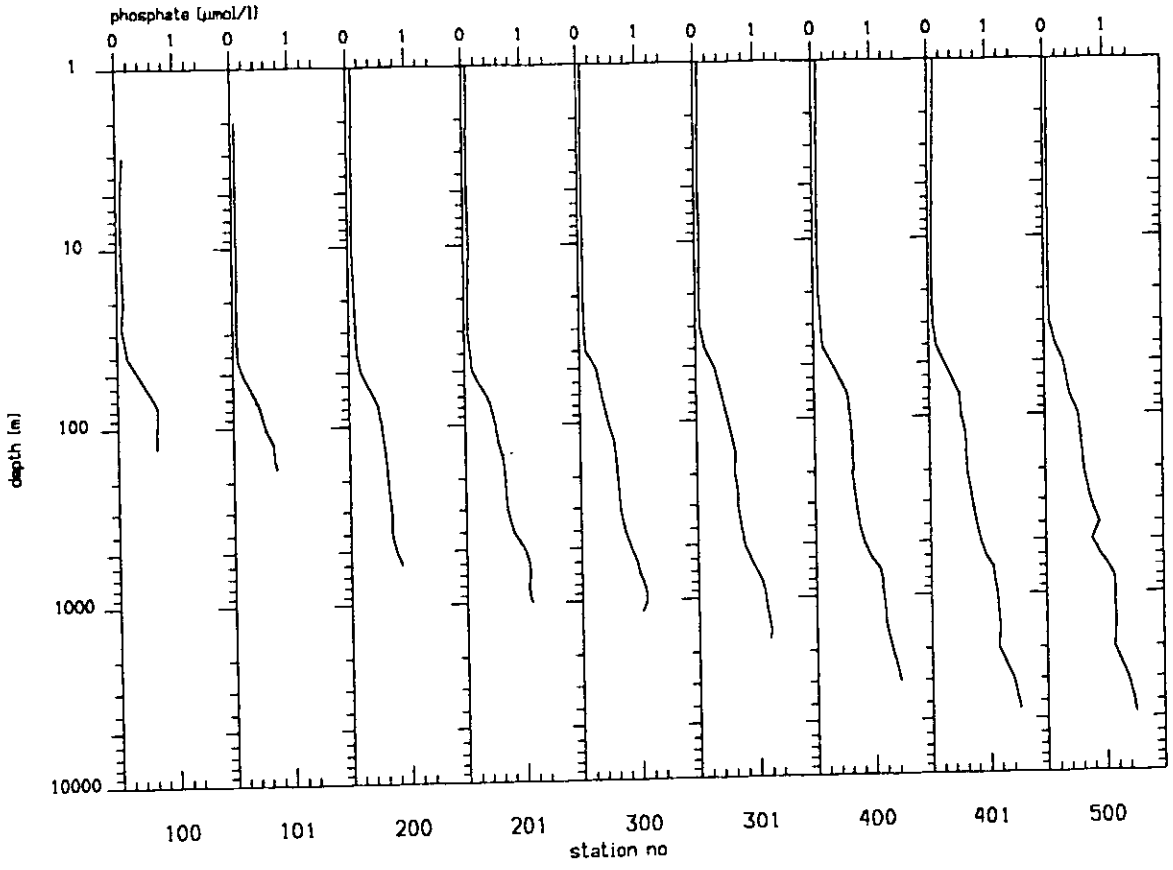
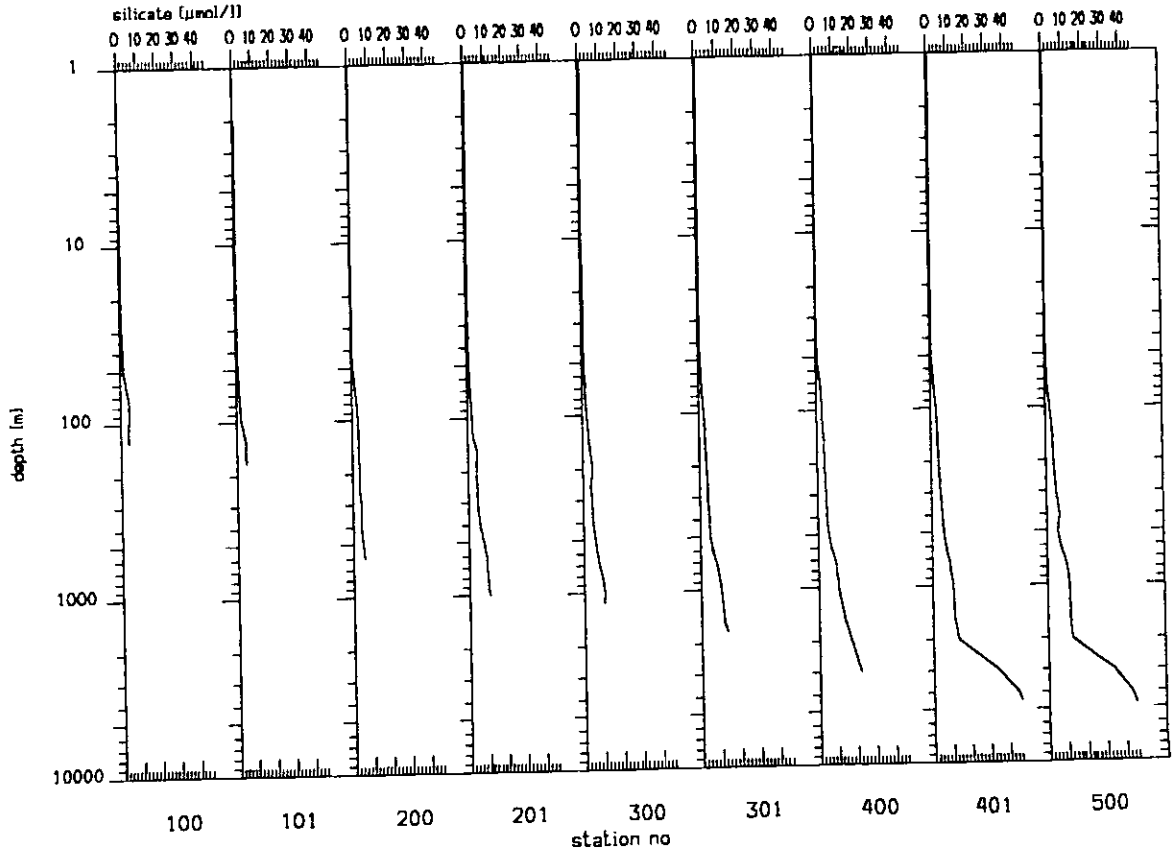
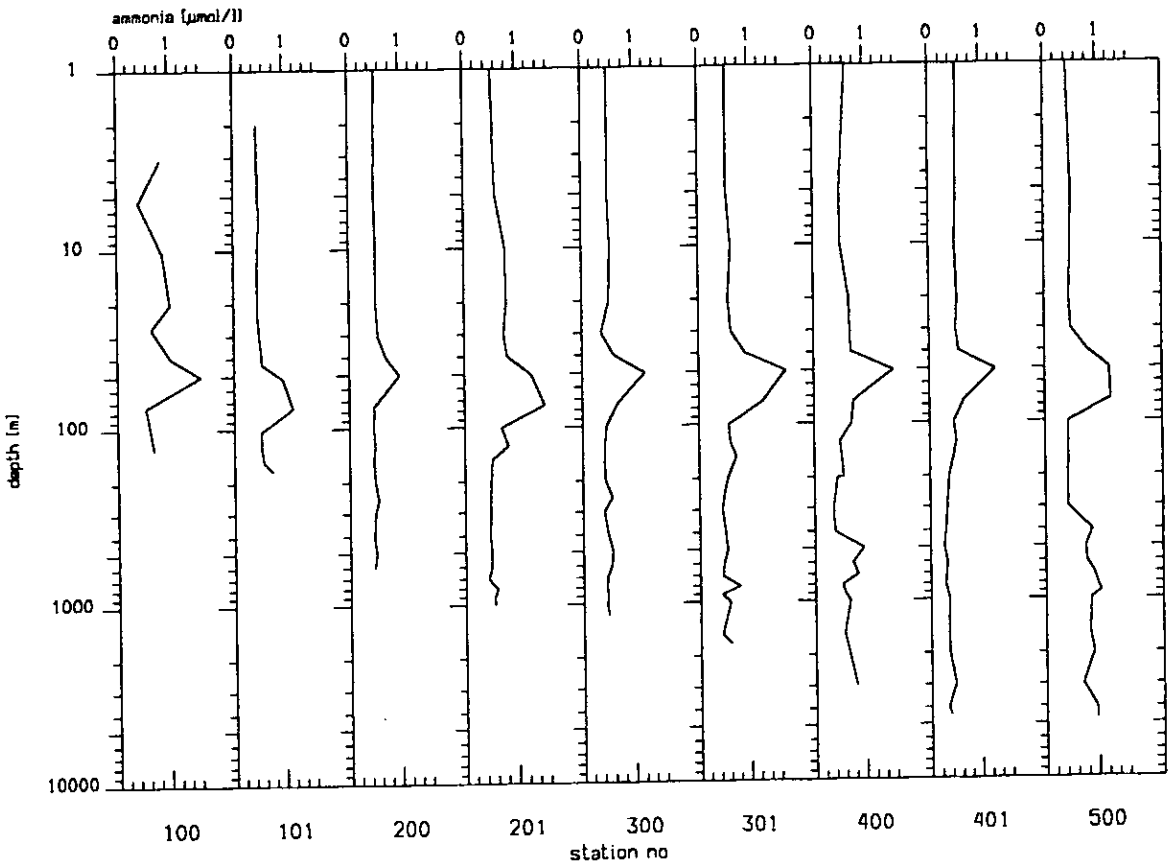


Figure 7: Vertical profiles of silicate concentrations on Goban Spur Transect 1



Compared to the 3 'conservative' nutrients nitrate, phosphate and silicate, the vertical profiles of ammonium and nitrite were different. The concentration of ammonium was around 0.5 µmol/l throughout the water column. Only in a depth of 50 m, sometimes down to 75 m, sharp peaks with maximum concentrations up to 1.7 µmol/l were found (see figure 8).

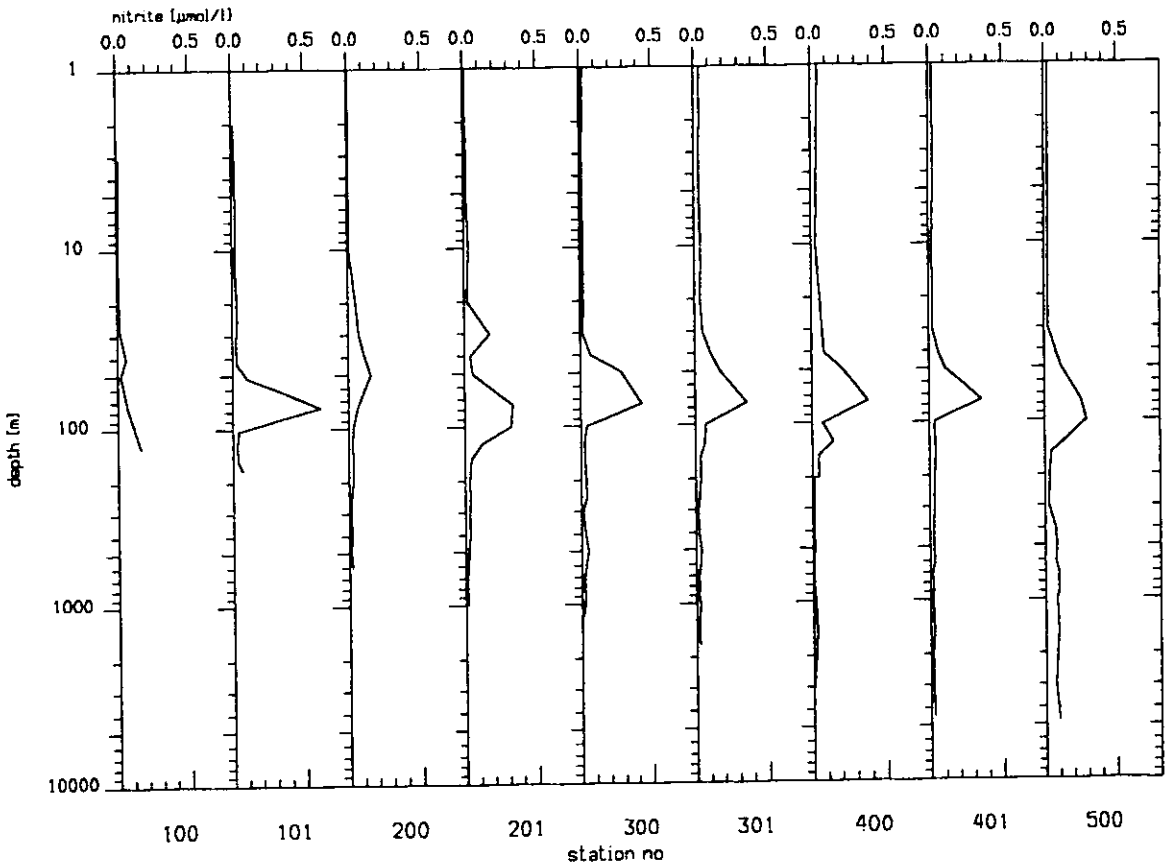
Figure 8: Vertical profiles of ammonium concentrations on Goban Spur Transect 1.



Nitrite concentrations were far below 0.1 µmol, in most cases about 0.02 µmol/l. This was observed in the surface as well as in the deep layers below 1000 m. In a depth of 75 m these concentrations usually increased to 0.3 to 0.4 µmol/l (see figure 9).

It was a remarkable observation that the maximum values of ammonium were found in depths located about 20 m above the depths, where the maximum concentrations of nitrite were measured.

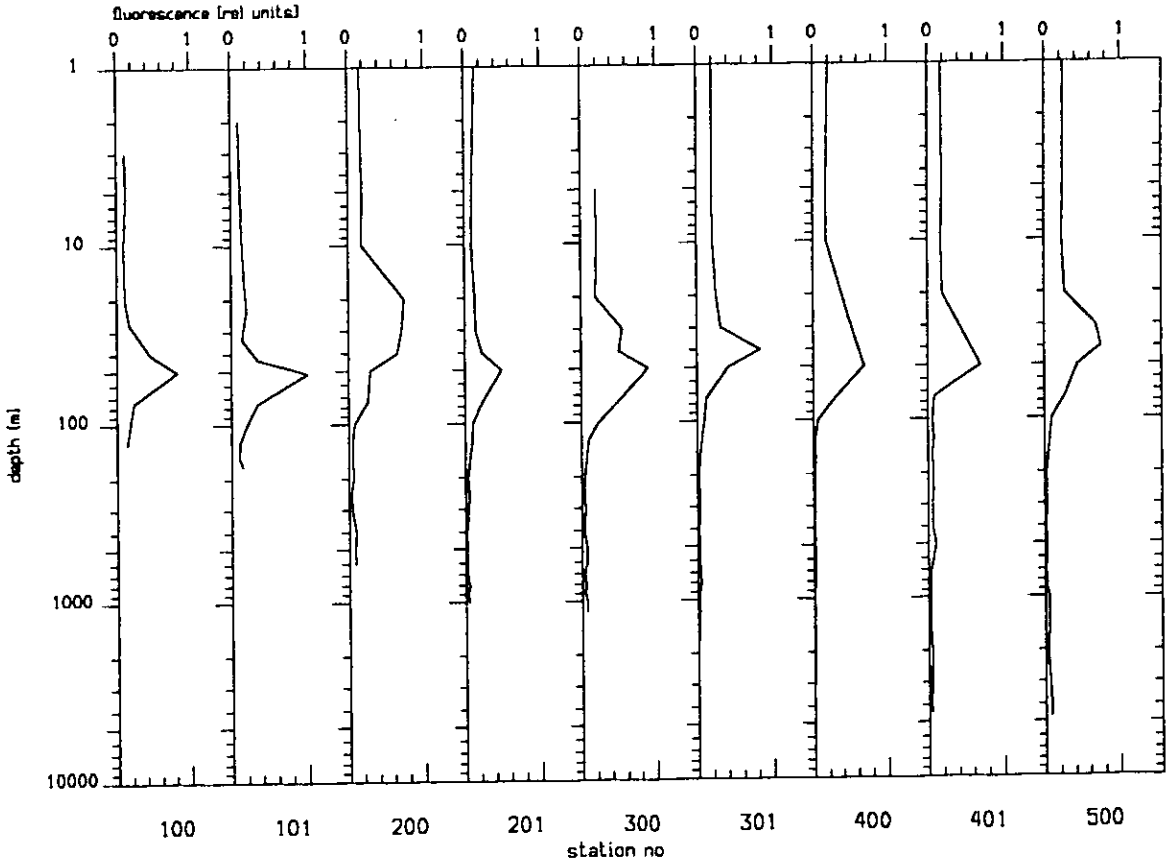
Figure 9: Vertical profiles of nitrite concentrations on Goban Spur Transect 1.



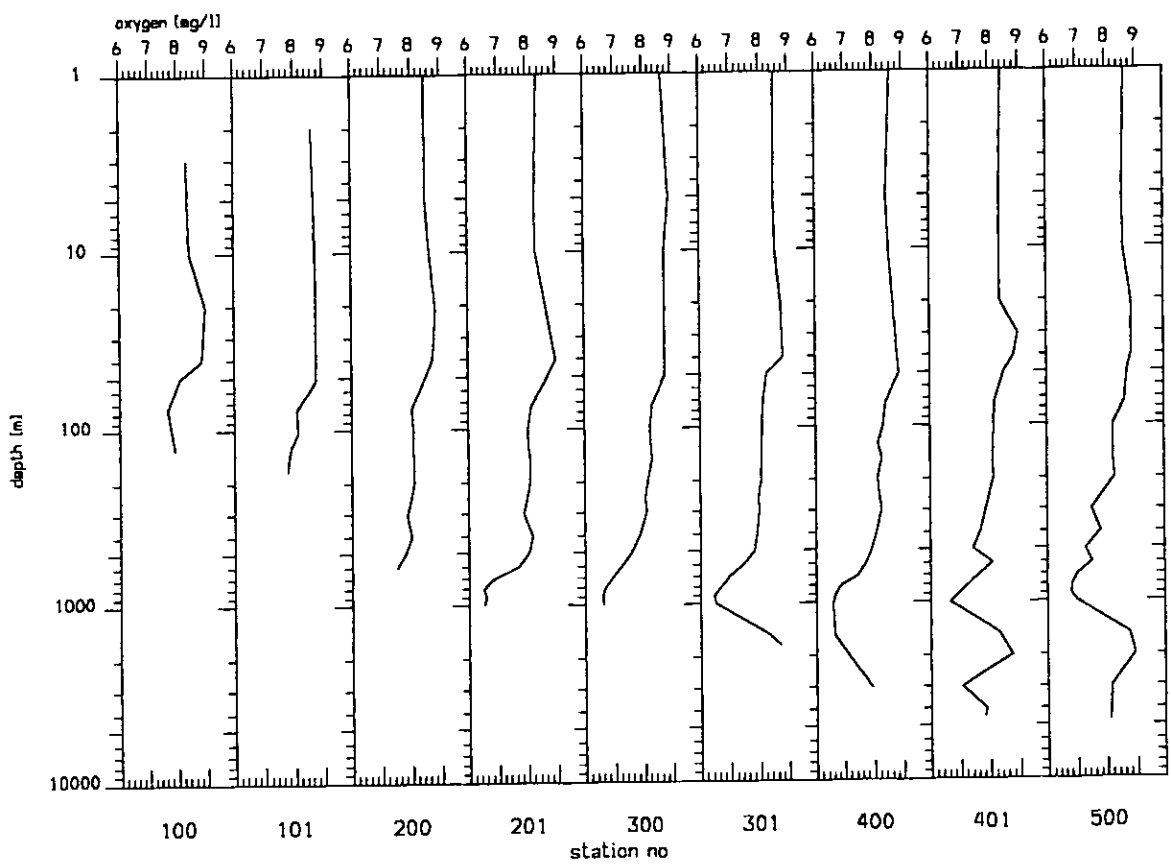
The observed nutrient situation is explained as following:
In the upper euphotic zone nutrients were kept close to limitation by primary production above the pycnocline, but in spite of that nutrients were still available within the lower euphotic zone (above the compensation depth) by diffusion from the nutrient rich deeper layer. Thus the main standing stock formed here. This could be derived from the fact that there were significant fluorescence signals in the first 100 m of the water column. The fluorescence showed a maximum at 40 to 50 m depth (see figure 1, CTD data, and figure 10, Turner fluorometer). Here and above the pycnocline phytoplankton cells were decomposed by zooplankton, excreting ammonium. Due to this process, ammonium concentrations remained quite high at the 50 m depth line. As far as the ammonium was not taken up by other plankton cells, it was oxidized to nitrite by bacteria attached to the sinking cell debris. This process could be assumed as an origin for the enrichment of nitrite in the depths of 50 to 75 m.

Another hint at the higher primary production in the layers between 30 and 40 m depth was found in the oxygen values, shown in figure 11. While average values for the dissolved oxygen in the euphotic zone were about 8.2 to 8.5 mg/l, concentrations of 8.8 to 9.2 mg/l were found in the 40 m layer. At the depths of nitrite maxima the oxygen concentrations decreased already, due to ammonium oxidation. Minimum concentrations of oxygen, amounts below 7 mg/l, were measured at depths of 1000 m, caused by degradation of sedimenting organic material.

Figures 10: Vertical profiles of fluorescence values on Goban Spur Transect 1.

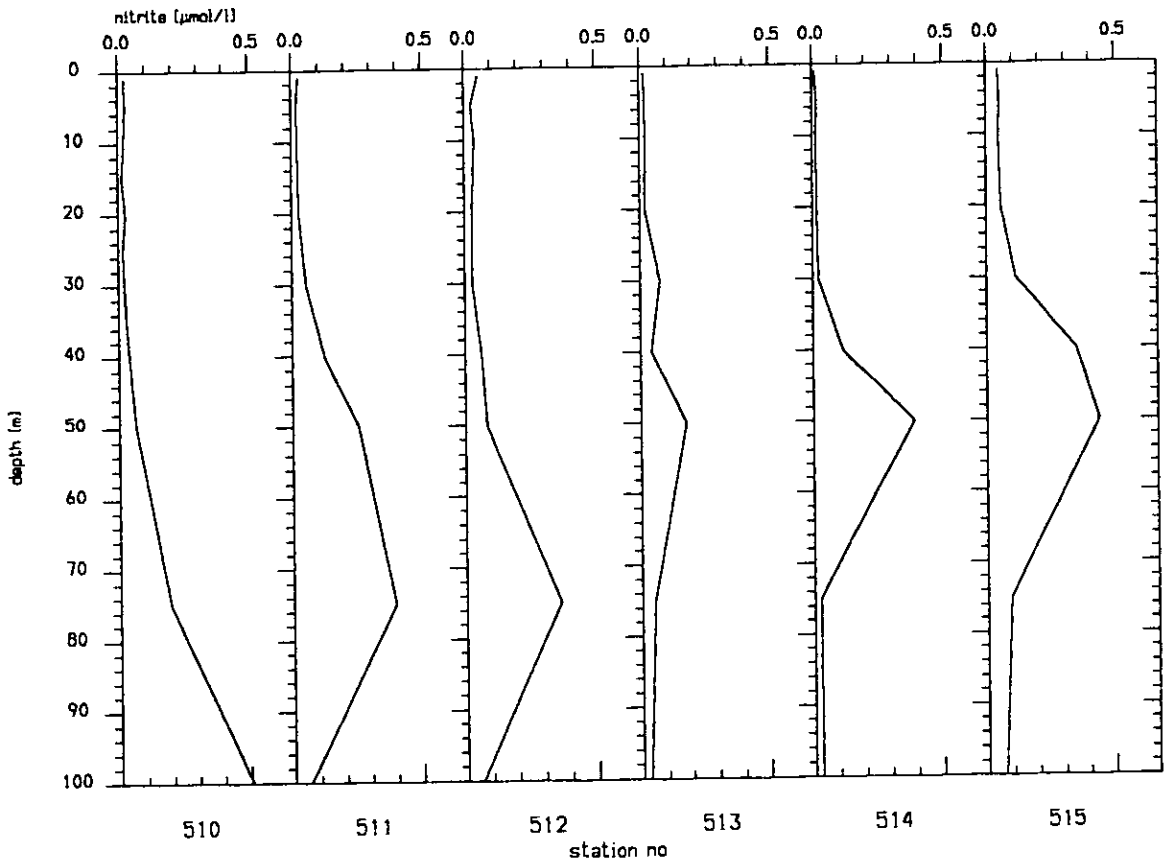


Figures 11: Vertical profiles of oxygen concentrations on Goban Spur Transect 1.



During the drift cruises another phenomenon was observed:
After pre-dawn sampling at station 510, for example, there was a nitrite maximum of 0.5 µmol/l at a depth of 100 m. While sampling near the drifting rig throughout the day, this maximum went up slowly into the upper layers of the water column. In the evening the highest values were recorded in a depth of 50 m (see figure 12). This upward shifting maximum was correlated closely to the movement of the fluorescence maximum, due to the increasing primary production in the upper layers during daytime. The reason for this was probably the formation of a transient secondary thermocline ('thermocline lifting').

Figure 12: Vertical profiles of nitrite concentrations during Goban Spur Drift 1



In order to get deeper into the analysis of these processes and to the related causes and the consequences, it will be necessary to obtain additional information by using the results of other working groups. On the one hand, the quantification of primary production processes in the euphotic zone would be of great interest, as well as the grazing effect of zooplankton. On the other hand, it would be very desirable to have available further information about the bacterial activity in the euphotic zone and the boundary layers. Additional supporting data will be originated by analysing the organic substances that were mentioned above.
To get information on advection terms would be essential, too, in order to recognise even slow upwelling processes. Extreme events have not been observed from the collected hydrographical data, as far as evaluated up to now.

5. Timetable

In the following table date, time and location of the stations are given. Furthermore, some data of surroundings such as wind, temperature/pressure of air and water depths are listed.

Abbreviations:

CTD	Probe for measuring conductivity, temperature and depth
Ros	Big rosette sampler with 6 30-l Niskin bottles
MC	Multicorer
AP	Apstein net
Drifter	Drifting incubation rigs for primary production measurements

stat.no	begin [date, time]	end [date, time]	φ N [degr, min]	λ W [degr, min]	depth [m]	wind direct. [degr]	wind speed [m/s]	temp. air [°C]	press. air [hPa]	devices
Test haul										
	27/06									
001	15:08	15:35	49°49.5'	05°30.1'	80	310	3	17	1023	CTD
Goban Spur Transect 1										
	28/06									
100	10:50	13:20	49°29.7'	10°30.0'	140	110	3	20	1018.5	CTD,Ros,MC,AP
101	15:25	16:50	49°29.8'	10°59.8'	180	-	-	17	1016.5	CTD,Ros
200	18:52	23:55	49°30.0'	11°30.2'	620	var	-	16	1017.5	CTD,Ros,MC,AP
	29/06									
201	02:05	06:55	49°25.2'	11°59.8'	1130	var	-	16	1015.5	CTD,Ros
300	09:12	13:15	49°20.0'	12°30.1'	1210	345	9	15	1017	CTD,Ros,MC
301	15:20	23:30	49°11.0'	12°57.1'	1830	330	9	16	1019	CTD,Ros,MC,AP
	30/06									
400	02:18	06:40	49°00.0'	13°29.8'	3530	360	14	15	1024	CTD,Ros
	09:50	13:40	48°51.0'	13°57.0'	4520	360	10	15	1027	CTD,Ros
500	18:10	02:10	48°30.0'	15°00.4'	4800	350	8	15	1030	CTD,Ros
Goban Spur Transect 2 (Drifting)										
	01/07									
510	03:40	09:40	48°30.0'	15°00.0'	4800	310	6	15	1029	CTD,Ros,AP, Drifter out
511	12:05	12:20	48°29.4'	14°58.0'	4800	300	6	16	1028	CTD
512	14:00	14:26	48°29.0'	14°56.4'	4800	310	8	16	1028	CTD
513	16:00	16:26	48°28.7'	14°55.4'	4800	315	9	16	1028	CTD
514	18:00	18:50	48°28.2'	14°55.3'	4800	315	9	16	1029.5	CTD
515	20:00	21:00	48°28.6'	14°55.1'	4800	320	8	15	1029.5	CTD,Drifter aboard
	02/07									
410	03:42	11:12	48°59.9'	13°30.1'	3690	300	6	15	1026	CTD,Ros,AP, Drifter out
411	12:00	12:38	48°58.0'	13°30.2'	3690	300	8	18	1028.5	CTD
412	14:00	14:45	48°58.0'	13°30.4'	3690	310	6	17	1027	CTD
413	16:00	16:35	48°58.7'	13°31.1'	3690	310	6	17	1027	CTD
414	18:00	18:40	48°58.5'	13°31.1'	3690	310	5	17	1028	CTD
415	20:00	21:05	48°58.1'	13°30.9'	3690	300	6	17	1029	CTD,Drifter aboard
	03/07									
321	00:06	01:42	49°12.6'	12°53.4'	1640	280	6	16	1029	MC
310	03:37		49°20.0'	12°30.0'	1220	290	8	15	1027	CTD,Ros,AP,
		09:40	49°20.2'	12°29.8						Drifter out,MC
311	12:00	12:17	49°19.2'	12°29.4'	1220	270	5	16	1029	CTD
312	14:00	14:18	49°19.7'	12°29.4'	1220	270	5	17	1028	CTD

stat.no	begin [date, time]	end [date, time]	φ N [degr, min]	λ W [degr, min]	depth [m]	wind direct. [degr]	wind speed [m/s]	temp. air [°C]	press. air [hPa]	devices
313	16:00	16:18	49°20.3'	12°28.6'	1220	270	4	17	1027.5	CTD
314	18:00	18:27	49°20.8'	12°28.5'	1220	270	4	17	1029	CTD
315	20:00	20:40	49°20.2'	12°26.8'	1220	280	4	17	1029	CTD,Drifter aboard
	04/07									
210	04:00		49°30.1'	11°30.0'	610	290	4	16	1027	CTD,Ros,AP,
		09:10	49°29.1'	11°28.7'						Drifter out,MC
211	12:00	13:42	49°27.7'	11°28.5'	570	300	3	16	1029	CTD,MC
212	14:00	14:22	49°27.0'	11°29.5'	600	320	4	17	1028	CTD
213	16:00	16:24	49°26.9'	11°28.5'	570	315	5	17	1028	CTD
214	18:00	18:40	49°27.5'	11°28.5'	570	340	7	16	1029.5	CTD
215	20:00	20:50	49°27.3'	11°27.3'	530	340	7	16	1029.5	CTD,Drifter aboard
	05/07									
110	04:00		49°30.0'	10°30.0'	150	10	14	15	1029	CTD,Ros,AP,
		09:20	49°29.7'	10°29.7'	135	35	14	16	1030	Drifter out,MC
111	12:00	13:20	49°28.2'	10°32.0'	135	35	7	16	1034	CTD,MC
112	14:00	14:30	49°27.8'	10°32.4'	135	40	7	16	1034	CTD
113	16:00	16:28	49°27.4'	10°32.6'	135	40	7	16	1035	CTD
114	18:00	18:43	49°28.0'	10°31.7'	135	30	7	16	1036	CTD
115	20:00	20:50	49°26.9'	10°32.0'	140	30	5	16	1037	CTD,Drifter aboard
King Arthur Canyon Transect 1										
	07/07									
600	04:00		48°40.0'	11°00.0'	1300	25	5	14	1034	CTD,Ros,AP,
		10:30	48°42.0'	11°00.1'	1070	25	5	17	1035	Drifter out,MC
610	12:45	17:45	48°40.0'	11°30.0'	3150	30	4	17	1033	CTD,Ros,AP
(600)		21.00	48°40.4'	11°00.0'	1200					Drifter aboard
	08/07									
611	04:00	07:50	48°40.0'	11°30.0'	3100	340	4	14	1027	CTD,Ros,
	10:15	11:40	48°42.4'	11°58.0'	1580	280	5	17	1027	Drifter out, MC
620	12:00		48°40.2'	12°00.0'	1810	240	4	17	1024	CTD,Ros,AP
(611)		20:40	48°38.3'	11°32.5'	3100	280	6	16	1022	Drifter aboard
King Arthur Canyon Transect 2										
	09/07									
700	04:00	08:18	48°20.0'	12°00.0'	1780	280	10	16	1016	CTD,Ros
710	10:20	16:40	48°20.0'	11°30.0'	3700	340	12	15	1016	CTD,Ros,AP
720	18:50	22:40	48°20.0'	11°00.0'	2500	340	12	15	1016	CTD,Ros,AP
Meriadzek Terrace										
	10/07									
800	08:20	12:06	47°33.0'	08°33.0'	2070	320	10	15	1016	CTD,Ros,AP

6. Final remark

The OMEX research cruise 'Valdivia 137' was in total very successful. This was due to very good weather conditions during the cruise, on one hand. The were no delays in setting out and taking aboard the devices. The sea had been calm most of the time, so on-deck work was possible almost without difficulties.

Another important contribution to the successful outcome was made by the crew of the 'Valdivia'. There was a good mood aboard the vessel, and everybody, the deck men as well as the officers and engineers, was very helpful and co-operative. And last but not least the motor men, the stewards and the cooks did their very best to keep on going the vessel and the scientists.

The University of Hamburg provided the RV 'Valdivia'.

Ahoy !

(Greeting aboard the sailing-ships of the 'good old times')