JOINT GLOBAL OCEAN FLUX STUDY

NORTH ATLANTIC PILOT STUDY

NIOZ DATA REPORT 1991-1

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RESEARCH VESSEL TYRO
LEG 1 UPPER OCEAN PROCESSES
DEN HELDER-REYKJAVIK-FUNCHAL
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See Next Page for Data Access and Citation Policy

DATA ACCESS AND CITATION POLICY

This data report contains part of the data collected during the cruise, other data is still forthcoming. These data and other Netherlands JGOFS data are available in digital form from the national JGOFS data manager J.W. Rommets. We recommend our standard EXCEL file on 3.5 inch diskette, upon request other formats are possible such as ASCII files for direct transfer over electronic mail.

Citation of data in manuscripts for publication (or other documents) would follow the normal scientific obligation to contact the originator for permission and send a copy of the manuscript in due course. Originators are indicated in below methods section as well as the list of participants. The latter will normally provide the proper reference of their own work for citation, occasionally this report may be cited instead as:

J.W. Rommets, R. Dapper and H.J.W. de Baar (1991) JGOFS North Atlantic R.V.Tyro Leg 1, Upper Ocean Processes, NIOZ Data Report 1991-1.

in which case J.W. Rommets would grant permission. When data of this report would constitute a significant part of a manuscript it would appear advisable to offer co-authorship to the originator.

Any further information can be obtained from J.W. Rommets.

NETHERLANDS JGOFS CRUISE REPORTS:

JGOFS RV TYRO Leg1, Upper Ocean Processes, 31 July-11 September 1989, H.J.W. de Baar chief scientist, NIOZ REPORT 1989-9

JGOFS RV TYRO Leg 2, Benthic Processes, September 1989, W. Helder chief scientist, NIOZ REPORT 1989-10

JGOFS RV TYRO Leg 3, Upper Ocean Processes, 17 April-31 May 1990, H.G. Fransz chief scientist, NIOZ-REPORT 1990-6

JGOFS RV TYRO Leg 4, Benthic Processes, 2-29 June 1990, G.A. Ganssen chief scientist, Unpublished Report.

NETHERLANDS JGOFS DATA REPORTS:

in preparation

TABLE OF CONTENTS

1. INTRODUCTION

For details of all activities during the cruise see the original cruise report (NIOZ REPORT 1989-9). Briefly the total of 76 stations were occupied at or nearby the 20°W section of the JGOFS Pilot Study. From 33°N to 47°N coverage was as planned, due to storms and technical problems coverage was less from 47°N to 61.5°N. In total 106 CTD/Rosette casts and over 100 net tows were done. The WOCE current meter mooring was deployed at 61.5°N 20°W, one JGOFS sediment trap mooring was recovered with 100% succes at 47°N 21°W.

Among 18 scientists some 16 of the 20 JGOFS Level 1 type measurements were accomplished routinely, in addition some related studies were also undertaken. At 6 August an intercalibration excercise was done between Discovery, Meteor and Tyro.

2. ACKNOWLEDGEMENTS

The North Atlantic Pilot Study was organized between six participating countries through the SCOR Committee for JGOFS and its Working Groups, with support from parent organizations, the Scientific Committee for Oceanographic Research and the International Council of Scientific Unions. Enthusiasm and hard work of the SCOR Executive Secretary have proven to be both inspiring and fruitful. While at sea we received excellent logistics support and hurricane updates from the Pilot Study Coordinator at NOAA, Washington D.C.

The expedition was funded by the Marine Research Foundation (Stichting Onderzoek der Zee, SOZ), subsidiary of the Foundation for Netherlands Scientific Research (Nederlands Wetenschappelijk Onderzoek, NWO) of the Government Ministry for Education and Sciences (O&W). The efforts of staff at the SOZ office are gratefully acknowledged. The overall national JGOFS plan and cruises are responsibility of a special SOZ JGOFS Group which includes the national coordinator whom is also a member of the above SCOR/JGOFS Committee. Scientific merits are evaluated regularly by the SOZ Scientific Committees for Marine Biology and Chemical Oceanography.

The Carbon Dioxide Research Division (CO_2 Werkgemeenschap), also subsidiary of NWO, provided additional funding of a graduate studentship and equipment. Funding for analytical equipment was further made available by the Government Ministry of Health, Urban Planning and Environment (VROM), Atmospheric Division of the Environment Directorate.

Considerable additional funds for purchasing equipment as well as for operating expenses were made available by the Netherlands Institute for Sea Research (NIOZ). Extensive logistical and technical preparations were all done at NIOZ as well. Frans Eijgenraam initially developed the JGOFS data management program. The dedicated efforts and skills of NIOZ staff in the various workshops is most gratefully recognized as crucial for the succes of the expedition.

Management of NWO-owned RV TYRO is provided by Van Nievelt Goudriaan Company. Master, officers and crew of RV TYRO provided dedicated and flexible support of our research in the most pleasant manner throughout the whole expedition: never mind the weather, as long as we are together.

3. PARTICIPANTS

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4. METHODS

Numbering 4.1-4.20 according to JGOFS Core Measurements protocols, additional projects 4.21-4.25.

4.1. Meteorology. Officers, Van Aken, DeBaar.

Meteorological observations have been carried out by the ship's officers on a three hourly basis according to the WMO "selected ships" protocol (FM 13 - VII SHIP). These data have been sent by telex as OBS messages into the international meteorological network. The legend of data tables is listed at end of the methods section.

4.2. CTD, O_2-probe, fluorometry. Van Aken.
Continuous underway. Van Aken.

Profiles of temperature, salinity, oxygen concentration and fluorescence have been recorded by means of an NBIS Mk III CTD-system, fitted with a Beckman oxygen sensor and an Aqua-tracka fluorometer. The data have been recorded with a sampling rate of 16 Hz.

Measurements with recently calibrated SIS electronic reversing thermometers, mounted on Niskin bottles 1 and 3 indicate an off-set of -20 mK in comparison with the manufacturers calibration. A post-cruise calibration of the CTD- system was executed for the final temperature determination.

For the calibration of the conductivity sensor about 250 water samples have been taken, especially from the deep casts. The salinity from these samples was determined by means of a Guildline Autosal salinometer.

Here we only report the values of pressure, temperature, salinity at the discrete depths where water samples were collected, along with calculated values of depth and potential density. The complete CTD records for all depths also including the data of the O_2 sensor and fluorimetry sensor will be reported separately (ROMMETS, DAPPER AND VAN AKEN, NIOZ Data Report, in prep.).

The sea surface temperature has been recorded continuously underway but is not reported here.

4.3. Dissolved oxygen by Winkler Titration. Manuels.

Over 900 dissolved oxygen samples were collected as duplicates at 39 stations, using the rosettesampler/CTD-combination and Niskin bottles and analyzed according to a High Precision Winkler Titration Method (TIJSSEN 1980, TIJSSEN AND VAN BENNEKOM 1989). At most stations from 2 or 3 depths and at 2 stations from all (= 12) depths, simultaneously seawaterblanks have been taken and analyzed. From 60°N to 33°N the blanks tend to be lower, while values at 10 m always are lower than values beneath 500 m. The mean blank value is 0.7 µmol/kg.

After sampling immediately reagents A and B have been added, while in a third bottle the "sample temperature" has been measured. Differences between T-in situ and T-sample appear to be much smaller as was expected. Deep samples were supplied with reagens in a shelter on deck, at air temperature is over 25 °C, differences are smaller than 5 °C. Before

starting each titration the temperature of the 0.2 N thiosulphate solution has been measured. To control the titer of the thiosulphate solution (0.17070 precisely), in the beginning of the cruise 24 samples had been taken out of 1 Niskin bottle and during the cruise every fifth day 2 samples have been titrated. This control shows non-systematic small differences within 1 µmol/kg. Data are corrected for titration temperatures and seawater blanks. Correction for sample temperature was also applied. The calculated value in µmol/liter at T-sample was divided by the density (at T-sample and given salinity) as to arrive at the reported µmol/kg. Differences between the mean values of duplicate samples generally are smaller than 0.2 µmol/kg, which is in accordance with the JGOFS criteria. On August the 6th 1989 an intercalibration program, on which also oxygen titration was involved, between German, English and Dutch participants on JGOFS 1, took place.

S.B.TIJSSEN (1981) Anmerkungen zur photometrischen Winkler- Sauerstofftitration und ihre Anwendung zur Schatzung der Primarproduktion im Meer. In: III Internationales mikrobiologisches Symposium, Smolenice, 3-6 Juni 1980. Editor L. Daubner. Veda, Verlag der Slowakischen Akademie der Wissenschaften, Bratislava 1981.
S.B.TIJSSEN AND A.J. VAN BENNEKOM (1989) High precision determination of dissolved oxygen. ICES Report CM 1989/C:6.

4.4. Nutrients. De Vries, Bakker.

Seawater was drawn directly from the Rosette samplers into high density PolyEthylene bottles which were rinsed twice with the seawater before filling. The seawater was not filtered and stored cool (4 °C) and dark prior to analysis within 12 hours. Standards made up in seawater matrix were run along the sample determinations. All analyses were done with Technicon Traacs 800 autoanalyzers employing the following wet colorimetric methods:

Orthophosphate. Formation of the reduced molybdophosphate complex at pH 0.9-1.1. PotassiumAntimonylTartrate as catalyst and Ascorbic Acid as reductant. Final measurement at 885 nm wavelength.

Nitrite and Nitrate. Diazotization with sulfanylamide and naftylethylene-diammoniumchloride, measurement at 540 nm.
Nitrate is reduced in a copperized cadmium coil.

Ammonia. Fenol-hypochlorite and citrate as a buffer and complexing agent. Measurement at 630 nm.

Silicic acid. Measured as the reduced molybdenum complex at 810 nm. Ascorbic acid as reductant.

From station 20 cast 1 onwards we also measured surface water samples for nitrate and nitrite in the low level range with a specially modified Technicon aa II analyzer. The wet chemical method is otherwise the same as described above. Levels of NO_3 below 1 µmol/kg and of NO_2 below 0.01 µmol/kg were analyzed with this procedure. The total number of samples analyzed on the two TRAACS 800 systems is about 1500, of which about 400 samples had to be rerun for phosphate. Estimates of accuracy and precision are given in below Table 4.4.1. From comparison with earlier cruises (Geosecs, TTO) our data appears to be of excellent accuracy. Intercalibration with Discovery did yield generally good

agreement for NO_3 and NO_2, where in our opinion the values of Discovery for phosphate and silicate are too high.

	Calculated	Measured	St. deviation
PO_4	1.70	1.73	0.02
$NO_2 + NO_3$	17.24	17.20	0.11
	2.79	2.82	0.04
NO_2	0.18	0.183	0.006
	0.53	0.54	0.004
Si	4.15	4.13	0.02
	40.15	40.12	0.02
NH_4	2.72	2.96	0.06

Table 4.4.1. Shipboard estimates of precision and accuracy of routine determinations with the Traacs 800 systems.

4.5 Optics. Kraay, Veldhuis, Gieskes.

Data not in this report, but available from investigators.

Optical measurements were conducted almost every day, around local apparent noon. Herefore were 4pi spherical light sensors (LICOR) used, measuring the photosynthetically active radiation (PAR) ranging from 400 to 700 nm, which was coupled to a depth sensor. The casts were done from the stern of the ship, facing towards the sun. A complete depth versus irradiance profile was made down to 80 m or 1 $\mu Ein.m^{-2}.sec^{-1}$. The results of the subsurface measurements were matched with the surface value; which was measured by an other 4-pi-sensor, drifting just above the seasurface.

Total irradiance (300 to 3000 nm) was recorded continously by a solarymeter (Kipp), measuring $J.cm^{-2}.day^{-1}$.

4.6. Total carbon dioxide and total alkalinity by acid titration. Rommets, Stoll

For the determination of both alkalinity and total carbon dioxide the method described by BRADSHAW et al (1981) was used. For the potentiometric titration a titration cell, with a volume of about 115 ml, was constructed of acrylic by the NIOZ instrument shop. It is cylindrical and surrounded by a jacket through which water is circulated in order to maintain a constant temperature of 20 °C ($\pm$0.1 °C). The complete apparatus was in an airconditioned laboratory kept at a constant temperature of 20 °C ($\pm$1 °C). Four ports in the top of the cell are provided for the glass electrode (Metrohm 6.0102.100), the reference electrode (Ag-AgCl type, Metrohm 6.0276.100), a Pt-100 thermometer and a 10 ml volume expansion plunger. A capillary tube with anti-diffusion tip supplies acid for the titration. The cell is stirred with a magnetic stir bar. The acid, 0.1 M HCl, fortified to the ionic strength of seawater with 35 grams of NaCl, is added from a 10 ml motor burette (Metrohm 665). The millivolt response of the cell was measured with a pH meter (Metrohm 654). Two titrator systems were used simultaneaously, under control of one HP85 computer with a titration programme written by F. Eijgenraam (NIOZ). Acid was added stepwise in 0.100 ml increments. Readings of mV

and ml were stored as datafiles. Files were further processed at the institute using the curvefitting method (JOHANSSON & WEDBORG; 1982) using the new carbonic acid dissociation constants of GOYET and POISSON (1990). The effect of various calculation routines on alkalinity and total carbon dioxide have been discussed by STOLL et al. (in review). Sodium carbonate (Baker analyzed reagent), weighed out in approximately 0.25 grams lots were used as the shipboard standards. Standard solutions as well as blanks were made up with 41 grams of NaCl in order to match the ionic strength of seawater. The precision of the method was better than 0.2% for total alkalinity and 0.3% for total inorganic carbon.

Samples for determination of total carbon dioxide contents were collected with Niskin bottles and transferred into 500 ml serum bottles and capped with aluminium screwcaps with a rubber septum. Immediately after sampling the bottles were poisoned with 0.5 ml saturated $HgCl_2$ solution (80 g/l). Bottles were then closed again taking care that as little air as possible was enclosed. They were analyzed according to the coulometric method of JOHNSON et al. (1987) with an automatic extractor system built and supplied by the University of North Wales at Bangor (Prof. P.J. LeB. Williams). The sample is acidified with H_3PO_4 (8.5%) and bubbled through with CO_2-free N_2 gas. The released CO_2 is back-titrated with a Coulometer Model 5011. For each sample four replicate analyses were executed.

From a total of 1250 measurements the average standard error of the replicates is <2 micromoles. This precision meets the JGOFS criteria.

BRADSHAW, A. L., P. G. BREWER, D. K. SHAFER AND R. T. WILLIAMS (1981). Measurements of total carbon dioxide and alkalinity by potentiometric titration in the GEOSECS program. Earth Planet. Sci. Lett. **55**:99-115

GOYET C. AND A. POISSON (1990). New determination of carbonic acid dissociation constants in sea water as a function of temperature and salinity. Deep-Sea Research **36(11)**:1635-1654

JOHANSSON O. AND M. WEDBORG (1982). On the evaluation of potentiometric titrations of seawater with hydrochloric acid. Oceanologica Acta **5(2)**:209-218

JOHNSON, K.M., P.J. LEB. WILLIAMS, L.BRANDSTROM AND J.MCN.SIEBURTH (1987) Coulometric total carbon dioxide analysis for marine studies: automatization and calibration. Mar.Chem.,**21**,117-133.

STOLL M. H. C., J. W. ROMMETS AND H. DE BAAR. Effect of selected calculation routines and dissocation constants on the determination of total carbon dioxide in seawater. in prep.

4.7. Particulate Organic Carbon. Hegeman.

Data not in this report, in due course available from investigator.

At the three superstations complete water column profiles of 24 discrete depths were taken. Triplicate samples of one liter each were drawn from GoFlo samplers. The water was then filtered over a GF/F filter. Each filter was placed inside a glass vial, upon which the persulfate oxidation reagent was added. The vials were heat-sealed with a flame. Then the vials were heated for 4 hours at 120 °C. Upon returning to the shore laboratory each vial will be cracked open again and upon bubbling with N_2 gas the evading CO_2 will be measured with an IR analyzer. With much effort going into development work on DOC (4.8.) no more samples for POC could be collected and processed.

4.8. Dissolved Organic Carbon. Hegeman, Schijf, De Baar.

The resulting small data set is listed in a separate table at the end of this report, legend at end of this chapter.

The objective was to start development and research on several methods simultaneously. In all cases we collected seawater in Teflon coated GoFlo samplers. The water was drawn into precleaned glass bottles (one liters each) and from there transferred into smaller vials or bottles. Samples were not filtered. Upon addition of 10 ml phosphoric acid per 100 ml seawater each sample was bubbled through for 10 minutes with N_2 gas at room temperature as to drive off its natural CO_2 contents (typically about 2100 µmol/kg as compared to about 100- 200 µmol/kg DOC). Subsequently the following four methods were subject of investigation:

1) Wet oxidation with persulfate, relying on an Oceanography International instrument, modified during two previous years at our laboratory. Most importantly the amounts of reagents added were very different than recommended by the manafacturer. Unfortunately the instrument did not function properly and no data was collected.

2) Wet oxidation with persulfate in batch mode. Samples of 5 ml seawater each were combined with various reagents in a glass vial which then was heatsealed and heated for 4 hours at 120 °C in a pressure cooker. In the shore laboratory the vials were cracked open again and upon bubbling with N_2 gas the evading CO_2 was measured with an IR analyzer.

3) Injection of 100 µl seawater into high temperature (IONICS 555 at nominal 900 °C) reactor for combustion over a pure Pt catalyst, purification with various traps and scrubbers and final analysis of CO_2 with IR spectroscopy.

4) Injection of 50 µl sample into high temperature reactor (SHIMADZU at nominal 680 °C) for combustion over a Pt catalyst coating on carborundum (Al_2O_3) carrier phase, purification with various traps and scrubbers final analysis of CO_2 with IR spectroscopy.

The method 2 was calibrated in the shore laboratory against sodiumcarbonate standards in solution. The methods 3 and 4 were calibrated with standard additions of potassiumphtalate to seawater collected at 1000 m depth.

4.9. Pigments and Chlorophyll. Kraay and Gieskes.

The pigments data is listed separately at the end of this report, legend at the end of this chapter.

Samples for pigments were taken at least each day at two depths. One was taken at the surface (ca. 10 m) and one at the 1% irradiance level or at the fluorescence maximum. In total 10 to 20 liters were filtered over GF/F filters (diameter 47 mm) by pressure filtration and analysed at the shore laboratory using the method of MANTOURA and LLEWELLYN (1983).

MANTOURA, R.F.C. AND C.A. LLEWELLYN, 1983: The rapid determination of algal chlorophyll and carotenoid pigments and their breakdown products in natural waters by reverse-phase high- performance liquid chromatography. Analytica Chimica Acta **151**: 297-314.

Samples for chlorophyll a were taken at almost each standard station (6 depths) as well as on stations where primary production was measured. The latter also included chlorophyll a samples from 10 m and 150 m depth. The filters were immediately after sampling deep frozen for analysis at the shore laboratory with acetone (90%) extraction and fluorescence determination.

4.10. Bacterial biomass. Ietswaart.

Separate data table at end of report, legend at end of this chapter.

Concurrent with all bacterial production measurements, as well as on a number of other occasions, samples were taken for the enumeration of bacteria. The samples were fixed with phosphate-buffered glutaraldehyde (pH 7.4), 1% final concentration. Later on they were counted in the laboratory, using epifluorescence microscopy and DAPI staining. Bacterial biomass was estimated using the biovolume method.

4.11 & 12. Zooplankton biomass. Kuipers & Gonzalez.

Seperate data table at the end of report, legend at the end of this chapter.

In order to estimate the standing stock of zooplankton in terms of carbon biomass, quantitative planktonsamples were taken with a variety of nets, each of which covered - with some overlap - a part of the zooplankton size-continuum from a few microns to several centimetres. With increasing mesh size of the nets, increasing volumes of water were filtered in order to cope with the inverse relationship between size and density.
Methods were as follows:
1. The smallest size group, the Microzooplankton (comprising Ciliates, Flagellates, Tintinnids, etc.), was covered by preserving in Lugol unsieved 250 ml samples from the large volume watersampler (see below 2.) and storing them dark at 4 °C.
(Initially the JGOFS B-protocol for microzooplankton was followed; after comm. G.Fransz, NIOZ, 28/8/89, only in Lugol).
2. Mesozooplankton ranging in size from 50 to 200 microns consists mainly of eggs, larvae and small stages of Copepods and larvae of larger species. This group was sampled with a large volume watersampler with automatic opening and closing (154 l).
Samples were taken from 320m, 150m, 75m, 37.5m and 12.5 metres depth (i.e. in the middle of the multinet intervals, see 3.), sieved over 50 micron and preserved in 4% buffered formalin solution. Mesozooplankton larger than 200 micron was collected with the Hydro-bios Multinet (opening 54x54 cm) mounted with 200 micron nets for the purpose. The multinet was towed at a speed of 1.5 knots; lowered to 500 dbar, and hauled back to the surface while sampling. The five nets covered the depth ranges 500-200(1), 200-100(2), 100-50(3), 50-25(4) and 25- surface(5). (the multinet depth sensor gave minus 10 dbar at the surface). Volumes filtered in m^3 (indicated by flow meter display) ranged from several hundred m^3 for net 1 to 20-50 m^3 for nets 4 and 5. Multinet samples were treated as follows:
a. division into two fractions: fine (50-100 micron), and coarse (>1000 micron). (The JGOFS recommended three fractions, this appeared too time consuming).
b. Each fraction was divided with the Folsom planktonsplitter into two equal halves. One halve was sieved over a Whatman micropore filter of known dryweight and frozen for later

dryweight-determination. One halve was stored in 4% buffered formalin for later analysis to the species level.

3. The Macroplankton (>2000 micron) was sampled with an Isaacs-Kidd midwater trawl (IKMT) with a net opening of 7.3 m^2 and meshes of 1.4x1.4 mm. Double oblique haules were made to 2300 metres depth. The net was mounted with electronic sensors for depth, temperature and water-current through the net opening, with reading and registration on deck. The speed of the net was kept just below 2 knots and volumes filtered ranged from 20,000 to 30,000 m^3. Catches were stored in 4% buffered formalin.

On "super-stations" the whole range of methods was applied daily around 12.00 and 24.00 hr., on "small-stations" once, irrespective of time. Depending on the weather and the time available, the watersampler and/or the IKMT were skipped, the Multinet having the highest priority (Table 4.11.1)

In addition we operated a continuous underway echosounder system in between stations as to record the possible occurrence of larger zooplankton. This data is available from Inge Sprong at the Institute for Taxonomic Zoology of the University of Amsterdam.

	Multinet		I.K.M.T.		154 l.sampl		egg-pr	growth
Aug/Sep	day/night		day/night		day/night			
8		x		x			x	x
9	x	x	x	x		x	x	x
10	x		x					
12	x		x		x		x	x
17	x		x		x		x	x
19					x			
22	x		x		x		x	x
24	x		x		x		x	x
25	x	x	x	x	x	x	xx	xx
26		x					x	x
27	x						x	
28	x	x			x		xx	
29	x	x			x	x	xx	
30	x		x		x		x	x
31	x	x	x	x		x	x	x
1		x		x				
3	x	x		x	x	x	xx	xx

Table 4.11.1 Deployment of various type plankton nets on successive days. Missing days due to storm conditions and initial (5-7 august) or later (2 sept) technical problems.

4.13. Primary productivity by ^{14}C incubation. Veldhuis, Kraay, Gieskes.

In order to estimate the daily phytoplankton primary production or ^{14}C assimilation rate as a function of the daily irradiance, samples were taken at various depths and incubated with inorganic ^{14}C-bicarbonate. The standard procedure was in a deck incubator but on the three

main stations (60°N 20W° , 47°N 20° W and 33°N 20° W) also a 24 hours in situ incubation was carried out. Beforehand an irradiance versus depth profile was made in order to calculate, in total 7 depths, corresponding with 65, 33, 14.5, 6.4, 3.0, 1.8 and 0.5% of the surface irradiance.

Phytoplankton samples were taken at approximately 5 A.M. using Go-Flo bottles, in order to reduce contamination with metals as much as possible. Beforehand a CTD profile was made down to ca. 200 m.

The samples for primary production were collected in duplicate in 250 ml acid cleaned polycarbonate bottles, to which 100µl of 5 µCi ^{14}C-bicarbonate (Amersham) was added. For the in situ measurements the bottles were shortly before sunrise connected to a nylon wire at the appropriate depths. The whole system was deployed in sea and connected to a floating buoy.

In case of the deck incubator the bottles were put in tubes covered with gray and blue screens matching with the light intensity and light spectra at which they were taken. The whole system was cooled with running surface seawater. Because especially at the southern stations there was a steep decline in the water temperature with depth on several occasions a Q10 of some deep water samples was carried out which enables correction of temperature variation.

After 24 hours (again before sunrise) bottles were recovered and samples filtered over GF/F, at low vacum pressure. Filters were fumed with concentrated HCl in order to get rid of excess inorganic radioactive bicarbonate. The filters were counted in liquid scintillation counter (LKB) against external standard after adding 10 ml of Instagel II solution. Dark bottles were collected and stored in a dark container which was constantly cooled with surface water. These samples were further treated similar as the light bottles.

The phytoplankton primary production over the light and light-dark period respectively was estimated using the following equation:

Fehler!

Whereas dpmL1: radioactivity in terms of disintegrations per minute of light bottle 1

dpmL2: the same but for light bottle 2

dpmD : the same but for the dark bottle

[CO_2]: concentration inorganic carbon in µM. The data of the inorganic carbon concentration were estimated according the methods as described in 4.6.

Measured over a certain light and/ or dark period this formula reveals the total amount of inorganic carbon fixated in µg/mg per liter/cubic metres respectively. By estimating the productivity at all depths the total integrated carbon fixation over the water column can be made, expressed as mgC/m^2/photoperiod.

4.14. Primary productivity by Winkler titration.
Kraay, Manuels.

Data was rejected and is not reported.

4.16. Bacterial production. Ietswaart.

Data is reported in a separate table at the end of this report, legend at the end of this chapter.

The bacterial production was estimated with the thymidine incorporation method, using a slight modification of the protocol composed by the JGOFS working group in Kiel. Sampling and incubation conditions matched as closely as possible those of the primary prodictivity measurements.

Sampling was carried out as described in the primary production section 4.13. In addition to the seven light depths of the primary production measurements, samples were taken from three deeper depths, usually 75, 100 and 150 m.

At t=0 the 5 nM ^{3}H-thymidine (Amersham, 82 Ci mmol^{-1}) was added. The samples from the photic zone were incubated in a deck incubator at the appropriate light levels and surface water temperature along with the primary production samples. The deeper samples were incubated in the dark at the temperature found just below the thermocline. Incubation times were mostly about 2 hours.

At the beginning and end of the incubation, subsamples were taken. The samples were filtered on 0.2 µm cellulose nitrate filters (Sartorius). Subsequently the filters were extracted three minutes with 5 ml ice-cold TCA, rinsed seven times with 1 ml ice-cold TCA and extracted with 5 ml 80% ethanol, also for 3 minutes.

The filters were then placed in a scintillation vial. Then 5 ml of Instagel was added, which completely dissolved the filters. The amount of radioactivity on the filters was assessed in a liquid scintillation counter (LKB Rackbeta), and corrected for quench using the external standard channel ratio method.

At regular intervals the linearity of the incorporation was checked, as well as the amount thymidine actually incorporated in DNA using the Wicks-Robarts method. At the 47°N and 33°N superstations an estimate of the conversion factor from moles thymidine incorporation to cells formed was made using the method described in the JGOFS protocol.

4.19. Free floating traps. Hegeman.
Deployments were abandoned, no data available.

4.20. Deep moored traps. De Porto, Schijf, De Baar.

At June 17 a series of four Technicap PPS 5 traps (rotating 24 sample cups each) was deployed at 47° 14.5N, 21° 59.8W by HMS Tydeman. Bottomdepth was 4450 m, trap depths were 460, 1020, 3020 and 4427 m. We recovered this array on 22-23 August, 1989. Data will be reported in separate traps report (BRUMMER et al., NIOZ Data Report, in prep.).

4.21. Trace Elements. Nolting, Schijf, De Baar

All sampling was done with Teflon coated, modified (spigots) GoFlo samplers of 12 liters each, mounted on an all-teflon coated stainless steel CTD/Rosette frame. Water samples for the determination of trace metals Fe, Cu, Cd, Ni, Zn and Pb were collected at 15 stations. At the three super stations a complete profile of 25 depths to the bottom was sampled, while at the intermediate stations 12 depths till 1000 metres were taken.
When possible, a rubberboat was used to collect surface water samples. *These data are given in a seperate table at the end of the report.*
With exception of the rubberboat samples, all samples were filtered over precleaned 0.40 µm nuclepore filters in a clean air container.

After filtering the 1 liter samples were acidified with 0.5 ml concentrated HCl and stored for several days. Then an extraction procedure was utilised to concentrate the trace metals. To 500 ml of sample 1 ml of an ammonium acetate buffer and 1 ml of a 1% APDC/DDDC solution was added. The solution was shortly shaken and 20 ml freon was added. After this addition the sample was shaken for 2 minutes. The solutions were separated, and the freon phase was collected in a teflon bottle. Another 5 ml freon was added to the sample, shaken and this 5 ml was added to the first 20 ml freon. Remaining water was pipetted off the freon. Then 0.5 ml conc. nitric acid was added to the freon, shaken for 30 seconds and than left to stand for at least 30 minutes, to break up the complex. Then 4.5 ml milli Q water was added to the solution for back extraction. The solution was shaken for 30 seconds and the bottles were then stored in the fridge for analyses in the home laboratory. There the samples were analysed by graphite furnace atomic absorption spectrometry using the platform technique and standards with the same concentration as the samples. Trace elements determined in this way are: Fe, Zn, Cu, Cd, Ni and Pb.

4.22. Isotopes. Kers, Nolting

Some 300 water samples were taken from the standard 1000 m hydrocasts and bottled for determination of ^{2}H (deuterium) by mass spectrometry, ^{3}H (tritium) by decay counting (proportional counter) and ^{18}O by mass spectrometry in the home laboratory.

Some 300 watersamples were collected simultaneously with samples for the CO_2 system (4.6.). Within a dedicated vacuum system the water was treated with phosphoric acid. Upon separation of water vapour in a cold trap at -78 °C (dry ice) the extracted CO_2 is collected by freezing at -186 °C (liquid nitrogen) and finally sealed in flamed off glass tubes for future analyses of ^{13}C by mass spectrometry and ^{14}C by accelerator mass spectrometry.

Large volume samples amounting to 108 (36 x 3) vessels of 25 liters each were treated onboard by hydrochloric acid addition for extracting the CO_2 into an alkaline solution. The ^{14}C contents of the resulting 36 samples, representing 3 vertical profiles at 60°N, 47°N and 33°N are measured in a proportional gas counter.

At ten stations Nolting collected ten seawater samples over the 10-500 m depth interval. Exactly three liters each were filtered over GF/F filters. The filters were stored in a freezer for analysis of natural ^{15}N abundance by Dr. Gregg Rau (UCSC). At one station ten filtered water samples of three liters each were also kept and stored frozen for ^{15}N determinations.

Conventionally the ^{14}C results are reported as relative deviations from the NBS oxalic acid standard activity after correction for a $\delta^{13}C$ deviation from -25 o/oo according to:

$$Activity_{corr} = Activity_{meas} [0.975 / (1 + \delta^{13}C)]^2$$

and

$$\Delta^{14}C = (Activity_{corr} / Standard\ act - 1) * 1000 \text{ o/oo}.$$

At this moment the ^{18}O and the ^{2}H data are not yet available.

4.23. Analytical Flow Cytometry. Veldhuis, Kraay.

Data not in this report but available on request from investigators. Otherwise most data has been incorporated in two below manuscripts.

Flow-cytometry is a novel technique for rapid characterization, quantification and sorting of particles in the range of 0.5 to 250 µm. This can be done on basis of a simultaneous measurement of their cellular light scatter and auto- or induced fluorescence. Of the in total 1500 instruments in use world wide only about 20 are used in freshwater- or marine science. Its application in marine microbiological research has only just started and the results are promising.

The basic principle of the Flow-cytometer is that the sample, injected in a so called sheat fluid leaves as a continuous stream, at a speed of ca. 10 m/sec, a very small nozzle with a pore diameter varying from 50 to 250 µm. Approximately 50 µm below this nozzle they pass a laser beam (Argon laser with wavelength of 488 nm). Particles within the stream will scatter when hit by the laser light and in case of living phytoplankton, due to their chlorophyll and other pigments, they also will fluorescence. Various detectors, in total two for light scatter and two for fluorescence, will detect these signals transmitted. The signals will be processed by a computer and ulitimately made visible on a screen in the form of histograms showing each of the parameters individualy or in combination against the number of events detected.

The Flow-cytometer used during this cruise, Epics CS from Coulter Electronics, was set in a configuration, using adaptive optics and nozzle, so that it should be possible to detect particles with a nominal size of 0.4 - 10 µm. The filter setting of the first photomultiplier was 656 to 700 nm (chlorophyll autofluorescence) and for the second photomultiplier 530 to 590 nm (fluorescence of phycoerythin of unicellular chroococcoid cyanobacteria).

Throughout the whole cruise cyanobacteria were observed at all stations tested, but their highest dominance was in the area around 45°N. An even more important "discovery" was the presence of prochlorophytes (VELDHUIS , KRAAY & GIESKES, 1990). These minute algae (0.6 µm in diameter) occurred predominantly in the southern region. Their highest abundance was at the deep chlorophyll maximum (up to 95,000 per ml), but were also found as dim fluorescence cells near the surface.

The great advantage of the Flow-cytometer is that within a relative short time, usually less than 15 minutes, of a fresh undisturbed watersample a complete overview of algal groups present and the number of cells belonging to each group. Thus, avoiding any damage done to cells or loss of algal cells as a result of the use of any kind preservation technique. However, this requires an almost immediate processing of samples after they have been taken.

Since the Flow cytometers were not originally designed to work on sea special arrangements had been made regarding vibration and changes in current. But as far as the present configuration is concerned this cruise has been a succes.

VELDHUIS, M.J.W., AND G.W. KRAAY (1990). Vertical distribution and pigment composition of a picoplanktonic prochlorophyte in the subtropical North Atlantic: a combined study of HPLC analysis of pigments and flow cytometry. Mar. Ecol. progr. Ser. **68**: 121-127.

VELDHUIS, M.J.W., G.W. KRAAY AND W.C.C. GIESKES (1992). Growth and fluorescence characteristiscs of ultraplankton on a North-South transect in th eastern North Atlantic. **submitted** Deep Sea Reseach.

4.24. Growth rate and egg production Mesozooplankton. Gonzalez.

Data not in this report but available on request from investigators.
In addition to the zooplankton sampling (4.11) life mesozooplankton was collected with a 50 micron planktonnet (opening 30 cm) handled vertically from 75 m depth.
The material was carefully sieved over 500, 200 and 100 micron and the fraction 100-200 and 200-500 were each divided over two 5 litre incubations jars filled with 50 micron sieved seawater from a 12.5 m depth watersampler. One jar per fraction was preserved in 4% buffered formaline at T=0, the other after 24 hours incubation at surface water temperature. At the NIOZ the T0 and T24 samples are analyzed to the developmental- stage level, the shift in wich will provide a measure of growth rate.

Other 5 litre incubation jars filled also with 50 micron sieved seawater served as egg-production jars. Life adult females of as many as possible copepods species were collected under a stereomicroscope from a lightly anesthesized sample (MS-Sandoz 2.22) and incubated during 24 hrs. in the jars. The number of eggs produced per female per 24 hrs., wich is directly related with the mezozooplankton conditions, was determined directly after the experiments.
Depending on geographical positions, egg production measurements were carried out with the following dominant species of copepods:

Calanus finmarchicus	Calanus helgolandicus
Oithona simmilis	Acartia clausi
Paracalanus pygmeous	Acartia danae
Ctenocalanus sp.	Metridia venusta
Euaetideus gisbrechti	Lucicutia longicornis.

LEGEND WITH TABLES

Meteorology

During the cruise ship's weather reports were sent to the Royal Netherlands Meteorological Institute. In this chapter the reports are given in the original format with an explication of the codes.

Explanation of the codes:

W = code 1855, wind indicator, 1= anenometer wind speed in m/sec , 3= estimated wind speed in knots.

$L_aL_aL_a$ = latitude.

Q_c = code 3333, position indicator, 1= North and East, 7= North and West.

$L_oL_oL_oL_o$ = longitude.

i_R = code 1819, 4 = no precipitation measurements.

i_x = code 1860, station indicator, 1= group 7wwW$_1$W$_2$ is given, 2= group 7wwW$_1$W$_2$ not given.

h = code 1600, height of the base of the lowest clouds.

VV = code 4377, horizontal visibility, .

N = code 2700, cloud amount.

dd = code 0877, direction, in tens of degrees, from which the wind is blowing.

ff = wind speed in units, indicated by i_w.

s_n = code 3845, 0= positive temperature.

TTT = air temperature in tenths of degrees Celsius.

$T_dT_dT_d$ = dew-point temperature in tenths of degrees Celsius.

PPPP = air pressure in tenths of hPa.

a = code 0200, changes in air pressure in last 3 hours.

ppp = change in air pressure in last 3 hours in tenths of hPa.

ww = code 4677, present weather.

W_1W_2 = code 4561, past weather.

N_h = code 2700, cloud amount.

C_L = code 0513, cloud types Stratocumulus, Stratus, Cumulus and Cumulonimbus.

C_M = code 0515, cloud types Altocumulus, Altostratus and Nimbostratus.

C_H = code 0509, cloud types Cirrus, Cirrocumulus and Corrostratus.

D_s = code 0700, course of ship in last 3 hours.

v_s = code 4451, speed of ship in last 3 hours.

$T_wT_wT_w$ = sea water temperature in tenths of degrees Celsius.

P_wP_w = value of the wave period in seconds.

H_wH_w = value of the wave height.

$d_{w1}d_{w1}$ = code 0877, direction, in tens of degrees, from which the swell is coming.

$d_{w2}d_{w2}$ = code 0877, direction, in tens of degrees, from which the swell is coming.

$P_{w1}P_{w1}$ = value of the wave period in seconds.

$H_{w1}H_{w1}$ = value of the wave height.

$P_{w2}P_{w2}$ = value of the wave period in seconds.

$H_{w2}H_{w2}$ = value of the wave height.

/ = no observation.

Bottle data

Bot.Nr	bottle number
Depth dbar	pressure of sampling as determined by the CTD, depth in decibar
Depth m	calculated sampling depth, depth in metres
TEMP ° C	CTD temperature in degrees centigrade
SAL psu	CTD salinity in practical salinity scale units
SigTHE	potential density (sigma-theta), listed as (pot.dens.-1.000) * 1000
O2 µmol	oxygen concentration in µmol/kg
SiO4 µmol	silicate concentration in µmol/kg
PO4 µmol	phosphate concentration in µmol/kg
NO3 µmol	nitrate concentration in µmol/kg
NO2 µmol	nitrite concentration in µmol/kg
NH4 µmol	ammonia concentration in µmol/kg
Alk.A µeq	alkalinity by acid titration in µeq/kg
CO2.A µmol	total CO_2 by acid titration in µmol/kg
CO2.C µmol	total CO_2 by coulometry in µmol/kg
pCO2 µatm	partial pressure of CO_2 in µatmosphere, parameter calculated from Alk.A and CO2.C for pressure=0 and TEMP in situ
H2CO3 µmol	H_2CO_3 concentration in µmol/kg, parameter calculated from Alk.A and CO2.C for pressure=0 and TEMP in situ
$HCO3^-$	HCO_3^- concentration in µmol/kg, parameter calculated from Alk.A and CO2.C for pressure=0 and TEMP in situ
$CO3^{--}$	CO_3^{--} concentration in µmol/kg, parameter calculated from Alk.A and CO2.C for pressure=0 and TEMP in situ
pH	pH, parameter calculated from Alk.A and CO2.C for pressure=0 and TEMP in situ
H2CO3p µmol	H_2CO_3 concentration in µmol/kg, parameter calculated from Alk.A and CO2.C for in situ pressure and TEMP
$HCO3^-$p µmol	HCO_3^- concentration in µmol/kg, parameter calculated from Alk.A and CO2.C for in situ pressure and TEMP
$CO3^{--}$p µmol	CO_3^{--} concentration in µmol/kg, parameter calculated from Alk.A and CO2.C for in situ pressure and TEMP
pHp	pH, parameter calculated from Alk.A and CO2.C for in situ pressure and TEMP
CHLOR µg	concentration of chlorophyll a in µg/kg
P.P inc µg	primary productivity by ^{14}C incubation in deck incubator in µg.l^{-1}.24hrs
P.P µg	primary productivity by ^{14}C incubation in situ in µg.l^{-1}.24hrs
Cu nmol	concentration of dissolved copper in nmol/kg
Zn nmol	concentration of dissolved zinc in nmol/kg
Cd pmol	concentration of dissolved cadmium in pmol/kg
Pb pmol	concentration of dissolved lead in pmol/kg
Fe nmol	concentration of dissolved iron in nmol/kg
Ni nmol	concentration of dissolved nickel in nmol/kg

C13 o/oo	deviation in o/oo of the C13:C12 ratio relative to the PDB standard
C14 o/oo	deviation in o/oo of the ^{14}C activity relative to the NBS standard activity
sd C14	standard deviation of C14 o/oo data
H3 tu	tritium concentration in tritium units (1 tu= concentration of 10^{-18})
sd H3	standard deviation of H3 data

Dissolved Organic Carbon

Unfiltered dissolved organic carbon concentration in µmol/kg.

S2O8	persulphate wet oxidation, batch method, 4 hours at 120° C
900° C	high temperature combustion method at 900° C (IONICS 555)
680° C	high temperature combustion method at 680° C (SHIMADZU)

Pigments

CHLLIDE-b	concentration of chlorophyllide-b in ng/kg
CHLLIDE-a	concentration of chlorophyllide-a in ng/kg
CHLC1+C2	concentration of chlorophyll c1+c2 in ng/kg
Pdn	concentration of peridinin in ng/kg
BuFxN	concentration of butanoyloxyfucoxanthin in ng/kg
FxN	concentration of fucoxanthin in ng/kg
PHAEOBIDE-a	concentration of phaeophorbide-a in ng/kg
HxFxN	concentration of hexanoylfucoxanthin in ng/kg
Ddxn	concentration of diadinoxanthin in ng/kg
LUTEIN	concentration of lutein in ng/kg
ZxN	concentration of zeaxanthin in ng/kg
CHLOR-b	concentration of chlorophyll-b in ng/kg
CHLOR-a	concentration of chlorophyll-a in ng/kg
PHAEOTIN-b	concentration of phaeophytin-b in ng/kg
PHAEOTIN-a	concentration of phaeophytin-a in ng/kg
b-CAROTEEN	concentration of b-carotene in ng/kg
a-CAROTEEN	concentration of a-carotene in ng/kg

Bacterial Biomass and Production

Bac.	Bacterial numbers, 10^7 L^{-1}
Thym.	Thymidine incorporated, pmole L^{-1} h^{-1}.

Zooplankton

Lat N	latitude in degrees North and hundredths of a degree, longitude is 20°W.

Zooplankton carbon biomass data (mg C/m^3) for two size fractions and five depth layers indicated as follows:

200µ 0-25m	size fraction 200-1000 micron 0-25 m depth,
1000µ 0-25m	size fraction >1000 micron 0-25 m etc.

Surface water trace metals

Lat N	latitude in degrees and minutes North, longitude is 20° W.
NO3	concentration of nitrate in µmol/kg
SiO4	concentration of silicate in µmol/kg
PO4	concentration of phosphate in µmol/kg
Cd	concentration of cadmium in pmol/kg
Cu	concentration of copper in nmol/kg
Ni	concentration of nickel in nmol/kg
Zn	concentration of zinc in nmol/kg

Bacterial biomass and production

Station: 4 **Cast: 3**
Date:89-08-06 GMT: 15:25
Pos: 059 11.3N 020 58.9W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
12	5		4.29
8	20		0.88
6	40		0.75
4	100		0.01
2	500		0.03

Station: 5 **Cast: 1**
Date: 89-08-07 GMT: 04:17
Pos.: 060 00.8N 019 59.9W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
18	4		0.84
16	9		1.36
14	13		4.07
12	19		3.70
10	25		2.82
08	30		2.77
06	46		1.61
04	73		0.42
02	153		

Station: 20 **Cast: 1**
Date: 89-08-23 GMT: 06:18
Pos: 047 14.7N 021 01.5W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
22	3	56.7	2.6
20	9	52.2	1.98
18	16	59.2	4.14
16	22	2.54	
14	28	77.4	2.79
12	32	76.6	3.43
10	40	2.44	
08	50	0.2	
06	74		
04	99	0.07	
02	149	0.15	

Station: 21 **Cast: 1**

Date: 89-08-24 GMT: 06:41

Pos.: 047 00.0N 019 59.0W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
20	9	40.60	2.65
18	14	95.10	lost
16	24	49.48	1.57
14	31	57.54	2.31
12	35	45.17	lost
10	45		3.84
08	48		1.13
06	72	26.75	lost
04	96	21.75	0.09

Station: 22 **Cast: 5**

Date: 89-08-25 GMT: 05:04

Pos.: 046 57.0N 020 02.0W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
18	5	2.11	15.17
16	12	95.50	1.60
14	23	83.80	0.86
12	29	2	14.31
10	35	44.10	1.28
08	43	39	2.32
06	56	11.30	1.34
04	102	36.80	0.08
02	152	40.30	0

Station: 26 **Cast: 1**

Date: 89-08-27 GMT: 05:40

Pos: 042 00.2N 019 59.0W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
24	6		1.06
22	12		0.96
20	21		0.31
18	33		0.88
16	36		0.60
14	45		1.17
12	56		0.66
10	59		0.07
08	70		0.02
06	79		0.08

Station: 32 **Cast: 1**

Date: 89-08-29 GMT: 06:01

Pos: 036 00.6N 020 00.3W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
16	10		2.87
14	25		2.80
12	50		0.82
08	79		1.76
06	92		1.15
04	110		3.67
02	121		3.20
01	146		0.50

Station: 35 **Cast: 1**

Date: 89-08-30 GMT: 05.58

Pos.: 033 00.0N 020 00.0W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
24	11	1.67	3.94
22	11	9.47	0.97
20	30	4.23	
18	50	8.42	1.76
16	50	16.78	5.31
14	67	15.30	4.86
12	83	17.21	2.96
10	83	2.35	0.57
08	97	0.24	
06	97	1.23	

Station: 37 **Cast: 5**

Date: 89-09-1 GMT: 05:00

Pos.: 032 59.0N 020 00.0W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
24	9		3.61
22	9		1.67
20	26		1.00
18	44		1.79
16	44		1.30
14	62		3.62
12	78		2.10
10	78		1.09
08	88		0.77
06	117		3.72

Station: 46 **Cast:1**

Date:89-09-03 GMT: 05:54

Pos.: 032 15.0N 020 00.0W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
24	9		1.24
22	23		1.43
20	42		0.75
18	42		1.61
16	61		1.77
14	80		1.11
12	80		1.49
10	94		0.35
8	120		0.67

Station: 62 **Cast: 1**

Date: 89-09-05 GMT: 04:58

Pos.: 033 00.2N 21 11.5W

Bot. Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
18	9		2.47
16	25		0.93
14	45		1.53
12	60		5.19
10	77		1.61
08	88		1.71
06	120		3.12
04	148		0.20
02	171		1.81
01	201		2.14

Zooplankton

LAT N	200 µ 0-25m	200 µ 25-50m	200 µ 50-100m	200 µ 100-200m	200 µ 200-500m
61.80	2.22	1.18	0.54	0.87	0.44
61.00	3.23	0.75	0.58	0.38	0.45
60.20	5.01	0.78	0.54	0.38	0.41
60.00	6.09	1.71	0.34	0.24	0.25
59.80	2.05	0.67	0.18	0.11	0.26
59.60	5.48	1.34	0.46	0.33	0.30
47.20	1.41	0.10	0.06	0.05	0.22
47.00	1.98	1.22	0.21	0.06	0.17
46.80	1.95	0.31	0.07	0.06	0.34
43.00	0.83	0.84	0.23	0.06	0.04
41.00	1.04	0.50	0.13	0.05	0.16
40.00	1.48	0.34	0.32	0.06	0.02
38.00	1.06	1.15	1.14	0.16	0.02
37.00	2.22	0.49	0.26	0.12	0.00
35.00	0.44	0.60	0.83	0.30	0.15
33.60	1.56	0.86	1.18	0.14	0.10
33.40	1.53	1.23	0.77	0.31	0.07
33.20	1.58	1.22	1.10	0.15	0.04
33.00	1.85	1.10	0.67	0.07	0.04
32.80	2.11	1.11	1.11	0.18	0.08
32.60	0.68	4.58	0.54	0.28	0.09
32.00	1.00	1.56	0.85	0.32	0.05
32.20	2.37	0.94	0.83	0.21	0.06
32.40	1.30	1.02	1.02	0.14	0.14

LAT N	1000 µ 0-25m	1000 µ 25-50m	1000 µ 50-100m	1000 µ 100-200m	1000 µ 200-500m
61.80	15.33	11.14	3.32	2.45	2.09
61.00	6.52	4.09	2.95	1.66	1.52
60.20	27.33	9.14	5.71	1.68	0.89
60.00	6.00	3.45	1.17	0.61	1.01
59.80	0.86	1.09	0.14	0.10	0.29
59.60	1.02	2.22	0.60	0.37	0.86
47.20	4.51	1.67	1.92	2.86	1.77
47.00	5.82	3.24	1.50	1.23	0.23
46.80	1.22	0.32	0.32	0.74	1.51
43.00	1.44	0.77	0.52	0.13	0.14
41.00	0.33	0.04	0.16	0.06	0.19
40.00	0.75	0.68	1.37	0.03	0.02
38.00	0.20	0.19	0.26	0.06	0.02
37.00	1.00	0.17	0.04	0.14	0.02
35.00	0.42	2.13	0.38	0.09	0.07
33.60	0.28	0.56	0.26	0.05	0.04
33.40	1.25	0.21	0.55	0.18	0.02
33.20	0.53	0.49	0.61	0.10	0.02
33.00	0.83	0.43	0.32	0.09	0.10
32.80	0.98	0.62	0.18	0.18	0.21
32.60	0.95	1.27	0.64	0.30	0.10
32.00	0.18	0.61	0.05	0.12	0.06
32.20	1.02	0.46	0.54	0.16	0.17
32.40	1.21	0.24	0.52	0.17	0.15

Surface water trace metals

Stat	Lat N	NO3	SiO4	PO4	Cd	Cu	Ni	Zn
05	60° 00	5.32	0.8	0.66	290	1.96	7.5	8.44
07	59° 59	3.79	0.5	0.43	104	2.78	1.7	18.37
09	61° 03	5.20	0.7	0.74	40	1.09	4.6	1.92
11	61° 32	5.23	1.1	0.46	72	2.95	4.4	5.04
13	61° 54	2.10	0.7	0.14	150	1.31	2.7	7.40
14	62° 04	2.90	0.8	0.12	166	1.07	2.1	14.46
15	62° 49	1.28	0.4	0.04	216	1.06	3.5	9.55
17	59° 00	4.10	0.5	0.40	178	4.56	2.4	8.97
18	54° 00	1.22	0.7	0.17	23	0.68	2.5	2.42
19	47° 16	0.30	0.4	0.08	39	0.71	3.9	1.91
21	44° 59	0.01	0.4	0.10	34	1.07	2.3	7.10
26	41° 59	0.01	0.7	0.10	21	1.57	5.3	4.50
27	41° 10	0.00	0.6	0.05	31	1.25	3.4	2.96
29	39° 00	0.03	0.6	0.01	30	1.32	1.1	3.12
30	38° 02	0.03	0.5	0.09	10	0.74	6.7	5.00
32	35° 58	0.01	0.5	0.05	91	5.04	14.4	9.35
33	34° 58	0.20	0.6	0.01	32	0.93	1.3	2.28
36	32° 55	0.01	0.5		12	0.75	2.5	
49	32° 00	0.00	0.7	0.00	25	1.06	1.1	7.33
62	33° 00	0.01	0.7	0.11	18	0.94	1.3	7.19