JOINT GLOBAL OCEAN FLUX STUDY

NORTH ATLANTIC PILOT PROJECT

R.V. TYRO

DEN HELDER-FUNCHAL-REYKJAVIK

17 APRIL TO 31 MAY 1990

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NIOZ DATA REPORT 1991-3

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RESEARCH VESSEL TYRO
LEG 3 UPPER OCEAN PROCESSES
DEN HELDER-FUNCHAL-REYKJAVIK
17 APRIL TO 31 MAY 1990
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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 diskettes, 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:

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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.

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1. INTRODUCTION

For details of all activities during the cruise see the original cruise report (NIOZ REPORT 1990-6). Between 17 April and 31 May 1990 81 stations were sampled at or near the transect of the JGOFS North Atlantic Pilot Study from 33°N to 60°N at the 20°W meridian with RV Tyro. In the mainly pelagic upperocean programme 177 CTD/Rosette casts and 93 net tows were completed. In addition several water samples were collected from an inflatable for trace metals, and from the Tyro with single Niskin bottles for algae and bacteria and a large volume sampler for microzooplankton. In the national framework of JGOFS two sediment trap moorings were recovered and redeployed. Two piston cores were collected for the university of Utrecht. An American team from Woods Hole employed in situ pumps for filtration of isotopes.
As with leg I in 1989 the 16 scientists on board took charge of most of the JGOFS Level 1 measurements and activities. Additionally there were special studies of coccolithophorid algae, dimethyl sulfide, and slides were prepared by microphotography of conspicuous zooplankton species. There was an intercalibration of corresponding methods applied at the British Charles Darwin and the Tyro on 16 May.

2. ACKNOWLEDGEMENTS

The cruise was part of the North Atlantic Pilot Study organised by six participating countries through the SCOR Committee for JGOFS. This organisation as well as our national steering group chaired by H.J.W.de Baar has masterminded also the present expedition. The expedition was funded by the Marine Research Foundation (Stichting Onderzoek der Zee, SOZ) and facilitated by the Netherlands Institute for Sea Research (NIOZ). Communication with both organisations kept logistic and technical operation smooth and efficient. The cooperation between master J. de Jong, officers and crew of the Tyro, and the technical and scientific teams was excellent.

3. PARTICIPANTS

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Joop Rommets	NIOZ	CO_2, alkalinity
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4. METHODS

Numbering 4.1-4.20 according to JGOFS core measurements protocols, additional projects 4.21-4.26.

4.1. Meteorology. Officers, Stoll

Meteorological observations have been carried out by the ship's officers on a six 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 and transmissometry. Ober

Oxygen sensor data, fluorometer and transmissometer data not in this report but available from investigator.
Almost 100 profiles of temperature, conductivity, dissolved oxygen-concentration, fluorescence and light-transmission have been recorded by means of a CTD-system. During most of the casts watersamples were taken at various depths.
The CTD-system mainly consists of:
- a NBIS Mk III CTD-probe (First 69 casts S/N 1135 rest S/N 1134)
- a Beckman oxygen-sensor
- a Chelsea Instruments Aquatracka fluorometer
- a SeaTech transmissometer (660 nm wavelength, 25 cm pathlength)
- an EG&G 1401 deckunit
- a General Oceanics rosette-sampler
- EG&G/Oceansoft Mk III/SCTD acquisition and post-processing software version 2.02.
- a 16 Mhz Chicony AT computer with a Conner harddisk and a special 20 Mhz math-coprocessor.
Applied operating systen: Compaq MS-DOS version 3.31.
- Niskin- and GoFlo-bottles.

Calibrations
The temperature-sensors are calibrated against a triple-point of water and a triple-point of phenoxy-benzene using a Pt-25 resistance-thermometer and SIS electronic reversing thermometers as transfer-standards. Preliminary results concerning the S/N 1135 indicate an offset of -1 mK in comparison with the manufacturers calibration. The offset of the S/N 1134 appeared to be -8 mK. A post-deployment-calibration of the transfer standards is carried out as soon as possible after the cruise. Accuracy after post-processing: ± 4mK or better.
The conductivity-sensors are calibrated with a Guildline Autosal salinometer using I.A.P.S.O. Standard Seawater batch P112. Preliminary results concerning the S/N 1135 indicate an offset of -0.002 psu incomparison with the manufacturers calibration determined with corrected temperature. Accuracy after post-processing: ± 0.004 psu or better.
The pressure-sensors are calibrated with a SIS reversing pressure-meter. Preliminary results indicate that the manufucturers calibration of the pressure-sensors is still valid. Accuracy after post-processing: ±0.15 % or better.

Intercalibration
An intercalibration with the CTD-system of the R.V. Charles Darwin was planned. This intercalibration could not take place because the system of the Charles Darwin was not working correctly on the inter-calibration-day.

Continuous underway salinity-measurement. Ober

Data not in this report, but available from investigator
The sea surface conductivity has been recorded continuously by a Seabird thermo-salinograph which was flushed by means of a pump-system. In the beginning of the cruise an electronic problem was found in the deck-unit after starting-up problems. After solving this problem the Seacat worked from 32°N 20°W to 60°N 20°W without a single problem.

Continuous underway temperature, fluorometry and TCO_2. Stoll.

Data not in this report, but available from investigator
The salinity of surface waters has been recorded by a thermo-salinograph (Brand: SEABIRD). The thermo-salinograph was flushed by means of the deckwash pump. Temperature was measured with a calibrated Pt-100 resistance which was mounted in the main cooling water inlet. Temperature and fluorescence has been recorded continuously with a strip chart recorder and with a data aquisition computer from Madeira on.

A special interface card combined with the data aquisition module gave one minute measurements and registrations of chlorophyll a, T, date,time, position, heading and speed. Whenever possible TCO_2 measurements of the surface waters have been made with an interval of approximately 6 minutes. After the cruise these two separate datasets will be combined into a final sea surface data base. The fluorescence meter is not calibrated at the NIOZ. Raw data files were continuously saved. For calibration of the (new) TCO_2 online measurements samples were taken regularly with either the rubber boat or if convenient with the CTD rosette sampler. Their appears to be a strong diurnal rhythm in theTCO_2 data.

4.3. Dissolved oxygen by Winkler titration. Flameling

Dissolved oxygen was measured according to the high precision Winkler titration method developed by Tijssen (HARTWIG AND MICHAEL 1978, TIJSSEN 1980, WILLIAMS AND JENKINSON 1982). Over 900 oxygen samples were taken at 16 stations from depths of 5 m until more than 4000 m. From each depth, duplicate- or, if time and the amount of water available allowed it, triplicate samples were taken. It was attempted to lead the water through a 200 µm zooplanktonfilter first. However, duplicate values were less accurate after that. At all stations from 2 depths seawaterblanks have been taken and analysed. The mean value is 0.77 $mM.m^{-3}$. There is no trend to be seen in the value of seawater-blanks from 33°N to 60°N. Immediately after sampling the reagentia were added while in a separate bottle the "sample temperature" was measured. Before starting each titration the temperature of the thiosulphate solution was measured. Data are corrected for titration temperature and seawater blanks. Correction for sample temperature was also applied. The calculated value in µmol/l 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 values of the duplicate/-triplicate samples are generally smaller than 0.5 µmol/kg.

HARTWIG, E.O. AND J.A. MICHAEL (1978) A sensitive photoelectric Winkler titrator for respiration measurements. Environmental Science &Technology **12(6):** 712-715.
TIJSSEN,S.B. (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.
WILLIAMS,P.J.LEB. AND N.W. JENKINSON (1982) A transportable micro-processor-controlled precise Winkler titration suitable for field station and shipboard use. Limnol. Oceanogr. **27(3):** 576-584.

4.4. Nutrients. de Vries. Bakker

Nutrients determined on board are: ammonia, nitrite, nitrate, ortho-phosphate and silicic acid. Seawater was drawn directly from the Rosette sampler in high density polyethylene bottles which were rinsed twice before filling. The seawater was not filtered and stored cool (4 °C) and dark prior to analysis within 12 hours. All analyses were done with Technicon TRAACS 800 autoanalyzers using the following wet colorimetric methods:
Ammonia - formation of the indo-phenol blue with phenol and sodium-hypochlorite, citrate as a buffer. Measured at 630 nm.
Phosphate - formation of the reduced molybdo-phosphate complex at pH 0.9-1.1. Potassium antimonyl tartrate as a catalyst and ascorbic acid as reductant. Measured at 885 nm.
Nitrite and nitrate - diazotization with sulfanylamide and naphtylenediamine, measured at 540 nm. Nitrate is reduced in a copperized Cd coil.
Silicic acid - measured as the reduced molybdenum complex at 810 nm. Ascorbic acid as reductant. Silica was measured standard in every sample - to see whether the Rosette-bottles were closing correctly.
From station 20 onwards we also measured water samples in the low level range nitrite and nitrate (NO_2 < .01 and NO_3 < 1.0 µM) with a specially modified Technicon AAII autoanalyzer. Detection limites were 5 nM for nitrate and 2 nM for nitrite.
An intercalibration was carried out with the "Darwin".

Shipboard estimates of precision accuracy on routine determinations with the TRAACS 800:

	Calculated µM	Measured µM	St. Deviation
Silica	1.65	1.62	.02
	15.15	15.10	.03
O-phosphate	1.08	1.06	.01
Ammonia	3.16	3.10	.11
Nitrite+nitrate	16.61	16.70	.05
Nitrite	.61	.62	.00

Nutrients uptake. de Vries, Kraay, Bakker

Data not in this report, but available from investigator
Acid cleaned polycarbonate bottles were filled with seawater from the production cast before sunrise. From these bottles subsamples were taken for the nutrient analysis at time zero. The experimental bottles were deployed together with the ^{14}C and oxygen production bottles in the deck incubator which simulated seven light depths. After 24 hours again before sunrise these bottles were collected and stored cool in the dark for analysis later on the day.

4.5. Optics. Kraay, van Bleijswijk

Data not in this report, but available from investigators.
Optical measurements were done every day around noon. Herefore were used 4 pi Si-cor spherical light sensors, measuring the photo-synthetically active radiation (PAR) with a wavelength from 400-700µm. The cast was done from the side of the ship with the sensor in the sun. A complete depth versus irradiance profile was made down to approximately 100 m. The sun variations were corrected by another 4 pi sensor drifting just below the sea surface. Total daily irradiance(300-2000 µm) was recorded continuously by a solary meter measuring $J.cm.^{-2}.day.^{-1}$.

4.6. Total carbon dioxid and total alkalinity. Stoll, Rommets

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 perspex (acrylic) by the NIOZ instrument workshop. It is cylindrical and surrounded by a jacket through which water is circulated in order to maintain a constant temperature of 20 °C (± 0.1 °C). The complete apparatus was installed in a air-conditioned laboratory kept at a temperature of 20 °C (± 1 °C).

Four ports in the top of the cell are provided for the glass electrode (Metrohm 6.0102.100), the reference electrode of the Ag-AgCl type (Metrohm 6.0726.100), a Pt-100 thermometer and a volume expansion plunger of 10 ml. A capillary tube with anti-diffusion tip supplies acid for the titration. The cell is stirred with a magnetic stir bar. The acid, 0.1M HCl, fortified to the ionic strength of seawater with 35 grams NaCl, is added from a motor burette (Metrohm 665). The miillivolt response of the cell was measured with a pH meter (Metrohm 654). Two titrator systems were used simultaneously under control of one HP 85 computer. The titration program was written by Frans 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 & 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, weighed out in aproximately 0.25 grams lots at the institute, was used as the shipboard standard. Standard solutions as well as blanks were made up with 41 grams of NaCl per liter in order to match the ionic strength of seawater.

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 gas is back-titrated with a coulometer model 5011. For each sample four replicate analyses were executed.

BRADSHAW, A.L., P.G. BREWER, D.K. SHAFER AND R.T. WILLIAMS (1981). Measurement 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 Res. **36(11)**: 1635-1654.
JOHANSSON O. AND M. WEDBORG (1982). On the evaluation of potentio-metric titrations of seawater with hydrochloric acid. Oceanol. 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.J.W. DE BAAR. Effects of selected calculation routines and dissociation constants on the determination of total carbon dioxide in seawater. In prep.

4.7. & 4.8. Total organic carbon. Brussaard

The resulting data set is listed in a separate table at the end of this report, legend at the end of this chapter.
For this cruise the objective was to measure total organic carbon (TOC) in seawater, using a IONICS TOC-analyzer, model 555. The following method was used: injection of 100 µl seawater into a high temperature (900 °C) reactor with various traps and scrubbers and final analysis of carbon dioxide with IR spectroscopy. Laboratory testing appeared to be too short, so the main objective became trouble shooting and optimizing of the apparatus and methods. The results look very promising and make the possibility of a working analyzer next year feasible. The obtained data had a high reproducibility and no tailing of the peaks.

Total organic carbon intercalibration:
At 49°N 17°W an intercalibration was sceduled with R.V. Charles Darwin. The IONICS TOC-analyzer, model 555 (high temperature combustion method, 900 °C) was calibrated versus a range of K-Phtalate standards dissolved as standard addition in seawater of AOU maximum. Preliminary results show that the TOC profile is almost the mirror image of the AOU profile. TOC levels ranged from 90 - 130 µM seawater.

4.9. Pigments and chlorophyll. Kraay

The pigment data is listed seperately at the end of this report, legend at the end of this chapter.
HPLC pigments
Samples for pigments were taken from every so called production cast in the early morning. One at the surface and one at the 1 to 6% light-level depth. On the main stations samples were taken at 8 depths from 10 to 1000 m. Up to 18 liters were filtered over GF/F and stored in the freezer for analysis at the laboratory.

Chlorophyll a extraction

1 l samples were taken from the so called production cast at every light depth and two or three more till 150 to 200 metres. Samples were filtered over GF/F and stored in the freezer for analysing on board later on the day. The deep frozen filter samples were extracted in 6 ml 90% aceton by sonification. After centrifugation the chlorophyll a were measured on the Perkin Elmer fluorometer model 2000, which was calibrated at home with HPLC pure chlorophyll a. The fluorometer was checked before every measuring with a standard chlorophyll a solution.

4.10. & 4.16. Bacterial biomass and production. Quist

Seperate 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 either glutaraldehyde or formaldehyde, 2% final concentration. They are counted later on in the laboratory, using epifluorescence microscopy and either DAPI or AOstaining. Bacterial biomass was estimated using the biovolume method.

Bacterial production

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 productivity measurements.

Sampling was carried out as described in the primary production section. In addition to the seven "light depths" of the primary productivity measurements, samples were taken from three deeper zones, usually 75 m, 125 m and 200 m. At the Superstations, 33°N, 47°N and 60°N, samples were taken at intervals of 500 m all to the bottom. At t=0 5 nM ^{3}H-thymidine (Amersham, 82 Ci·mmol^{-1}) was added. The samples were incubated in the dark. The samples from above the thermocline were incubated at sea surface temperature, those from below it were incubated at 5 °C. Incubation times were approximately 2 hours.

At the beginning and end of the incubation, subsamples were taken. The samples were filtered on .2 µm cellulose nitrate filters (Sartorius). Subsequently the filters were extracted three minutes with 5 ml ice-cold TCA (5%), rinsed five times with 1 ml ice-cold TCA(5%) and extracted with 5 ml ice-cold EtOH (80%) for another 3 minutes. After 12 hours of drying the filters were placed in a scintillation vial, 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. To get some idea of the diurnal variation two time series were made at 47°N and 60°N, respectively. At the Superstations the linearity of the incorporation was checked as well as the conversion factor from molesthymidine incorporated to cells formed.

4.11. & 4.12. Meso- and microzooplankton biomass. Gonzalez, Witte

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 plankton samples were taken with a variety of nets, each of which covered 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, Tintinids, etc.), was covered by preserving in Lugol unsieved 250 ml. samples from the large volume watersampler and storing them dark at 4 °C.

2. Mesozooplankton ranging in size from 50 to 200 mm consists mainly of eggs, larvae and small stages of Copepods and larvae of larger species. This group was sampled with a large volume watersampler (154 l). Samples were taken from 375, 150, 75, 37.5 and 12.5 metres (i.e. the middle of the multinet intervals), sieved over 50 µm and preserved in 4% buffered formalin solution. Mesozooplankton larger than 200 µm was collected with the Hydro-bios Multinet and with the WP2 vertical net. Both nets were mounted with 200 µm nets for the purpose.

The multinet (opening 54 x 54 cm) was towed at a speed of 1.5 knots. It was lowered to 500 m 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). Volume filtered in m^3 ranged from several hundred m^3 for net 1 to 20-50 m^3 for nets 4 and 5. The WP2 net (diameter 56 cm) was lowered to 200 metres and hauled back to the surface with a speed of 20 metres/min. Only while going upwards the WP2 net is collecting plankton. The depth of the haul together with the surface of the net opening give an indication of the filtered volume (app. 75 m^3).

Samples taken with both nets were divided into two fractions, a fine one (200-1000 µm), and a coarse one (>1000 µm). After this each fraction was divided with the Folsom plankton splitter into two equal parts. One halve was sieved over a Whatman micropore filter of known dryweight and frozen for later dryweight-determination. The other halve was stored in 4% buffered formalin for later analysis to the species level.

3. The Macroplankton (>2000 µm) was sampled with an Isaacs-Kidd midwater trawl (IKMT) with a net opening of 7.3 m^2 and mesh width of 1.4 mm. Double oblique hauls were made to a depth of 200 m. The net was mounted with electronic sensors for depth, temperature and current meter. 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 the main stations (33°N 20°W, 47°N 20°W and 60°N 20°W) the whole range of methods was applied around 12.00 hr. and 24.00 hr. and on the other stations once, around noon.

		Multinet		I.K.M.T		watersamp.		WP2 net		egg-pr.	growth
date	pos	day	night	day	night	day	night	day	night		
27-4	33N		x		-		-		x	x	x
29-4	33N	x		x		x		x		x	x
07-5	33N	x		x		x		x		x	x
08-5	33N		x		x		x		x	x	-
09-5	35N	x		x		x		x		x	x
10-5	37N	x		x		x		x		x	x
11-5	39N	x		x		x		x		x	x
12-5	41N	x		x		x		x		-	x
14-5	45N	x		-		x		x		x	x
18-5	47N	x		x		x		x		x	x
18-5	47N		x		x		x		x	x	-
19-5	47N		x		x		x		x	x	-
20-5	47N	x		x		x		x		x	x
22-5	50N	x		x		x		x		x	x
23-5	52N	x		x		x		x		-	x
23-5	53N									x	
24-5	55N	x		x		x		x		x	x
24-5	56N									x	
25-5	57N	x		x		x		x		x	x
27-5	60N	x		x		x		x		x	x
27-5	60N		x		x		-		x	x	-
28-5	60N		x		x		x		x	x	-
29-5	60N	x		x		x		x		-	x

Table 4.11.1: Deployment of various type plankton nets during the cruise.

4.13. Primary production by ^{14}C. Kraay

In order to estimate the daily phytoplankton ^{14}C production, samples were taken at seven depths which were calculated from the optical light measurements. The standard procedure was the in situ incubation on a rigg but on the short station the procedure was carried out in the deck incubator. The samples were collected in the early morning before sunrise and the incubation was ended 24 hours later. Two duplicates of 250 ml were taken in acid cleaned polycarbonate bottles to which 100 µl of ±5 µCi ^{14}C bicarbonate was added. After incubation the samples were filtered over 47 mm GF/F filters at low vacuum pressure. Filters were fumed with damp of fuming HCl in order to remove inorganic radioactive bicarbonate and the calcification of some algae species. The filters were then counted in the liquid scintillation counter (LKB) after adding 10 ml of Instagel solution. Dark bottles were stored in a dark container which was cooled by running water from the deck incubation. These samples were treated in the same way at the light bottles.

4.14. Primary productivity by Winkler titration. Kraay , van Bleijswijk

Samples for the community oxygen respiration and production were taken from the same bottles as used for the ^{14}C production. Three to four samples were taken for one initial or production value. Of the initial bottles immediately oxygen Winkler reagents were added. The production bottles were deployed in the deck incubator together with the ^{14}C bottles or on the main stations at the primary

production rigg. After 24 hours the production bottles were collected and treated like the initial bottles. The Winkler titration was done with a high precise titration.

4.20. Deep moored traps

Due to bad weather conditions the sediment trap rigs moored at 45°16.9 N 25° 30.6 W and 40° 29.9 N 20° 10.9 W could not be recaptured since their deployment in 1988/1989. To avoid more delay in these dimentation research program of the benthic team of next leg the moorings were successfully recaptured on 23 and 27 April, and the samples were fixed. Some traps were redeployed at rigs moored on 17 May at 47° 40.2 N 20° 50.5 W (4430 m), and 26 May at 58° 29.98 N 20° 29.98 W (2916 m). This work required about 3 days but does not belong to the pelagic program of the expedition.

4.21. Trace metals. Nolting, de Jong

Surface data in a seperate table at the end of this report, legend at the end of this chapter.
From the departure of Den Helder we tried to collect twice a day a surface sample obtained by use of a rubber raft. Two days this was not possible because of rough weather. Before Madeira we were able to cover the whole area sailed by Tyro and collected 21 surface samples. Positions of surface samples were roughly bordered by 52° 18'N and 33° 00'N and 3° 13'E till 25° 06'W. At two positions 40° 33.2'N 20° 08' W and 32° 59.3'N 20° 00.9'W vertical deep water profiles were sampled. At the first station samples were collected at 12 depths till 1000 m. At the second station water samples were collected at 36 depths till the bottom. After collection all samples were directly filtered in an all 100% class clean laboratory container. The water was acidified with ultra pure concentrated HCl and stored for one or two days. Filters with suspended particulate matter were stored for later analysis. After one or two days the water samples were extracted with an APDC/DDDC extraction method using freon as the solvent. The freon fraction was collected in small teflon vials and the trace metals were back extracted by means of nitric acid and ultra pure water 1:9. These extracts were stored in a frigidaire till later analysis by atomic absorption spectrometry in the home laboratory. The investigated metals were Cu, Zn, Cd, Ni, Pb and Fe and were all determined with a Perkin Elmer Zeeman 5100 atomic absorption spectrophotometer. As technique the stabilised temperature platform furnace was used for Cu,Zn, Cd, Pb and Fe. For the determination of Ni wall atomisation was the perfect method.

In all samples the nutrients phosphate, silicate and nitrate were determined. Also with every surface sampling a bottle was filled to determine the salinity. All nutrients showed a decrease in concentration in offshore direction, so away from the continent and in southward direction, but were not depleted at the most southern stations.

4.22. Isotopes. Wijma

Over 1200 samples in total were collected for analysis at the Centre for Isotope Research, University of Groningen. Some 300 water samples were taken from the standard 1500 m hydrocasts and bottled for determination of ^{2}H (deuterium) and ^{18}O by massspectrometry in the home laboratory. Some 300 watersamples were collected simultaneously with samples for the CO_2 system. 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 massspectrometry. Large volume samples amounting to 117 (39 x 3) vessels of 25 liters each were treated on board by hydrochloric acid addition for extracting the CO_2 into an alkaline solution. The ^{14}C contents of the resulting 39 samples, representing 3 vertical profiles at 60°N, 47°N and 33°N, are measured in a proportional gas counter. 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

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

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

In situ filtration of isotopes. Hammer, Andrews

The goals of Terry Hammar and John Andrews from Woods Hole Oceanographic Institution for the JGOFS III cruise aboard Tyro were to take Niskin bottle samples for ^{210}Pb analysis and large volume watersamples at two stations along 20°W longitude, 33°N and 41°N latitudes.The large volume samples are taken with an in situ pumping system which passes 1000-2000 liters of water through a prefilter and then through 2 filter cartridges which have been saturated with MnO_2. These samples are used for analysis of ^{234}Th. The prefilter provides us with the particulate fraction, and through adsorption, the MnO_2 cartridges provide us with the dissolved fraction. Two MnO_2 cartridges are used to provide a means of calculating the efficiency of adsorption of the radionuclides from the water. In addition to these, we take filter samples from the surface each day we are on station for ^{234}Th analysis. We use either a deck pump or the ships clean water surface pump if available.
Overall, we were moderately successful in our mission. All the Niskin samples went well, but the large volume pumps were disappointing at first. We managed to collect 23 good samples out of a possible 32. Problems that occurred were an even mix of electrical and mechanical which resulted in 2 initial poor performance casts followed by 1 goodcast after we finally managed to get everything fixed. Fortunately, the shallow cast at 33°N, which was the most important for us, was also our best.

Sample Schedule; JGOFS III, TYRO

Station	Niskin depth m	large volume pump depth (m)	volume pumped l
41°N	500	500	68
	700	-	-
	900	-	-
	1200	1200	4
	1400	1400	2809
	1600	1600	2604
	2100	2100	375
	2600	2600	2222
	3100	3100	2196
	3600	3600	2324
	3900	3900	2635
	4000	4000	836
		surface pump (ships)	4342
33°N (shallow)	surface	surface (3 times)	8158 (total)
	5	5*	no initial flow
	20	20*	meter readings taken
	40	40	3513
	60	60	3850
	80	80	0
	100	100	3982
	150	150	1862
	200	-	-
	250	250	3286
	400	400	1597
	600	600	3713

* These two pumps performed well, but we missed the initial flow meter readings, so no volumes are available. I will measure flow rates on these pumps later to get an approximation of volumes.

Station	Niskin depth m	pump depth m	volume l
33°N	400	400	8
(deep cast)	600	600	8
	800	800	3028
	1000	1000	3430
	1500	1500	11
	2000	2000	2366
	2500	2500	2158
	3000	-	-
	3500	3490	2143
	4000	4165	1707
	4400	4400	30
	4600	-	-

4.23. Coccolithophorids. van der Wal

Sampling procedures

For phytoplankton taxonomic studies water samples were taken with Niskin bottles at depths varying between 0 and 250 metres. Our attention was especially focused on the occurrence of the various lifeforms of the coccolithophorid alga Emiliania huxleyi. A quantity of 25 ml of each seawater sample was immediately fixed by adding an equal amount of a 4% paraformaldehyde, Tris-buffered solution (pH 7.2; osmolarity 1050 mOs) and stored at 4 °C. In order to concentrate the plankton present in the seawater several liters were filtered over 1.0 mm polycarbonate filters by either vacuum or pressure filtration. The filters were put in 15 ml test tubes containing 5 ml seawater and cleaned by shaking the tubes, or by means of a light ultrasonic treatment. The material resuspended in this way was viewed on board of the ship in a phase-contrast microscope equipped with a UV-lightsource and the appropriate filters for the assessment of (auto) fluorescence. The seawater containing the concentrated plankton was fixed by adding an equal amount of a 4% paraformaldehyde, Tris-buffered solution and stored at 4 °C.

Sediment traps

At the main stations three sediment traps were employed, each having a catch area of about 80 cm^2. They were filled with filtered seawater to which an additional amount of NaCl was added so as to enhance the salinity to either 3.8 %, or 7.0 %. The traps were tightened to a rope that at one end was attached to a buoy and at the other end to an iron load. After a period of about 12 hours they were recovered and emptied, refilled with filtered seawater and set in position again.The seawater contained in the traps was treated in the same way as the seawater derived from the Niskin bottles: Part of it was immediately fixed in paraformaldehyde, the remainder was filtered over 1.0 µm polycarbonate filters prior to fixation.

Immunocytochemistry

On board of the ship we had at our disposal two antisera raised against the complex, water-soluble polysaccharide present in the coccoliths of Emiliania huxleyi. The antigens were derived from two strains: strain 92D and strain L. Each antiserum was so specific as to not react with the antigen of the other strain. Immunolabelling experiments were performed on phytoplankton material sampled atstations 39, 51, 55, 66, 68 and 81. The plankton was first brought in a thick suspension by filtration and centrifugation. Immunolabelling and staining of the antibodies with a fluorescent dye were performed according to standard procedures. Subsequently, the samples were viewed in a fluorescence microscope.

Phytoplankton studies

Water masses and primary production.

From Madeira to Iceland the Tyro crossed three different types of water, judged by chlorophyll a content, transparancy, and species diversity (Table 4.23.1.). The euphotic zone measured about 100 metres in the southern waters and about 30 metres in the northern half of the cruise trajectory. However, despite the much smaller volume of the euphotic in the northern waters, the primary production measured in these waters was twice as high as the primary production determined in the southern waters. It is interesting to note that the primary production in the summer of 1989 was equal in both parts and appreciably lower, viz. about 300 $mgC/m^2/day$. Primary production was not only measured with the ^{14}C-method, but also by determining O_2 production and in a single case also

by measuring CO_2 production. Table 4.23.2. shows the results for one station. Also shown is the consumption of nitrogen compounds measured in seawater samples from the same depths.

Emiliania huxleyi - Immunocytochemistry

The coccolithophorid alga Emiliania huxleyi was present at all stations where water samples were taken. The antisera raised against the polysaccharide associated with the coccoliths of this species were allowed to react with the phytoplankton specimens sampled at stations 39, 51, 55, 66, 68 and 81. With antiserum 92D staining of the phytoplankton was either absent, or very weak and probably non-specific. With antiserum L varying numbers of coccolith-bearing cells of E. huxleyi were brightly stained. Apart from calcified cells of this species, no other cells were labelled.
The results of the immunolabelling experiments are published in van BLEIJSWIJK ET AL.,(1991).

J. VAN BLEIJSWIJK, P. VAN DER WAL, R. KEMPERS, M. VELDHUIS, J. YOUNG, G. MUYZER, E. DE VRIND-DE JONG AND P. WESTBROEK, 1991. Distribution of two types of Emiliania huxleyi (Prmnesiophyceae) in the North EastAtlantic region as determined by immunofluorescence and coccolith morphology. Journal of Phycology **27,** 5.

Table 4.23.1. Characterization of water masses encountered by the Tyro cruising along the 20°W meridian (leg 3).

	Type 1 waters 33°N - 45°N	type 2 waters 45°N - 54°N	type 3 waters 54°N - 60°N
K	0.0590 - 0.0682	0.128 - 0.143	0.119 - 0.207
Cs	0.13 - 0.30	0.89 - 1.38	1.67 - 3.51
Cm	0.32 - 0.98	0.89 - 1.42	2.33 - 3.51
Dc	30 - 75 1)	0 - 30	0 - 30
Pd	coccolithophores	dinoflagellates	diatoms

K = light attenuation coefficient
Cs = chlorophyll a content in surface waters (mg/m^3)
Cm = chlorophyll a content at chlorophyl maximum (mg/m^3)
Dc = depth of chlorophyll maximum (m)
Pd = dominant phytoplankton

1) NB: Chlorophyll maximum in the summer of 1989 was found at a depth of around 120 meter.

Table 4.23.2. Primary production, O_2 generation, and CO_2 and NOx consumption in seawater samples from various depths after 24 hours of storage in the deck-incubator. Station 71.

depth (m)	dC (µM/l)	dO_2 (µM/l)	dCO_2 (µM/l)	dNOx (µM/l)
1	17.7	24.0	-19	-2.14
2	19.8	28.4	-27	-2.08
6	19.2	29.3	-28	-2.22
10	15.2	21.8	-18	-1.98
14	9.9	14.0	-8	-1.67
17	5.1	5.3	-9	-1.10
23	1.5	0.0	-3	-0.66

Detection of Emiliania huxleyi cells by immunofluorescence.van Bleijswijk

From laboratory cultures of Emiliania huxleyi three different cell types have been isolated: cells with a carbon skeleton (C-cells), naked cells without a skeleton (N-cells) and cells that bear organic scales and flagella (S-cells). In field situations by means of light microscopy one is only able to recognize E. huxleyi C. cells as such. As our goal is to study bloom dynamics of E. huxleyi we started to use an immunological method that enables us to recognize N and (in the future) S-cells as well. At the geobiochemistry department of Leiden University antibodies were raised against two E. huxleyi strains: 92D and L. When these (primary) antibodies are added to a suspension of living or fixed algae addition of a (second) fluorescent antibody allows microscopical detection of apositive reaction: positive algae show a clear green fluorescent halo. From laboratory experiments we know that our antibodies react with both C- and N-cells and are strain specific (the anti-92D antiserum does not react with L-strain cells and vice versa). During JGOFS leg III we had the opportunity to test the antisera for the first time on field samples of phytoplankton.

Preliminary results

At the main stations (33°N 20°W, 47°N 20°W and 60°N 20°W) phytoplankton samples contained coccolithophorid species in relatively large amounts besides diatom and/or Peridinium species. After immunolabelling of the samples screening with the fluorescence microscope revealed a very clear fluorescence of calcified E. huxleyi cells treated with the anti L-strain antibody but not with the anti-92D antibody. So E. huxleyi cells caught at the main stations belong to the L-strain. No positive naked cells were found which possibly means that these were not (sufficiently) present in our samples as in the laboratory both calcified and naked cells reacted with our antisera. Other coccolithophorid species did not show a clear immunofluorescent halo. Neither did the diatoms or the Peridinium species. So it appears that the antibodies we have are specific and therefore suitable for studying the biogeography of different E. huxleyi strains even in non-bloom situations. As we did not find any positive N-cell we still cannot be sure that the antisera are also useful for the study of bloom dynamics but that we hope to prove in the near future.

4.24. Mesozooplankton growth rates and egg production. Gonzalez

In addition to the zooplankton sampling mesozooplankton was collected with a 50 micron planktonnet (opening 30 cm) handled vertically from 75m. to the surface. The material was carefully sieved over 500, 200 and 100 µm and the fraction 100- 200 and 200-500 were each divided over two 5 liter incubation jars filled with 50 µm sieved seawater. One jar per fraction was preserved in 4% buffered formalin at T=0, the other after 24 hr. incubation at surface water temperature. At the NIOZ,

the T0 and T24 samples will be analyzed to the development-stage level, the shift in which will provide a measure of growth rate.

Other 5 liter incubation jars filled also with 50 µm sieved seawater served as egg-production jars. Life adult females of as many as possible copepod species were collected and incubated during 24 hr. in the jars. The number of eggs produced per female per 24 hr. which is directly related with the mesozooplankton conditions, was determined directly after the experiments.

The plankton samples collected during JGOFS 3 will be analyzed on NIOZ.

The only results we can present are those of the egg-production experiments which were all completed on board (table 4.24.1). Depending on geographical positions, egg production measurements were carried out with the following species of copepods:
Calanus helgolandicus (1)
Calanus minor (2)
Paracalanus parvus (3)
Ctenocalanus vanus (4)
Aetideus armatus (5)
Euaetideus giesbrechti (6)
Scolecithricella minor (7)
Metridia lucens (8)
Metridia venusta (9)
Pleuromamma gracilis (10)
Lucicutia longicornis (11)
Acartia clausi (12)
Acartia danae (13)
Pleuromamma robusta (14)

species															
date	pos	1	2	3	4	5	6	7	8	9	10	11	12	13	14
27-4	33N									0.2		0			
29-4	33N				4.1							0		2.5	
07-5	33N		7.2		6.0									6.5	
08-5	33N		6.0									0		2.2	
09-5	35N			2.4										4.2	
10-5	37N				10									15.4	
11-5	39N	5.8			0.9										
14-5	45N				11.4					0.3					
18-5	47N				11.5		1.8								
18-5	47N									3.9	0				
19-5	47N			2.3	6.5		0		0	0.2	0				
20-5	47N				8.7		1.8								0
22-5	50N				9.5		0			0.9					
23-5	52N	10.1		5.5					2.0						
24-5	55N												22.2		
24-5	56N								1.4						
25-5	57N						0.5	0							
27-5	60N						0	0.8							
27-5	60N	67.0						4.4							
28-5	60N						0								

table 4.24.1.Eggs produced per female per 24 hr.

4.25. Dimethyl sulphide concentrations. Stefels

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

To estimate the concentrations of the volatile dimethyl sulphide in solution, water samples were preconcentrated with the purge and trap method.

Samples of approx. 800 ml were collected in blood transfer bags, filtered over a GF/F filter and heated during a 40 min. period, while a 200 ml/min He flow purged the sample. Diethyl sulphide was added as an internal standard. Excess water vapour was trapped from the He flow with a condensor followed by a Nafion dryer. The resulting gas sample was trapped in a U-shaped cold trap of borosilicate glass tubing, suspended in liquid nitrogen, and subsequently sealed by melting the legs of the trap with a burner. Samples were stored deep frozen to wait analysis in the laboratory.

Water samples were taken parallel to those for primary production and bacterial production measurements. In addition to the seven lightdepths, samples were usually taken from 100, 150 and 200 m depths as well. On six occasions, samples were taken from around the oxygen minimum, and on three occasions from near bottom water. In a first attempt to look for diurnal variations, samples were regularly taken from one depth during a 24 hour period at the superstations 47°N and 60°N. A total of approx. 220 samples was collected.

4.26. Intercalibration with Charles Darwin

On 16/5 we met Darwin and completed our intercalibration programme.
Buoy 3907 was transferred to Darwin. Its drogue was not found because if there was any it apparently loosened itself before we arrived. While approaching Darwin's position from 46°N 20°W and while returning to 47°N 20°W we did not carry out any profiling, but we have a continuous record of surface temperature, salinity and chlorophyll along our track. This may add later to interprete the intricate hydrographical pattern. The following results could be derived on board and could be forwarded to the former and present team on Darwin.

^{14}C production on rig, incubation time 10.50 to 19.45 and chlorophyll a (Kraay):

depth(m)	light	dpm	mmolC/m^3	µg/l chlor. a
2		45357	8.9	3.00
2		43758	8.6	
2	dark	393		
10		16144	3.2	2.54
10		16289	3.2	
10	dark	263		
15		6663	1.27	1.87
15		6266	1.19	
15	dark	263		
20		1976	0.28	0.50
20		2050	0.29	
20	dark	596		
25		1226	0.16	0.22
25		1770	0.27	
25	dark	422		
35		1555	0.27	0.17
35		1646	0.28	
35	dark	203		

Production ^{14}C from 0 to 35 m: 81.3 mmolC/m^2
Stock solution Darwin 246000000 dpm/ml
Stock solution Tyro 108000000 dpm/ml

Total irradiation 300-2000 nm: 1160 J.cm^{-2}.d^{-1}
Attenuation coefficient 0-18 m: 0.24 m^{-1},
18-40 m: 0.07 m^{-1}

Oxygen production on rig from 10.50 to 19.45: oxygen values in µmol/l

depth(m)	initial	light	dark
2	295.78 ± 0.11	306.92 ± 0.51	293.90 ± 0.61
10	293.27 0.27	296.39 0.87	290.72 0.50
20	274.54 0.46	274.22 0.58	274.54 0.46
35	269.89 0.58	269.55 0.33	269.60 0.54

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 µM	primary productivity by ^{14}C incubation in deck incubator in $\mu M.l^{-1}.24hrs$
P.P µM	primary productivity by ^{14}C incubation in situ in $\mu M.l^{-1}.24hrs$
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.

900° C	high temperature combustion method at 900° C (IONICS 555)

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

Position	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
Lon W	longitude
sal	salinity in practical salinity scale units
Fe	concentration of iron in nmol/kg
Pb	concentration of lead in picomol/kg
Ni	concentration of nickel in nmol/kg
Cu	concentration of copper in nmol/kg
Cd	concentration of cadmium in pmol/kg
PO4	concentration of phosphate in μmol/kg
SiO4	concentration of silicate in μmol/kg
NO3	concentration of nitrate in μmol/kg

date	23/4/90	23/4/90	24/4/90	24/4/90	24/4/90	24/4/90	25/4/90	25/4/90
Hour	12	18	0	6	12	18	0	12
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99451	99445	99456	99428	99419	99411	99410	99409
$Q_cL_oL_oL_oL_o$	70252	70244	70232	70221	70211	70201	70200	70201
i_Ri_xhVV	40497	40298	40199	40196	40497	40297	41/98	41599
Nddff	72309	82709	82909	83609	83609	80218	70318	70413
1S_nTTT	10148	10190	10140	10142	10169	10172	10138	10143
2$S_nT_dT_dT_d$	20133	20175	20109	20130	20120	20180	20097	20105
4PPPP	40265	40270	40275	40260	40265	40255	40265	40285
5appp	54010	52010	58005	50000	50005	57010	50000	51013
7wwW_1W_2	70026	70128	703//	75020	70220	70002	70025	702//
8Nh$C_LC_MC_H$	82298	879//	86///	88///	85991	88480	89///	83762
222D_sv_s	22232	22232	22233	22232	22232	22233	22200	22242
0Sn$T_wT_wT_w$	150	150			160	160		160
2$P_wP_wH_wH_w$	20401	20401						
3$d_{w1}d_{w1}d_{w2}d_{w2}$	327//	32700						
4$P_{w1}P_{w1}H_{w1}H_{w1}$	4//02							
5$P_{w2}P_{w2}H_{w2}H_{w2}$								

date	25/4/90	26/4/90	26/4/90	26/4/90	26/4/90	27/4/90	27/4/90	27/4/90
Hour	18	0	6	12	18	0	12	18
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99405	99405	99393	99382	99371	99358	99337	99330
$Q_cL_oL_oL_oL_o$	70201	70202	70201	70201	70201	70201	70200	70200
i_Ri_xhVV	41598	41898	41398	41399	41498	41/99	41597	41397
Nddff	60408	30317	70418	30713	70718	10716	10716	40110
1S_nTTT	10190	10140	10178	10155	10198	10152	10201	10210
2$S_nT_dT_dT_d$	20024	20105	20151	20108	20139	20093	20117	20020
4PPPP	40278	40295	40278	40280	40253	40245	40220	40215
5appp	56003	51010	57002	56005	57007	50000	54000	55000
7wwW_1W_2	70101	700//	70012	70200	70312	70212	70212	70012
8Nh$C_LC_MC_H$	83233	83031	87/00	82920	86060	80005	82210	86100
222D_sv_s	22210	22243	22243	22243	22243	22243	22243	22200
0Sn$T_wT_wT_w$	160	160		156			194	
2$P_wP_wH_wH_w$								
3$d_{w1}d_{w1}d_{w2}d_{w2}$								
4$P_{w1}P_{w1}H_{w1}H_{w1}$								
5$P_{w2}P_{w2}H_{w2}H_{w2}$								

date	28/4/90	28/4/90	29/4/90	30/4/90	30/4/90	30/4/90	30/4/90	1/5/90
Hour	6	13	12	1	6	12	18	0
W	3	3	3	1	1	3	3	3
99$L_aL_aL_a$	99330	99330	99330	99330	99331	99330	99329	99328
$Q_cL_oL_oL_oL_o$	70200	70200	70200	70200	70200	70198	70188	70178
i_Ri_xhVV	41598	41/98	41/98	4/198	41598	4//99	4/698	4//99
Nddff	30110	30118	70010	80011	80009	40000	70005	80407
1S_nTTT	10180	10165	10160	10166	10188	10169	10220	10170
2$S_nT_dT_dT_d$	20016	20117	20120	20130	20190	20112	20158	20125
4PPPP	40202	40212	40185	40185	40170	40185	40173	40180
5appp	56008	51000	54000	54000	56015	51015	55015	58005
7wwW_1W_2	70100	700//		702//	70022	702//	70300	702//
8Nh$C_LC_MC_H$	80100	87200		8////	881//	82694	86093	88700
222D_sv_s	22280	22280			22200	22222	22222	22222
0Sn$T_wT_wT_w$		177				184		
2$P_wP_wH_wH_w$								
3$d_{w1}d_{w1}d_{w2}d_{w2}$								
4$P_{w1}P_{w1}H_{w1}H_{w1}$								
5$P_{w2}P_{w2}H_{w2}H_{w2}$								

date	3/5/90	3/5/90	4/5/90	4/5/90	4/5/90	4/5/90	5/5/90	5/5/90
Hour	12	18	0	6	12	18	2	12
W	3	3	3	3	3	3	3	1
99$L_aL_aL_a$	99325	99325	99323	99322	99321	99321	99320	99320
$Q_cL_oL_oL_oL_o$	70173	70187	70202	70215	70229	70240	70242	70241
i_Ri_xhVV	41/99	4/698	4/898	41497	4/599	41395	4/898	4/599
Nddff	11407	21305	41405	72409	32307	31913	31812	11813
1S_nTTT	10182	10232	10180	10211	10189	10218	10180	10190
2$S_nT_dT_dT_d$	20129	20020	20151	20012	20128	20024	20150	20165
4PPPP	40155	40140	40138	40118	40135	40127	40135	40155
5appp	54000	56005	50000	56002	51015	57003	50000	50025
7wwW_1W_2	700//	70000	70200	70126	70211	70200	70300	70200
8Nh$C_LC_MC_H$	81400	81500	83080	8/3//	832//	83900	83050	81300
222D_sv_s	22262	22263	22263	22263	22263	22263	22241	22200
0Sn$T_wT_wT_w$	198				185			187
2$P_wP_wH_wH_w$								
3$d_{w1}d_{w1}d_{w2}d_{w2}$								
4$P_{w1}P_{w1}H_{w1}H_{w1}$								
5$P_{w2}P_{w2}H_{w2}H_{w2}$								

date	5/5/90	6/5/90	6/5/90	6/5/90	6/5/90	7/5/90	7/5/90	8/5/90
Hour	18	0	6	12	18	0	18	6
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99320	99321	99320	99320	99320	99325	99329	99331
$Q_cL_oL_oL_oL_o$	70242	70233	70221	70210	70200	70200	70200	70200
i_Ri_xhVV	4/599	4/898	4/598	41598	41598	41598	41497	41/97
Nddff	12209	21705	62009	62005	52305	32202	42218	42705
$1S_nTTT$	10220	10191	10105	10248	10208	10191	10220	10192
$2S_nT_dT_dT_d$	20018	20170	20182	20175	20163	20175	20163	20159
4PPPP	40148	40165	40160	40172	40165	40170	40110	40095
5appp	56002	51010	50010	51012	57002	51012	56000	50000
7wwW_1W_2	70000	70300	70310	70211	70211	70100	70011	70128
8Nh$C_LC_MC_H$	81060	84050	87340	86330	85100	811//	84410	849//
222D_sv_s	22200	22222	22222	22222	22222	22282	22200	22211
0Sn$T_wT_wT_w$				182	184	191		
2$P_wP_wH_wH_w$								
3$d_{w1}d_{w1}d_{w2}d_{w2}$								
4$P_{w1}P_{w1}H_{w1}H_{w1}$								
5$P_{w2}P_{w2}H_{w2}H_{w2}$								

date	8/5/90	8/5/90	9/5/90	9/5/90	10/5/90	10/5/90	10/5/90	10/5/90
Hour	12	18	6	18	0	6	12	18
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99334	99338	99350	99357	99364	99370	99370	99377
$Q_cL_oL_oL_oL_o$	70200	70200	70200	70200	70200	70200	70199	70200
i_Ri_xhVV	41598	41397	41096	41598	41/97	41497	41597	41497
Nddff	50418	24022	61018	60420	80316	80410	70505	80045
$1S_nTTT$	10185	10202	10192	10190	10170	10140	10189	10169
$2S_nT_dT_dT_d$	20146	20153	20152	20142	20112	20127	20128	20125
4PPPP	40115	40130	40170	40192	41022	40202	40220	40205
5appp	50010	52010	52010	53014	52020	57003	51038	56005
7wwW_1W_2	70300	70000	70222	70122	70322	70022	70022	70222
8Nh$C_LC_MC_H$	852//	82400	866//	865//	887//	8807/	877//	88071
222D_sv_s	22282	22282	22200	22282	22282	22200	22210	22282
0Sn$T_wT_wT_w$	182	182		180			175	
2$P_wP_wH_wH_w$		20303		20603			2//01	
3$d_{w1}d_{w1}d_{w2}d_{w2}$		327//		304//			305//	
4$P_{w1}P_{w1}H_{w1}H_{w1}$		408//		41003			40704	
5$P_{w2}P_{w2}H_{w2}$Hw2								

date	11/5/90	11/5/90	11/5/90	11/5/90	12/5/90	12/5/90	12/5/90	12/5/90
Hour	0	6	12	18	0	6	12	18
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99380	99387	99391	99395	99403	99410	99410	99416$_a$
$Q_cL_oL_oL_oL_o$	70199	70200	70200	70200	70200	70200	70200	70200
i_Ri_xhVV	41497	41497	41397	41/98	41398	41397	41598	41498
Nddff	70402	81515	82017	12705	43109	82720	62711	52713
1S_nTTT	10171	10160	10164	10170	10169	10138	10169	10130
2$S_nT_dT_dT_d$	20120	20112	20144	20141	20137	20127	20100	20108
4PPPP	40200	40130	40082	40053	40071	40050	40070	40060
5appp	56005	57020	56038	56002	51021	55000	52005	56005
7wwW_1W_2	70022	70322	70226	70001	70200	70322	70122	70201
8Nh$C_LC_MC_H$	8////	8604/	885//	8//00	8322/	8/2//	85540	85402
222D_sv_s	22282	22282	22280	22282	22282	22261	22280	22282
0Sn$T_wT_wT_w$	170		170				143	
2$P_wP_wH_wH_w$	20000		20604				20502	
3$d_{w1}d_{w1}$dw$_2$d$_{w2}$	305//						327//	
4$P_{w1}P_{w1}H_{w1}H_{w1}$	4////						41206	
5$P_{w2}P_{w2}H_{w2}H_{w2}$								

date	13/5/90	13/5/90	13/5/90	13/5/90	14/5/90	14/5/90	14/5/90	14/5/90e
Hour	0	6	12	18	0	6	12	18
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99424	99430	99435	99445	99449	99450	99450	99456
$Q_cL_oL_oL_oL_o$	70200	70200	70200	70200	70199	70200	70200	70200
i_Ri_xhVV	41598	41598	41597	41397	41497	41397	41596	41296
Nddff	52709	52224	62130	71828	81823	42218	62224	72330
1S_nTTT	10138	10145	10152	10160	10143	10140	10147	10150
2$S_nT_dT_dT_d$	20073	20079	20095	20108	20101	20101	20101	20116
4PPPP	40068	40040	40025	49980	49970	49968	49981	49962
5appp	54008	56003	56005	56020	54002	56005	54002	56010
7wwW_1W_2	70222	70222	70222	70222	72526	70181	76226	79222
8Nh$C_LC_MC_H$	85621	85203	86243	87776	87754	84400	86700	82691
222D_sv_s	22280	22261	22282	22282	22200	22200	22281	22281
0Sn$T_wT_wT_w$	140	142	140	140	140	140	130	130
2$P_wP_wH_wH_w$	20503	20804	20804	20704	20704	20502	20502	20702
3$d_{w1}d_{w1}d_{w2}d_{w2}$	327//	32230	329//	31827	316//	320//	320//	322//
4$P_{w1}P_{w1}H_{w1}H_{w1}$	41206	41004	41607	41208	41608	40806	41006	41004
5$P_{w2}P_{w2}H_{w2}H_{w2}$		51208		51208				

date	15/5/90	15/5/90	15/5/90	15/5/90	16/5/90	16/5/90	16/5/90	17/5/90
Hour	0	6	12	18	0	6	12	0
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99463	99473	99483	99487	99489	99491	99490	99488
$Q_cL_oL_oL_oL_o$	70199	70198	70198	70193	70183	70171	70170	70177
i_Ri_xhVV	41598	41598	41698	41498	41497	41497	41598	41496
Nddff	13330	33007	53010	33013	33113	42705	62002	70502
1S_nTTT	10155	10139	10198	10168	10140	10142	10166	10145
2$S_nT_dT_dT_d$	20067	20085	20105	20108	20085	20101	20096	20127
4PPPP	40012	40048	40080	40100	40125	40130	40145	40130
5appp	52040	52028	52020	51010	51015	51010	51010	50000
7wwW_1W_2	70100	70101	70302	70101	70200	70202	70202	70302
8Nh$C_LC_MC_H$	81100	83060	85851	83100	83600	88890	86534	87///
222D_sv_s	22282	22282	22212	22222	22222	22200	22200	22252
0Sn$T_wT_wT_w$	130	133	140	140	130	130	128	129
2$P_wP_wH_wH_w$	20703		20501					
3$d_{w1}d_{w1}d_{w2}d_{w2}$	322//		319//					
4$P_{w1}P_{w1}H_{w1}H_{w1}$	41204		40802					
5$P_{w2}P_{w2}H_{w2}H_{w2}$								

date	17/5/90	17/5/90	18/5/90	18/5/90	18/5/90	18/5/90	19/5/90	19/5/90
Hour	6	12	0	6	12	18	0	12
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99482	99476	99474	99470	99470	99470	99470	99470
$Q_cL_oL_oL_oL_o$	70194	70207	70206	70200	70200	70200	70200	70200
i_Ri_xhVV	41296	41396	41396	41497	41597	41497	41597	41597
Nddff	80002	61802	40911	70914	40611	60407	40411	30407
1S_nTTT	10152	10160	10151	10150	10192	10182	10174	10173
2$S_nT_dT_dT_d$	20133	20142	20135	20133	20126	20145	20127	20134
4PPPP	40118	40122	40115	40142	40117	40181	40100	40214
5appp	50002	54002	51010	57005	51018	52010	52010	51006
7wwW_1W_2	72056	70222	70211	70222	70211	70310	70201	70200
8Nh$C_LC_MC_H$	886//	8667/	84941	87770	83971	86070	84671	83400
222D_sv_s	22252	22252	22231	22231	22200	22241	22200	222//
0Sn$T_wT_wT_w$	130	130	132	130	145	145	140	
2$P_wP_wH_wH_w$				20602	20501	20302	20302	
3$d_{w1}d_{w1}d_{w2}d_{w2}$				30000	30000	30000	30000	
4$P_{w1}P_{w1}H_{w1}H_{w1}$								
5$P_{w2}P_{w2}H_{w2}H_{w2}$								

date	19/5/90	20/5/90	20/5/90	20/5/90	21/5/90	21/5/90	21/5/90	22/5/90
Hour	18	0	12	18	6	12	18	0
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99471	99472	99472	99472	99478	99483	99488	99495
$Q_cL_oL_oL_oL_o$	70200	70199	70199	70199	70200	70200	70200	70200
i_Ri_xhVV	41597	41497	41596	41497	41296	41696	41296	41496
Nddff	70402	30407	30315	70413	50409	50407	60205	23605
1S_nTTT	10170	10158	10188	10162	10150	10163	10158	10142
2$S_nT_dT_dT_d$	20137	20135	20110	20122	20101	20095	20112	20097
4PPPP	40227	40232	40245	40243	40248	40250	40250	40250
5appp	52010	51002	54000	57002	50002	50002	50000	54002
7wwW_1W_2	70311	70100	70200	70311	702//	70202	70202	70100
8Nh$C_LC_MC_H$	85040	83650	83232	875//	85600	85400	86700	82/00
222D_sv_s	222//	22200	22200	22200	22200	22200	22282	22282
0Sn$T_wT_wT_w$	143	152	147	145	143	145	143	140
2$P_wP_wH_wH_w$	30201	20201	20402	20502	2//01	20301	20001	20000
3$d_{w1}d_{w1}d_{w2}d_{w2}$		30000	30000	30406	305//	305//	308//	
4$P_{w1}P_{w1}H_{w1}H_{w1}$				40502	40902	40601	40902	
5$P_{w2}P_{w2}H_{w2}H_{w2}$				51004				

date	22/5/90	22/5/90	22/5/90	23/5/90	23/5/90	23/5/90	23/5/90	24/5/90
Hour	6	12	18	0	6	12	18	0
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99503	99503	99510	99517	99525	99526	99532	99540
$Q_cL_oL_oL_oL_o$	70200	70200	70200	70200	70200	70200	70200	70200
i_Ri_xhVV	41597	41597	41597	41598	41597	41697	41797	41697
Nddff	72503	72503	72607	73107	72205	61805	71610	70909
1S_nTTT	10143	10170	10162	10150	10148	10150	10152	10140
2$S_nT_dT_dT_d$	20114	20116	20127	20128	20118	20127	20116	20125
4PPPP	40240	40238	40230	40230	40215	40220	40218	40215
5appp	54000	55002	57005	54000	54000	54000	54002	54005
7wwW_1W_2	70011	70302	70322	70322	70022	70222	70310	70222
8Nh$C_LC_MC_H$	86036	86036	87709	87806	87035	85006	87099	87089
222D_sv_s	22200	22200	22283	22282	22200	22200	22282	22282
0Sn$T_wT_wT_w$	140	132	130	130	130	141	133	130
2$P_wP_wH_wH_w$	20000	20000	20401	20602	20000	20000	2////	20402
3$d_{w1}d_{w1}d_{w2}d_{w2}$	30000				30032	32300	3//36	
4$P_{w1}P_{w1}H_{w1}H_{w1}$					40000	40502	4////	
5$_{Pw2}P_{w2}H_{w2}H_{w2}$					51002		51002	

date	24/5/90	24/5/90	24/5/90	25/5/90	25/5/90	25/5/90	25/5/90	26/5/90
Hour	6	12	18	0	6	12	18	0
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99552	99556	99563	99572	99576	99579	99584	99586
$Q_cL_oL_oL_oL_o$	70200	70200	70200	70200	70200	70200	70204	70205
i_Ri_xhVV	41396	41496	41497	41496	41497	41497	41598	41498
Nddff	71210	71310	70912	80810	80815	60915	71010	61011
$1S_nTTT$	10130	10150	10128	10118	10103	10145	10120	10115
$2S_nT_dT_dT_d$	20127	20123	20113	20095	20095	20103	20102	20092
4PPPP	40202	40217	40225	40245	40240	40246	40242	40244
5appp	56003	54011	50005	51015	57002	50001	50002	54001
$7wwW_1W_2$	75062	74224	70122	70222	71522	70222	70322	70222
$8NhC_LC_MC_H$	877//	87710	871//	889//	885//	83845	876//	86881
$222D_sv_s$	22282	22200	22282	22282	22282	22200	22271	22200
$0SnT_wT_wT_w$	130	114	113	110	100	95	93	93
$2P_wP_wH_wH_w$	2////	20601	20401	20502	20502	20502	2////	20401
$3d_{w1}d_{w1}d_{w2}d_{w2}$	3//02	300//	304//	304//	30522	322//	322//	322//
$4P_{w1}P_{w1}H_{w1}H_{w1}$	4////	41203	41204	41204	40502	41004	41004	40602
$5P_{w2}P_{w2}H_{w2}H_{w2}$	51204				51203			

date	26/5/90	26/5/90	26/5/90	27/5/90	28/5/90	28/5/90	28/5/90	29/5/90
Hour	6	12	18	0	0	12	18	0
W	3	3	3	3	3	3	3	3
99$L_aL_aL_a$	99585	99585	99592	99598	99602	99602	99602	99602
$Q_cL_oL_oL_oL_o$	70205	70205	70200	70200	70196	70195	70194	70193
i_Ri_xhVV	41497	41598	41698	41598	41195	41496	41697	41395
Nddff	71411	40911	42213	51013	81424	72320	82109	81909
$1S_nTTT$	10110	10138	10118	10122	10110	10122	10105	10120
$2S_nT_dT_dT_d$	20092	20091	20091	20098	20110	20095	20113	20100
4PPPP	40232	40238	40240	40240	40085	40095	40100	40090
5appp	54000	53000	54000	54000	58085	51015	54000	54000
$7wwW_1W_2$	7032/	70211	70222	70211	78188	70044	70122	76247
$8NhC_LC_MC_H$	87668	84046	86081	85712	88///	8772/	886//	885//
$222D_sv_s$	22200	22212	22200	22200	22200	22200	22200	22200
$0SnT_wT_wT_w$	92	92	90	90	90	94	93	94
$2P_wP_wH_wH_w$	2//01	20401	20501	20501	21003	20603	2////	2////
$3d_{w1}d_{w1}d_{w2}d_{w2}$	318//	318//	318//	318//	318//	318//	318//	318//
$4P_{w1}P_{w1}H_{w1}H_{w1}$	40802	41003	41004	41004	41204	41406	41005	40803
$5P_{w2}P_{w2}H_{w2}H_{w2}$								

date	29/5/90	29/5/90	30/5/90	30/5/90	30/5/90	30/5/90
Hour	12	18	0	6	12	18
W	3	3	3	3	3	3
99$L_aL_aL_a$	99604	99604	99606	99613	99620	99628
$Q_cL_oL_oL_oL_o$	70192	70193	70194	70202	70209	70217
i_Ri_xhVV	41497	41497	41597	41395	41497	41597
Nddff	62109	72413	52509	81709	79902	71305
$1S_nTTT$	10122	10106	10118	10120	10146	10100
$2S_nT_dT_dT_d$	20095	20095	20087	20102	20106	20087
4PPPP	40118	40119	40130	40118	40111	40108
5appp	51001	52004	51000	57010	54001	54000
$7wwW_1W_2$	70222	70211	70211	75352	70322	70222
$8NhC_LC_MC_H$	8672/	86548	85942	886//	8787/	87581
$222D_sv_s$	22200	22200	22271	22272	22272	22272
$0SnT_wT_wT_w$	92	92	92	91	91	90
$2P_wP_wH_wH_w$	20502	20402	20402	2////	2////	2////
$3d_{w1}d_{w1}d_{w2}d_{w2}$	325//	324//	324//	323//	323//	323//
$4P_{w1}P_{w1}H_{w1}H_{w1}$	40803	40803	40603	40802	40802	40802
$5P_{w2}P_{w2}H_{w2}H_{w2}$						

Station and Cast list

Station	Cast	Date	G.M.T.	Latitude	Longitude
13	2	1990-04-25	7:50	041 08.9N	019 59.3W
15	1	1990-04-25	20:38	040 33.2N	020 08.1W
15	4	1990-04-25	22:26	040 34.3N	020 10.0W
20	1	1990-04-27	16:15	033 00.9N	019 59.7W
20	3	1990-04-27	20:34	032 59.3N	020 00.9W
20	9	1990-04-28	4:58	033 01.1N	019 59.6W
20	11	1990-04-28	10:00	033 00.2N	019 59.3W
20	14	1990-04-28	13:13	032 59.8N	020 00.3W
20	17	1990-04-29	5:18	033 04.3N	020 06.4W
20	19	1990-04-29	8:28	032 58.9N	019 59.9W
20	22	1990-04-29	10:39	032 57.3N	020 01.9W
20	29	1990-04-29	15:42	032 59.7N	019 57.7W
20	31	1990-04-29	20:58	032 59.7N	020 00.3W
20	33	1990-04-30	10:11	033 00.7N	019 59.9W
30	3	1990-05-07	5:00	032 59.0N	020 00.0W
30	5	1990-05-07	8:52	032 59.1N	019 59.4W
30	12	1990-05-07	15:51	032 55.7N	020 01.0W
37	1	1990-05-09	5:36	034 59.9N	019 59.0W
37	2	1990-05-09	8:34	035 00.2N	019 59.8W
39	1	1990-05-10	5:39	036 59.9N	019 59.7W
39	2	1990-05-10	8:34	036 59.9N	020 00.0W
41	2	1990-05-11	8:45	038 59.9N	020 00.2W
43	1	1990-05-12	5:43	041 00.2N	019 59.9W
43	2	1990-05-12	8:44	040 59.7N	020 00.0W
45	1	1990-05-13	5:10	043 00.0N	020 00.0W
47	1	1990-05-14	5:38	045 00.0N	020 00.0W
47	2	1990-05-14	8:38	044 59.3N	020 00.3W
48	1	1990-05-14	20:37	046 00.0N	019 59.4W
49	1	1990-05-16	9:33	049 02.3N	017 03.3W

Station	Cast	Date	G.M.T.	Latitude	Longitude
49	4	1990-05-16	16:20	049 00.2N	017 02.1W
51	8	1990-05-18	15:17	047 03.4N	019 54.0W
51	9	1990-05-18	16:25	047 03.9N	019 56.2W
51	10	1990-05-18	19:22	047 00.2N	020 00.6W
51	16	1990-05-19	4:33	047 00.1N	019 59.8W
51	18	1990-05-19	9:05	047 00.2N	019 59.9W
51	20	1990-05-19	14:03	047 00.2N	019 59.9W
51	26	1990-05-20	3:59	047 10.9N	019 57.8W
51	28	1990-05-20	6:22	047 10.9N	019 58.2W
51	36	1990-05-20	15:10	047 13.2N	019 54.4W
53	1	1990-05-20	23:30	047 20.0N	019 59.4W
55	1	1990-05-21	3:47	047 39.9N	020 00.0W
57	1	1990-05-21	7:44	048 00.0N	020 00.0W
64	1	1990-05-22	4:29	050 20.7N	019 59.8W
64	2	1990-05-22	8:47	050 20.7N	020 00.2W
66	1	1990-05-23	4:08	052 31.7N	020 00.0W
66	2	1990-05-23	8:49	052 32.0N	020 00.0W
68	1	1990-05-24	4:08	054 51.5N	020 01.4W
69	8	1990-05-24	13:07	055 37.1N	019 58.2W
71	1	1990-05-25	4:08	057 29.8N	020 00.4W
72	1	1990-05-25	8:32	057 52.7N	020 00.3W
81	1	1990-05-27	2:14	059 59.8N	020 00.6W
81	9	1990-05-27	7:34	060 02.1N	019 51.9W
81	11	1990-05-27	9:03	060 03.3N	019 49.0W
81	19	1990-05-27	15:32	060 05.6N	019 42.0W
81	20	1990-05-28	9:23	060 10.7N	019 33.6W
81	23	1990-05-28	14:51	060 11.5N	019 27.9W
81	31	1990-05-29	2:07	060 17.2N	019 17.3W
81	33	1990-05-29	6:50	060 18.7N	019 19.5W
81	41	1990-05-29	13:57	060 22.8N	019 12.5W

Bacterial biomass and production

Station: 30 **Cast:** 3
Date: 90-05-07 GMT: 05:00
Pos: 032 59.0N 020 00.0W

Bot Nr.	**Depth m**	**Bac. $10e^7$/l**	**Thym. pmol/l/h**
24	8	71.5	0.61
21	21	53.6	0.51
18	36	81.7	1.13
15	50	43.6	1.02
12	65	26.5	0.63
9	75	23.2	0.37
6	98	10.7	0.12
3	151	8.3	0.42
2	177	7.9	0.48
1	202	5.7	0.37

Station: 30 **Cast:** 12
Date: 90-05-07 GMT: 15:51
Pos: 032 55.7N 020 01.0W

Bot Nr.	**Depth m**	**Bac. $10e^7$/l**	**Thym. pmol/l/h**
24	844	5.3	0.07
23	1263	5.1	0.16
18	2024	4.6	0.13
9	3040	6.9	0.21
6	4068	3.8	0.11

Station: 51 **Cast:** 10
Date: 90-05-18 GMT: 19:22
Pos: 047 00.2N 019 59.9W

Bot Nr.	**Depth m**	**Bac. $10e^7$/l**	**Thym. pmol/l/h**
10	251	6.4	0.43
9	505	1.5	0.29
8	756	1.4	1.12
5	1010	1.6	0.46
3	1266		0.40
1	1519		-0.02

Station: 51 **Cast:** 16

Date: 90-05-19 GMT: 04:33

Pos: 047 00.1N 019 59.8W

Bot Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
24	3	30.2	5.04
21	8	86.3	2.46
18	15	48.3	5.98
15	23	28.0	4.54
12	30	38.8	4.69
9	36	25.7	3.26
6	48	26.9	2.89
3	76	11.2	0.47
1	153	11.6	1.77

Station: 51 **Cast:** 20

Date: 90-05-19 GMT: 14:03

Pos: 047 00.2N 019 59.9W

Bot Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
11	2536	2.1	0.02
7	3558	2.6	0.13
5	4073		0.08
1	4603		-0.07

Station: 51 **Cast:** 26

Date: 90-05-20 GMT: 03:59

Pos: 047 10.9N 019 57.8W

Bot Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
24	2	66.2	8.72
21	6	46.3	7.48
18	11	34.3	5.54
15	18	31.6	4.76
12	24	29.2	2.16
9	28	33.2	2.35
6	39	12.9	
3	50	24.5	
1	126	30.0	

Station: 51 **Cast:** 36

Date: 90-05-20 GMT: 15:10

Pos: 047 13.2N 019 54.4W

Bot Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
12	203	6.4	
10	509	4.1	
8	759	2.2	
6	1013	2.3	0.46
2	1523	12.0	0.21

Station: 81 **Cast:** 1

Date: 90-05-27 GMT: 02:14

Pos: 059 59.8N 020 00.6W

Bot Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
21	6	43.8	12.19
18	11	38.4	10.57
12	23	20.9	12.80
9	28	27.9	4.94
6	36	18.0	4.17
5	49	7.9	1.87
3	102	3.6	0.27
2	151	4.5	0.13
1	206	6.4	0.17

Station: 81 **Cast:** 11

Date: 90-05-27 GMT: 09:03

Pos: 060 03.3N 019 49.0W

Bot Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
7	511	6.9	0.11
5	765	1.6	-0.25
3	1013	1.7	
2	1267	0.8	
1	1523	0.8	0.16

Station: 81 **Cast:** 23

Date: 90-05-28 GMT: 14:51

Pos: 060 11.5N 019 27.9W

Bot Nr.	Depth m	Bac. $10e^7$/l	Thym. pmol/l/h
8	2032		-0.09
6	2460	2.4	
4	2562	2.5	0.13
2	2659	3.6	0.24

Station: 81 **Cast:** 31

Date: 90-05-29 GMT: 02:07

Pos: 060 17.2N 019 17.3W

Bot Nr.	**Depth m**	**Bac. $10e^7$/l**	**Thym. pmol/l/h**
24	4	26.9	12.27
21	10	41.6	6.34
18	20	24.9	11.67
15	30	42.1	11.94
12	40	22.0	7.25
10	62	25.3	1.80
8	92	15.0	0.91
6	126	14.3	1.01
4	152	6.4	-0.01
1	205	3.7	0.48

Station: 81 **Cast:** 41

Date: 90-05-29 GMT: 13:57

Pos: 060 22.8N 019 12.5W

Bot Nr.	**Depth m**	**Bac. $10e^7$/l**	**Thym. pmol/l/h**
10	509	2.5	0.34
8	762	2.3	0.17
6	1015	2.1	0.30
4	1269	1.8	0.33
2	1523		0.25

Zooplankton

DATE	POSITION	TIME	0-25 200 μ	0-25 1000 μ	25-50 200 μ	25-50 1000 μ	50-100 200 μ
27-Apr-90	33.00	22.56	16.0	5.8	7.1	2.2	3.9
29-Apr-90	33.00	11.15	6.9	3.3	6.9	2.8	4.6
7-May-90	33.00	12.30	5.1	5.0	3.8	4.4	2.2
7-May-90	33.00	0.00	6.4	9.9	4.2	7.9	3.9
9-May-90	35.00	10.00	1.6	1.3	1.4	1.4	1.4
10-May-90	37.00	11.15	4.9	3.5	0.7	0.3	1.6
11-May-90	39.00	14.30	0.7	0.3	0.6	0.6	1.6
12-May-90	41.00	10.00	0.9	3.4	0.6	0.4	1.1
14-May-90	45.00	10.00	8.8	3.6	0.2	0.6	1.5
16-May-90	Darwin Intercal	17.50	7.7	0.8	15.4	1.3	2.1
18-May-90	47.00	10.54	9.8	6.2	4.0	2.0	0.9
19-May-90	47.00	0.00	19.0	16.7	4.9	4.3	0.6
19-May-90	47.00	22.56	17.4	29.4	2.0	2.9	1.1
20-May-90	47.00	11.00	15.1	13.1	0.5	1.0	1.4
22-May-90	50.19	10.00	15.4	6.9	3.2	4.8	1.3
23-May-90	52.29	10.00	2.1	3.4	1.8	3.0	0.8
24-May-90	55.38	10.00	8.6	2.9	9.9	3.2	1.0
25-May-90	57.53	10.01	25.9	3.2	3.0	1.1	1.0
27-May-90	60.00	11.10	9.3	2.9	0.7	0.2	0.3
27-May-90	60.00	23.00	11.2	2.7	0.5	0.6	0.3
28-May-90	60.00	22.00	12.2	2.2	15.8	2.6	2.5
29-May-90	60.00	12.00	11.8	2.2	20.4	1.1	0.9

DATE	POSITION	TIME	50-100 1000 μ	100-200 200 μ	100-200 1000 μ	200-500 200 μ	200-500 1000 μ
27-Apr-90	33.00	22.56	2.7	1.9	0.7	0.4	0.2
29-Apr-90	33.00	11.15	3.1	1.4	1.4	0.6	0.7
7-May-90	33.00	12.30	3.6	0.6	0.7	0.4	1.0
7-May-90	33.00	0.00	7.3	0.6	1.7	0.4	1.0
9-May-90	35.00	10.00	0.9	0.8	0.7	0.2	0.5
10-May-90	37.00	11.15	0.8	0.1	0.1	0.2	0.6
11-May-90	39.00	14.30	0.6	0.1	0.1	0.2	0.2
12-May-90	41.00	10.00	0.9	0.6	1.4	0.2	2.2
14-May-90	45.00	10.00	0.4	0.6	0.2	0.4	1.1
16-May-90	Darwin Intercal	17.50	0.6	1.9	0.5	no sampling	no sampling
18-May-90	47.00	10.54	1.0	0.6	0.5	0.7	1.2
19-May-90	47.00	0.00	1.4	0.4	0.4	0.4	0.6
19-May-90	47.00	22.56	2.0	0.3	0.4	0.5	0.6
20-May-90	47.00	11.00	2.0	1.0	1.0	1.4	3.6
22-May-90	50.19	10.00	0.7	0.6	0.9	0.6	1.8
23-May-90	52.29	10.00	0.2	0.6	0.2	1.0	1.5
24-May-90	55.38	10.00	0.8	0.1	0.1	0.3	0.4
25-May-90	57.53	10.01	0.9	0.2	0.2	0.3	1.1
27-May-90	60.00	11.10	0.4	0.2	0.4	0.2	0.5
27-May-90	60.00	23.00	0.8	0.2	0.4	0.1	0.3
28-May-90	60.00	22.00	1.8	0.2	0.4	0.1	0.2
29-May-90	60.00	12.00	1.1	0.6	0.5	0.1	0.3

Surface water trace metals

St	Lat. N	Lon W	Sal.	Fe [nM]	Pb [pM]	Ni [nM]	Cu [nM]	Cd [pM]	PO4 [µM]	SiO4 [µM]	NO3 [µM]
1	52.18.1	3.13.0	35.263	117	1696	4.24	7.13	175	0.12	0.37	0.19
2	50.34.7	0.16.5		292	840	4.46	5.51	155	0.67	3.65	8.31
3	50.12.0	1.36.0	35.285	264	863	5.19	4.29	145	0.46	1.98	5.96
4	47.22.4	15.29.8	35.604	97	487	3.13	2.55	129	0.54	4.09	8.41
5	46.58.0	17.33.0	35.635	133	438	3.29	2.73	157	0.48	3.31	6.46
6	46.05.2	21.43.2	35.648	116	421	4.4	2.75	119	0.48	3.31	7.44
7	45.01.0	23.46.0	35.784	81	1203	4.58	2.64	84	0.34	3.38	5.61
8	44.59.9	25.05.8	35.885	33	779	2.93	1.63	40	0.35	2	3.82
9	44.21.5	24.13.5	35.85	29	586	2.6	1.39	88	0.3	2.03	3.99
10	42.01.9	21.13.5	35.841	24	340	2.12	1.48	30	0.19	1.09	4.8
11	41.00.3	19.59.9	35.994	28	338	2.32	1.26	23	0.11	1.49	2.51
12	41.11.0	19.58.9	35.947	23	311	3.27	1.03	12	0.01	1.6	3.43
13	40.31.8	20.08.4	35.993	70	691	5.53	1.71	29	0.08	1.55	3.02
16	38.23.3	20.07.4	36.065	33	1101	2.63	1.36	10	0.2	1.36	2.32
17	36.51.6	20.07.8	36.317	25	598	2.04	0.97	12	0.08	0.84	
20.03	32.00.0	20.03.7	36.466			2.19	1.46	12	0.06	1.05	
20.12	32.59.6	19.58.6	36.442	11	633	2.15	1.05	17	0.05	0.92	0.36
20.16	33.01.0	20.02.3	36.445			2.65	1.97	22	0.09	0.93	0.39
20.21	32.58.7	19.59.8	36.435	8		2.62	2.02	36	0.09	1.02	0.29
20.3	33.00.0	19.08.0	36.438	6	1227	3.16	0.84	16		0.75	0.19
20.35	33.01.0	20.00.0	36.463	4	303	4.94	0.89	8	0.07	0.78	0.16

Unfiltered Dissolved Organic Carbon [µM/kg]

Station : 20 Cast: 3 Date: 27-04-90 GMT: 20:34 Pos: 032°59.3N 20°00.9W

Bottle No.	Depth [m]	DOC 900°C
3	750	125
1	1003	116

Station : 30 Cast: 5 Date: 07-05-90 GMT: 08:52 Pos: 032°59.1N 19°59.4W

Bottle No.	Depth [m]	DOC 900°C
9	203	125

Station : 30 Cast:12 Date: 07-05-90 GMT: 15:51 Pos: 032°55.7N 20°01.0W

Bottle No.	Depth [m]	DOC 900°C
1	4347	158

Station : 49 Cast: 1 Date: 16-05-90 GMT: 09:33 Pos: 049°02.3N 17°03.3W

Bottle No.	Depth [m]	DOC 900°C
20	601	116
16	800	104
14	1001	91
8	1999	91
4	2998	100

Station : 49 Cast: 4 Date: 16-05-90 GMT: 16:20 Pos: 049°00.2N 17°02.1W

Bottle No.	Depth [m]	DOC 900°C
14	51	129
8	93	133
2	304	125

900°C High temperature combustion at 900 °C (IONICS 555)