OMEX I DATABASE
DATA DOCUMENTATION INDEX

Introduction

The database data documentation is structured as a series of documents. Generally, these documents cover the data from one or more database data tables. Occasionally, a table is covered by more than one document where it contains data that map to similar data structures but are generically different.

ADCP Data (Table ADCP)

Vertical current velocity profiles measured by underway acoustic doppler current profiler, including signal return amplitude that provides an indication of zooplankton biomass.

Drifting Buoy Data (Table ARGOS)

Tracks of drogued buoys released from OMEX cruises.

CTD Profiles (Table BINCTD)

Vertical profiles of temperature and salinity. Some of the profiles also include dissolved oxygen, chlorophyll, optical attenuance and light channels.

Nephelometer Profiles (Table NEPH)

Vertical profiles recorded by nephelometers fitted to CTD packages. Due to system limitations (currently being addressed) these are handled separately from the other CTD parameters.

Marine Snow Camera Profiles (Table MSP)

Profiles of particle size distribution and concentration collected by analysis of photographs taken by a CTD-mounted camera.

XBT Data (Table XBT)

Vertical temperature profiles.

SeaSoar Data (Table BINCTD)

Data from a towed undulating fish containing a CTD and a fluorometer. The data are presented in the database as a series of vertical profiles.

Light Profiles (Table PRPROF)

Vertical light profiles.

Water Bottle and Air Sample Data (Table BOTDATA)

A wide range of physical, chemical and biological parameters measured on discrete water and air samples collected using bottles, pumps (shipboard and in-situ) and landers.

Trace Metal Uptake Kinetic Data (Table MTALDAT)

Results from radiotracer trace metal uptake kinetic experiments.

Integrated Size-fractionated Chlorophyll Data (Table INTBOT)

Column integrated size-fractionated chlorophyll data computed from discrete measurements held in table BOTDATA.

Production Data (Tables C14DAT, N15DAT, P33DAT and P33DARK)

Data from long (usually 24 hour) in-situ and on-deck production experiments plus data from non-parameterised P:I experiments.

Bulk Core Measurements (Table CORETOT)

Parameters measured on bulk core samples or grab samples.

Sediment Profiles (Table COREPROF)

Profiles of a wide range of chemical and sedimentological parameters along cores.

Benthic Fauna Data (Tables MEIODAT, MFDAT, FORAMS and MEGADAT)

Benthic meiofauna, macrofauna and megafauna species distribution data.

Continuous Plankton Recorder Data (Tables CPR_COLOUR, CPR_PHYTO and CPR_ZOO)

Phytoplankton and zooplankton species distribution data from CPR tows through the OMEX area of interest from 1993-1995.

Longhurst-Hardy Plankton Recorder Data (Table LHPR)

Zooplankton biomass data recorded from LHPR tows.

Rectangular Mid-water Trawl Data (Table RMT)

Zooplankton and nekton biomass data from RMT tows.

Sediment Trap Data (Table TRAPDATA)

Parameters measured on the samples collected by the OMEX sediment traps.

Underway ADCP Data

Introduction

Underway acoustic doppler current profilers were operated on a significant number of OMEX cruises. However, these data are of little use in water depths beyond the range of bottom tracking (>3-400 m) unless great care has been taken in the determination of the ship's velocity used to convert relative current velocities into absolute current velocities.

BODC is currently developing an ADCP processing and quality control system but this was not in place in time for handling the data from OMEX I. Fully worked up data were made available for two of the OMEX cruises, Charles Darwin CD85 and Discovery DI217, and these have been included on the CD-ROM. The data were collected using identical hardware, software and protocols by the same team at Southampton Oceanography Centre and are therefore documented together.

Instrumentation

Charles Darwin and Discovery are both fitted with an RDI 150 kHz ADCP mounted on the hull approximately 4 m below the water line. The system was set up to average over a 15-minute period with 8 m bins on CD85 and 4 m bins on DI217.

Data Acquisition

The data were logged by a PC running the RDI DAS software. At the end of each data acquisition period, the data were transferred to the Research Vessel Services Level C (a Sun workstation) via a printer buffer. Time stamps on these data were applied by the PC. GPS navigation was logged by the RVS ABC system, time stamped by the Level A which is automatically synchronised with the ship's scientific clock. Great care was taken to ensure that the PC clock was synchronised with the scientific clock throughout the cruise.

Both cruises included periods when the ship's course was designed to facilitate ADCP calibration.

SOC Data Processing

The data were transferred from the Level C to a second Sun workstation running the P-EXEC data processing software suite. A bin depth channel was computed, taking the depth of the ADCP below the water line into account, such that the quoted depths represented the mid-point of each bin.

The current velocities relative to the ship were converted into absolute current velocities using the procedures described in Pollard and Read (1989). The misalignment angle (the offset between the ADCP and the ship's gyro compass) and scaling factors were determined by minimising the effect of the calibration manoeuvres on the absolute current velocities. The following values were obtained:

CD85	Misalignment angle:	0.3 degrees
	Scaling factor:	0.993
DI217	Misalignment angle:	6.6322 degrees
	Scaling factor:	1.0137

The data were quality controlled with suspect absolute current velocities being set null. Profiles when the ship was manoeuvring were removed from the data set as the ship's velocity could not be determined reliably over a 15 minute period.

BODC Processing and Quality Control

The data were supplied in the P-EXEC P* format. This was converted into the BODC internal format (PXF) with the data split into individual profiles.

A screening program was run that automatically flagged suspect any absolute currents for which the percentage of good returns was <85 per cent or the error velocity exceeded 0.09 ms^{-1}. A second program cross checked the profile header information (date/time, position and water depth) against the underway data from the cruise. Times and positions refer to the mid-point of the sampling interval.

The profiles were then visually inspected using an interactive graphical editor and any further data considered suspect (mostly signal amplitude data from bins below the sea floor) were flagged.

A custom loader program was used to insert the data into Oracle. Any datacycles with a bin depth in excess of the water depth and no good data in the amplitude or absolute current velocity channels were deleted from the data set. All remaining datacycles with bin depths in excess of the water depth were manually inspected and if the data were considered to be

artefacts (i.e. if the water depth was deemed correct) then the records were deleted.

Three profiles from DI217 collected when the ship was in very shallow water during a visit to Falmouth harbour were deleted from the data set.

Reference

Pollard, R.T. and Read, J.F. (1989). A Method for Calibrating Ship-mounted Acoustic Doppler Profilers and the Limitations of Gyro Compasses. ***Journal of Atmospheric and Oceanic Technology***, 6, 859-865.

Drifting Buoy Data

Introduction

The OMEX I drifting buoy data set includes the space/time co-ordinates of buoys deployed specifically to make Lagrangian current measurements and of drifting sediment traps. The drogued buoys were deployed on cruises Charles Darwin CD83 and Charles Darwin CD97. The sediment traps were deployed during several of the Jan Mayen cruises off Norway.

Drogued Buoys

The tracks of four drogued buoys are presented on the CD-ROM. Three of these were released off the Iberian Margin in January 1994. Two of the buoys (5030 and 5031) were the TOGA style ocean drifter supplied by Metocean Data Systems of Canada. These buoys are much larger than other drifter types, giving an improved buoyancy reserve which was further enhanced by fitting Balmoral elastomer floatation collars. The drogues were set at 1000 m (5030) and 750 m (5031). Buoy 5030 was recovered on cruise CD97. The third (3916) was a buoy of unknown type with its drogue set at 200m.

The fourth (3350), of unknown type, was deployed in November 1995 in the vicinity of the Goban Spur with the drogue set at 40 m.

In all cases, the drogues used were manufactured at Plymouth Marine Laboratory from polyethylene netting. All Talurit splices used in the PVC-covered stainless steel strops were made of copper to reduce corrosion. Much attention was paid to all joints to ensure that there was no undue freedom of movement which might cause excessive component wear. All shackles were given extra security by the insertion of locking pins with their ends hammered over.

Deployments were done with the ship steaming slowly. The buoy was released first, followed by the tether and, once all slack had been taken up, the drogue was carefully paid out. A retaining line was used to ensure that there was no fouling of the drogue on either its own components or the ship. The ship stood by to observe the drogue sink and acquire its initial transmissions.

The buoys were tracked by the Argos satellite system for between eight and twenty months after deployment.

Drifting Sediment Traps

The drifting sediment trap rigs had traps every 10 m between 20 m and 100 m and every 20 m between 100 m and 200 m. The traps were cylindrical in shape and held horizontally by a mounting frame.

The rigs were released from the ship for a period of approximately 24 hours. During this time, the rig was followed by the ship which provided the information on position stored in the database.

Nephelometer Profiles

Introduction

On a number of OMEX cruises, the CTD package included some form of nephelometer. Due to a design limitation in the BODC data processing system, the nephelometer data could not be included with the other CTD channels. Consequently, the data have been handled as discrete profiles. Note that these have been binned using identical procedures to the other CTD channels. This gives both data sets a common independent variable that should make merging the nephelometer data with the CTD data straightforward.

Instrumentation

Two basic types of instrument have been used as nephelometers on the OMEX cruises. The first was the Chelsea Instruments Aquatracka fluorometer that can be configured for use as a nephelometer by replacing the coloured filters in the strobe light and receiver by colourless windows. The data logged by these instruments is actually a voltage, but may be regarded as a measure of the particle concentration in arbitrary units. This type of instrument was used on Charles Darwin cruises CD83 and CD84 and on Discovery cruise DI217. Note that the instrument used on DI217 was supplied and set up by a different group to the instruments used on the Charles Darwin cruises.

The second type of instrument used was an optical backscatter sensor (OBS), often of SeaBird manufacture. The data from these instruments is a particle concentration in standard turbidity units (ftu). Due to the difference in properties between marine particles and the glass beads used in the calibration, these should again be regarded as arbitrary units. OBS sensors were fitted on the CTD for Belgica cruises BG9521 and BG9522, Charles Darwin cruise CD86, Cote d'Aquitaine cruises NAOX1 and NAOX2, and the Auriga/Andromeda cruises PLUTUR1-6.

Data Warning

The nephelometer profiles are in arbitrary units and have been collected by different techniques from one cruise to another. Great care should therefore be taken when comparing profiles from different cruises.

The cruises may be subdivided into a number of groups:

Group 1	CD83, CD84
Group 2	BG9521, BG9521
Group 3	NAOX1, NAOX2
Group 3	PLUTUR1 through PLUTUR6
Group 4	CD86
Group 7	DI217

Comparison of the data between cruises in a single group is less risky than comparison of data from cruises in different groups.

XBT Data

Introduction

XBT profiles were taken on two of the OMEX cruises, Charles Darwin 83 and 97. Data were transferred to BODC as RVS internal format files and reformatted into PXF, the BODC internal format. The data were examined on a graphics workstation where they were manually topped and tailed and any spikes flagged. The data were then loaded into the Oracle RDBMS and linked to their header information using a custom load program.

The data originator was Dr. Robin Pingree of the Plymouth Marine Laboratory.

Specific comments from the cruise reports concerning the XBT data are given below.

Charles Darwin Cruise CD83

The XBTs deployed were mainly deep water T5s with a design depth of 2000m but some of the shallower T7s were also used. The system used was a Sippican SA810 launcher and Bathy Systems 'SEAS' software. Data were transferred by floppy disk onto the RVS Level C computer where launch times were corrected for delay between entering the header information and actual launch and major transients in the data were flagged using a graphics editor.

At BODC, the data were converted from RVS format into the BODC internal format, and screened using an interactive graphical editor. Additional data spikes not flagged by RVS plus the data affected by the surface displacement problem described below were flagged as suspect. The data were then loaded into the Oracle relational database.

Large, unreal displacement to low temperatures on entering the water which then slowly decayed were encountered on all casts. These have been flagged suspect.

Charles Darwin Cruise CD97

T7 shallow XBTs where used for the Goban Spur section. The deployment system was a Sippican SA810 launcher with Bathy Systems 'SEAS' software. Data were transferred by floppy disk onto the RVS Level C computer where launch times were corrected for delay between entering the header

information and actual launch and major transients in the data were flagged using a graphics editor.

At BODC, the data were converted from RVS format into the BODC internal format, and screened using an interactive graphical editor. Additional data spikes not flagged by RVS plus the data affected by the surface displacement problem described below were flagged as suspect. The data were then loaded into the Oracle relational database.

Surface data exhibited an unreal displacement to low temperatures on entering the water that reduced exponentially. The cause of this was reported to be a fault in the data acquisition hardware. Consequently, much of the near surface data have been flagged out either by RVS or BODC.

The XBT accuracy was assessed against CTD measurements and empirical corrections were determined and applied to the XBT temperatures and depths. The temperature corrections ranged from 0.65 °C near the surface to 0.18 °C at depth. Depth corrections, determined by matching isotherm levels, ranged from 9m near the surface to 56m at maximum depth.

SeaSoar Data

Introduction

The SeaSoar is a hydrodynamic fish towed behind the ship travelling at 8-9 knots linked by a faired cable. The unit has two stub wings whose angle of attack may be set by hydraulic servo motors. Thus the fish is able to climb or dive under the control of command signals from the ship or, more usually, by automatic command signals driven by the on-board pressure sensor. The wavelength and amplitude of the locus of the fish through the water depend upon the cable length, the ship's speed and the angle of attack selected for the wings.

The fish can carry a range of sensors. Invariably, a CTD is fitted but fluorometers, transmissometers, light sensors and plankton counters may also be included.

The SeaSoar data were worked up to produce a cleaned (i.e. de-spiked) and calibrated 1 Hz data file. From this, a gridded file of either 6 or 8 db vertical resolution and between 3 and 4 km horizontal resolution (chosen to match the wavelength of the fish oscillations) was generated. It should be noted that calibrated SeaSoar salinity data are less accurate than calibrated deep CTD data with a figure of 0.02 PSU being generally accepted as the target accuracy for the instrument.

At BODC, this grid file was split into individual columns. Each column was converted into BODC internal format (PXF) and inspected using a graphical editor. Any spikes or gridding artefacts observed were flagged suspect. Once screening was completed, the grid columns were loaded into Oracle as if they were a series of discrete CTD casts. Header information, such as water depth and position, were automatically obtained from the underway data in the database.

Two quite different instruments were deployed on the OMEX cruises Charles Darwin CD85 and Discovery DI217. The cruise-specific details are given below.

Charles Darwin Cruise CD85

The SeaSoar vehicle used was supplied by the Defence Research Agency (DRA) and was fitted with a Chelsea Instruments Aqualink CTD and a Chelsea Instruments Aquatracka fluorometer. A cable length of 500m was used at a towing speed of 8 knots giving a penetration depth of just over 300 m. In shallow water the cable length was reduced to 200 m giving an oscillation down to 140 m. No operational problems were reported other than

a flooded cable connection that required recovery of the instrument for a re-termination and a failure of the hydraulic unit which was duly replaced.

Data were logged in parallel by the DRA Chelsea Instruments HP data logger and the Research Vessel Services ABC system. Water samples were drawn from the ship's non-toxic supply such that the water taken was traversed by the SeaSoar as it approached the surface. Salinity was determined on a Guildline Autosal and extracted chlorophyll was determined by a spectrophotometric technique (by Plymouth Marine Laboratory) for calibration purposes.

The data were worked up by the originators using the P-EXEC data processing system. All channels were inspected for spikes and salinity offsets produced by biological fouling of the conductivity cell were eliminated. Salinity was calibrated against surface bottle data and checked by intercalibration with calibrated thermosalinograph data. The fluorometer was calibrated against the extracted chlorophyll data. Temperature and pressure calibrations were not modified from those determined pre-cruise.

The worked up data were supplied to BODC as 1Hz data (archived but not included on the CD-ROM) and in gridded form which were loaded into the BODC database and subsequently dumped onto the CD-ROM.

Discovery Cruise DI217

A Southampton Oceanography Centre vehicle was used fitted with a Neil Brown Mk3B CTD and a Chelsea Instruments Aquatracka fluorometer. Depths of up to 240 m were achieved with up to 420 m of cable deployed.

The SeaSoar work on this cruise was plagued with problems. The intended CTD, which included an 8-channel ADC board to allow a UV nitrate sensor to be carried, was inoperative throughout the cruise. A back up unit was available but this could not operate the nitrate sensor. A sediment trap fell onto the fish before it had been deployed and snapped off the top plastic wing and a replacement had to be fashioned out of marine plywood.

During the first deployment, conductivity was found not to be functioning and on recovery the bottom wing was seen to have been snapped off. The conductivity problem (a loose wire) was apparently repaired and a second wooden wing was made and fitted.

On the second deployment, the fish would not fly properly and conductivity was still inoperative. Upon recovery, the rudder stabilising bar was found to be missing. A replacement was built from current meter fins and the conductivity problem was fixed by changing the circuit board.

After this, the SeaSoar operated for some 16 hours without problem until lack of control and belly up flying were experienced once again.

It should be noted that the problems described served to restrict the quantity of data available, rather than affect the quality of the data on the CD-ROM which were obtained during the period whilst the instrument was functioning correctly.

Data were logged by the Research Vessel Services ABC system. Water samples were drawn from the ship's non-toxic supply such that the water taken was traversed by the SeaSoar as it approached the surface. Salinity was determined on a Guildline Autosal and extracted chlorophyll was determined by a fluorometric technique (by Plymouth Marine Laboratory) for calibration purposes.

The data were worked up by the originators using the P-EXEC data processing system. All channels were inspected for spikes and salinity offsets produced by biological fouling of the conductivity cell were eliminated. Salinity was calibrated against surface bottle data and checked by intercalibration with calibrated thermosalinograph data. The fluorometer was calibrated against the extracted chlorophyll data. Temperature and pressure calibrations were not modified from those determined pre-cruise.

The worked up data were supplied to BODC as 1Hz data (archived but not included on the CD-ROM) and in gridded form which were loaded into the BODC database and subsequently dumped onto the CD-ROM.

Light Profiles

Introduction

The light profiles presented in the database were collected during Belgica cruises. Note that a small number of additional light profiles are included in the CTD data set when light meters were included as part of the CTD package on the UK ships.

Sampling Protocols

Data are present for four cruises. On the first two cruises (BG9412 and BG9506) a quantometer measuring radiance in the bandwidth 350 to 700 nm, calibrated in W/m^2 was used. The instrument sampled at 1 Hz.

On the second two cruises (BG9521 and BG9521) the light profiles were measured using a LiCor irradiance quantum sensor attached to an SBE19 CTD package. This has a bandwidth of 400 to 700 nm and was calibrated in units of $\mu E/m^2/s$. The instrument sampled at 0.5 Hz. Temperature and salinity were also measured by the CTD package but these were deemed inferior to the SBE9 plus profiles obtained on the same stations and were discarded.

An empirical correction factor of 1/4.6, valid for daylight, was supplied by MUMM, Ostend. This was used to convert these data from $\mu E/m^2/s$ to W/m^2 to give consistent units in the database. Note that this conversion may be used to convert the BG9521 and BG9522 data back into $\mu E/m^2/s$. However, it should not be used for the data from BG9412 and BG9506 which were collected using a sensor with different spectral response characteristics.

The light profiling instruments included integral data loggers and were lowered from the hydrographic winch over a small A frame on the starboard side of the ship. Care was taken to ensure that the ship was aligned with the sun to starboard whilst the light profiles were taken. The quantometer data were collected on the upcast to ensure that the sensor was always vertical. The SBE19 data were collected on the downcast but lead weights attached to the base of the CTD cage kept the instrument vertical.

Trace Metal Uptake Kinetic Experiments

Experimental Protocol

Water samples were taken using trace metal clean GoFlo bottles. The water samples were immediately spiked with ^{54}Mn, ^{60}Co, ^{65}Zn and ^{109}Cd. Some samples were poisoned with sodium azide or totally sterilised. A set of inoculated samples were then placed into an incubator with the required lighting conditions. Incubation temperature was controlled by continuously flushing with surface sea water.

At regular intervals during the experiment, one of the samples was removed for analysis to produce a time series of uptake rate determinations. The analytical procedure was as follows.

After vacuum filtration on 0.45 micron membrane filters, the radioactivity of the filters and acidified filtrates was measured with an HPGe Camberra detector, with a relative efficiency of 20%, and a series 20, model 282 multichannel spectrometer. The minimum number of counts was fixed at 1000 to reduce the standard deviation to 3%.

To ensure that perturbation of the natural conditions was kept to a minimum, concentrations of the radionuclides and their carriers were maintained at a minimum level. The activity of the spike was usually approximately 100 nCi/l for each individual radionuclide. However, to obtain this level, the concentration of the corresponding dissolved metal was raised by 5-10 nM due to the presence of the carrier. In the area investigated, the ambient concentration of the trace metals considered was of the order of 0.02 nM for Co, 0.08 nM for Cd, 0.7 nM for Mn and 5 nM for Zn in the upper 100m of the water column. The increase in trace metal concentrations due to the addition of the tracers were therefore significant.

Integrated Chlorophyll Data

Introduction

Column integrated size-fractionated chlorophyll data (units mg/m^2) were supplied for a small number of stations and have been stored in table INTBOT. Depth of integration is included in the table and was chosen on the basis of light meter (if available) or transmissometer data.

The chlorophyll profile data used to generate the integrated data are presented in table BOTDATA. A description of the measurement protocols used for these is included in the 'Pigments' section of the Water Bottle and Air Sample data document.

Production Data

Introduction

The production data tables hold the results of uptake experiments that cannot sensibly be mapped into the water bottle data table (BOTDATA) because the amount of supporting information required exceeds what can be included in an 8-byte parameter code. The data in these tables come from two sources. First are the 24-hour ^{14}C, ^{15}N and ^{33}P experiments carried out by PML (Principal Investigator: Dr. Ian Joint) in screened on deck incubators or in-situ incubation rigs. Secondly, there are normalised ^{14}C and ^{32}P uptakes determined over a light gradient in an artificial light incubator by ULB, Brussels (Principal Investigator: Dr. Lei Chou). The detailed protocols of these investigators are given below.

Dr. Ian Joint

Data were collected on cruises Valdivia VLD137, Charles Darwin CD85 and Discovery DI217.

Water samples were collected using either 30-litre GoFlo bottles deployed on a kevlar hydrographic wire or, if sufficient water was available, from GoFlo bottles deployed on the CTD rosette. The samples were always taken pre-dawn and water was collected from between 6 and 9 depths.

For the ^{14}C uptake experiments, the water was transferred to 60ml acid-washed polycarbonate bottles prepared to JGOFS standards to eliminate metal contamination. Each bottle was inoculated with 370 kBq (10 μCi) of $NaH^{14}CO_3$ (Amersham International plc). The specific activity of each stock solution was determined immediately after inoculation of the experimental samples by adding aliquots to a CO_2-absorbing scintillation cocktail and counting immediately in a liquid scintillation counter.

For the ^{15}N experiments, replicate samples were distributed into clear polycarbonate bottles and $^{15}NO_3$ and $^{15}NH_4$ were added. The concentrations of added isotope were kept as low as practicable. On cruises VLD137 and CD85, the added concentrations were 0.1 μM (10% ambient) but this was reduced through improving methodology to 0.03 μM on cruise DI217.

Samples for phosphate uptake (cruise CD85 only) were handled in the same manner as the ^{14}C samples except for the nature of the tracer added.

The preferred method of incubation was to attach three light and one dark bottle to a clear acrylic rack suspended from a free-floating incubation rig at the depths from which the samples were taken. The rig was deployed before dawn and recovered at dusk. The incubations were continued to 24 hours by placing the samples in a black plastic dustbin flushed with surface sea water to maintain temperature. Where operational considerations precluded use of the in-situ rig, the samples were incubated in an on-deck incubator, flushed by surface sea-water, with neutral density acrylic screens of varying opacity (97%, 75%, 36%, 21%, 6% and 1% incident light) to control the proportion of natural light reaching the samples. Again, the samples were in the incubators from before dawn to dusk and the incubations were completed in darkness.

After incubation, the ^{14}C samples were filtered sequentially through different pore-size track-etched polycarbonate filters in a cascade filtration apparatus. The pore sizes used routinely were 5, 2 and 0.2 microns although there were some variations (see details in the records of C14HDR). After filtration, the samples were dried and counted on board ship in an LKB Rackbeta 1219 liquid scintillation counter. Counting efficiency was determined with an external standard, channels ratio method. ^{14}C incorporation in the dark bottles was always low and the dark values were not subtracted from the measurements obtained from the light bottles.

The ^{15}N samples were filtered (<40cm Hg vacuum) through pre-ashed Whatman GF/F filters which were rinsed with filtered sea water and stored frozen until analysis back at the laboratory. The thawed filters were oven-dried at 50 °C before analysis. Atomic percentage ^{15}N was measured by continuous-flow nitrogen analysis mass spectrometry (Europa Scientific Ltd.) using the techniques described by Barrie et al. (1989) and Owens and Rees (1989). The rates of assimilation were calculated using the equations of Dugdale and Goering (1967).

The ^{33}P samples were filtered through 2 and 0.2 micron pore size polycarbonate filters which had been soaked with LiCl solution. The filters were then washed with dilute lithium chloride-phosphate buffer using the method of Grillo and Gibson (1979) to remove phosphate adsorbed onto particles rather than incorporated into cellular material. The samples were then dried and counted in a liquid scintillation counter.

Dr. Lei Chou

The measurements were made on cruises Belgica BG9322, BG9412 and BG9521/22.

Water samples were taken from the CTD rosette, placed in clear plastic bottles and inoculated with 3.2-12 (BG9322) or 20-30 (BG9412 and BG9521/22) μCi ^{32}P per 200 ml sample. One experiment on BG9412 also included samples inoculated with 11.9 μCi ^{14}C. The bottles were sandwiched

between a series of neutral density screens to give the required light gradient and incubated for 6-12 hours in an artificial light incubator. In one of the experiments on BG9412 bacterial activity was inhibited by the addition of antibiotics (see COMM field in table P33HDR).

At the end of the incubation, the samples were filtered through polycarbonate pore filters. On BG9322, size-fractionated data were obtained by filtering through 2 and then 0.2 micron pore size filters. On BG9412, 1 micron pore size filters and on BG9521/22 GF/F filters were used.

The filters were dried and subsequently counted.

References

Barrie, A., Davies, J.E., Park, A.J. and Workmann, C.T., 1989. Continuous flow stable isotope analysis for biologists. ***Spectroscopy*** 4, 42-52.

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Grillo, J.F. and Gibson, J., 1979. Regulation of phosphate accumulation in the unicellular cyanobacterium *Synechococcus*. ***J. Bact.*** 140, 508-517.

Owens, N.J.P. and Rees, A.P., 1989. Determination of nitrogen-15 at sub-microgram levels of nitrogen using automated continuous-flow isotope ratio mass spectroscopy. ***Analyst*** 114, 1655-1657.

Benthic Fauna Data

Introduction

The benthic fauna data are held in a series of holding tables awaiting the resources to generate the parameter codes required to integrate them into the normalised benthic data structures. The storage of the data is based on the manner in which the data were subdivided by the originators when supplying the data to BODC.

Four sets of data were supplied, each of which is documented separately:

Living and dead benthic foraminifera

Benthic meiofauna data

Benthic macrofauna data

Benthic megafauna data

Living and Dead Benthic Foraminifera

Sampling Protocol

Box core samples were taken using the NIOZ 50 cm diameter circular box core fitted with a lid to prevent sediment surface disturbance and allow retention of a sample of the overlying bottom water. Sub-cores were taken by slowly inserting 9 cm diameter PVC liners after the overlying water had been siphoned off.

The sub-cores were sectioned into 0.5 or 1 cm slices and their wet volume determined in a measuring cylinder by adding a fixed volume of a solution of Rose Bengal in ethanol (1.0 g/l). Samples were stored at 4 °C.

The sediment was wet-sieved over a 150 micron sieve and the >150 micron size fraction was inspected under a stereo microscope for foraminifera species identification.

Data Presented

The data presented are profiles of foraminifera species counts. Each count is accompanied by an indicator of whether the specimen was alive or dead and whether it belonged to the calcareous, arenaceous or astrorhizid groups.

Benthic Meiofauna Data

Sampling Protocol

The samples were collected using a modified box corer (surface area 50 cm^2) fitted with a closing lid. This was capable of taking undisturbed cylindrical cores of the surface sediment. A sub-core was taken for meiofaunal analysis using a plastic tube (surface area 10 cm^2). Two box cores were taken on most stations (the exception being at site OMEX-D on Pelagia cruise PLG93) and processed separately. The results from these were averaged to produce the final data set.

The sub-cores were sectioned into horizontal slices between 2.5 mm and 10 mm thick covering the top 5 cm of the sediment. The slices were fixed in hot (70 °C), 4% neutral formaldehyde tap water solution.

Meiofauna organisms were extracted from the sediment by centrifugation with Ludox. Macrofauna were excluded by means of a 1 mm mesh sieve. All animals retained on a 32 μm sieve were counted. From each slice, 120 nematodes were picked at random and mounted in glycerine slides. If less that 120 individuals were present in the slice then the whole population was mounted.

The length (excluding filiform tails, if present) and width of the slide-mounted nematodes were measured using an image analyser (Quantimet 500+) and biomass was computed using Andrassay's formula (Andrassay, 1956). A dry to wet weight ratio of 0.25 was assumed.

The nematode community structure was analysed using the TWINSPAN (Hill, 1979) classification technique.

At BODC, the following changes were made to the data. Data supplied in units per 10 cm^2 have been converted to units per m^2 by multiplying by 100. Some data were supplied as replicates and some as averages of the replicates. All data have been unified to averages. The genus level nematode data were supplied as percentages of the total population. These have been converted to abundances.

Data Presented

Data were supplied from two cruises: Pelagia PLG93 and Charles Darwin CD86. The Pelagia data included abundance profiles of meiofauna by group, nematode biomass profiles (dry weight: a carbon conversion factor of 0.5 has

been suggested by the originators), and nematode community structure (genus level) profiles.

The Charles Darwin data include profiles of total meiofauna abundance and meiofauna community structure (group level) for the top 5 cm of the sediment (i.e. whole core data).

References

Andrassay, I., 1956. The determination of volume and weight of nematodes. ***Acta Zool. (Hungarian Academy of Science)***, 2(1-3), 1-15.

Hill, M.O., 1979. TWINSPAN - A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. ***Ecology and Systematics***, Cornwell University, Ithaca, New York, CP48.

Benthic Macrofauna Data

Introduction

Benthic macrofauna data were provided by two groups headed by Prof. Carlo Heip at NIOO (cruises Pelagia PLG93, PLG95A and Charles Darwin CD86) and Prof. Peter de Wilde at NIOZ (cruises Pelagia PLG93 and Charles Darwin CD86). The protocols and data sets produced by each group are described below.

Sampling Protocols

Professor Carlo Heip

The samples were collected using a NIOZ circular box core. Two corers were used with diameters of either 30 cm or 50 cm with the smaller corer generally used at shallower stations. Some cores were sub-sampled with the remainder of the sample taken for macrofaunal analysis. The resulting variation in sample size (from 707 to 5891 cm^2) has been taken into account with the data calculated on a per unit area basis.

The samples were sliced into layers between 1 and 5 cm thick and sieved through a 0.5 mm mesh. Specimens were preserved in 4% buffered formaldehyde, stained with Rose Bengal and sorted under a 10x stereo microscope.

Biomass was estimated as wet weight per major taxon after drying the animals for a few seconds on absorbent paper. Weighing was done to an accuracy of 0.1 mg. Due to their small size, no attempt was made to puncture the shells of bivalves to drain them of water.

Professor Peter de Wilde

The macrofauna were collected from 30 cm diameter box core samples that had been used for shipboard sediment oxygen demand measurements. The samples were gently washed over nested 1 and 0.5 mm sieves. The residues were preserved in buffered formaldehyde solution and sorted back in the laboratory. Any animals with a wet weight >50 mg were excluded from the analysis.

Data Presented

Professor Carlo Heip

Total macrofauna abundance profiles.

Profiles of macrofauna abundance and wet weight biomass at the group level with Echinodermata, Arthropoda and Mollusca subdivided into lower level taxa.

Professor Peter de Wilde

Whole core polychaete and total species diversity.

Whole core macrofauna abundance and wet weight biomass at the group level.

Benthic Megafauna Data

Sampling Protocol

An Agassiz trawl was used with an opening 1 m high and 3.5 m wide. The aperture is fitted with a mechanical trap door to prevent organisms being caught during lowering and hauling. The stretched mesh width of the net used was 1 cm.

The trawl was kept on the sea floor by a 750 kg weight attached to the cable 500 m ahead of the trawl.

The fishing distance was estimated using a 1 m diameter odometer wheel. This was checked by a video camera fitted to the trawl with a real time counter and logged cable tension data.

The catch was sieved on board with a mesh size of 5 mm. Most organisms were preserved in formalin except for selected species that were dissected immediately. Parts of the body wall and the gut contents of these were frozen in liquid nitrogen and stored at -80 °C.

The taxonomy of the trawl samples was studied in the laboratory and the principal taxa were counted. All specimens were wet weighed. Carbon weights were calculated using the deep sea animal conversion factors given in Rowe (1983).

It was reported that a significant number of sponges were damaged by the trawl. Only intact specimens were counted and consequently the abundance and biomass of the sponges were underestimated.

Data Presented

The following are included in the data set.

Total abundance.
Total biomass (wet weight)
Abundance of the principal taxa.
Biomass of the principal taxa (wet weight)
Population by feeding guild (abundance and wet weight biomass)
Average individual specimen wet weight.
Principal taxa biomass (carbon).
Other taxa biomass (carbon).

Reference

Rowe, G.T. (1983). Biomass and production of the deep sea macrobenthos. In: ***The Sea***, 8, ***Deep Sea Biology***, G.T. Rowe, editor, John Wiley & Sons, New York, pp. 97-121.

Continuous Plankton Recorder

Sampling Protocol

The Continuous Plankton Recorder (CPR) has been deployed continuously on ships of opportunity since the early 1960s. The instrument is towed at a depth of approximately 10 m and water is continuously filtered through gauze that is wound through the instrument onto a spool in a tank of preservative.

Back at the Sir Alister Hardy Foundation for Ocean Science, the gauze was cut into sections such that each sample represented approximately 10 nautical miles of track. The samples were analysed for phytoplankton and zooplankton abundance, to species where possible, or higher taxonomic groups. Chlorophyll concentration was estimated by visual assessment of the colour of the gauze.

The estimated abundance presented in the data is the 'accepted value' for the CPR quantification class divided by the fraction of the sample counted. For phytoplankton, the quantification class definitions are as follows:

Accepted value	Class Limits
0	Presence
1.5	1-2
3.5	3-4
6.5	6-7
9.5	9-10
13	12-14
17	16-18
22.5	21-24
30	28-32
42	38-46
75	60-90

For zooplankton, the quantification class definitions are:

Accepted value	Class Limits
0	Presence
1	1-1
2	2-2
3	3-3
6	4-11
17	12-25
35	26-50
75	51-125
160	126-250
310	251-500
640	501-1000
1300	1001-2000
2690	2001-4000

Further details of CPR operations may be found in Colebrook (1960) and Glover (1967).

Data were supplied from routes crossing the shelf break in the vicinity of the Goban Spur from 1964 to 1995.

References

Colebrook, J.M., 1960. Continuous plankton records: methods of analysis, 1950-1959. ***Bull. Mar. Ecol.***, 5, 51-64.

Glover, R.S., 1967. The Continuous Plankton Recorder survey of the North Atlantic. ***Symp. Zool. Soc. Lon.***, 19, 189-210.

Longhurst-Hardy Plankton Recorder

Sampling Protocol

The Longhurst-Hardy Plankton Recorder (LHPR) consisted of a fibreglass inlet cone with a small aperture, through which the water flowed into a larger cross-section of net. It was then channelled into the cod-end which collected the plankton on a band of 200 μm mesh gauze. The gauze was periodically wound on to present a fresh section for collection. The sampling resolution and depth were controlled by the speed of descent and a timer. Water temperature, salinity and instrument depth were logged by an on-board paper chart or, on later cruises, electronically on the ship via a conducting cable.

Hauls were made down to a depth of 400 m where possible with samples taken on both the descent and the ascent or just on the descent. On recovery, the gauze roll was removed, wrapped in muslin to prevent organisms escaping and placed in 4% buffered formaldehyde solution in sea water.

Back in the laboratory, the gauze was unrolled onto a white melamine covered board to aid identification of the bands of plankton. It was then cut into the respective number of sub-samples and the plankton was washed off each into preserving fluid.

Each sample was split using a Fulsome splitter to no more than 1/128 and the organisms were separated into taxa to give their numerical abundance.

The displacement volume of the total sample was determined by placing it into a known volume of water and noting the displacement.

Data Presented

For the bulk of the hauls, the data supplied were normalised displacement volume in units of ml/m^3. These were converted to ml/1000 m^3 at BODC to standardise units with Rectangular Mid-Water Trawl data. The originators suggest applying the equations of of Wiebe et al. (1975) as modified by Wiebe (1988) to convert this to carbon biomass.

For some of the hauls, counts of the individual taxa contained in the sample were provided.

References

Wiebe, P.H., Boyd, S. and Cox, J.L. (1975). Relationships between zooplankton displacement volumes, wet weight, dry weight and carbon. ***Fisheries Bulletin***, 73, 777-786.

Wiebe, P.H. (1988). Functional regression equations for zooplankton displacement volumes, wet weight, dry weight and carbon: a correction. ***Fisheries Bulletin***, 86, 833-835.

Rectangular Mid-water Trawl Data

Sampling Protocol

Samples were collected using the RMT(1+8)M sampler (Roe and Shale, 1979). This is an opening and closing net system that collects three pairs of samples. Each sample pair comprises a macroplankton sample collected in a nominal 1 m^2 net (RMT1) with a mesh size of 0.32 mm and a micronekton sample collected in a nominal 8 m^2 net (RMT8) with a mesh size of 4.5 mm.

The sample pairs were collected during tows of approximately one hour duration at a speed of about 1 m/s (2 knots). During this time, the RMT1 sampled some 2500 m^3 and the RMT8 some 25,000 m^3. A flow meter mounted above the nets was used to measure the precise distance of the tow. The volumes of water filtered were calculated assuming 100% efficiency using the formulae given in Roe et al. (1980).

The samples were initially preserved in 4% formaldehyde in sea water which was changed after about a day.

Back in the laboratory, the displacement volumes were measured by draining off the preservation fluid, adding the material to a known volume of water and noting the increase in volume. Replicated measurements showed measurement errors of 5-10%. In addition, there were errors due to variation in the volume of water trapped between the organisms. This could not be eliminated without significantly damaging the specimens.

The samples were then sorted into the major taxonomic groups and the displacement of each individual group was determined.

The volume data were standardised to displacement volume per 1000 m^3 and then the volumes per m^2 were estimated for each of the sampling ranges (total range sampled, upper 100 m, 200 m and 400 m).

Volumes were converted to carbon content as follows. For non-gelatinous plankton, the conversion of Wiebe et al. (1975) as modified by Wiebe (1988) was used. For gelatinous plankton, the estimate of Larson (1986) was used assuming that the specimens had a density of 1.025 g/cm^3 (1ml of gelatinous plankton assumed to contain 3.649 mg of carbon). Taxa considered to be gelatinous were medusae, siphonophores, salps and chaetognaths. The taxa considered to be non-gelatinous were fish, decapods, euphausiids, mysids, amphipods and pteropods.

References

Larson, R.J. (1986). Water content, organic content and carbon and nitrogen content of medusae from the Northeast Pacific. ***Journal of Experimental Marine Biology and Ecology***, 99, 107-120.

Roe, H.S.J. and Shale, D.M. (1979). A new multiple rectangular trawl (RMT1+8M) and some modifications to the Institute of Oceanographic Science's RMT 1+8. ***Marine Biology***, 50, 283-288.

Roe, H.S.J., Baker, A. de C., Carson, R.M., Wild, R. and Shale, D.M. (1980). Behaviour of the Institute of Oceanographic Science's Rectangular Mid-water Trawls: theoretical aspects and experimental observations. ***Marine Biology***, 56, 247-259.

Wiebe, P.H., Boyd, S. and Cox, J.L. (1975). Relationships between zooplankton displacement volumes, wet weight, dry weight and carbon. ***Fisheries Bulletin***, 73, 777-786.

Wiebe, P.H. (1988). Functional regression equations for zooplankton displacement volumes, wet weight, dry weight and carbon: a correction. ***Fisheries Bulletin***, 86, 833-835.

Marine Snow Profiler Data

Introduction

This document covers the acquisition of abundance profiles of the amorphous aggregates commonly known as marine snow by means of a photographic system mounted on a CTD frame.

The Marine Snow Profiler

The marine snow profiler is a system for quantification of the marine snow abundance by photographic means. The principle of the technique is similar to that reported by Honjo et al. (1984), but with the advantages gained from mounting the system on a CTD equipped with a transmissometer, fluorometer and rosette sampling system.

Some 40 litres of water (only part of which was used for analysis) were illuminated by a strobe light collimated by a set of Fresnel lenses. Great care was taken with the geometry of the system, to ensure that a truly parallel beam of light was produced.

Particles along 52 cm of the beam were photographed orthogonally every 15 or 30 seconds by an IOS Mk4 35mm camera with 400 frame capacity using Ilford XP2 film. Each frame included a time stamp, printed by an LED display in the camera, which was used to determine the depth of the exposure by cross-referencing with the CTD pressure channel.

The films were developed on board ship using a Bray film processor.

Image Analysis

The negatives produced were analysed using a Kontron Vidas image analyser. Each frame was analysed twice, once using 6.2 litres (13% of the photographed volume) to examine particles in the size range 0.4 to 5mm and then using 23 litres (48% of the volume) to quantify particles in the range 5 to 9.8mm.

Particle size was determined, based on the assumption that all of the particles lay in the mid-plane of the 30cm thick light slab and 80cm from the camera lens.

Each particle with an in-situ diameter >0.4mm was measured in two dimensions and the volume (V) computed using:

$$V = (r^2.R.p)(1.33+0.66C)$$

where: C = (R-r)/R
R = One half of the maximum particle dimension
r = One half of the minimum particle dimension

The factor C was chosen to give the best approximation of volume for various geometrical shapes.

On the very rare occasions that zooplankton were identifiable in the frames, their volume was excluded from the analysis.

The data are presented as the number and volume of particles for the following size classes (expressed in terms of equivalent spherical diameter):

0.60 to 0.98mm
0.98 to 1.56mm
1.56 to 2.48mm
2.48 to 3.94mm
3.94 to 6.25mm
6.25 to 9.93mm
>9.93mm

The total marine snow volume and abundance were estimated by summing the size fractionated data for all size classes except the >9.93mm class.

Reference

Honjo, S., Doherty, K.W., Agrawal, Y.C., Asper, V.L., 1984.
Direct optical assessment of large amorphous aggregates (Marine Snow) in the deep ocean. ***Deep Sea Res.*** 31(1): 67-76.