Work Package II

Spatial and seasonal fluxes and biogeochemical processes in the water column

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Introduction

Significant progress has been made within WP II over the past 12 months. As well as 3 successful WP II cruises this year, a number of WP II partners participated in WP I cruise *CD114* in August '98 and WP III *M43/2* in Dec/Jan '99. A physics workshop was held in Bangor 24-25 Nov. to review progress and synthesise results for **Tasks II.1**, **II.2**, **II.3** and **II.12**. Following this, a modelling workshop was held in Galway 28-29 Nov, to ensure integration across WP II tasks. At the OMEX II-II Annual Workshop in Plymouth 25-28 April 1999, WP II partners presented 28 posters and a large number of informal presentations of recent results were given during parallel sessions.

Task II.1 Moorings, currents, circulation and flow fields

II.1.1 *Review Historic Current Meter and Hydrographic Data*
The analysis of historical data has continued in year 2 with the addition of both MORENA and current OMEX II-II measured data sets. Data is now being used to validate the IST and SINTEF models (07 UCG). Data have been collected from historical hydrographic measurements of the large scale northeastern Atlantic, as well as of the Galician margin. These data have been used for the evaluation of large scale and local hydrography (NIOZ-b). Following continual problems with obtaining MORENA data from the University of Lisbon data bank, it was decided to apply to the originators. Nearly all the useful data have now been acquired and made available to interested OMEX partners by UWB; they are now also stored at BODC. Only one line of current meter data from about 41°N is still outstanding and, as this is held at Lisbon, it is deemed unobtainable (06b UWB-b). Partner 2 POL contribution to WP II completed. Analysis of data bases, set up earlier, is proceeding according to plan (08a IH).

II.1.2 *Deploy Current Meters and Traps on Moorings*
It has not been possible to recover the 700-m slope mooring in year two, but there are plans to use a local Vigo vessel to attempt a recovery in July, 1999 (07 UCG). Current meters and sediment traps were deployed and recovered twice on *Pelagia*, *Poseidon* and *Meteor* cruises on two moorings (IM 2 and IM 3) as planned. Deliverables completed according to schedule (17 IfM). One mooring has been maintained over the mid-shelf off Porto (41ºN) from January - May '98. This mooring was redeployed mid-July '98 but only the uppermost current meter (20 m) was recovered. During March '99 one mooring with 4 current meters was deployed over 2000 m on the Porto Canyon and will be maintained for several months. Two days of observations were conducted over the mid-shelf, off Porto, using one mooring with 4 current meters (1 RMC-7 and 3 RCM-9), one thermistor chain, one moored ADCP, one WAVEC wave buoy and repeated CTD casts (08a IH-a).

II.1.3 *Current Meter Data Analyses*
No UCG measured data has been recovered to date. Other data recovered in being analysed at the present time (07 UCG). Processing and analysis of data from the 1996 and 1998 moorings are proceeding according to plan. Data and technical reports will soon be sent to BODC (08a IH-a).

II.1.4 *Shipborne ADCP for Upper Ocean Currents*
During the second year of the project UWB-a has participated in two cruises, one in summer (*CD114*) and one in winter (*M43/2*). Contacts with BODC have furthered the inventory and processing of previous Acoustic Doppler Current Profiler (ADCP) data sets. Discussions with other partners have been

established to arrive at estimates of fluxes and budgets of scalar properties within the OMEX II-II box. Data collection has consisted of along track ADCP data during *CD114* and *M43/2* and deployment and tracking of 8 Argos drifters 4 in summer and 4 in winter, plus one short-term drifter which was recovered at the end of the summer cruise, together with standard hydrographic measurements (06a UWB-a).

II.1.5 *Sourcing Currents*
The assembled historical CTD-data have been analyzed in order to define source regions for deep, intermediate and upper ocean water types as found near the northwest Iberian margin (05b NIOZ-b). Model validation is underway with comparison to measured and model-generated statistics (07 UCG).Chelsea Instruments Plc 'Aquapacks' have been fitted to all CPR tows and data transferred to BODC up to July 1998. Remaining 1998 data will be transferred imminently (12 SAHFOS). A circulation model was implemented and statistics of simulated and observed currents have been compared (11 IST).

II.1.6 *Detection, Typology and Statistics of Sea Surface Temperature and Colour*
Composite front map techniques have been further developed for optimal visualisation of fronts, eddies and filaments. Compilation of front maps from 1993 to date has been completed and this is available on the OMEX web site. Long-term upwelling indices for OMEX II-II region have been obtained, and statistics on filaments and eddies are currently being compiled (09 NSS).

Task II.2 Water mass analysis by conservative and transient tracers

II.2.1 *Classical Hydrography and Water Masses*
The hydrographic data collected on *Pelagia* cruises have been processed. With BODC, quality control of hydrographic data (CTD, oxygen, nutrients) from OMEX II-II cruises has been carried out. Questions regarding calibrations have been sent to the data originators. The existing multi-parameter water mass description of the Eastern North Atlantic has been revised. A first analysis and description of the water mass structure in the OMEX II-II research area has been set up for the summer of 1997 and the winter of 1997/98 (05b NIOZ-b). Cruise data has been acquired as envisaged and has been party to physics discussions (02 POL). CTD data from *OMEX0898* cruise have been processed and submitted to BODC. This is a voluntary contribution from IEO to the above Task in the OMEX II-II project (20 IEO). One cruise was held between 3 and 30 March 1999, onboard the NRP Almeida Carvalho, as planned. Area covered: northern Portuguese coast between 41º and 42º and from the coast to 11ºW. Goals achieved: *a*) 154 CTD stations, *b*) moorings deployed; *c*) water samples for calibration, nutrients, O_2 and SPM, *d*) bottom sediment samples stations, *e*) seismic and side-scan sonar coverage of the study area. Cruise reports for this cruise and for the CORVET96 and CLIMA97 cruises are being prepared (08a IH-a).

II.2.2 *Tracers and Mixing End Members*
Water mass advice is given on request and has been supplied to the OMEX II-II workshop in Plymouth. Alternatives for linear combination models for the water mass description have been explored (05b NIOZ-b). Water samples, for analysis of the $\delta^{13}C$ of dissolved CO_2 and $\delta^{18}O$, have been collected on *BG9815* and *M43/2*. Carbon isotope analysis from *BG9714*, *Poseidon P211*, and *M43/2* has been completed successfully. Samples from B9815 will be analysed during the next couple of months. The oxygen isotopes will be analysed in autumn, 1999. Analysis of methane along OMEX Line S and some additional stations have been performed during *M43/2*. Collection of radiocarbon samples took place on the same cruise. All targets are being met (24a GEOMAR-a). A particle-tracking model has been coupled to the circulation model allowing water mass identification (11 IST).

Task II.3 Spatial distribution of turbulence and mixing

II.3.1 *Deploy Free-Falling YOYO*
This task have been completed and the *CD114* raw data have been banked by the end of June, as required. The calculation of the vertical diffusion coefficient has been slightly delayed due to technical problems

with the FLY but it is hoped that computed vertical diffusion coefficients will be reported in the near future, and communicated to the relevant modelling groups.

II.3.2 *Map 3-D Distribution of Turbulent Kinetic Energy and K_z.*
Dr M.E. Inall left the UWB on 2nd Oct 1998 to take up employment with the Highlands and Islands University Project at Oban. He is however, still working for OMEX, although in a reduced capacity concentrating on turbulence measurements on the shelf. UWB hosted a physics group meeting at Menai Bridge in Nov 1998. Drs Inall and Sherwin were at the full OMEX workshop at Plymouth in April 1999. Dr Sherwin gave a solicited talk to EGS 99 in the Hague, where he pointed out the necessity of considering the three dimensionality of the Iberian shelf edge when attempting to model internal tides in the region. (06b UWB-b). SAR data have been processed and delivered before and during *CD114* cruise (09 NSS).

II.3.3 *Provide Parameters for Comparison with Turbulence in Closure Models*
The facility to impose a forcing function as a time series of (vertical) profiles has been added to the NIOO model. This will enable the profile of vertical diffusion coefficients, as measured by UWB-b, to be imposed on the 1-D model of the Lagrangian experiment that will be modelled next year. UWB-b estimated a lower bound of vertical diffusivity of 4-13 10^{-4} m^2 s^{-1} that will be imposed on the turbulence-closure formulation. E. Flach, K. Soetaert, V. de Clippele, P. Herman and C. Heip attended the OMEX annual workshop in Plymouth (15 NIOO-a). A turbulence model has been implemented in a 1-D vertical model in order to determine some turbulence characteristics. Field data will be used to refine parameterisations (11 IST).

Task II.4 Nutrient distribution, speciation, upwelling and fluxes

II.4.1 *Nutrient Oceanography*
Analysis of 5 nutrients (NO_3, NO_2, NH_4, PO_4 and Si) on fresh samples have been analysed on board during *BG9815C* and the data have been submitted to BODC (13 IIM). ULB-1b participated in *BG9815* and collected nutrient samples. Dissolved phosphate has been analysed on board. Duplicate samples were taken and kept frozen for later analysis of other nutrients. Dissolved phosphate data have been banked at the BODC (01b ULB-b). Dissolved inorganic nutrients (nitrate, nitrite, ammonium, phosphate and silicate) were analysed at IEO-La Coruña from samples frozen on board during *ST0898* cruise. Analytical procedures used at IEO-La Coruña were tested regularly in QUASIMEME inter-comparisons. Parallel samples were collected and distributed to 13 IIM for inter-calibration (**Task IV.3**) (20 IEO). Total dissolved nitrogen (TDN) samples have been collected during *ST0898* and *Meteor M43/2* cruises, data are currently being processed and quality controlled and should be submitted to BODC in summer 1999 (04a PML-a). Nutrient samples have been analysed from cruise *CD114* (August 1998) (04c PML-c). Nutrient samples (NH_4, Urea) have been collected along vertical profiles on *BG9815*. The samples have been analysed (23 VUB).

II.4.2 *Conserved Nutrient Tracers*
Historical nutrient and oxygen data have been assembled and quality controlled. Alternative methods to construct quasi-conservative nutrient tracers have been studied. Nutrient data from OMEX II-II cruises are becoming available and have allowed a first analysis of the effect of production/regeneration on the water mass structure for the cruises carried out in the summer of 1997 and winter of 1997/98 (05b NIOZ-b). AOU data was obtained during five cruises: *BG9714* (44 stations and Niskin sampling at 310 depths), *CD110b* (7 stations and Niskin sampling at 58 depths), *BG9815* (51 stations and Niskin sampling at 236 depths), *CD114a* and *b* (33 stations and Niskin sampling at 229 depths) and *M43/2* (12 stations and Niskin sampling at 169 depths). The last cruise is planned on the *Belgica* in late August 1999. Data is processed and banked at BODC (22 ULg).

II.4.3 *Nutrient Boundary Fluxes*
The nutrient and oxygen data to be used in the estimate of boundary fluxes have been assembled and quality controlled (05b NIOZ-b). Assembly of a nutrient database has been postponed till the final year

when more data will be in the BODC database (15a NIOO-a). Fluxes across OMEX box boundaries have been computed from the 3-D ocean circulation model. A simple biochemical model has been coupled to the particle-tracking model (11 IST).

II.4.4 *Nitrate Remote Sensing Algorithms*
Sea surface temperature and nitrate concentrations have been developed (see science report, 04c PML-c). Analysed *in situ* SST and NO_3 data from *CD114* to develop algorithms to be used for creating seasonal nitrate maps (09 NSS).

Task II.5 Source markers of particulate matter

II.5.1 *Biomineral and Lithogenic Composition*
Sampling with Stand Alone Pumps (SAP) in moorings could not be performed as planned due to technical problems with two SAPs and loss of the third one at sea (for details see **Task II.11.1**) (17 IfM). Suspended matter collected by centrifugation during *BG9714* and *BG9815* were analysed for major, minor and trace elements. Analyses of SAP samples collected during the *CD110* have been completed. Particulate material was also sampled by SAPs during *BG9815* the analyses of which are well in progress and close to completion.

II.5.2 *Stable Isotopic Signatures*
As mentioned in the previous management report, the ^{15}N signature of surface suspended matter displayed considerable variability in samples collected during the *BG9714* cruise. This was ascribed to nitrate exhaustion in surface waters and to the fact that regenerated production was predominant during the investigated period. Most probably, varying isotope fractionation factors were associated with these uptake and remineralisation processes. As a consequence, ^{15}N results were difficult to interpret and to relate to new production, which was our primary objective. In July 1998, the situation evolved towards an extension to the south of the upwelling area starting at Cape Finisterre. A few samples were collected in this area and analyses are in progress (23 VUB).

II.5.3 *Particle Residence Times*
Large seawater volumes for ^{234}Th and ^{228}Th measurements were collected on *M43/2* (January 1999) and *PE138* (May 1999) cruises. Measurements are achieved for *M43/2* samples, and in course for *PE138* samples. The treatment of *CD105* data (estimation of scavenging rates, particle residence time) is achieved (27 CFR).

II.5.4 *Pigment Biomarker*
The distribution of chlorophyll and carotenoid pigments has been studied in depth profiles and surface transects across the NW Iberian shelf break in a synergetic contribution to both OMEX WP I and WP II activities. Samples have been collected from four WP II cruises (*CD105*, *CD110*, *Poseidon P237*, and *BG9815*) and from one WP I cruise (*CD114*). Analysis of all samples has been completed and the bulk of data has been banked with BODC (04a PML-a). Size fractionated chlorophyll concentrations have been analysed from *CD114* (04c PML-c) and *ST0898* (21 UVI). Chlorophyll *a* samples were taken during *BG9815*. They have been analysed and data have been submitted to BODC. The determination of the chlorophyll *a* concentration for samples collected during the *CD110* has been completed and will be banked at the BODC. The results will contribute to **Task II.7.1** CO_2 Partial Pressures and Upper Ocean Biogeochemistry, led by ULg (01b ULB-b).

II.5.5 *Biomass Carbon*
Microzooplankton data are being generated from 5 cruises (04b PML-b). Integration of this data together with bacteria, phytoplankton and mesozooplankton data sets from relevant partners has been initiated (04b PML-b). Bacterial biomass estimates are available from 4 WP II cruises in 1998 (14 UAL-a). Distribution of chlorophyll and carotenoid pigments has been determined from four WP II cruises (04a PML-a). Phytoplankton counts from *ST0898* are complete and have been sent to PML-b for conversion to C biomass (20 IEO). Measurements of zooplankton body lengths using light microscopy have now been

completed for the 24 WP2 net samples collected on cruises *CD105b*, *CD110b* and *Belgica BG9815*; these will be later converted to carbon biomass using length-weight equations, many of these having already been compiled (16 SOC). Zooplankton carbon estimates for *ST0898* are complete and data has been sent to PML-b for integration (UOV). Other mesozooplankton carbon measurements are dependent on the CPR data collected under **II.10.1** and **II.10.2**. (12 SAHFOS).

Task II.6 Dissolved organic carbon

II.6.1 *Seasonal and Spatial Distribution of DOC*
Analytical systems have been used during three shipboard sampling programmes (*CD110b*, *ST0898* and *M43/2*). Data from all three cruises are currently being processed and quality controlled. Miss Georgina Spyres has completed the first year of her Ph.D. studentship (jointly between PML and Univ. Plymouth) working on the OMEX II-II programme measuring TDN distributions as part of WP II. A berth has been secured for Georgina Spyres (TDN studies) on the forthcoming RV *Belgica* cruise, September 1999 (04a PML-a). Partners responsible for measurements of DOC using comparable techniques are IIM (WP I) and PML-a (WP II). A number of measures have been and continue to be taken as a matter of course, to ensure consistency between the analytical facilities at IIM and PML. These include publication of a joint-authorship DOC/TDN methodological manuscript, analyses of common samples from the "OMEX Box", and on-going participation in an international DOC inter-comparison exercise, funded by US oceanographic agencies (04c PML-c). An algorithm has been implemented to derive DOM from SeaWiFS data, and compared with historical *in situ* data provided by IIM (09 NSS).

II.6.2 *Planktonic production of DOC*
Shipboard measurements of DOC production by plankton were measured at a series of stations during cruise *ST0898*. The data set has been processed and is ready for data banking (20 UVI). Additional measurements of size-fractionated chlorophyll *a*, primary production and net community production were also carried out during cruise *ST0898*. The data set is ready for delivery (21 UVI). On the same cruise, one experiment was performed, in collaboration with UVI, to estimate the role of mesozooplankton in DOC production using two species of copepods (*Calanus helgolandicus* and *Calanoides carinatus*) (19 UOV). The results have been processed and are currently being discussed.

II.6.3 *Bacterial Utilisation of DOC*
Bacterial biomass estimates from 1998 WP II cruises (*BG9815* and *ST0898*) were concluded in the first semester of 1999. UAlg participated in *Almeida Carvalho* OMEX cruise from 3/5/1999 to 30/5/99. This cruise overlapped the southern most OMEX reference line, and WP II tasks were addressed in the cruise experimental program by sampling five vertical profiles for bacterial abundance, mean cell volume, biomass and production and fraction of respired leucine. Data from 1998 cruises were included in the OMEX workshop in Plymouth (April 99) in the form of oral presentations by Prof. Dr. Helena Galvão and Ana Barbosa and also a poster, entitled "Variability of Bacterioplankton processes off the Galician shelf"(UAL-a).
Future plans involve participation in Leg 2 of the *Belgica* WP II Slope Survey cruise, 5-17/9/1999. Besides collection of vertical profiles for bacterial abundance, mean cell volume, biomass and production along the OMEX reference transects, DOC uptake experiments will be run in order to complete WP I tasks, once again due to the cancellation of the planned WP I cruise. If possible, additional grazing experiments will be carried out, in order to provide seasonal variation for WP I grazing task. If DOC uptake experiment data from the *Belgica* cruise are not satisfactory, UAlg will participate in the *Thalassa* October 99 WP II cruise. It is to be noted that data obtained from this late cruise might not make the Dec. 99 deadline to be included in the CD-ROM (14 UAL-a). Collaborative shipboard experiments have been performed to investigate the phytoplanktonic production of DOC (with UVI) and the bacterial utilisation of DOC (with UAL-a) (04a PML-a).

Task II.7 CO_2 drawdown and ventilation

II.7.1 *CO_2 Partial Pressures and Upper Ocean Biogeochemistry*
Surface mapping of dissolved pCO_2, atmospheric pCO_2, pH and dissolved oxygen has been accomplished during five cruises: *BG9714* (44 stations and Niskin sampling at 310 depths), *CD110B* (7 stations and Niskin sampling at 58 depths), *BG9815* (51 stations and Niskin sampling at 236 depths), *CD114a* and *b* (33 stations and Niskin sampling at 229 depths) and *M43/2* (12 stations and Niskin sampling at 169 depths). The last cruise is planned on the *Belgica* in late August 1999. Data is processed and banked at BODC (22 ULg). An intercalibration of continuous underway *p*CO2 measurements was performed with ULg during *M43/2* (24a GEOMAR-a).

II.7.2 *Air-Sea Exchange of CO_2*
The complete data sets from *BG9714*, *CD110B*, *BG9815*, *CD114A* and *B* and *M43/2* cruises were made available to RISØ (22 ULg). Within the second year of OMEX II-II, the modelling work was concluded as a Ph.D. project (followed by a post-doc continuation). The project report has been defended and accepted at University of Odense, Denmark (Kjeld, 1999). Field data from the first OMEX II-II cruises on pCO_2, as obtained by ULg and the transformation of these data to surface fluxes has been initiated. The data from 5 OMEX cruises has been obtained from BODC and is being treated. It is intended to form an integrated presentation of the flux estimates in co-operation with ULg in autumn 1999. Modelling of field data is slightly behind schedule because the RISØ model development has been slower than anticipated. Within the context of OMEX II-II, the participants have participated in the OMEX Annual Workshop in Plymouth, April 1999. The participants have also participated in the EC- ENVIRONMENT European Climate Science Conference, Vienna, October 19-23, 1998 and the MAST Meeting on: Air-Sea-Ice Studies, Brussels, January 7-8 1999 (10 RISØ).

II.7.3 *Marine* versus *Anthropogenic CO_2*
Water samples for analysis of the $\delta^{13}C$ of dissolved CO_2 have been collected on *BG9815* and *M43/2*. Carbon isotope analysis from *BG9714*, *Poseidon P211*, and *M43/2* has been completed at the Leibniz laboratory, University of Kiel. Samples from *BG9815* will be analysed during the next couple of months. Collection of radiocarbon samples took place on *M43/2* (24 GEOMAR). The intercalibration of continuous underway *p*CO2 measurements between ULg and GEOMAR was performed during *M43/2* (24 GEOMAR, 22 ULg). The data from the University of Liège has been processed and made available to GEOMAR (22 ULg).

Task II.8 Primary, new and size-fractionated primary production

II.8.1 *Spatial and Temporal Distribution of Phytoplankton Biomass. Species, Pigments and their Remote Sensing*
Pigments samples have been collected from four WP II cruises (*CD105*, *CD110*, *Poseidon P237*, and *BG9815*) and from one WP I cruise (*CD114*). Analysis of all samples has been completed and the bulk of data has been banked with BODC (PML-a). The data has been used in calibration of *in situ* optical and fluorometric sensors and development of ocean colour remote sensing algorithms. All targets are being met. Microphytoplankton counts of samples taken during the cruises *BG9714* and *CD110B* have already been submitted to BODC. Microphytoplankton samples taken during cruise *BG9815C* are currently being analysed by microscopy (13 IIM). From May 1997 to May 1999 there have been 24 CPR tows, of which 3 have not produced data owing to bad weather or mechanical failure. Analysis of phytoplankton species is in hand and data to the end of July 1998 have been banked at BODC. Analysis is complete for the remainder of the 1998 samples, they are undergoing quality control and will be transferred to BODC imminently (12 SAHFOS). SeaWiFS ocean colour data processed daily and disseminated on web site. HPLC data provided by PML-*a* used to validate Chl *a* pigment algorithms using latest version of SeaWiFS data (09 NSS).

II.8.2 *Intercalibration of Primary and New Production*
Intercalibration between PML-c and IIM has been carried out (see Science Report 04c PML-c). Discrepancy between results will mean that a further intercalibration exercise needs to be carried out. This is to be held in Plymouth on 19-21 July 1999 (04c PML-c). The partners involved are PML-c, ULB-b and IIM for ^{14}C, PML-c and ULB-b for ^{33}P, and PML-c and VUB for ^{15}N.

II.8.3 *Parameterisation of Primary Production*
Photosynthetic parameters were obtained by performing incubation experiments using ^{14}C under variable conditions at 8 stations during *BG9815* (01b ULB-b). Completion of the parameterisation is not possible until the problem outlined above is resolved (04c PML-c). Photosynthesis-irradiance (P *vs*. I curves) from WP I *CD114A* and from WP II *CD110B* and *BG9714* have been submitted to BODC (13 IIM). Underwater light field and spectra of phytoplankton absorption coefficients from these cruises have also been delivered to BODC (13 IIM). The more complex phytoplankton model implemented during the first year will be tested to the depth-variation of P *versus* I curves. If these are caused by the variable physiological condition of the algae, this model should be able to reproduce the trends (15 NIOO-a).

II.8.4 *New Production*
New production measurements were done on *CD114* and an analysis of 15N samples is almost complete (04c PML-c). Eight stations were sampled at 2 depths (surface and bottom of the euphotic layer) for the assessment of the nitrogen uptake regime and kinetics. One of the stations was sampled twice within several days for an upwelling/non-upwelling situation. The following experiments were carried out: (*i*) $^{15}NO_3$, $^{15}NH_4$ and ^{15}N-urea uptake experiments with a constant light of 200 µE m^{-2} s^{-1}; (*ii*) $^{15}NO_3$, $^{15}NH_4$ and ^{15}N-urea uptake kinetics at 200 µE m^{-2} s^{-1} to assess Michaelis-Menten parameters and inhibition of NO_3^- uptake by ammonium. The samples were all analysed by emission spectrometry and all targets are being met (23 VUB). Awaiting OMEX II-II ^{15}N data to be lodged in database, progressing towards deliverables (09 NSS).

II.8.5 *Assimilation of Phoshorus*
Phosphate measurements on *CD114* have been worked up (04c PML-c). Incubation experiments on the assimilation of phosphorus using ^{32}P were carried out under variable and constant light conditions during *BG9815*. Size-fractionated assimilation of phosphorus was determined. Uptake due to various fractions (photosynthetic, non-photosynthetic, bacterial, and abiotic) was evaluated using various inhibitors. Menten-Michaelis kinetics for the phosphorus assimilation were also investigated at a limited number of stations and the rate constants evaluated (01b ULB-b).

II.8.6 *Spatial and Seasonal Distribution of Primary and New Production*
Data now available for winter 1998, spring 1997 and summer 1998 (04c PML-c). Primary production data from cruises *BG9714* and *CD110B* have been submitted to BODC (13 IIM). Size-fractionated production was determined and the integrated production was evaluated for stations investigated during the *BG9815C* (01b ULB-b).

Task II.9 Microbial populations as pelagic sinks

II.9.1 *Distribution of Bacteria and Microzooplankton*
Microzooplankton samples have been collected on 2 WP II cruises (*BG9815* June/July - 16 stations and *ST0898* Aug - 15 stations). Sample analysis by inverted microscopy has begun (04b PML-b). Analysis of 72 heterotrophic nanoflagellate samples collected during *Poseidon P237/1* has been completed and data on their abundance and biomass will be deposited with BODC by the end of July. It was envisaged that heterotrophic nanoflagellate samples would be collected on *ST0898* and transferred to *CD114*, for slide preparation prior to analysis. However, due to a lack of radio contact between the two ships the proposed inter-calibration did not occur and samples not transferred.

II.9.2 *Nitrogen and CO_2 Regeneration by Bacteria, Micro- and Mesozooplankton*
Experimental incubations of microplankton with 15N have been made during *ST0898* cruise at 7 stations to determine DON production rates. Samples are being processed at IEO-La Coruña and results are expected to be available to OMEX II-II partners by the end of summer 1999 (20 IEO). As for **Task II.9.1**, further microzooplankton samples have been collected and once analysed the respiratory role of microzooplankton will be determined. (04b PML-b).

Task II.10 Mesozooplankton distribution and production processses

II.10.1 *Zooplankton Distribution and Seasonality*
In order to study the distribution of size fractionated biomass and mesozooplankton abundance, 20 stations were sampled during *ST0898*. The samples are being analysed to determine the abundance of the different taxonomic groups, and total copepod abundance (19 UOV). From May 1997 to May 1999 there have been 24 CPR tows, of which 3 have not produced data owing to bad weather or mechanical failure. Analysis of zooplankton species is in hand and data to the end of July 1998 have been banked at BODC. Analysis is complete for the remainder of the 1998 samples, they are undergoing quality control and will be transferred to BODC imminently (12 SAHFOS). The taxonomic identification of the WP2 samples collected on *CD105b*, *CD110b* and *BG9815* is now complete. The Tromsø group has taxonomically sorted samples collected with UITØ on *CD110b*. The sorting of Longhurst-Hardy Plankton Recorder samples collected during *CD105b* across the Galician box is about to begin; this will provide information on larger scale spatial (long-shelf) and temporal distribution patterns. The two OMEX II-II publications ("Towards a global model of *in situ* weight-specific growth in marine planktonic copepods" A.G. Hirst and R.S. Lampitt, *Marine Biology*, **132**, 247-257 and "A global synthesis of growth in marine pelagic metazoans" A.G. Hirst, J.C. Roff and R.S. Lampitt, in prep.), have contributed to our ability to predict growth and production, and will in due course be applied with respect to the size distributed biomass data (16 SOC).

II.10.2 *Zooplankton Grazing, Exudation and Faecal Export*
Grazing experiments were carried out in collaboration with UITØ on cruise *CD114b*. The analysis of this data is now close to completion, and much that remains concerns the integration of these data with other biological parameters measured on the cruise (16 SOC). Further biomass measurements have been made, conversion of CPR abundances and estimates of grazing will be produced in year 3 (12 SAHFOS) Microscopic analyses of trap samples for fecal pellets of various planktonic origins are being carried out and are well on schedule (17 IfM). Copepods ingestion rates and their impact on phytoplankton was estimated at 20 stations during *ST0898*. A method to determine gut passage time in appendicularian has been developed, and accepted for publication in Marine Ecology - Progress Series ("Gut throughput dynamics in the appendicularian *Oikopleura dioica*"). Four experiments to determine respiration and excretion rates and five experiments to estimate egg production were carried out in *ST0898* (19 UOV).

Task II.11 Suspended and sedimenting marine and terrestrial matter

II.11.1 *Sediment Trap Moorings: Speciation, Deployment and Sampling*
Instrument deployments in two moorings IM 2 and IM 3 were carried out according to schedule. The mooring work is considered an overall success as, together with current meter and transmissiometer data, a time-series of altogether 140 sediment trap samples was obtained, each integrating over a period of 10 to 14 days. The sampled period covers the period July 1997 - January 1999, with an intermediate recovery/ redeployment in March 1998 and a final retrieval, both under challenging weather and sea conditions (17 IfM). Problems arose with mooring IM 2 during the second deployment period and with instrument failures due to corrosion and electronic malfunctions.
A) Mooring problems: a fishing vessel recovered the upper half of mooring IM 2 in autumn 1998. Following negotiations, the instruments (1 current meter, 1 Stand Alone Pump, 1 sediment trap) were handed over to IfM and a valuable set of samples could thus be saved. The bottom-most half of IM 2 (1 current meter, 1 SAP, 1 sediment trap) could not be recovered and must be considered lost at sea.

B) Moored instrument performance:
- 3 SAP´s had been deployed in moorings in March 1998 only, i.e. later than planned and for the second period only. Late delivery by the company and need for *in situ* testing necessitated this delay. We have to state, however, that no samples could be obtained from this operation due to the following reasons: SAP No 1 was lost at sea (in bottom half of IM 2). No 2 (in upper half of IM 2, retrieved by fishing vessel) had functioned. Essential protocol data could not be retrieved, however, as rough handling had had a fatal impact on the SAP 2 electronics and housing. No data come from SAP 2 as filter holders, furthermore, had not resisted this treatment and leakage is assumed to have led to unquantifiable losses of collected materials. SAP No 3 in mooring IM 3 was safely retrieved, but had stalled due to malfunctioning of the electricity supply. Circumstances with all SAP operations clearly were not blessed.
-corrosion problems led to malfunctions of two current meters and 2 sediment traps. Thus, no data could be gathered from mooring IM 3 below 1100 m, and the second time series from IM 2 is restricted to the 600-m depth horizon.

Splits from the first time-series trap samples were distributed to OMEX partners, and data from various elemental analyses were presented on the OMEX workshop in Plymouth, UK. Treatment of the second deployment period is almost completed and splits will be distributed in the coming weeks according to schedule (17 IfM).

II.11.2 *Seasonal Vertical Fluxes from Biogeochemical and Morphometric Analyses of Suspended and Sediment Trap Material*
The necessary hard-shelled plankton data are being collected as described in II.8.1 and II.10.1. Comparisons will be made with sediment trap material when this has been processed by IfM (12 SAHFOS). Trap sample analyses are proceeding according to schedule. Samples from the first mooring period July 1997 - March 1998 are processed, sub-samples were distributed to OMEX partners, and bulk variable analyses (mass flux, POC, PON, Opal, Carbonate) are completed. Results were presented on Posters and in discussions on the OMEX II-II Annual Workshop in Plymouth in April 1999. Time-consuming microscopic counting of hard-shelled organisms and fecal pellets are well underway. Swimmer sorting and splitting of samples from the second period (March 1998 - January 1999) moored sediment traps is almost completed and respective analyses of bulk variables have been started in parallel and will be completed in the coming weeks. Results will be available and delivered on schedule (17 IfM). Trap samples were received from IfM for the period from June 97 to February 98 and have been analysed for major, minor and trace elements (01b ULB-b). Radionuclide measurements, by direct gamma spectrometry, on sediment trap samples received from IfM, are on course (27 CFR).

Task II.12 Remote sensing and biogeochemical algorithms

II.12.1 *Archived and Real-Time Remote Sensed Data*
Undertook near-real time support of cruises *M43/2* and *OMEX99* using SST and front imagery. Presented all cruise data and daily AVHRR and SeaWiFS data on web site (09 NSS).

II.12.2 *Algorithm development and validation*
Developed remote sensing algorithms for total production and Chl *a* pigments; awaiting ^{15}N data for new production algorithm, and investigation of pCO_2 algorithms proceeding as expected. Significant additional task resulting from the participation of Dr Tim Smyth on *BG9815* was the use of *in situ* optical radiance measurements to validate pigment algorithms and calibrate SeaWiFS sensor (09 NSS). Surface mapping of pCO_2 was accomplished during five cruises, (*BG9714*, *CD110B*, *BG9815*, *CD114A* and *B* and *M43/2*). The last cruise is planned on the *Belgica* in late August 1999. Data is processed and banked at BODC. The analysis of underway chlorophyll samples is complete and data banked at BODC. Data and ideas were exchanged with PML (22 ULg). Algorithm development is on schedule (04c PML-c). Primary production data from the OMEX area have been delivered to BODC (13 IIM). One of the objectives within this Task is to calculate nitrogen flux rates and *f*-ratio with uncertainties from the results of ^{15}N tracer experiments obtained during *BG9714* and *BG9815*. This has been achieved through numerical modelling and focused on the statistical propagation of errors (systematic and random errors).

The numerical model describes nitrogen cycling during ^{15}N tracer experiments through aggregated chemical (nitrogen pools) and biological compartments (plankton). It includes the Monte-Carlo simulation technique, which is more accurate than linearisation methods especially when the distribution function of the response variable is too complicated to be analytically calculated. The output of this model provides confidence limits for N-flux rates and *f*-ratio at a specified level of significance and is used to refine empirical relationships between *f*-ratio and nutrient concentrations. These empirical relationships are based on non-linear regression models for which the search for good parameterisation has a purposeful basis. The goal of reparameterisation is to obtain close-to-linear model since the latter has many advantages, i.e. it provides almost unbiased, normally distributed and minimum variance estimators, and the confidence intervals for each parameter are close to being exact. Results of the uptake and inhibition kinetics (**Task II.8**) are currently being used to refine empirical models for the Iberian margin zone (23 VUB).