Primary, new and size fractionated primary production

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WP1 Task 1.3 Nutrient Dynamics, Primary Production, Biomass and Phytoplankton

As a preliminary to the WP1 cruise in August 1998, samples for nutrients have been taken for an intercalibration with other WP 1 partners (*c.f.* results in WP4 report).

Cruise planning meetings were held in November 1997 (Paris) and April 1998 (Lisbon) and the following detailed plans were made for the cruise which will be lead by PML-a (Leg 1) and PML-c (Leg 2).

WP1 Cruise Outline for *RRS Charles Darwin* cruise 114

The dates of the cruise are 29 July to 24 August. The ship will sail from the UK on 29 July and people and equipment will join the ship by boat transfer in the Ria of Vigo; there will also be a mid-cruise exchange of personnel. The groups which will participate on each leg of the cruise are shown in the table below.

The cruise will investigate two regions. On Leg 1, the sampling will concentrate on the shelf in the vicinity of an upwelling. On Leg 2, sampling will target a filament and measurements will be made as the filament moves off shelf. In both experiments, extensive use will be made of satellite images which will be processed at the PML and transmitted to the ship. AVHRR sensors will provide temperature images up to 4 times daily and SeaWiFS should provide an image of chlorophyll distribution at about daily intervals. In addition, during Leg 1, sampling by the OMEX Work Package 2 cruise (Dr Antonio Bode Chief Scientist) will produce data over a wider spatial scale. Close contact will be maintained between the two ships. When the ships are sampling in the same area, samples will be exchanged for an intercalibration of temperature, salinity, phytoplankton pigments, DOC and phytoplankton production

Leg 1 – Shelf Experiment
The aim of the experiment is to measure changes in biological activity in shelf waters in response to upwelling of nutrient-rich waters from the deep ocean onto the shelf. A particular emphasis of this experiment will be the measurement of phytoplankton processes, but measurements will also be made of microzooplankton, mesozooplankton and bacteria. In addition, analyses will be done or samples taken for phytoplankton pigments, dissolved organic carbon, dissolved CO_2 and carbonate.

The experimental design will involve the release of an Argos drifting buoy on the shelf which will then be followed for 2-3 days. Water and plankton samples will be taken throughout the day and night to measure changes in plankton biomass and activity. In addition, there will be repeat measurements of the physical structure of the water column using CTDs and ADCP on a small grid of stations round the Argos buoy. Turbulence measurements will be made with the turbulence probe FLY. The daily timetable of sampling activities is shown in Table 2.

It will probably not be possible to follow the buoy for more than 2 to 3 days since it will either drift off the shelf or will be close to the shore. The buoy will, therefore, be recovered and returned to the original station position. One day will then be spent in sampling over a tidal cycle at the original station position; this will provide information on the spatial distribution of plankton and of the physical structure on the shelf..

After sampling this transect for one day, the Argos buoy will be redeployed and the experimental cycle will continue with another 2-3 days following an Argos buoy, with a lateral survey after 3 days. This cycle could be done 3 times during Leg 1. At the end of Leg 1, there will be a

change of personnel (by boat transfer in the Ria of Vigo so maximising the time spent at sea during the cruise).

Leg 2 - Filament Experiment

The aim of the Filament Experiment is to track a body of water as it is transported away from the shelf in a filament (*N.B.* filaments usually form every few weeks when there is strong upwelling but the presence of a filament cannot be guaranteed during Leg 2. In this case, the objectives of the cruise will change in response to the conditions prevailing and the study will focus on either an upwelling or relaxation condition). The emphasis of this Leg of the cruise is on mesozooplankton grazing, but measurements will continue of all parameters measured on Leg 1.

The water mass will be marked with 4 or 5 Argos drifting buoys which will be deployed at the shelf break. Sampling will continue as the Argos buoys are followed over a 7-10 day period. The daily sampling schedule is shown in Table 3.

As in Leg 1, there will be small scale surveys around the Argos buoy using CTD and FLY which will last for about 3h each survey.

After 4 or 5 days, this routine sampling will be changed for one day when an intensive CTD and FLY survey will be done. As in Leg 1, the aim is to place the daily measurements into a better spatial context; therefore, a transect will be sampled across the main Argos drift. Sampling on the original schedule will be resumed on the day after the CTD/FLY transect. At the end of the experimental period, the Argos buoys will be recovered and there will be a boat transfer of personnel and equipment in the Ria of Vigo.

STABLE deployment

On passage from the UK, before the beginning of Leg 1, STABLE will be deployed as the ship crosses the Iberian shelf. At the end of Leg 2, after the exchange of personnel and equipment, the ship will recover STABLE on passage from Vigo to the UK.

Work Package 2 – Spatial and Seasonal Fluxes and Biogeochemical Processes in the Water Column

Introduction

In the OMEX 1 study of the Celtic Sea Shelf Break, the annual contribution of different size fractions of phytoplankton to annual production was assessed (Joint *et al*., 1998). Microphytoplankton and small nanophytoplankton (<5µm) were most productive during the spring bloom in April and May, when nitrate was the major nitrogen source for the phytoplankton and measured new production rates were high, with F-ratios >0.7 (Elskens *et al.* 1998: Rees *et al.* 1998).

The Iberian Shelf Break – the site for the OMEX II study - is interesting for a number of reasons; for phytoplankton, the supply of nutrients from deep water by wind-driven upwelling events gives the greatest contrast with the Celtic Sea. The objectives of the PML-c group are to assess the relative contribution of phytoplankton cells of different size to primary production, to measure how much of this production is due to the utilisation of nitrate (new production) and how much is due to ammonium assimilation (regenerated production), and to develop an understanding of the seasonal variation in primary and new production at the Iberian Shelf Break.

Primary and new production were measured on 2 cruises during the period of this report. The first cruise (*RRS Charles Darwin* cruise 105) was from 9-22 June 1997, shortly after the beginning of the OMEX II project; this cruise was expected to provide data from the period immediately preceding the seasonal upwelling and possibly to experience an upwelling event. The second cruise (*FS Poseidon*

cruise 237) was from 26 February to 16 March 1998, and was expected to sample winter and, possibly, early spring conditions.

Methods

Primary production determinations

Water samples were taken before dawn from 6 to 9 depths and transferred to 60ml acid-washed polycarbonate bottles (prepared to JGOFS standards to minimise metal contamination). Each bottle was inoculated with 370kBq (10µ Ci) $Na^{14}HCO_3$, (Amersham International plc, UK); 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. Primary production was determined by either *in situ* or on-deck incubations; the preferred method was *in situ* incubation, but this was not always compatible with other activities on the ship.

On-deck incubations involved placing the 60ml bottles in acrylic tubes which had surface sea water pumped through to maintain ambient temperature. Irradiance profiles were simulated by covering tubes with neutral density acrylic of differing transmission to give irradiances of 97%, 75%, 36%, 21%, 6% and 1% of surface values. To prevent any effect of ship's lights at night, the samples in the deck incubator were transferred at dusk to a black tube, also cooled with surface sea water. This system has been used on a number of programmes and gives reliable results (Joint and Pomroy, 1993: Joint *et al*., 1993) with no statistical difference between the data obtained by on-deck or *in situ* incubations. The samples were incubated for 24h *in situ* and filtered sequentially through different pore-size track-etched polycarbonate filters in a cascade filtration apparatus (Joint and Pomroy, 1983); routinely the size fractions used were 5, 2 and 0.2µm. After filtration, samples were dried, and counted in an LKB Rackbeta 1219, liquid scintillation counter; the efficiency of counting was determined with an external standard, channels ratio method.

Nitrogen assimilation.

Assimilation rates for nitrate and ammonium were determined following inoculation of a seawater sample with the stable isotope ^{15}N. Replicate samples from each depth were distributed into clear 500ml polycarbonate bottles and $^{15}NO_3$ and $^{15}NH_4$ were added. The concentrations of added isotope were kept as low as practicable, generally <0.03µmol l^{-1}. After inoculation, the incubation was began before dawn; *in situ* samples were recovered at dusk and maintained at surface seawater temperature in the dark overnight. Incubations were terminated after 24h by filtration (< 40cm Hg vacuum) onto ashed Whatman GF/F filters, which were rinsed with filtered sea water and stored frozen until return to the laboratory. The filters were oven dried at 50°C before analysis. Atom% ^{15}N was measured by continuous flow nitrogen analysis-mass spectrometry (Europa Scientific Ltd., U.K.) using the techniques described by Barrie *et al*, (1989) and Owens and Rees (1989), and rates of assimilation calculated from the equations of Dugdale and Goering (1967).

Phosphate uptake

Measurements of phosphate uptake were made in winter/spring 1998, during the *Poseidon* 237 cruise. Phosphate assimilation was measured using ^{33}P. Uptake was measured on the same water samples as ^{14}C and ^{15}N uptake and the incubations were done in the same size bottles as, and under identical conditions to, the ^{14}C experiments. At the end of the experiment, the samples were filtered through 2 and 0.2µm pore size polycarbonate filters, which had been soaked in lithium chloride solution. Since phosphate is readily adsorbed onto surfaces and particles, it was necessary to wash the filters with dilute lithium chloride-phosphate buffer, using the method of Grillo and Gibson (1979). This method gives an estimate of phosphate which is incorporated into cellular material and not just adsorbed onto the surface of the cell or onto other detritus. The samples were dried and counted in a liquid scintillation counter.

Nutrient concentrations

Nutrient concentrations were measured on the *RRS Charles Darwin* (CD 105) cruise in June 1997, nitrate, nitrite, ammonia and phosphate were measured, with standard autoanalyser methods as described by Rees *et al* (1995).

Bacterial production

Bacterial production was determined from rates of incorporation of [methyl-^{3}H] thymidine and of L-[4,5-^{3}H] leucine (specific activities 79Ci mmol^{-1} and 171Ci mmol^{-1} respectively; Amersham International plc, U.K.

^{3}H-thymidine incorporation and ^{3}H-leucine incorporation experiments were done by the microcentrifuge technique of Smith and Azam (1992). Five replicate, 1.5ml aliquots from each depth sampled were transferred to sterile, microcentrifuge tubes and placed in an incubator in the dark, at *in situ* temperatures. Glutaraldehyde was added to one replicate sample from each depth at a final concentration 2.5% v/v to act as controls. ^{3}H-thymidine or ^{3}H-leucine was added to each tube to give final concentrations of 5 and 10nmol l^{-1} respectively. The samples were routinely incubated for 1h but time-course assays showed that incorporation was linear for 2h and frequently longer.

At the end of the incubation, samples were transferred to an ice/water bath and ice-cold TCA added to give a final concentration of 5% v/v. The samples were left in the water bath for 15-30 minutes and centrifuged for 10min, washed with 5% TCA and re-centrifuged. Whole centrifuge tubes were counted in a LKB, Rackbeta 1219, liquid scintillation counter. Counting efficiency was determined by an external standard, channels ratio method and checked by the occasional addition of internal standards.

Bacterial numbers

Samples for the enumeration of bacteria were fixed with 2.5% v/v electron microscope grade glutaraldehyde (filtered through 0.2µm pore size filters before use), stained immediately with DAPI (4'6-diamidino-2-phenylindole) as described by Porter and Feig (1980) and filtered. Samples were either examined immediately or stored frozen at -20°C until return to the laboratory. Fluorescent-stained bacteria were counted with an epifluorescence microscope by the method of Hobbie *et al.* (1977). The microscope used was a Leitz Ortholux II equipped with 50W HBO light source, Ploempak 2.2 fluorescence vertical illuminator with filter block A, and an NPL Fluorotar 100/1.32 oil objective lens.

Results

June 1997

The production of 3 size fractions (>5µm, 5-2µm and 2µm), measured at each station during cruise CD105, is shown in Fig. 1; the data are plotted as bars to aid comparison between stations. The lowest overall rate of carbon fixation was measured at the most southerly station on transect "V". Throughout the region, the highest rates of production were consistently found in the smallest (<2µm) size fraction. There was no clear indication that primary production was enhanced at the shelf edge or on the shelf.

Most of the nitrogen requirement of the phytoplankton was met by ammonium assimilation. Fig. 2 shows that nitrate accounted for the minor proportion of nitrogen assimilation at all stations. Therefore, in June 1997, regeneration processes were dominant. There was no evidence of upwelling of cooler nutrient rich water and nitrate concentrations in the surface mixed layer were very low, below the limit of detection of the autoanalyser methods. The low ambient nitrate concentration is consistent with the low rates of nitrate assimilation. This period is characteristic of the pre-upwelling season, with low nitrate concentrations, low phytoplankton biomass and primary production dependent on ammonium regeneration.

February/March 1998

During this cruise, nutrient concentrations were much lower than expected. There was a strong pole-ward current bringing nutrient poor waters along the Iberian shelf. Primary production rates were lower than measured in June 1997 (Fig. 3). At some stations, principally inshore on transects "P" and

"S", the largest phytoplankton fraction (>5µm) accounted for most of the primary production, but at most stations, picophytoplankton (<2µm) was most active.

^{15}N samples have not yet been fully analysed but will indicate the relative importance of nitrate and ammonium to phytoplankton production at this time of year. The results should be available by the end of June 1998. Phosphate assimilation was also measured on this cruise and the spatial variation in uptake rate is plotted in Fig. 4. As with the primary production data, there is little variation with geographical position; the data will be analysed further when the ^{15}N samples are available at the end of June.

Nitrification measurements
Preliminary experiments were done to assess the rate of potential nitrification (ammonium oxidation) during cruise CD105 in June 1997; measurements were made using the inhibition of autotrophic ^{14}C fixation by the nitrification inhibitor ATU (allyl thiourea). Table 4 compares the rates of nitrate uptake by phytoplankton, the nitrification rate and the ambient nitrate concentration. These results are very preliminary but seem to indicate the potential for significant nitrification in these water; however, the rates appear to be very high and would result in an accumulation of nitrate in the surface water which is not observed. Other experiments were done to measure changes in nitrate and ammonium concentration in incubated water samples but the data analysis is not yet completed. When available, these data well help to gauge the significance of the ATU incubations.

Bacterial Production
Table 5 shows the rates of thymidine and leucine incorporation measured on CD105 and Poseidon cruise 237. Bacterial activity in February/March was as high as in June 1997 and at some stations significantly higher. These data will now be compared with primary production measurements to scale the significance of bacterial production in summer and winter at the Iberian Shelf Break.

Work Package 4 – Integrated Margin Exchange Product
Task IV.3 Nutrients, trophodynamics and fertility (Partners PML-*c* , ULB and IIM)

Two nutrient intercalibration exercises have taken place. The first intercalibration took place in June 1997 and the data have been fully worked up; the second was in January 1998 and some data are still preliminary and will be worked up in the coming months.

June 1997
During the OMEX II cruise on *RRS Charles Darwin* (CD105), water samples were taken at three stations in water depths of 90m, 200m and 2250m and distributed to partners from the Plymouth Marine Laboratory (PML), the Université Libre de Bruxelles (ULB), the Vrije Universiteit Brussel (VUB) and the Instituto de Investigaçiones Marias (IIM). The depths sampled were 10. 20, 30, 40, 50 and 70m at station S90 (90m water depth), 10, 20, 40, 60, 80, 100, 120, 200m at station S200 and 10, 20, 50, 100, 200, 500, 750, 1000, 1250 and 1500m at station S2250. The water samples were filtered and frozen for subsequent analysis by PML, ULB, VUB and IIM. In addition, the PML analysed another replicate set of samples immediately, *i.e.* without freezing and storage.

A second intercalibration exercise was done when the *RRS Charles Darwin* and the *RV Belgica* met on 20 June 1997. In this case, CTD casts were done by each ship and water samples were taken from 12 depths. Replicate samples were exchanged between the 2 ships and either analysed immediately or stored frozen for subsequent analysis.

Comparison of nitrate, ammonium, phosphate and silicate concentrations measured by the PML and IIM
Fig. 5 shows the data on nitrate concentrations determined by the PML and IIM for the first intercalibration exercise. There is excellent agreement between the nitrate measurements made by the PML on unfrozen samples and by the IIM on frozen and stored samples.

The comparison of phosphate determinations is slightly more variable but still shows good agreement between the two determinations (Fig. 6). Over most of the phosphate concentration range there is comparability but there is some divergence in the measurements at highest concentrations.

The silicate analyses showed the value of intercalibration exercises. When the silicate values analysed at sea were first compared with the IIM values, the PML values were significantly less than the IIM values. When the PML frozen samples were analysed, an error was discovered in the at sea calculations and the PML values have now been corrected. However, there continue to be differences between silicate in fresh and frozen samples (Fig.7 and 8).

Table 6 summarises the intercalibration between the PML and the IIM. A regression of the nitrate concentrations determined by the two laboratories shows almost perfect agreement with a slope of 1.04 for the fitted line, an intercept of zero and an R^2 value of 1.00. The phosphate intercalibration is also good with R^2 of 0.85. However, the slope is no longer unity and the IIM estimates are higher than those of the PML. The R^2 value for the silicate determinations suggests that the precision of both laboratories is good for both fresh and frozen samples – the regressions yield a straight lines with R^2 value of 0.98 – but there is a problem with accuracy; that is, the relative changes in silicate concentration are well described by both laboratories but there is doubt about the absolute value of silicate concentration. Finally, the analysis of ammonium shows wide variations with the IIM estimates being higher than the PML estimates. However, in the case of ammonium, both precision and accuracy are suspect. This may be a consequence of storage of samples or of contamination on board ship, which is a recognised problem in ammonium determinations.

Comparison of nitrate, phosphate and silicate concentrations measured by the PML, VUB and ULB
The second intercalibration involved exchange of samples between the 2 ships (Table 7). All data have now been worked up and intercalibrations are shown for nitrate (Fig. 9), phosphate (Fig. 10) and silicate (Fig. 11).

There is excellent agreement between the phosphate measurements made by the ULB and the PML. The slope of the fitted line is 1.09, the intercept is –0.01 and the R^2 is 0.99. That is, precision and accuracy are both excellent in these measurements. Although both nitrate and silicate also show a perfect linear trend with R^2 value of 1.00, the slope is not unity and the PML estimates are less than those obtained by ULB.

January 1998

The data from the intercalibration exercise in January 1998 have not all been analysed. However Fig. 12 shows a comparison of nitrate measured by IIM on the cruise and by PML on frozen samples. Again there is good precision with an R^2 value of 1.0 but the slope of the fitted line is 1.10, indicating that the PML analysis of frozen samples is giving higher values than the IIM analysis of fresh samples. In fact, although the PML values at high nitrate concentrations are higher than those of IIM, in the near surface water, IIM find nitrate concentrations of 1.2µmol l^{-1} and the PML analysis is 0.23 µmol l^{-1}.This requires further investigation and any discrepancies may be obvious when the VUB data are analysed.

Conclusions

Both intercalibration exercises in OMEX II excellent agreement in nitrate determinations made by the PML and the IIM; phosphate and silicate determinations are also good. There appear to be no problems in precision of any of the determinations but accuracy could be improved. The ammonium determinations show wide variation between the PML and the IIM and will require further analysis at sea on fresh samples to resolve the observed differences.

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Table 1. Cruise participation

Leg 1			**Leg 2**		
Institution	**PI**	**Berths**	**Institution**	**PI**	**Berths**
PML-a	Stuart Gibb (Chief Scientist)	1	PML-c	Ian Joint (Chief Scientist)	1
UITØ-a	Paul Wassmann	1	UITØ-a	Paul Wassmann	2
UITØ-b	Kurt Tande	1	UITØ-b	Kurt Tande	2
PML-b	Peter Burkill	1	PML-b	Peter Burkill	1
PML-c	Ian Joint	2	PML-c	Ian Joint	2
UWB-a	Toby Sherwin	2	UWB-a	Toby Sherwin	2
UWB-b	Des Barton	1	UWB-b	Des Barton	1
IIM	Paco Figueiras	3	SAHFOS	Sonia Batten	1
UAL-a	Helena Galvao	1	UAL-a	Helena Galvao	1
Ulg	Michel Frankignoulle	1	Ulg	Michel Frankignoulle	1
	RVS Winch	1		RVS Winch	1
	RVS Winch	1		RVS Winch	1
	RVS Computing	1		RVS Computing	1
	RVS CTD Technician	1		RVS CTD Technician	1
Total		**18**	**Total**		**18**

Table 2 Sampling activities on each of the 2-3 days following an Argos drifting buoy on Leg 1 of the cruise.

Time	Duration (h)	Activity	Partners	Time	Duration (h)	Activity	
00.00	0.5	CTD/faecal	UiTO	12.00		FLY transect	
00.30	1	MOCNESS	UiTO	12.30	0.5	Apstein net	PML-b
01.00		MOCNESS		13.00	1	MOCNESS	UiTO
01.30				13.30		MOCNESS	
02.00				14.00	1	CTD/faecal	UiTO
02.30				14.30		CTD/spectro radiometer	IIM
03.00	0.5	GO-FLO	PML-b	15.00	3	FLY transect	UWB
03.30	1.5	CTD/rosette	PML-a/c, IIM. UAG	15.30		FLY transect	
04.00		CTD/rosette		16.00		FLY transect	
04.30		CTD/rosette		16.30		FLY transect	
05.00	1	Rig Deployment		17.00		FLY transect	
05.30		Rig Deployment		17.30		FLY transect	
06.00	1	MOCNESS	UiTO	18.00	1	MOCNESS	UiTO
06.30		MOCNESS		18.30		MOCNESS	
07.00				19.00			
07.30				19.30	1	Rig Recovery	PML-c
08.00				20.00		Rig Recovery	
08.30				20.30		FLY Possible	UWB
09.00	0.5	CTD/spectro radiometer	IIM	21.00		FLY Possible	
09.30	3	FLY transect	UWB	21.30		FLY Possible	
10.00		FLY transect		22.00		FLY Possible	
10.30		FLY transect		22.30		FLY Possible	
11.00		FLY transect		23.00		FLY Possible	
11.30		FLY transect		23.30			

Table 3 Sampling activities on each day following an Argos drifting buoy on Leg 2 of the cruise in the study of a filament.

Time	Duration (h)	Activity	Partners	Time	Duration (h)	Activity	
00.00	0.5	CTD/faecal	UiTO	12.00		FLY transect	
00.30	1	Plankton nets	UiTO	12.30	0.5	Apstein net	PML-b
01.00		Plankton nets		13.00	1	Plankton nets	UiTO
01.30				13.30		Plankton nets	
02.00				14.00	1	CTD/faecal	UiTO
02.30				14.30		CTD	PML-c
03.00	0.5	GO-FLO	PML-b	15.00	3	FLY transect	
03.30	1.5	CTD/rosette	PML-a/c, IIM. UAG	15.30		FLY transect	
04.00		CTD/rosette		16.00		FLY transect	
04.30		CTD/rosette		16.30		FLY transect	
05.00	1	Rig Deployment	PML-c	17.00		FLY transect	
05.30		Rig Deployment		17.30		FLY transect	
06.00	1	Plankton nets	UiTO	18.00	1	Plankton nets	UiTO
06.30		Plankton nets	SAHFOS	18.30		Plankton nets	UiTO
07.00				19.00			
07.30				19.30	1	Rig Recovery	
08.00				20.00		Rig Recovery	
08.30				20.30		FLY Possible	
09.00	0.5	CTD	PML-c	21.00		FLY Possible	
09.30	3	FLY transect	UWB	21.30		FLY Possible	
10.00		FLY transect		22.00		FLY Possible	
10.30		FLY transect		22.30		FLY Possible	
11.00		FLY transect		23.00		FLY Possible	
11.30		FLY transect		23.30			

This sampling will be done if ship works 24h

Table 4: Nitrification estimates, nitrate uptake and ambient nitrate concentrations

	Depth (m)	NO_3 uptake µmol l^{-1} d^{-1}	Nitrification µmol l^{-1} d^{-1}	Difference µmol l^{-1} d^{-1}	Ambient NO_3 µmol l^{-1}
N2000	10	0.087	-		0.05
	20	0.042	0.196	0.154	0.02
	60	0.055	0.123	0.068	0.22
	100				4.20
O140	10	0.028	-		0.00
	20	0.025	0.399	0.373	0.00
	50	0.011	0.377	0.366	0.02
	100	-	0.124		5.36
Q2500	10	0.041	-		0.01
	20	0.052	0.668	0.616	0.02
	60	0.272	0.285	0.013	0.29
	100	-	0.326		5.79
V2600	10	0.053	-		0.03
	45	0.044	0.753	0.708	0.03
	80	0.040	0.800	0.761	3.19
	120	-	0.129		5.49
U200	10	0.011	-		0.00
	35	0.319	1.258	0.939	0.30
	60	0.024	0.765	0.740	4.18
	100	-	0.857		4.29
R1000	10	0.017	-		0.00
	30	0.015	0.000	-0.015	0.00
	50	0.035	0.000	-0.035	0.01
	100	-	0.000		4.26
S600	10	0.009	-		0.00
	35	0.011	1.813	1.801	0.00
	60	0.007	0.954	0.947	0.00
	100	-	0.618		4.88
Q100	10	0.019	-		0.00
	20	-	-		0.00
	67	-	0.151		1.11

Table 5: Bacterial production estimated from ^{3}H thymidine and ^{3}H leucine incorporation

Charles Darwin 105

Date	Station	Lat (°N)	Long (°W)	Leucine pmol l^{-1} h^{-1}	Thymidine pmol l^{-1} h^{-1}
12/06/97	N2000	43	9.81	18.84	1.56
13/06/97	O140	42.83	9.4	98.01	2.82
14/06/97	Q2500	42.5	10.01	25.31	1.47
15/06/97	V2600	41.41	9.66	24.84	1.10
16/06/97	U200	41.8	9.29	33.00	2.22
18/06/97	R1000	42.34	9.5	64.89	5.51
19/06/97	S600	42.16	9.44	23.40	1.17

Poseidon 237

Date	Stn	Lat (°N)	Long (°W)	Leucine pmol l^{-1} h^{-1}	Thymidine pmol l^{-1} h^{-1}
28.02.98	P 002	42.61	10.02	18.27	1.27
01.03.98	P 005	42.63	9.72	212.42	9.33
02.03.98	P 008	42.67	9.21	121.19	25.80
03.03.98	P 017	42.67	9.50	52.52	8.94
05.03.98	S 025	42.16	9.05	90.25	4.25
06.03.98	N 037	42.00	9.52	48.97	3.29
07.03.98	N 044	42.00	10.01	36.49	1.67
08.03.98	S 051	42.70	9.65	49.83	2.43
09.03.98	S 058	42.15	9.47	38.97	1.60
10.03.98	S 067	42.15	10.30	22.65	1.31
11.03.98	P 071	42.65	9.70	63.39	3.32
12.03.98	Q 072	42.62	9.52	20.03	2.16
13.03.98	P 074	42.66	9.50	30.04	1.83

*Table 6. Comparison of nutrient concentrations measured by the PML and IIM**

	Slope	Y Intercept	R^2
Nitrate	1.04	0.00	1.00
Phosphate	0.85	0.01	0.92
Silicate[a]	0.70	-0.47	0.98
Silicate[b]	0.84	0.01	0.98
Ammonium	0.27	0.22	0.11

[a]PML measurements made immediately after sampling and IIM measurements made on frozen samples; [b]PML and IIM measurements both done on frozen samples.

*Table 7. Comparison of nutrient concentrations measured by the PML and ULB/VUB**

	Slope	Y Intercept	R^2
Nitrate	0.83	-0.01	1.00
Phosphate	1.09	-0.01	0.99
Silicate	0.72	-0.60	1.00

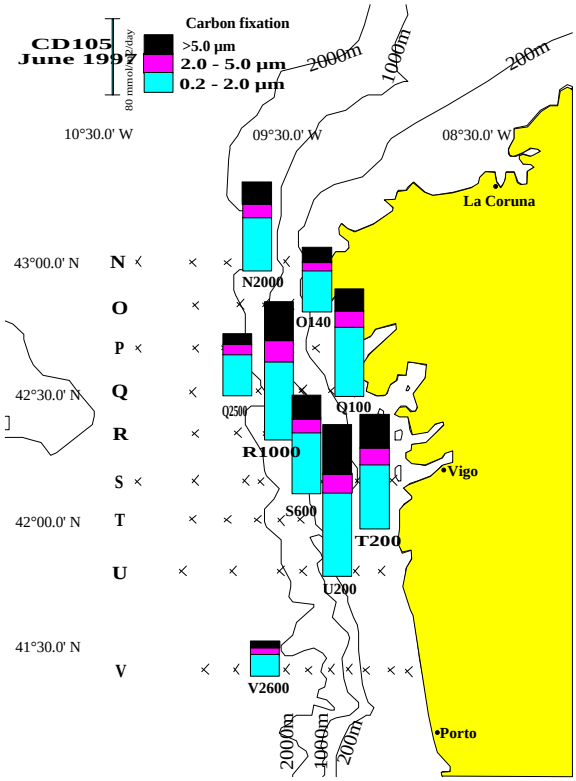

Fig 1 Size fractionated primary production during CD105 in June 1997

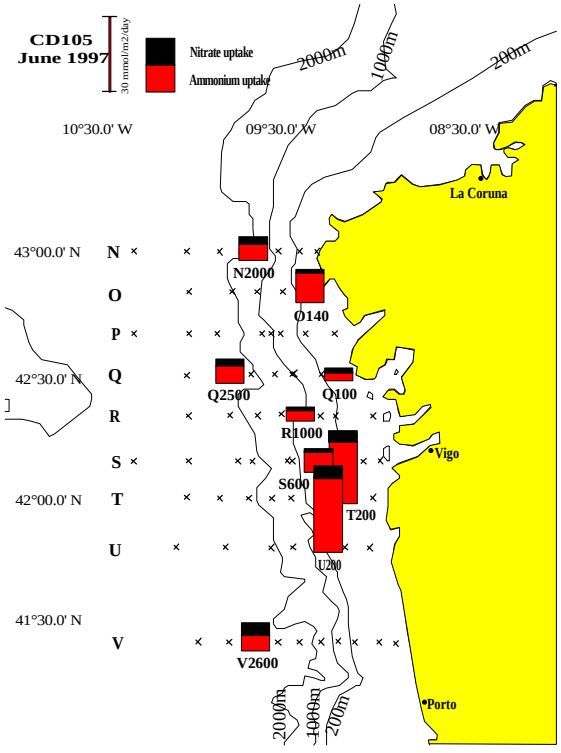

Fig 2 Assimilation of ^{15}N nitrate and ammonium during CD105

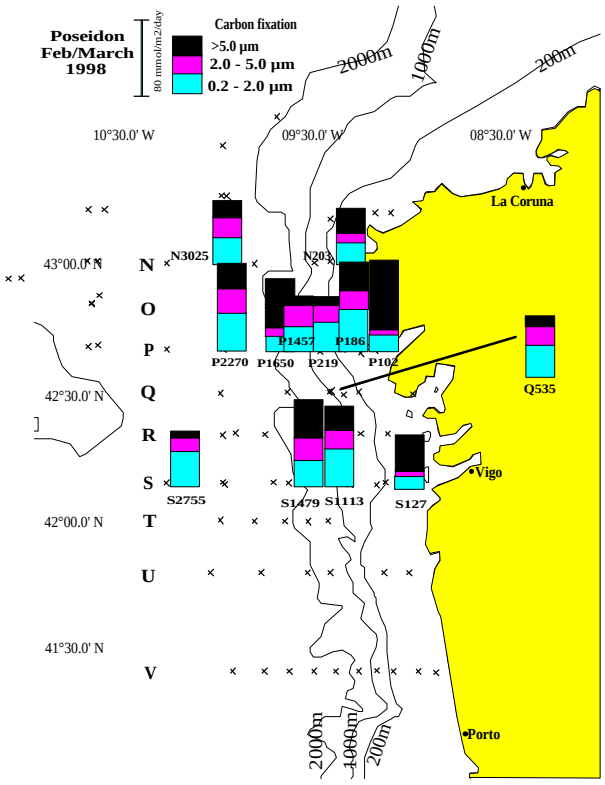

Fig 3 Size fractionated primary production during Poseidon 237 in February/March 1998

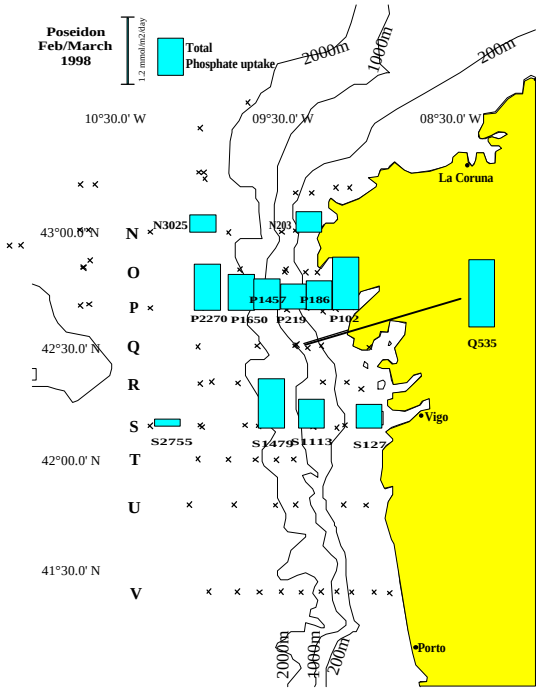

Fig 4 Assimilation of ^{33}P phosphate during Poseidon 237 in February/March 1998

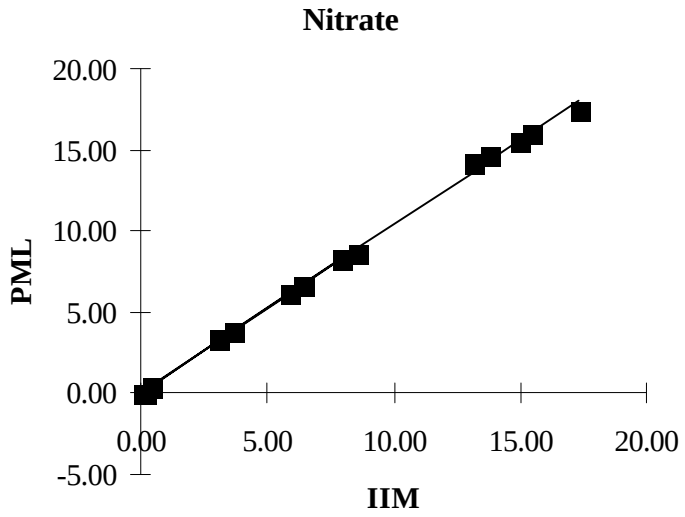

Fig. 5 Comparison of nitrate measurements made by PML and IIM

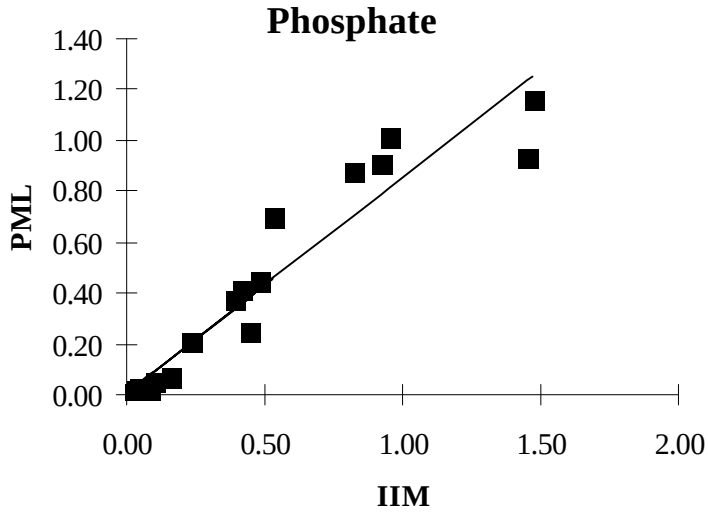

Fig. 6 Comparison of phosphate measurements made by PML and IIM

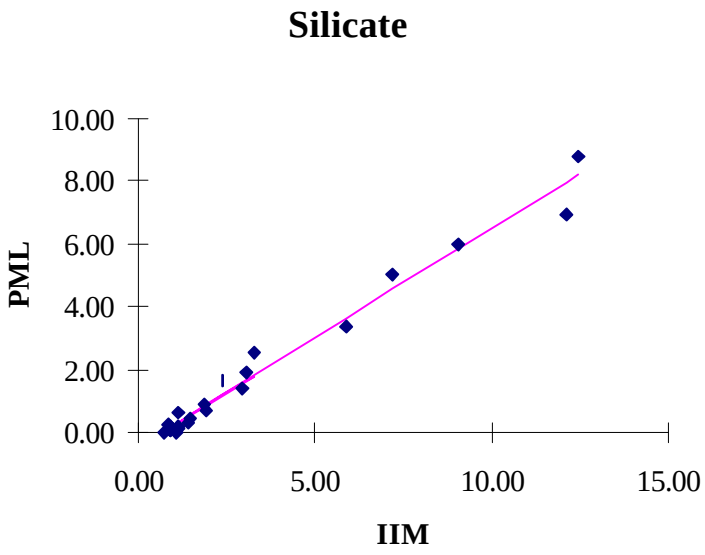

Fig. 7 Comparison of silicate concentrations measured on fresh samples by the PML and frozen samples by IIM

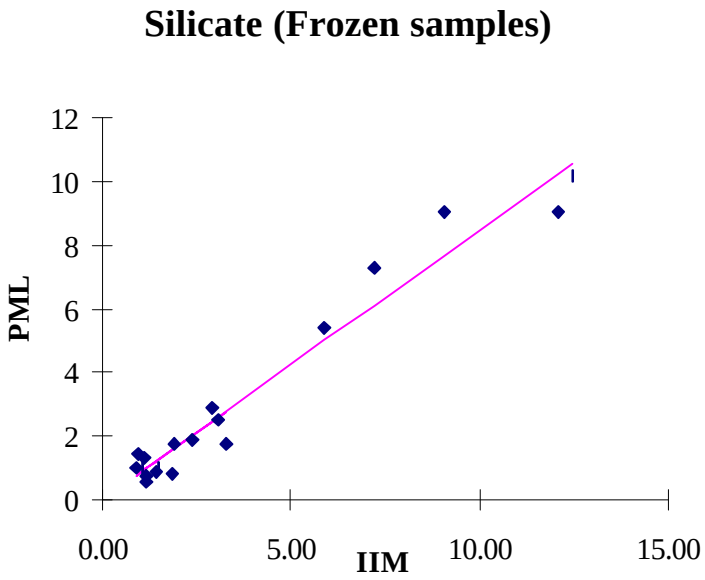

Fig. 8 Comparison of silicate concentrations measured on frozen samples by both the PML and IIM

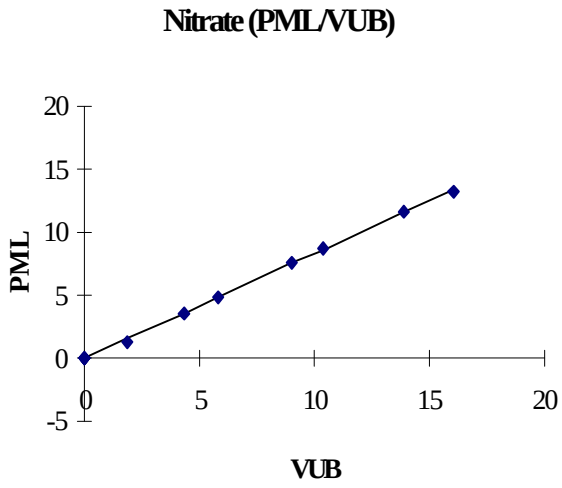

Fig. 9 Comparison of nitrate measurements made by PML and VUB

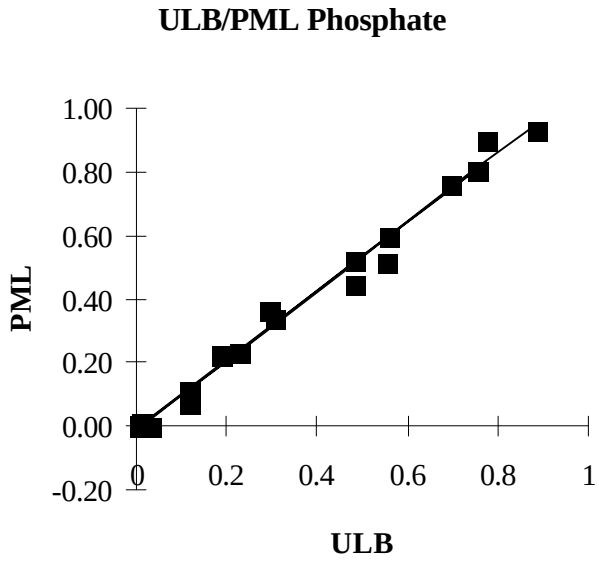

Fig. 10 Comparison of phosphate measurements

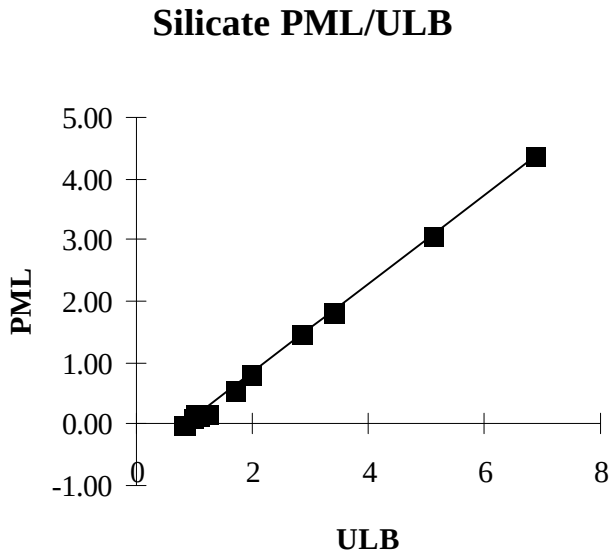

Fig.11 Comparison of silicate measurements

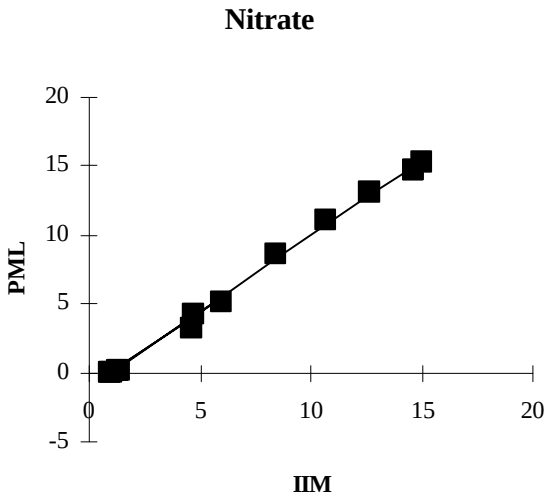

Fig. 12 Comparison of nitrate measurements made by PML and IIM