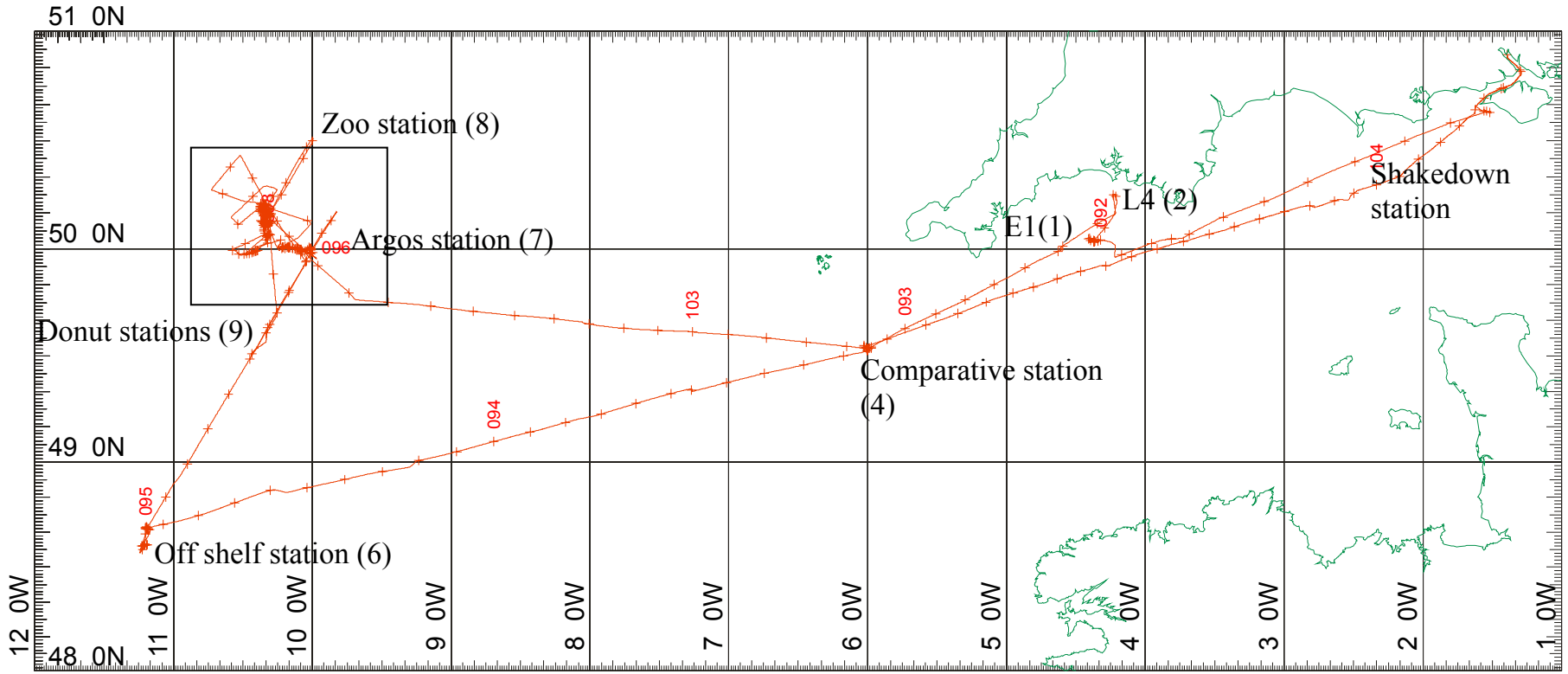
1.2 Cruise.track



MERCATOR PROJECTION

SCALE 1 TO 5000000 (NATURAL SCALE AT LAT. 0)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

GRID NO. 1

Track plotted from gps_g12

RRS Discovery cruise 261

4 Satellite imagery

Kate Evans-Jones and Pete Miller (PML)

SeaWiFS chlorophyll-a composite images for week one and week two of the cruise with the approximate position of the lagrangian drift station circled.

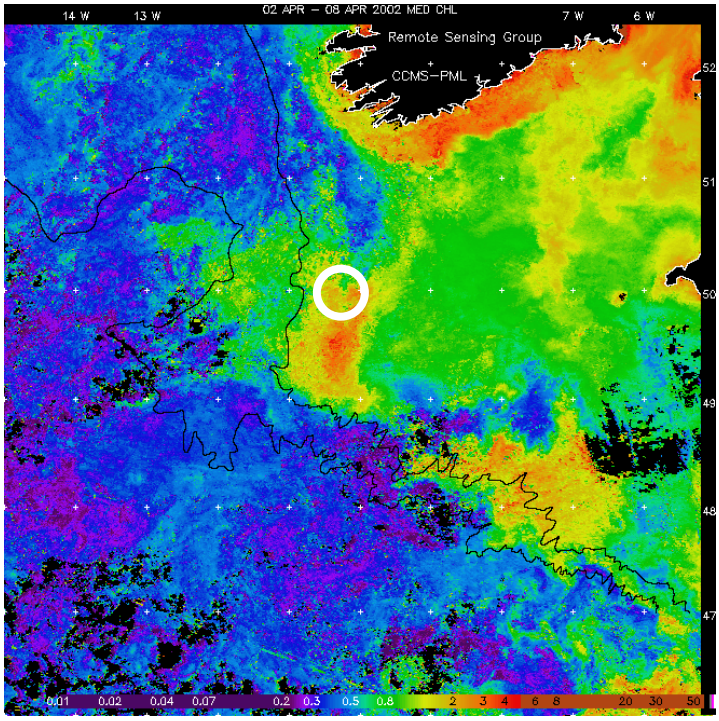


Fig 4.1 SeaWiFS chlorophyll-a composite ocean colour image for 02-08 April 2002

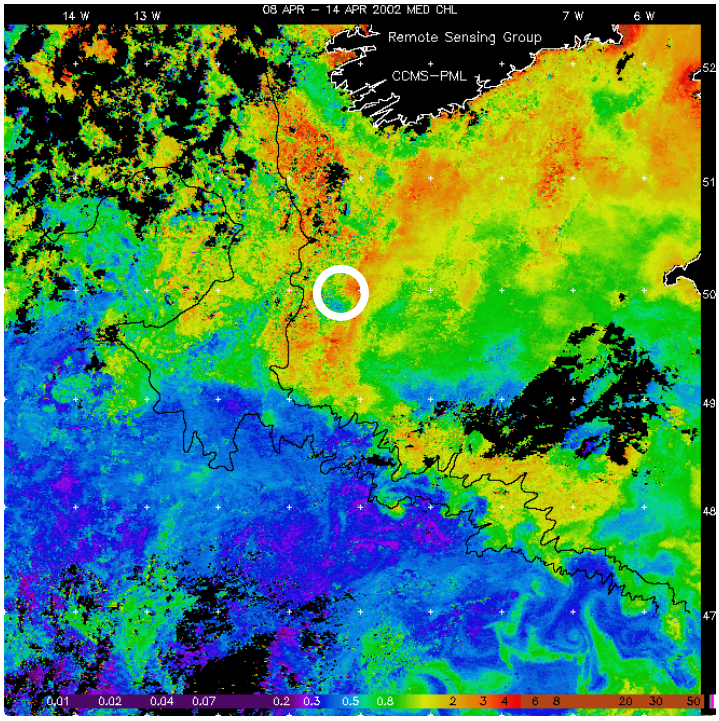


Fig 4.2 SeaWiFS chlorophyll-a composite ocean colour image for 08-14 April 2002

Further images used during the cruise can be found at
http://www.npm.ac.uk/rsdas/projects/mdb/d261_apr02/

NE Edge of Bloom:
$N0_3$ = 3.8uM
Si = 2uM
Fl =0.36v
Phyto = happy & healthy
Zoop = early stages

Centre of Bloom:
$N0_3$ = 1.5uM
Si = 0.5uM
Fl =0.72v
Phyto = unhappy & unhealthy, breakdown pigments - grazed
Zoop = more developed stages

SW Edge of Bloom:
$N0_3$ = 3.8uM
Si = 2uM
Fl =0.45v
Phyto = happy & healthy, few breakdown pigments
Zoop = early stages of nauplii

Off Shelf:
$N0_3$ = 7uM
Si = 5uM
Fl =0.12v
Pre-bloom

The other side of the Bloom:
$N0_3$ = 5uM
Si = 4uM
Fl =0.14v

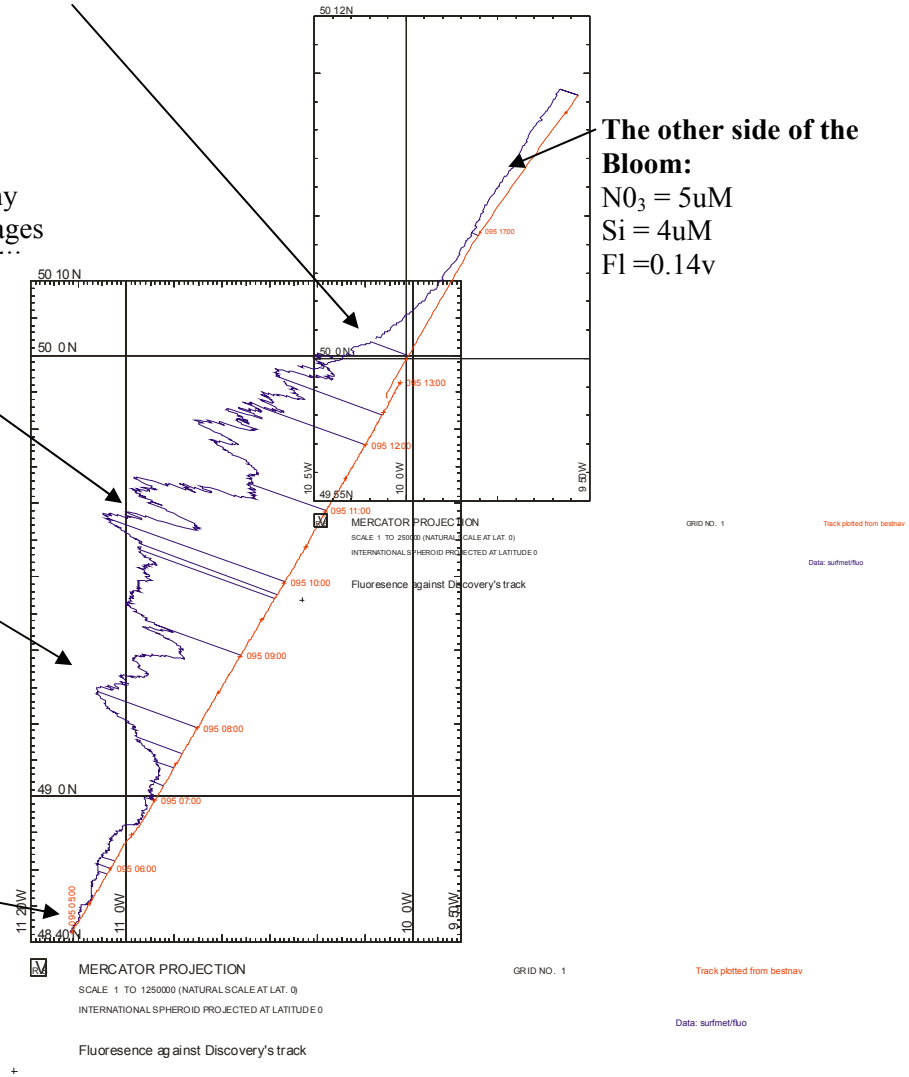


Fig 5.2.2. Underway fluorescence along cruise track from off shelf station through the spring bloom

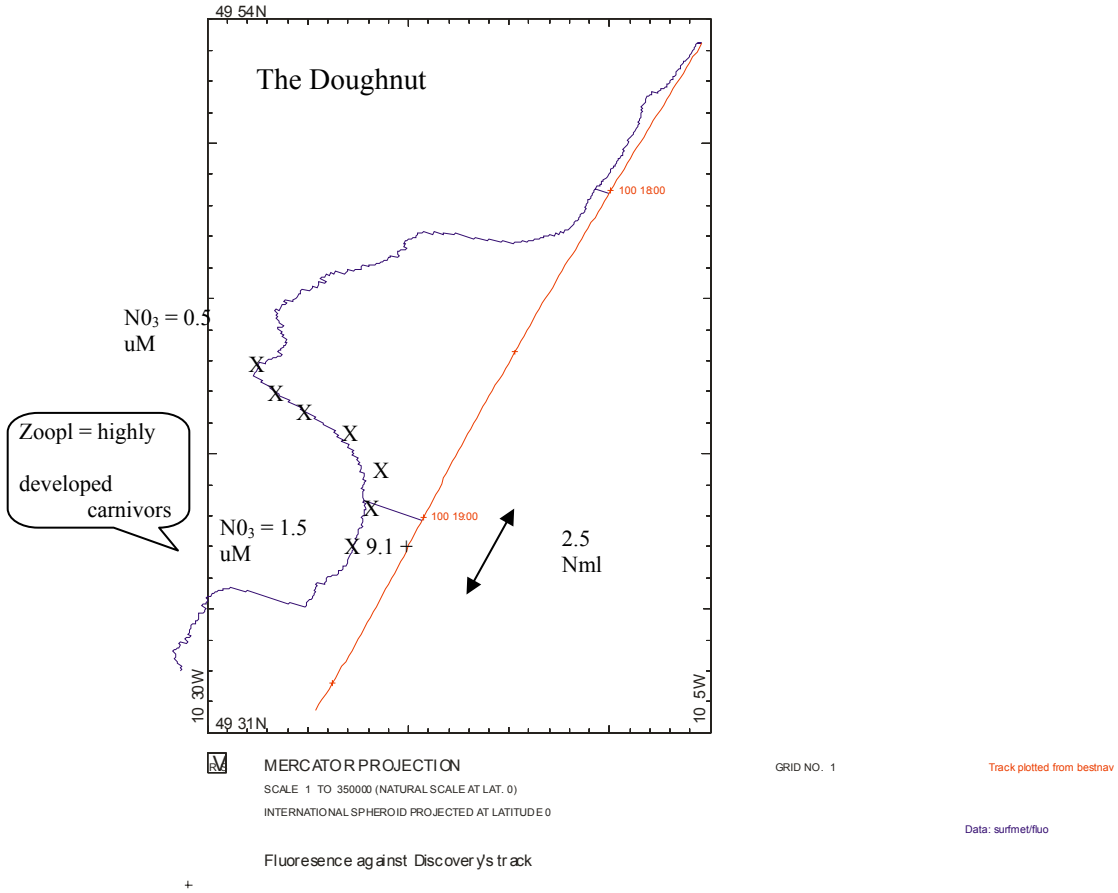


Fig 5.3.1. Underway fluorescence against cruise track during the Doughnut transect

Aspirator No. & vol	Station No.	Time BST	Lat (N) Long (W)	Fluor (v)	chl	HPLC	HaloC	ETS	Leuc	Lugols	Formalin	AFC	Nuts	Resp
97% 20L	9.1	2155	49°36.35 10°19.84	0.29	√	√	1	√	1	√	1408	13	1	√
20% 10L	9.2	2225	49°37.31 10°18.98	0.39	√	√	2		2	√	1409	14	2	
55% 20L	9.3	2230	49°37.67 10°18.63	0.429	√	√	3	√	3	√	1410	15	3	√
E-4 10L	9.4	2232	49°38.09 10°18.25	0.56	√	√	4		4	√	1411	16		
33% 20L	9.5	2234	49°38.33 10°18.04	0.61	√	√	5	√	7	√	1412	17	4	√
3% 10L	9.6	2236	49°38.61 10°17.77	0.64	√	√	6		6	√	1413	21		
1% 20L	9.7	2240	49°39.15 10°17.28	0.76	√	√	7	√	5	√	1414	18	5	√
					2l	4l	100ml	5l	25ml	250ml	250ml	150ml	60ml	3l

Table 5.3.1 Summary of samples taken during the Doughnut transect

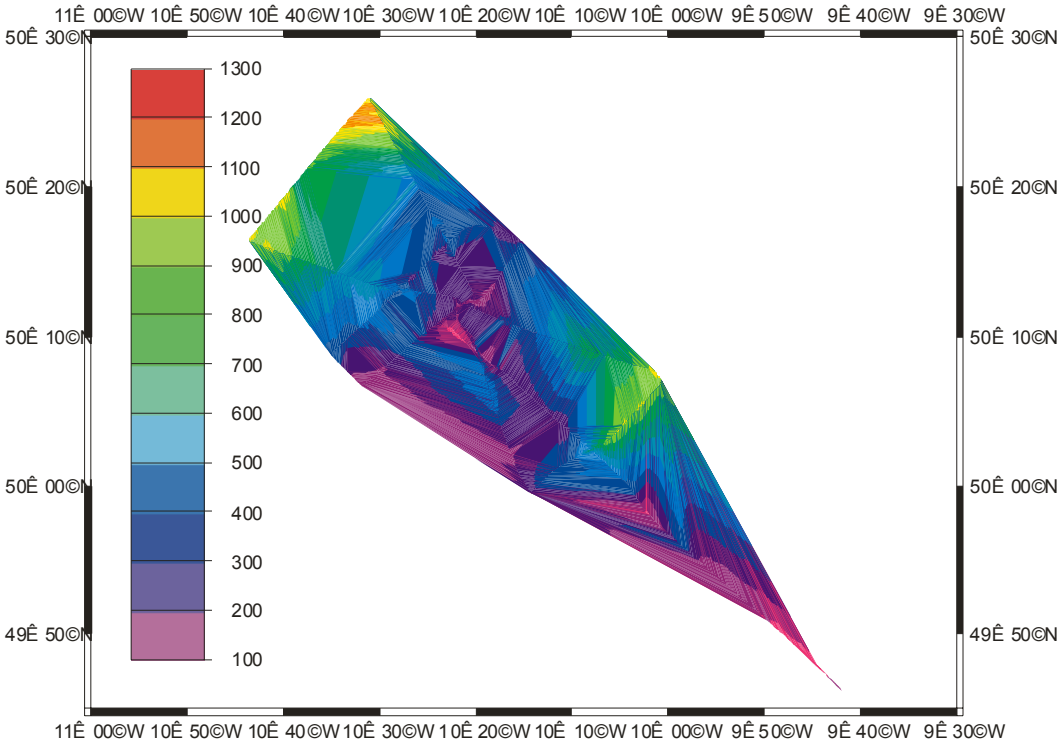
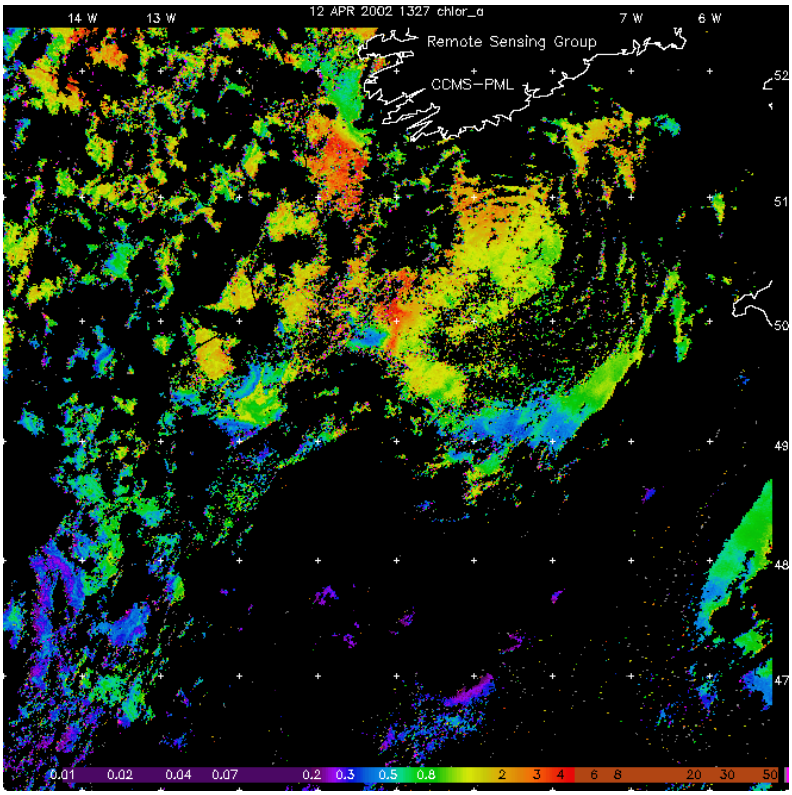


Fig 5.4.2. Contour plot of fluorescence in Lat/Long box of Bowtie and box survey



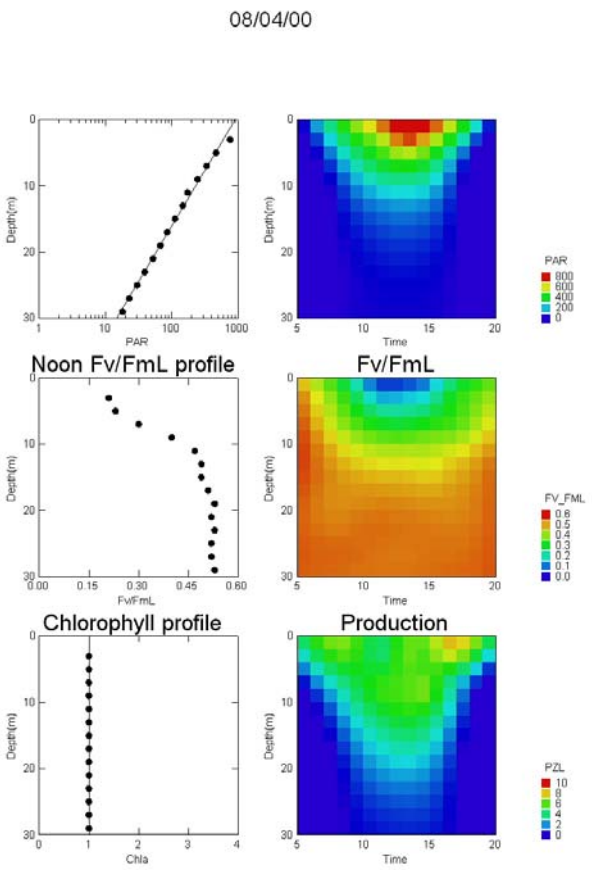


Figure 6.5.1: Top panels: Left; noon PAR profile, Right; temporal variation of PAR throughout the water column. Middle: Left; noon Fv/FmL profile, Right; temporal variation of Fv/FmL throughout the water column. Bottom: Left; vertical profile of chlorophyll (normalised to 1), Right; temporal variation of primary production throughout the water column.

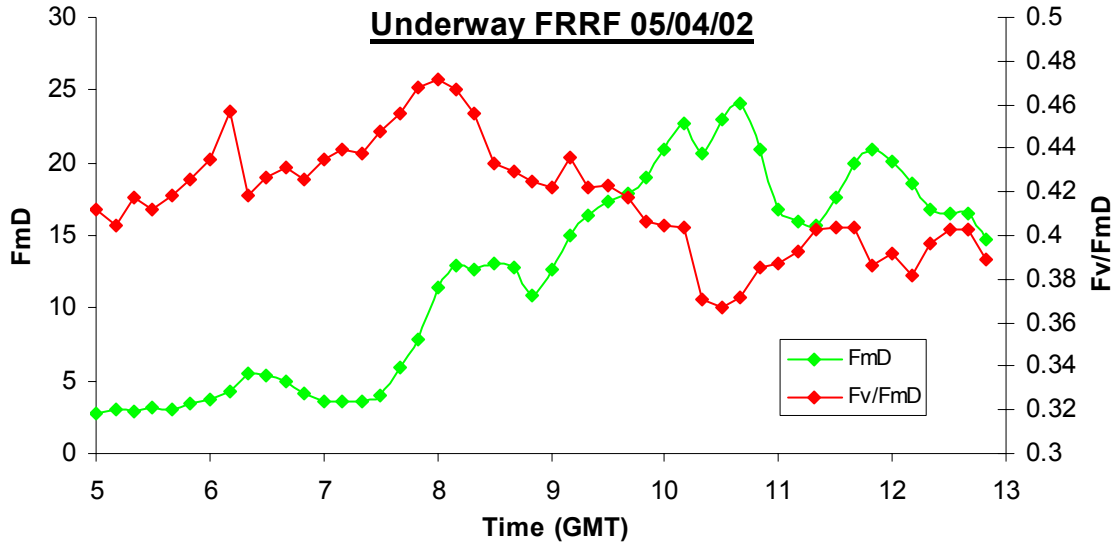


Figure 6.5.2: Underway transect taken using the FRRF across the centre of the bloom

A calibration was established for chlorophyll *a* HPLC measurements by serial dilution of a stock solution to three other concentrations. The concentration of the stock solution was measured, by UV/vis spectrophotometry, at 7.7 x 10^{-6} g L^{-1}. The stock solution and each of the dilutions were measured and a linear calibration was established over two orders of magnitude. Data for phaeopigments were calculated using a conversion factor from the extinction coefficient of chlorophyll *a* and will need to be re-evaluated post-cruise.

Duplicate samples were collected for more detailed examination of the pigment distributions in York and for analysis by liquid chromatography–mass spectrometry to confirm assignments and identify a greater range of components.

Preliminary Results

Water Samples

The water samples showed significant variation in chlorophyll concentration across the bloom (recorded in both transects – see Figure 6.6.1 for example) and with depth in the water column. Good correspondence to the fluorescence responses determined from the underway samples and from the CTD was apparent. The pigment distributions exhibited a high degree of similarity throughout the cruise, being dominated by chlorophyll *a* but with a substantial contribution from chlorophylls *c.* Changes in the relative proportions of chlorophyll to phaeopigments (phaeophytin *a* and pyrophaeophytin *a*) were apparent with the latter present in increased relative proportion as the bloom developed. Distinct changes with depth were also evident, particularly at the sampling stations later in the cruise. Further studies will attempt to establish if this change relates to grazing or senescence. Example depth profiles for three Stations are given in Figure 6.6.2.

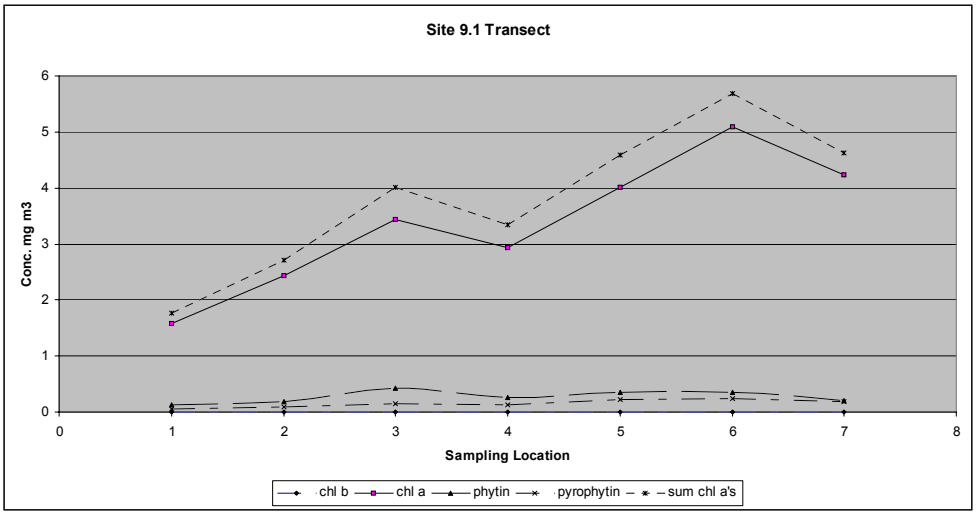


Figure 6.6.1: Pigment concentrations recorded from analysis of water samples collected from the non-toxic supply during the doughnut transect across the bloom.

The presence of oxidation products of chlorophylls was noted throughout the programme, with the greatest relative abundance being observed in the oligotrophic waters at Station 8.1. Detailed analysis by LC-MS is required to ascertain the identities of the derivatives and for the purposes of quantification. Throughout the duration of the monitoring programme there was no evidence for the presence of bacteriochlorophylls.

Plankton Concentrates

During the initial transect across the bloom that had been identified from the satellite images the pigments were analysed in the SW extent, the centre, and twice in the NE. The analysis showed the lowest chlorophyll levels in the centre of the bloom. The highest chlorophyll levels were present in the NE extent of the bloom, accompanied by high levels of phaeopigments. The phaeopigments are indicative either of active grazing of the phytoplankton or of senescence.

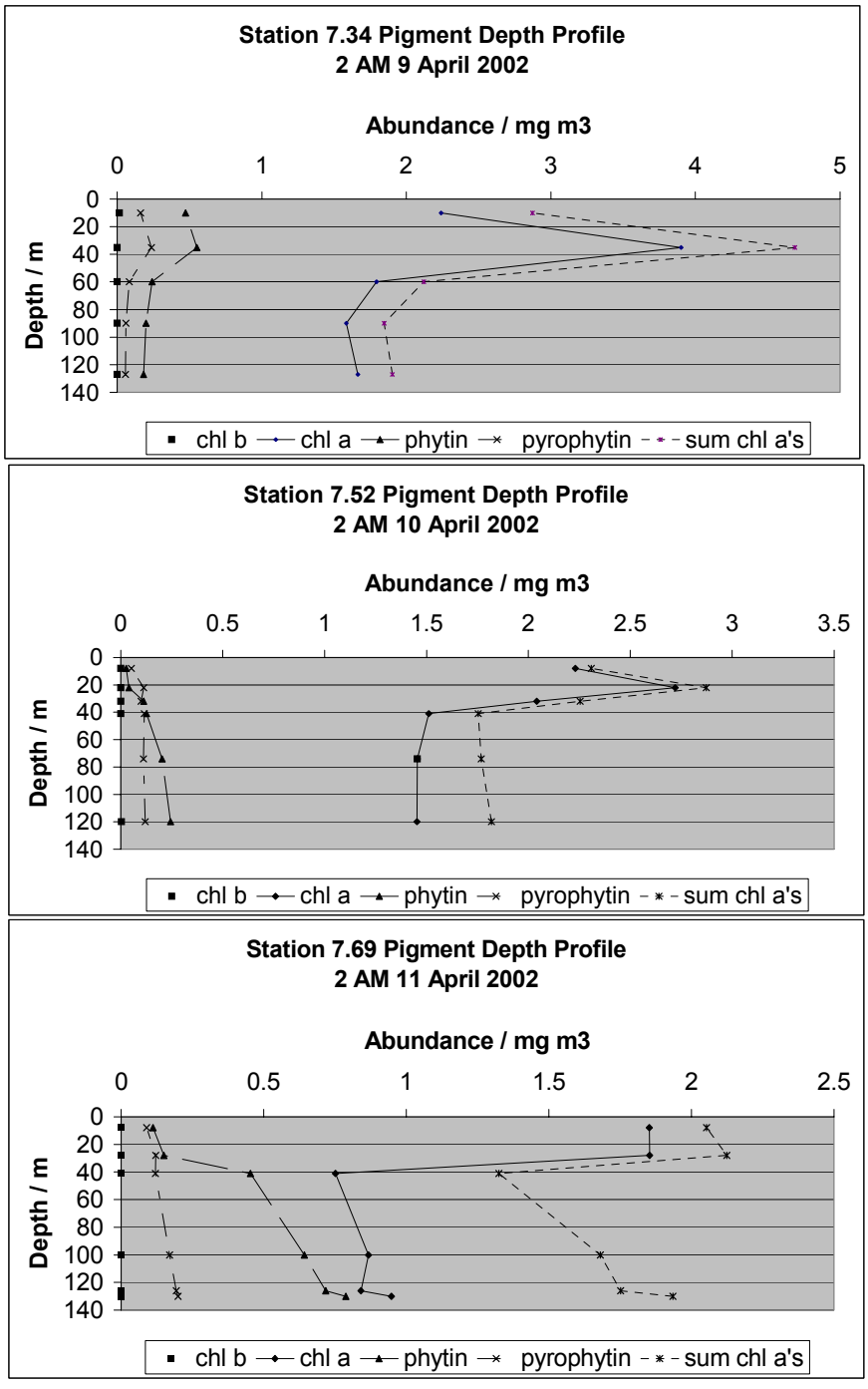


Figure 6.6.2: Pigment depth profiles recorded at three Stations.

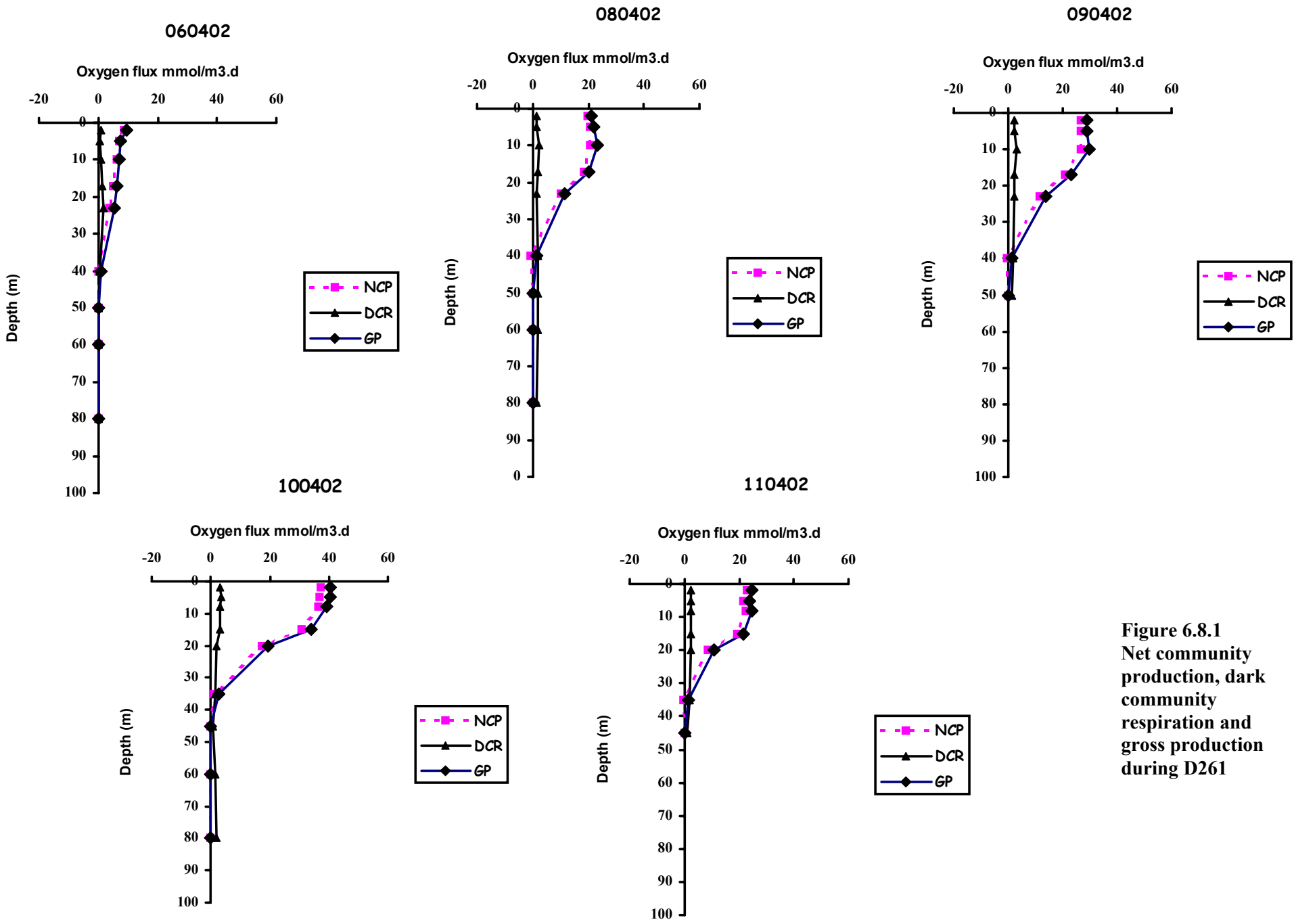


Figure 6.8.1
Net community production, dark community respiration and gross production during D261

methyl bromide, iodoethane, bromoethane and both 1- and 2-iodopropane during the course of this experiment.

2. Diatom mat incubation

A zooplankton net tow carried out on 5th April at 49° 37' N, 10° 20' W at 25m for 15 minutes and 40m for a further 15 minutes brought a mucous mat to the surface. On microscopic examination this mucous was found to be a diatom mat with cells of *Thalassiosira* embedded within. To investigate the ability of this mat to produce halocarbons, a portion of it was placed in a glass syringe and incubated for 14.5 hours (samples taken at 0, 2.5, 7.5 and 14.5 hours). As a control, the seawater in which the mat was placed when it was brought to the surface was filtered and also placed in a syringe. The mat was found to be a prolific producer of a number of halocarbons.

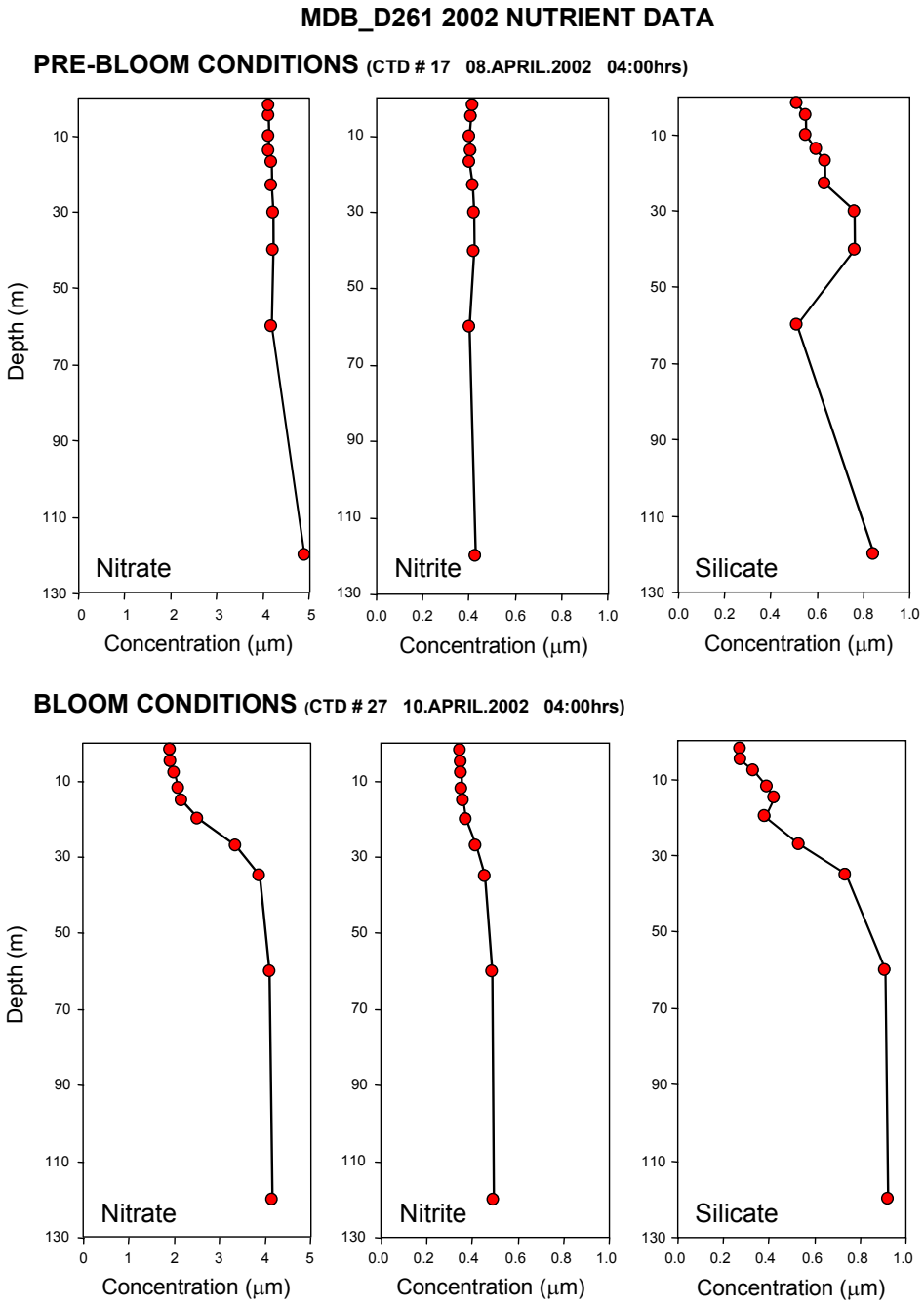
Fig 6.9.1a. Phytoplankton cells at the start of the decomposition experiment

Fig 6.9.1b. Phytoplankton cells towards the end of the decomposition experiment

the dark (to minimise phytoplankton uptake) for 24 hours after which a further 40ml was removed and filtered into a clean medicine bottle for T_{24} urea analysis.

Results

Very little information is available at this stage and a period of intense laboratory analyses is required in forthcoming months, so that most data should be available within six months. Preliminary analysis of nutrient data is complete and available on request.



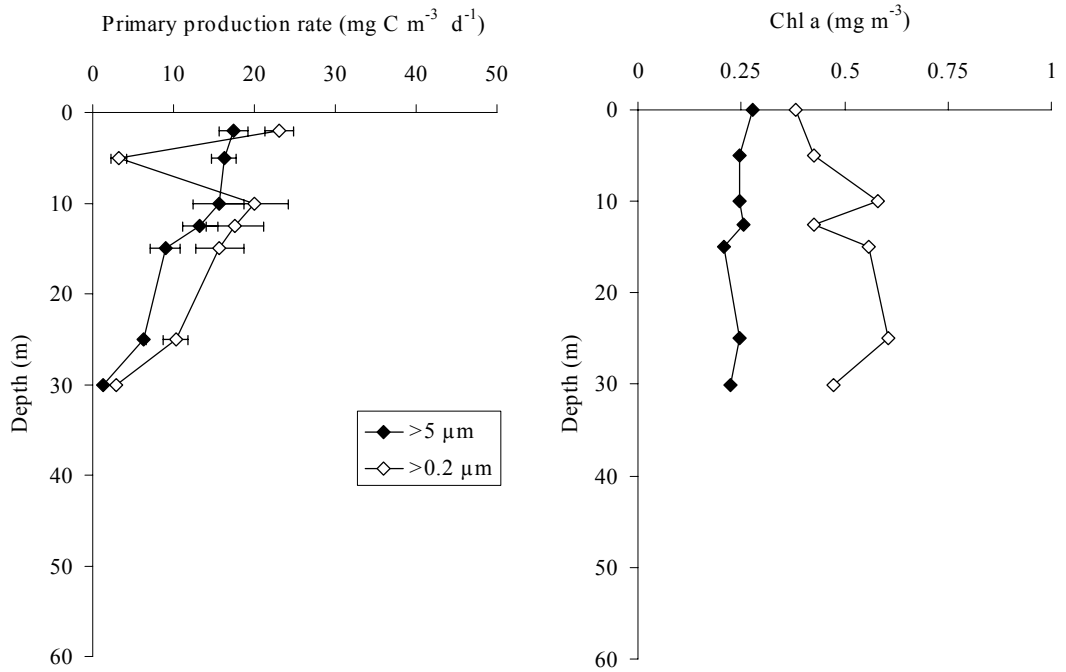


Fig. 6.13.1. Primary production rate and chlorophyll a of phytoplankton size fractions >5 µm and 0.2-5.0 µm in the photic layer of station E1.

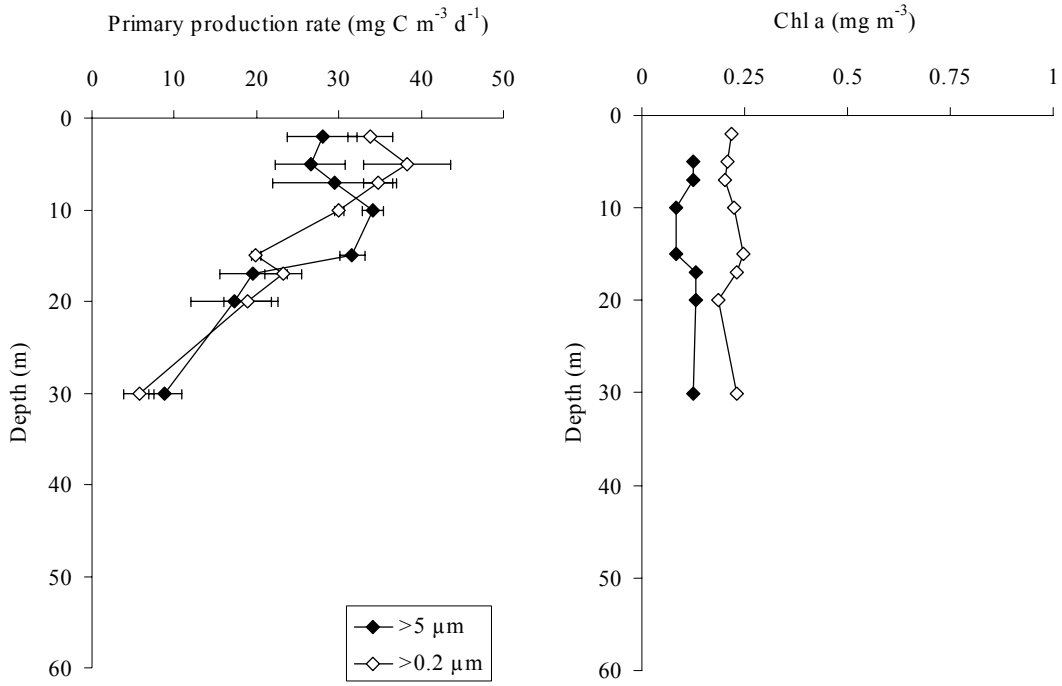


Fig. 6.13.2. Primary production rate and chlorophyll a of phytoplankton size fractions >5 µm and 0.2-5.0 µm in the photic layer of the comparative station.

Off-shelf station

The values of phytoplankton found in this area were very similar to those measured in the previous Comparative station (Fig. 6.13.3). Chlorophyll concentration ranged 0.06-0.13 mg m^{-3} in >5 μm fraction and 0.16-0.25 mg m^{-3} in >0.2 μm fraction. Total primary production rate by large phytoplankton was also very close to the Comparative station estimation (641 mg C m^{-2} d^{-1}). The small fraction, however, increased their production rates over 1700 mg C m^{-2} d^{-1}.

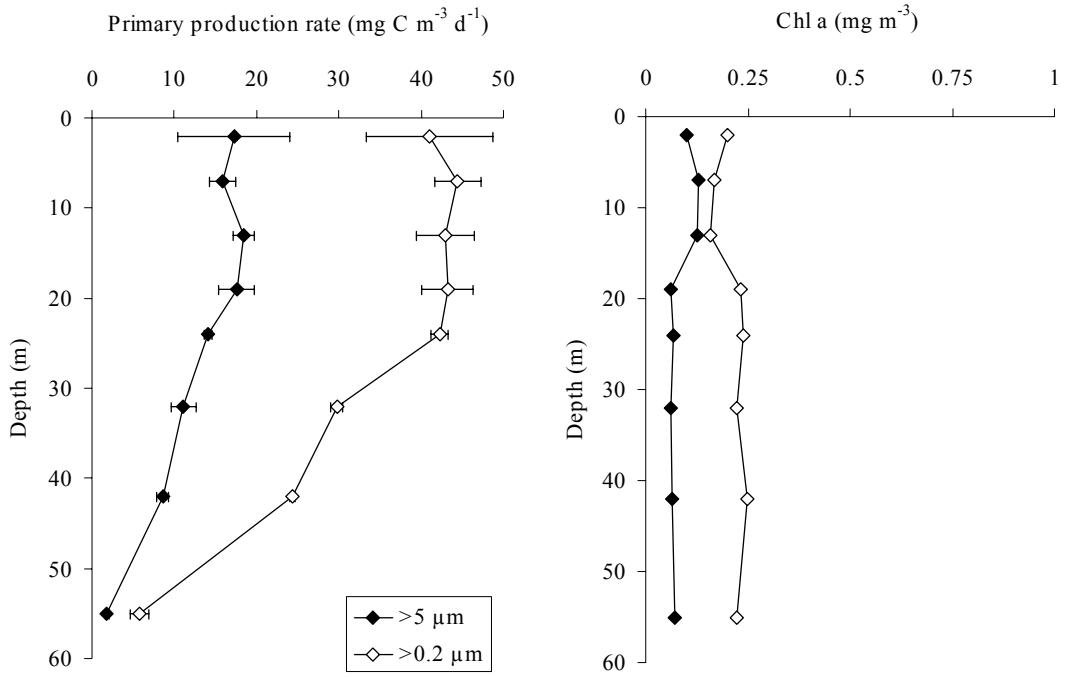


Fig. 6.13.3. Primary production rate and chlorophyll a of phytoplankton size fractions >5 μm and 0.2-5.0 μm in the photic layer of the off-shelf station.

Lagrangian experiment, Great Sole Bank bloom

During the Lagrangian experiment, a water body in the periphery of a dense patch of phytoplankton on Great Sole Bank was followed with an Argos drogue for several days to study the developing and the decline of the bloom.

The data of chlorophyll concentration and primary production rates collected during 8-11 April precisely depicted the complete sequence of the bloom (Fig. 6.13.4). As indicated by the chlorophyll fractions, large phytoplankton dominated the bloom waters and reached notably high values of biomass and production during the "peak" of the bloom on 9-10 April. A weak maximum of chlorophyll was only visible around 10-m depth during that peak; the production maximum however was shallower at 5 m (Fig 6.13.4b,c). The resultant primary production rates were notably high (Table 6.13.2). Particularly, the biomass and production of the large phytoplankton thrived in just 24-48 hours. Chlorophyll data available from April 6 confirmed the rapid growth of the large phytoplankton and the recession of the pico-cells at the onset of the bloom, which continued until the end of the experiment. This situation contrasted sharply with the observations at the shelf and off-shelf stations previously visited during the cruise track, which showed typically winter characteristics (vertical mixing, small cell sizes and low biomass and production).

Data suggest that in the Lagrangian station the bloom completed its rise and fall in a few days. Likely, storm events at the start and at the end of the experiment would have contributed to the initial mixing

and to the final dispersion of the bloom. A stable and bright weather in between enhanced the observed high values of phytoplankton.

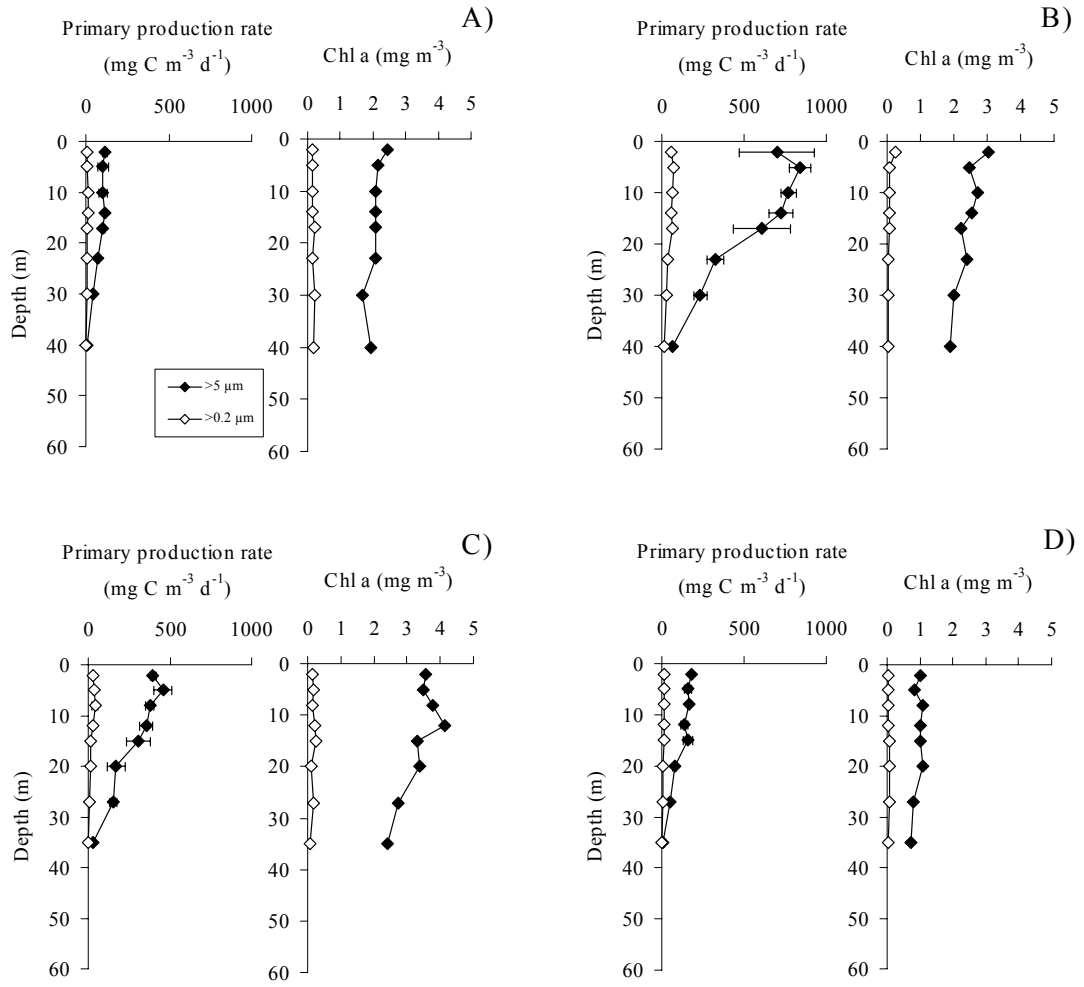


Fig. 6.13.4. Primary production rate and chlorophyll a of phytoplankton size fractions >5 µm and 0.2-5.0 µm in the photic layer during the Lagrangian experiment (5-12 April 2002): A) day 8, B) day 9, C) day 10, D) day 11.

Date	>5 µm		>0.2 µm	
	Primary production (mg C m^{-2} d^{-1})	Biomass (mg Chla m^{-2})	Primary production (mg C m^{-2} d^{-1})	Biomass (mg Chla m^{-2})
*6 Apr		28.6		14.69
8 Apr	2749	75.8	316	6.50
9 Apr	17592	87.6	1696	2.41
10 Apr	8135	107.1	626	5.24
11 Apr	3336	30.8	305	1.69

*only chl a data, no production available

Table 6.13.2. Integrated values (0 – 35 or 40m) of phytoplankton biomass and production during the Lagrangian experiment.

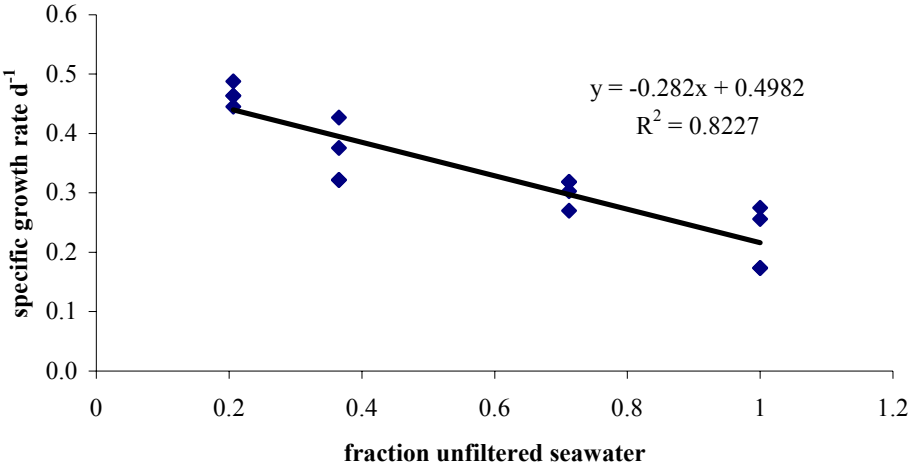


Figure 6.13.2. Results from the dilution experiment conducted on the 8th April. The growth and grazing rates are calculated from the net change in chlorophyll a over the 24 hour incubation. The results indicate a specific growth rate of 0.5 d^{-1}, equivalent to 0.7 doublings per day, and a daily turnover rate of 24% of the chlorophyll standing stock through grazing by the microzooplankton.

Date	Station	Lugol's, Formaldehyde & Glutaraldehyde	Dilution experiment	Enzyme assay
2 April	1.2	2, 5, 10, 15, 20, 30, 45 & 65m	10m	10m
3 April	4.2	2, 5, 10, 23, 30, 40, 60 & 80m	7m	7m
5 April	6.12	2, 5, 10, 23, 30, 40, 60 & 80 m	13m	13 & 55m
6 April	7.7	2, 5, 10, 23, 30, 40, 60 & 80m	10m	10m
6 April	7.8	50µm net	-	-
8 April	7.20	2, 5, 10, 23, 30, 40, 60 & 80m	10m	10m
9 April	7.36	2, 5, 10, 23, 30, 40, 60 & 80m	10m	10m
9 April	8.2	25m	-	-
10 April	7.54	2, 5, 8, 20, 27, 35, 60 & 80m	8m	8 & 35m
10 April		Donut transect – non-toxic	-	-
11 April	7.71	2, 5, 8, 20, 27, 35, 60 & 80m	8m	8m
12 April	7.90	2, 5, 8, 20, 27, 35, 60 & 80m	-	-

Table 6.14.1. Details of sampling schedule

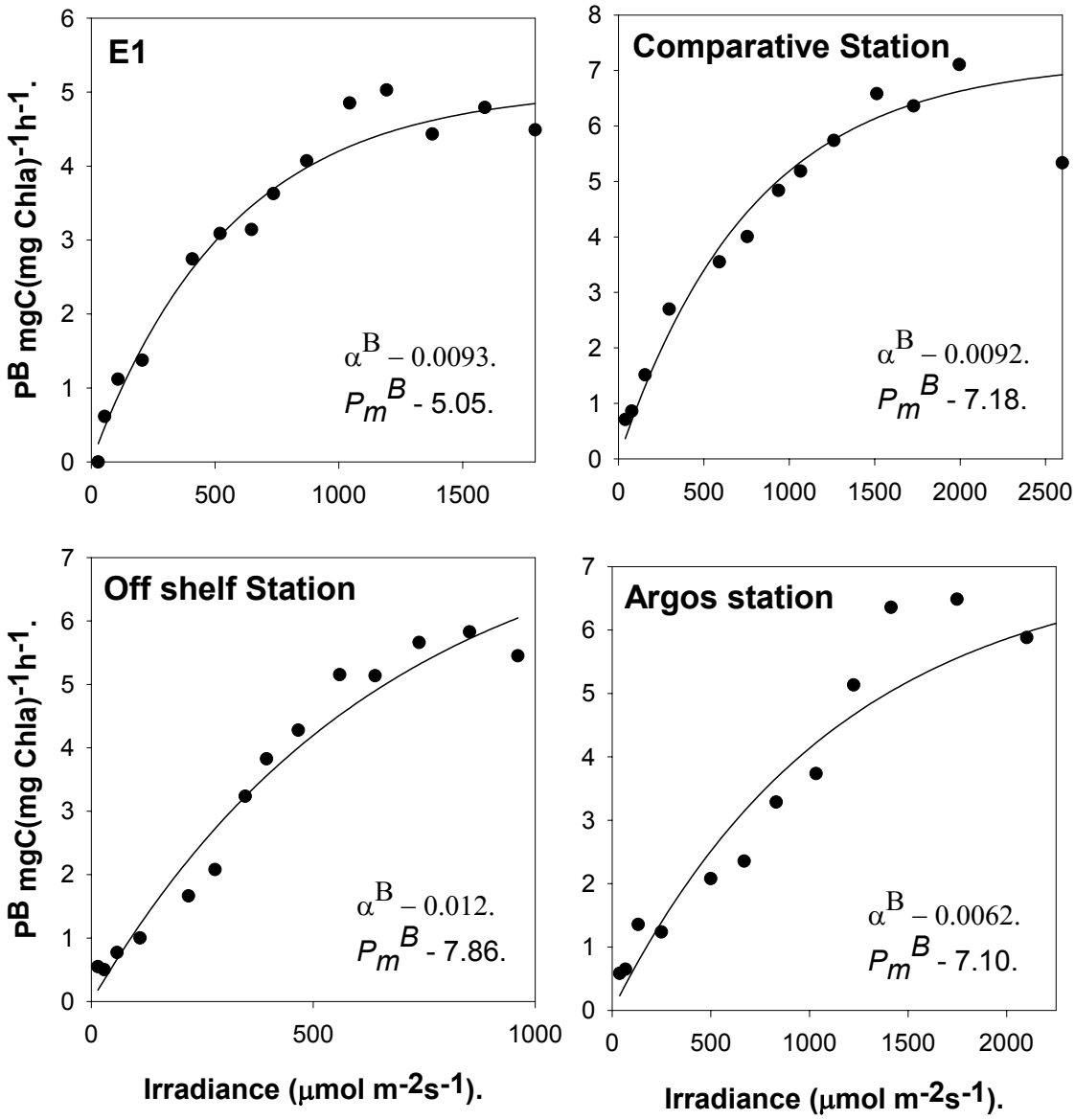


Fig 6.15.1. Photosynthesis – irradiance curves from E1, comparative station, off shelf station and Lagrangian station. Corresponding light limited slope of photosynthesis (α^B, mg C(mg chl) $^{-1}$ h^{-1} μmol m^{-2} s^{-1}) $^{-1}$) and maximum photosynthetic rate values (P_m^B, mg C(mg Chl)$^{-1}$ h^{-1}) for each station are given in the figure legend of each graph.

steel mesh filter, and distributed to the laboratories. The OPC was connected to this supply, continuously sampling surface (6m) seawater at ~20 litres min^{-1} via a de-bubbling device to prevent spurious counts. The OPC-1L has a 20mm square section glass flow cell, through which water containing the sample was pumped. An in-line flow meter was installed to give a record of volume of water passing through the OPC.

Validation of OPC data

Laboratory calibration against spherical glass beads of known size provides the initial calibration. Size calibration exercises were performed during the cruise using calibration beads of 501 ± 10, 1004 ± 20, and 2022 ± 40µm ESD (Duke Scientific Corporation, Inc.). These were each mixed with filtered seawater and recirculated through the system. Continuous OPC underway counts are compared to microscope counts of zooplankton from in-line samples taken from the outlet of the OPC once a day. There is good agreement between the microscope and real time OPC continuous underway counts, and between OPC biovolume and carbon analysis of preserved samples (Gallienne & Robins, 1998; Gallienne *et al.*, 2001). It should be acknowledged that avoidance of the pump intake might result in under-sampling of some of the larger organisms within the size range of the system.

6.18.3. Preliminary results

A summary of the profiling OPC data for the Lagrangian drift station is given in Figure 6.18.2. Data represent three size fractions for each station integrated over the water column (0-120m depth). Note that the smallest size fraction (less than 800µm ESD) is consistently low. Although the manufacturer claims 250µm ESD as the lower size limit for the OPC, it is the experience of most users that the towed OPC (OPC-1T) used in the profiler has a realistic lower limit of around 700µm ESD (e.g. Heath (1995). The OPC-1L, having a much shorter path length, is more sensitive and is reliable down to 250µm ESD (Gallienne & Robins, 1998; Gallienne *et al,* 2001).

The data for the two larger fractions (800-1600µm and >1600µm ESD) show a trend to decreasing biomass after the storm event, followed by a steady increase from 2 days after the storm. No diurnal variation is evident from these data, indicating that diel vertical migration was not significant during the Lagrangian study.

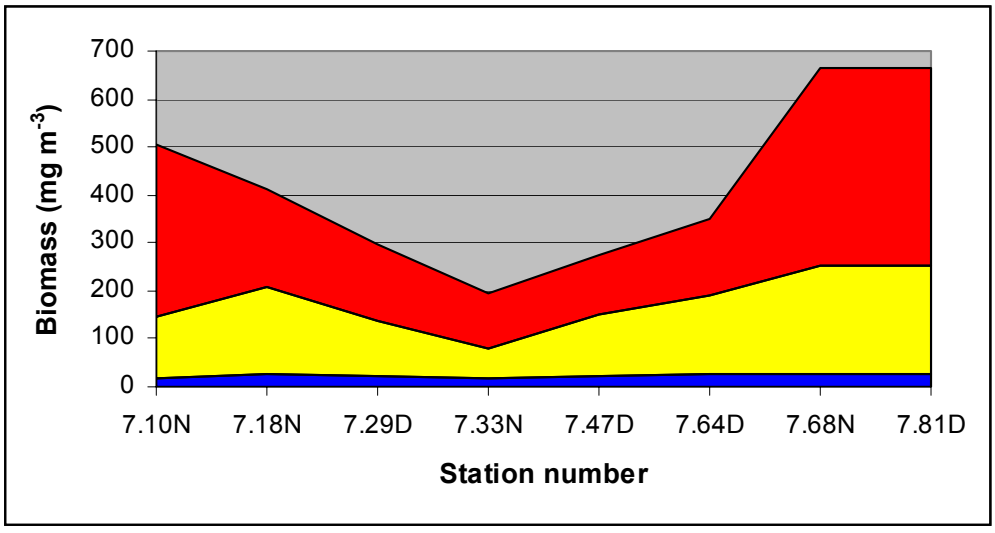


Fig. 6.18.2. Integrated OPC Profile 0-120m for Drift Station 7.10 (6th April 04:30) to 7.81 (11th April 13:10). Key: Blue - <800µm ESD; Yellow – 800 – 1600µm ESD; Red - >1600µm ESD. D: daytime; N: nighttime

The continuous surface underway OPC data for the transect between station 1 (E1) and the off-shelf station are presented in figure 6.18.3, below. Biomass is seen to increase from a low value at station 1 (<100mg m^{-3}, 20:20 hrs, 2nd April) to a peak around midnight the following day (3rd April, c. 900mg m^{-3}). This peak is associated with the transect through a bloom centered to the south of the transect in French territorial waters. Its occurrence around midnight, together with an increase in the relative contribution of the larger size fractions, suggests that diel vertical migration of larger mesozooplankton may be responsible for some if this increase. The comparative station (station 2) occurred during this transect from 0200 to 1400hrs. During the first 11 hours of the 4th April, continuing across the shelf break to the off-shelf station, biomass declines to a minimum of 33mg m^{-3}.

Figure 6.18.4 shows similar continuous data for the transect during 5th April from the off-shelf station, through the bloom and the Argos deployment position, to the 'pre-bloom' waters to the north of the bloom. The data in figure 6.18.4 are contaminated by very abundant large phytoplankton cells, as may be seen from the unusually high biomass values as we pass through the bloom and the complete dominance by the smaller size fractions (250-500µm ESD). This was assumed be a combination of plant cells larger than 250µm and somewhat smaller plant cells passing through the OPC in sufficient numbers to cause coincidence (several particles smaller than 250µm ESD being present in the beam at the same time, and being registered as a single larger particle). Examination of samples filtered from the OPC outlet at these times using a 53µm mesh and examined under a microscope confirmed this assumption. Although this makes the data less than useful in terms of characterisation of mesozooplankton, the instrument used in this mode was very useful as an aid in responsive-mode sampling, indicating areas of ecological change and aiding in the location of the edge of the bloom, where we wished to deploy the Argos buoy.

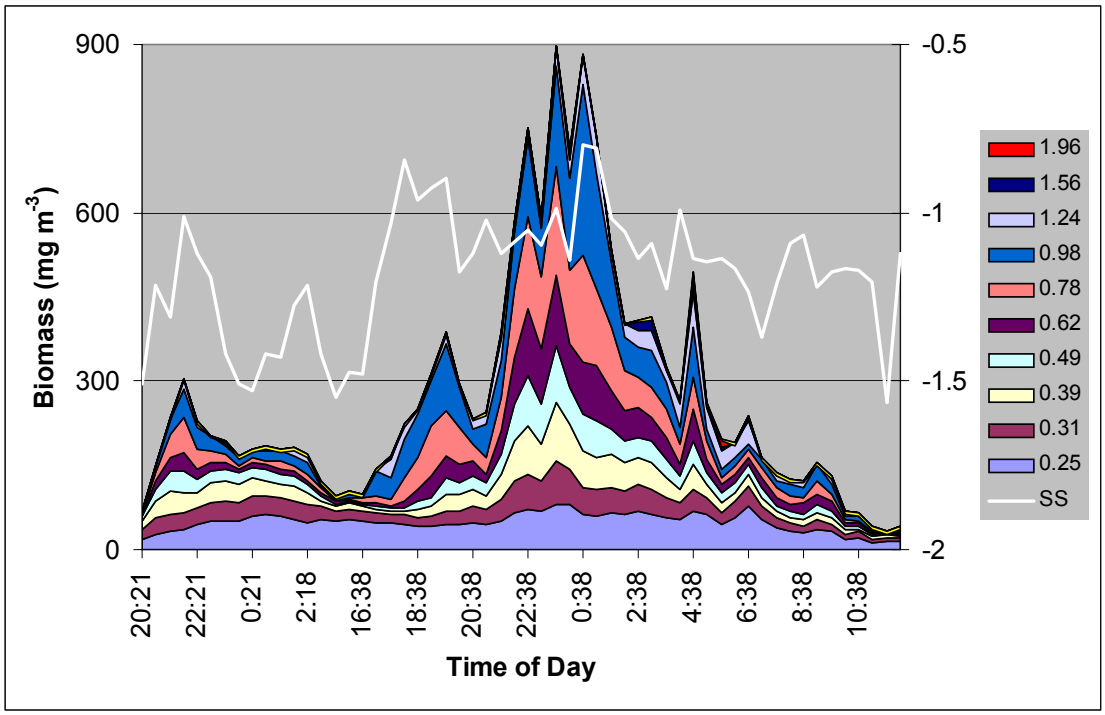


Fig. 6.18.3. Size fractionated OPC biomass data from continuous surface underway sampling between Station 1 (E1) and the off-shelf station. Key: ESD in mm. SS = biomass spectral slope.

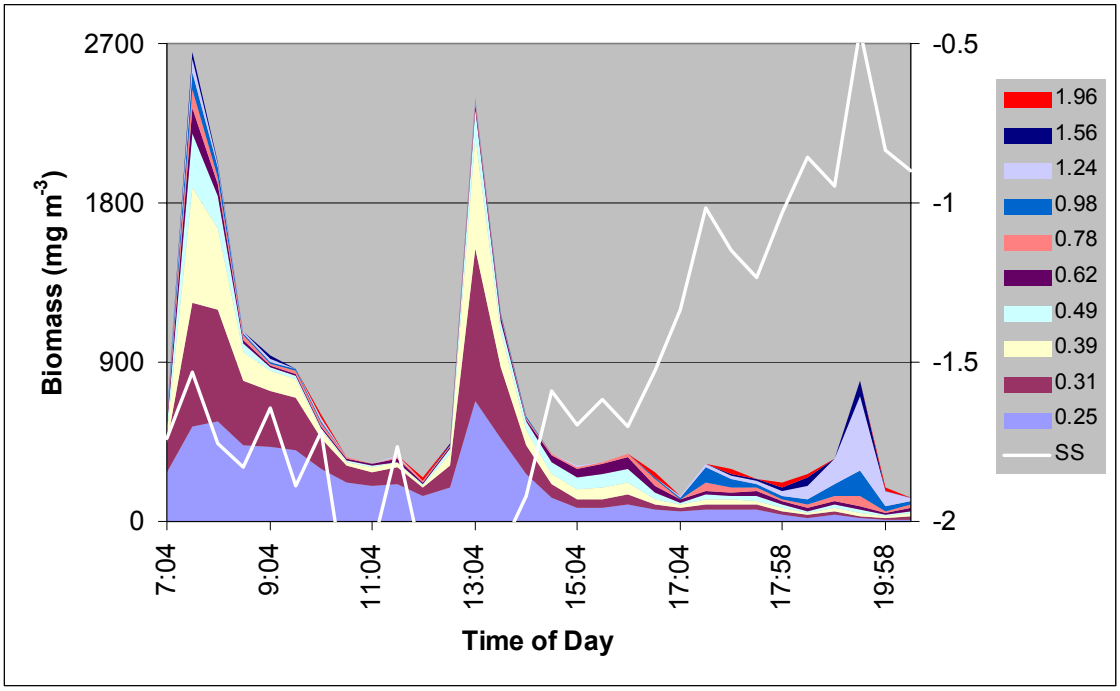


Fig. 6.18.4. Size fractionated OPC biomass data from continuous surface underway sampling between off-shelf station 6 (5th April) and the 'pre-bloom' waters to the north of the Argos deployment site (5th April). Key: ESD in mm. SS = biomass spectral slope.

6.18.4. Further analysis

Net samples from the 125 and 200µm mesh nets have been preserved and returned to the laboratory. During the weeks following the cruise the 125µm mesh samples will be passed through the OPC-1L system to produce rather more precise data on vertically integrated mesozooplankton biomass, and for validation of the profiling OPC data. This validation will be further aided by microscopic analysis of the 200µm mesh samples, which will also give valuable information on taxonomic distribution of zooplankton, and the developmental stage of the zooplankton at the various stations during the Lagrangian drift study.

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