

RRS James Clark Ross



JR98 Cruise Report

July 25th – August 14th
2003



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1. Introduction to the Project.

Cruise JR98 is the first of two major research cruises associated with the NERC funded project “PHYSICAL-BIOLOGICAL CONTROL OF NEW PRODUCTION WITHIN THE SEASONAL THERMOCLINE” (NER/....). The research is fundamentally interdisciplinary, and the cruise entailed the co-ordination of two vessels (RRS *James Clark Ross*, and the University of Wales’ RV *Prince Madog*) to combine the complex physical, biological, and chemical process measurements required.

Scientific Background.

The sub-surface chlorophyll maximum (SCM) is an ubiquitous feature of the thermocline of both permanently and seasonally stratified waters of the world’s oceans. Interest in the functional properties of the SCM include its importance as a source of food for pelagic herbivores, including larval fish, its effect on the thermal structure of the water column, and its role within the biological pump for the transfer of carbon from the surface water to deep water or bottom sediments. The SCM tends to be situated within the middle or lower part of the thermocline and at the top of the nutricline, so that it is the principal site of new production within the water column that defines the potential for organic carbon export to deep water. On tidally energetic continental shelves, such as the NW European shelf, the seasonal thermocline is relatively shallow (typically 10 to 40 m) so that the SCM represents a biomass maximum as well, with the phytoplankton having a carbon to chlorophyll ratio similar to that for surface water. Furthermore, under conditions of favourable illumination (i.e. shallow depth, low diffuse attenuation coefficient, and/or high solar radiation), it will also tend to represent a primary production maximum. Recent applications of satellite ocean colour sensors for estimating annual production rates in shelf waters have highlighted the need to for a better understanding of the SCM in terms of its contribution to total water column production and of its role in the development of surface phytoplankton blooms.

The existence of the SCM depends on, and is an indicator of, turbulent mixing at the base of and within the thermocline. This mixing plays two important roles. First, turbulent transfer of nutrients between the deeper water and the thermocline fuels new production within the SCM, and second turbulent mixing within the thermocline controls the ability of the algae to photoadapt to their environment. However, present vertical exchange models do not adequately represent mixing processes in the seasonal thermocline, particularly in the stratified regions of shelf seas. There is a marked under-estimate of rates of dissipation and mixing relative to observations, hypothesised to be due to poor representation of the contributions from internal motions. Internal gravity waves of a variety of frequencies may transport energy into the pycnocline and drive mixing. The internal tide generated by the forcing of stratified water over steep topography, notably at the shelf edge, can produce large thermocline displacements which may be transformed into highly nonlinear tidal waves, carrying energy onto the shelf and initiating mixing far from the generation zone. At the same time, barotropic tidal flow over rough topography in stratified regions may produce internal waves that propagate up the water column. A third possibility is that near inertial motions, generated by the wind, result in water column shear and therefore increased TKE in the pycnocline. Understanding and modelling these processes as controls on new production and carbon export associated with the SCM needs to be developed.

A seasonal thermocline develops across about 70% of the NW European shelf in spring and early summer and is characterised for up to 3 months (between May and August) by an SCM which represents the sub-surface extension of surface chlorophyll maxima at tidal fronts. In the Celtic Sea levels of chlorophyll in the SCM in midsummer range from $\sim 1 \text{ mg m}^{-3}$ where the thermocline is deep, to $>50 \text{ mg m}^{-3}$ in the shallower thermocline close to tidal fronts. The latter situation arises when the phytoplankton grow at the base of the thermocline, thus sharpening the nitracline and creating a strong flux of nutrient out of the bottom mixed layer, and supporting growth under favourable conditions of illumination. Apart from a number of

site- and time-specific measurements, our general knowledge about rates of phytoplankton growth in the SCM of NW European shelf systems remains limited. Numerical models have shown how a shallow SCM acts as an efficient trap for nutrients being mixed upwards from the bottom mixed layer. This situation appears to persist until the rate of photosynthesis in the thermocline is eventually inhibited by reduced day length and increased cloudiness in late summer, allowing dispersion of the SCM and mixing of nutrients to the surface layer. One important uncertainty is the potential role of photoadaptation and photoacclimation in maintaining higher-than-expected growth rates. Appropriate experimental measurements with natural populations are difficult to make as the SCM is often found as a layer <2m thick at an ambient temperature >5° below that of surface water.

In 1999 we carried out an interdisciplinary study of the relationships between vertical mixing and phytoplankton distributions at a stratified station in the Celtic Sea (cruise CH145, NERC grant GR3/11829). The study established the feasibility of making physical, chemical and biological measurements at compatible scales and resolutions. We found an intense SCM at the base of the thermocline, dominated by a single species of coccolithophore, that was actively eroded by tidal mixing during the period leading up to spring tides. Estimates of the upward mixing of nitrate, based on *in situ* measurements of turbulent mixing and the vertical gradient in nitrate, suggested that the tidally-driven export of cells to the bottom mixed layer exceeded potential growth rates calculated from the nitrate supply. We suggested that the maintenance of this population required the spring-neap modulation of tidal turbulence, driving a fortnightly growth-export cycle in the thermocline. In addition, growth rates of the phytoplankton determined from simulated *in situ* ¹⁴C measurements were low, and incompatible with the estimated rate of nitrate assimilation. A comparison of specific rates of light absorption for this population from the ¹⁴C data and from *in situ* Fast Repetition Rate Fluorometer (FRRF) measurements suggests that this discrepancy was due to physiological impairment of the cells within the ¹⁴C incubations. A key development from the 1999 cruise was the demonstration that rates of primary production can be derived from FRRF measurements. The weaker correlation between ¹⁴C and FRRF data for samples showing high rates of production appeared to result from either greater photoinhibition or loss of photoadaptive properties during ¹⁴C incubations, both effects giving relatively low estimates of productivity by this method. These observations and experiments not only gave some unexpected results, in particular concerning the role of mixing processes in driving the export of algal carbon to deep water, but also demonstrated how key parameters within the SCM can be directly measured by *in situ* techniques.

Aims and Objectives.

The main aims of this work are to investigate the generation and dissipation of turbulence in the thermocline, and to quantify how the resulting mixing (supplying nutrients and controlling the light experienced by the algae) affects the growth of phytoplankton within the sub-surface chlorophyll maximum (SCM). The individual hypotheses under investigation can be summarised as:

1. *Mixing into and within the thermocline, which is missing from existing models, is driven by internal tide and wave motions.*

The main approach was the deployment of arrays of moored rapid-sampling thermistors and ADCPs to gather time series of thermocline structure and turbulence, allowing the identification of the periodicities of thermocline variability.

2. *Variability in physical mixing processes controls the supply of nutrients from the bottom mixed layer into the thermocline, and leads to predictable fluctuations in primary production.*

A key component of the work carried out during the cruise entailed the occupation of 25-hour stations, sampling with the FLY turbulence sensor (from the RV *Prince Madog*) and a CTD+FRRF (from the RRS *James Clark Ross*) to investigate the relationships between

variations in the vertical fluxes of nitrate and the rates and efficiency of SCM photosynthesis over a range of tidal mixing conditions.

3. *The physiological (e.g. photoacclimation) properties and survival strategies of phytoplankton in the SCM determine the efficiency of nutrient assimilation within the thermocline and lead, in turn, to broadly predictable patterns in the density and species composition of the population.*

In the Celtic and Irish Seas horizontal variations of thermocline structure range from weakly stratified (frontal), to the very strong, narrow thermoclines seen in the southern Celtic Sea, and to the weak, deep surface layer associated with internal wave mixing at the shelf edge. At the representative 25-hour stations, the effects of vertical stability and irradiance on the growth rate, species composition and patchiness of SCM phytoplankton were examined. Seasoar transects were also planned to provide large-scale pictures of the coupling between physical structure and SCM position and concentration, and to provide the local context for the 25 hour stations.

Ultimately the project aims to:

- Provide a better understanding of internal mixing processes in stratified regions, including the development of better parameterisations of this mixing for numerical models.
 - Provide a better understanding of the sub-surface primary production, which can be used alongside satellite-based methods for quantifying marine primary production.
 - Quantify the role of the SCM in the shelf sea carbon cycle.
-

2. Cruise Personnel.

Science Personnel:

Name	Institute	Role
Jonathan Sharples	Southampton Oceanography Centre	PSO and co-PI
Patrick Holligan	Southampton Oceanography Centre	PI – Primary production and FRRF
Mark Moore	Southampton Oceanography Centre	FRRF phytoplankton physiology
David Hydes	Southampton Oceanography Centre	Nutrient analysis
Mike Lucas	Southampton Oceanography Centre	Primary production and nutrient uptake
Jacqui Tweddle	Southampton Oceanography Centre	FRRF in situ
Anna Hickman	Southampton Oceanography Centre	Primary production and P vs E
Florence Nedelec	Southampton Oceanography Centre	Iron chemistry
Tim Adey	Southampton Oceanography Centre	Oxygen production
Sinhue Torres	Southampton Oceanography Centre	Ammonia analysis
Young Nam Kim	Southampton Oceanography Centre	FRRF and size-fractionation
Huw Thomas	Southampton Oceanography Centre	Chlorophyll and remote sensing
David Suggett	University of Essex	Phytoplankton physiology, FRRF, pigments.
Emilie Le Foch	University of Essex	Imaging fluorescence
Gail Harris	University of Essex	Pigment absorption
Gavin Tilstone	Plymouth Marine Laboratory	Optics
Valesca Rial	University of Vigo	Primary production
Pedro Ainsa	University of Vigo	Primary production
Sarah Jones	University of Wales, Bangor	Particle analysis (LISS)
Ray Delahunty*	University of Wales, Bangor	Particle analysis (LISS)

UKORS scientific engineering and technical support:

Name	Institute	Role
Jon Short	Southampton Oceanography Centre	TLO – Seasoar and CTD
Terry Edwards	Southampton Oceanography Centre	Seasoar and CTD
Ian Waddington	Southampton Oceanography Centre	Moorings
Chris Crowe	Southampton Oceanography Centre	Moorings
Kevin Smith	Southampton Oceanography Centre	Scientific engineering

BAS scientific engineering and technical support:

Name	Institute	Role
Doug Willis	BAS	IT support
Sevy Afanasyev	BAS	Electronics support
Doug Trevett	BAS	Deck engineer
John Summers	BAS	Deck operations

* Ray joined the ship in Portsmouth on July 24th 2003. At noon on the 25th, having set up his cruise equipment, he went ashore for some sightseeing prior to sailing. He did not rejoin the ship, and was found two days later at his home on Anglesey having taken his own life. Everybody aboard the RRS *James Clark Ross* was deeply shocked and saddened by the news. With such an immense tragedy our thoughts were for Ray's family, Ray's colleagues who were about to embark on the RV *Prince Madog* to join us, and particularly for Ray - it is impossible for us to imagine the enormous distress that he must have been trying to deal with.

3. Summary Cruise Narrative.

The following is a brief description of the course and main activities of the RRS *James Clark Ross* during JR98. The activities included are the basic sampling procedures (CTD, Seasoar, moorings) carried out to collect water and the background information for the project. Details on the individual laboratory work are to be found in section 4. Stations referred to can be seen in Fig. 3.1. CTD and mooring positions are listed in appendix 1.

A Note on Time : During the cruise all operations and watch keeping were carried out on ship's time (BST), but all data collected was marked in GMT. Therefore all times associated with data are expressed in GMT. Some data (e.g. ADCP data) is marked in terms of Julian day and/or year day. Julian day begins at 1 on January 1st 2003 and is always a whole number. Year days begin at 0.0 at 0000 hours on January 1st 2003. Thus the Julian day is the year day rounded UP to the nearest integer.

Wednesday July 23rd 2003. JD=204
Cruise mobilisation begins in Portsmouth.

Thursday July 24th 2003. JD=205
Mobilisation continues. Scientific party set up laboratories. Ship safety briefing takes place.

Friday July 25th 2003. JD=206
Mobilisation completed. Final details of the RRS *James Clark Ross* refit are completed. Ship sails from Portsmouth at 1830 BST.
Surface non-toxic supply switched on 2100 BST.

Saturday 26th July 2003. JD=207
0930 BST arrive at guard buoy mooring off Eddystone. Mooring recovered.
1100 BST begin load testing and operation of CTD winch.
1647 BST first CTD cast – ctd001, station PML E.
Extensive tests were conducted on Seasoar Penguin data acquisition system. Communication with the system failed when attempted along the tow cable, so work began on setting up the Neil Brown UKORS Seasoar system.
2030 BST started to steam towards position U2, with the aim of deploying Seasoar as soon as it was ready.
Noon weather: E'ly force 3, slight sea.

Sunday 27th July 2003. JD=208
0600 – 1300 BST several attempts made to deploy Seasoar. Continual problems with power supply, slippings, and possibly the deck unit.
1300 BST complete shutdown of vessel (everything except lighting) to fix a problem with main engine cooling system.
1530 BST ship re-started. Another failed Seasoar test. Decision made to steam to CS2 and utilise underway surface data for mapping shelf edge conditions.
2250 BST arrive CS2, depth approximately 360 metres.
2258 BST – ctd002 conducted at CS2.
Noon weather: W'ly force 4, moderate sea.

Monday 28th July 2003. JD=209
Steam from CS2 to N7, to S7, to S1, to N1, to CS2.
0700 BST arrive CS2 to begin mooring deployment. Weather w'ly force 6 – 7. Position of CS2 modified to attain 200 metre depth. New position: 48° 31.9' N, 09° 27.8' W.
0940 BST main guard buoy away.
1240 BST surface toroid (temperature logger mooring) in water.

1315 BST subsurface buoy (temperature logger mooring) in water.
1415 BST Temperature logger mooring away.
1440 BST ctd003 with optics measurements.
Mooring deployments halted until tidal flow changes direction (surface markers were being drifted over the ADCP deployment sites).
2010 BST subsurface ADCP mooring away.
2030 BST both bedframe ADCPs away.
2100 BST Notice to Mariners information faxed to Hydrographic Office.
Initial plan made to conduct cross-shelf edge CTD section with titanium frame clean CTD system. Delays caused by problems with titanium CTD. Eventually decision made to remain on station and await RV *Prince Madog*.
Noon weather: SW'ly force 6, moderate sea.

Tuesday 29th July 2003. JD=210

0400 BST on station with RV *Prince Madog* to begin 25 hour CS2 CTD station.
First CTD cast ctd004 at 0357 BST.
CTD casts conducted approximately every hour.
Noon weather: SW'ly force 6, moderate sea.

Wednesday 30th July 2003. JD=211

CS2 station completed. Last CTD cast ctd030 at 0609 BST.
0700 Neil Brown Seasoar deployed. Begin steam to CS1.
1700 Seasoar recovered. FRRF on Seasoar fails to respond. Problem found to be a dislodged internal battery. Seasoar CTD data not available as software “dongle” missing.
1816 BST ctd031 – first CTD cast with SUV6 nitrate sensor.
1900 BST continue steam to CS1.
Noon weather: NW'ly force 4, moderate sea.

Thursday 31st July 2003. JD=212

Rendezvous with RV *Prince Madog* at CS1.
First CTD cast ctd032 at 0404 BST.
Winch slipping problems experienced towards end of station (casts 047, 048, and 049).
Station has poor temporal resolution in last few hours.
Noon weather: SW'ly force 5, moderate sea.

Friday 1st August 2003. JD=213

Last CTD cast at CS1 conducted – ctd051 at 0437 BST.
Steam to CS3b, with a plan to assess potential sites for the CS3 mooring.
CTD at CS3b – ctd052 at 1151 BST.
CTD north of CS3b – ctd053 at 1407 BST. Discussion with RV *Prince Madog* leads to decision to deploy mooring CS3 at position north of CS3b in 90 metres of water: 51° 28.4' N, 6° 25.8' W. RV *Prince Madog* deploys CS3 mooring at approximately 1930 BST.
Steam to IS1 to find a vertically mixed site for 25 hour station.
2131 BST ctd054 at IS1 to determine if water column is mixed. Weak, deep thermocline, possibly caused by deep water advection. Decision made to steam 1 hour north of IS1 to find mixed water. New position IS1b at 52° 34.01'N, 5° 28.02'W.
Noon weather: W'ly force 3, slight sea.

Saturday 2nd August 2003. JD=214

First CTD cast on IS1b 25 hour station – ctd055 at 0357 BST.
Water column depth about 76 metres. Completely mixed.
Noon weather: S'ly force 3, slight sea.

Sunday 3rd August 2003. JD=215

Last CTD cast at IS1b – ctd080 at 0457 BST.

Begin cross-front CTD section from IS1b/X1 to X11. At X6 and X7 evidence of internal waves. Last cross-front CTD cast ctd090 (position X11) at 1857 BST.

Begin along-front section Y1 to Y5 (ctd091 to ctd095).

Noon weather: SSW'ly force 2, slight sea.

Monday 4th August 2003. JD=216

Steam to X3, arrive 0830 BST.

Day spent attempting to fix the Penguin Seasoar.

Optics cast and ctd096 at noon.

1800 BST Seasoar fixed and working. Deployed north of X3, section carried through CS3.

Noon weather: NE'ly force 2, slight sea.

Tuesday 5th August 2003. JD=217

Seasoar section finished 0200 BST.

Steam to CS3 mooring position.

Begin 25 hour station with RV *Prince Madog*. First CTD cast ctd097 at 0400 BST.

0830 BST boat transfer of CTD spares from RV *Prince Madog*.

Noon weather: SE'ly force 4, moderate sea.

Wednesday 6th August 2003. JD=218

Last CTD cast on CS3 station ctd122 at 0506 BST.

Steam to U2, via east of the Isles of Scilly.

Arrive U2 1700 BST.

CTD cast ctd123 aborted (rosette not responding).

CTD cast ctd124 at 1728 BST.

Penguin Seasoar deployed 1800 BST for tow to N1 (shelf edge). Briefly recovered at 2200 BST to fix data dropouts. Immediately redeployed.

Noon weather: SW'ly force 3, slight sea.

Thursday 7th August 2003. JD=219

Continue Seasoar line from U2. Arrive N1 1315 BST.

Begin cross-shelf edge CTD transect (N1 through to N9) with clean titanium CTD and frame.

First station at 1500 BST, ctd125 at N1.

Noon weather: ESE'ly force 2, slight sea.

Friday 8th August 2003. JD=220

Cross-shelf edge line completed at position N9, ctd133, at 1200 BST. Note that ctd133 went to only 200 metres depth – time constraints prevented full depth.

Time then spent on getting Seasoar to work; problems encountered with the Penguin hard drive and the winch slip rings. Seasoar deployed at N9 at 1530 BST. Seasoar line planned to run from N9 to CS2, and then along line A to CS1, and then to CS3.

Brief communication problems with Seasoar at 1830 BST, requiring temporary recovery.

Noon weather: S'ly force 2, slight sea.

Saturday 9th August 2003. JD=221

Seasoar transect line continues. Speed increased by 0.5 knots at 0815 BST in order to make sure we rendezvous with the *Prince Madog* on time.

Some gaps in the Seasoar data later in the day, cause not clear but seemed to be associated with cycling the data files on Penguin. Not cycling the data files seemed to fix the problem.

Noon weather: WNW'ly 3, slight sea.

Sunday 10th August 2003. JD=222

Seasoar run finishes at CS3 at 0300 BST.

On station CS3 with *Prince Madog*, first CTD cast ctd134 at 0356 BST.

At 2030 BST Seasoar lowered through water column for calibration against CTD data (ctd150 at 2000 BST and ctd151 at 2100 BST).

Seasoar Frrf data file: frrf7058.000

Seasoar Minipack data file: minipack7057.000

Noon weather: N'y 4, slight sea.

Monday 11th August 2003. JD=223

Last CTD cast at CS3 ctd159 at 0453 BST. Conducted with titanium frame; full set of salinity samples collected.

Begin CTD stations D1 to D4, CS1, CS1b, A3, A6, A9, A13, and CS2.

Noon weather: N'y 3, slight sea.

Tuesday 12th August 2003. JD=224

CS2 CTD cast completed 0830 BST (ctd170).

Mooring recovery operations begin.

All instruments on board by 1130 BST.

CTD cast ctd171 at noon to coincide with satellite overpass.

CTD cast ctd172 begun at 1500 BST – CTD held at fixed depth for 2 hours.

Begin steam back to Cork.

End of cruise dinner.....

Noon weather: NE'y 3, slight sea.

Wednesday 13th August 2003. JD=225

Day spent packing equipment.

Arrive Cork 1800 BST.

Thursday 14th August 2003. JD=226

Packing equipment and storing in scientific hold.

Friday 15th August 2003. JD=227

Disembark *James Clark Ross* 1000 BST.

The full vessel track followed during the cruise is shown in Figure 3.1.

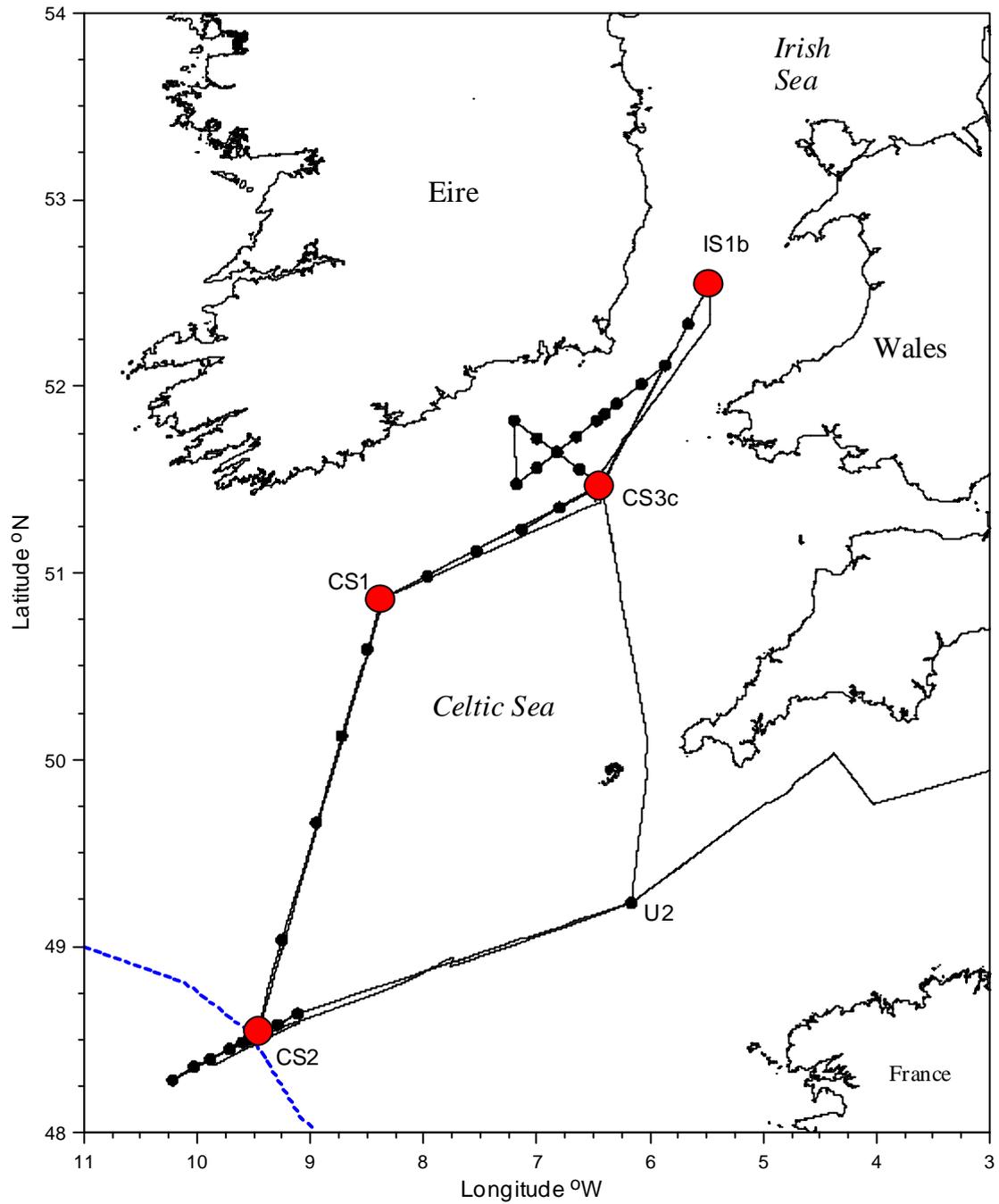


Figure 3.1

Cruise track followed during JR98. The small black dots are the CTD positions. The large, red dots are the stations occupied for the 25 hour work alongside the RV *Prince Madog*.

4. Reports on Work Completed.

4.1 CTD operations.

Two separate CTD systems were used during the cruise. The main CTD, with a 24 bottle stainless steel rosette, was used for most of the CTD work. A second CTD system, with a 24 bottle titanium framed rosette and Teflon-coated bottles, was used for some CTD work later in the cruise associated with sampling for iron (see section 4.10).

Main CTD instrumentation:

Seabird 911 CTD, with two conductivity and two temperature sensors.

2 Chelsea Instrument Fastracka FRRFs with PAR sensors.¹

1 Chelsea Instruments Aquatracka MKIII chlorophyll fluorometer.

1 Transmissometer.

1 Seabird dissolved oxygen sensor.

1 Seatech LS6000 backscatter sensor / 1 SUV-6 nitrate spectrophotometer.²

1 LISST 100C laser diffraction in situ particle size analyser.¹

¹ The Fastrackas and the LISST were standalone instruments, powered by their own batteries and recording data internally.

² The Seatech backscatter sensor was attached for CTD casts 001 to 030. The SUV-6 replaced the LS6000 for all CTD casts 031 onwards.

Second CTD instrumentation:

Seabird 911 CTD, with two conductivity and two temperature sensors.

1 Chelsea Instruments Aquatracka MKIII chlorophyll fluorometer.

1 Transmissometer.

1 Seabird dissolved oxygen sensor.

The titanium frame second CTD system was used on CTD casts: 125 – 133, and 159.

CTD cast 159 was used to collect a full set of salinity samples for calibration of the second CTD system.

CTD Start Times (all times are GMT)

CTD: ctd001 Date and Time: Jul 26 2003 15:47

CTD: ctd002 Date and Time: Jul 27 2003 21:58

CTD: ctd003 Date and Time: Jul 28 2003 13:40

CTD: ctd004 Date and Time: Jul 29 2003 02:57

CTD: ctd005 Date and Time: Jul 29 2003 03:58

CTD: ctd006 Date and Time: Jul 29 2003 05:21

CTD: ctd007 Date and Time: Jul 29 2003 06:01

CTD: ctd008 Date and Time: Jul 29 2003 06:58

CTD: ctd009 Date and Time: Jul 29 2003 08:02

CTD: ctd010 Date and Time: Jul 29 2003 09:17

CTD: ctd011 Date and Time: Jul 29 2003 10:23

CTD: ctd012 Date and Time: Jul 29 2003 11:15

CTD: ctd013 Date and Time: Jul 29 2003 12:29

CTD: ctd014 Date and Time: Jul 29 2003 13:37

CTD: ctd015 Date and Time: Jul 29 2003 14:06

CTD: ctd016 Date and Time: Jul 29 2003 15:00

CTD: ctd017 Date and Time: Jul 29 2003 16:12

CTD: ctd018 Date and Time: Jul 29 2003 17:01



CS2

CTD: ctd019 Date and Time: Jul 29 2003 18:00
CTD: ctd020 Date and Time: Jul 29 2003 18:58
CTD: ctd021 Date and Time: Jul 29 2003 20:00
CTD: ctd022 Date and Time: Jul 29 2003 20:58
CTD: ctd023 Date and Time: Jul 29 2003 21:57
CTD: ctd024 Date and Time: Jul 29 2003 23:07
CTD: ctd025 Date and Time: Jul 29 2003 23:57
CTD: ctd026 Date and Time: Jul 30 2003 00:58
CTD: ctd027 Date and Time: Jul 30 2003 01:57
CTD: ctd028 Date and Time: Jul 30 2003 02:57
CTD: ctd029 Date and Time: Jul 30 2003 03:59
CTD: ctd030 Date and Time: Jul 30 2003 05:09

CS2

CTD: ctd031 Date and Time: Jul 30 2003 17:16

CTD: ctd032 Date and Time: Jul 31 2003 03:04
CTD: ctd033 Date and Time: Jul 31 2003 04:01
CTD: ctd034 Date and Time: Jul 31 2003 05:07
CTD: ctd035 Date and Time: Jul 31 2003 06:07
CTD: ctd036 Date and Time: Jul 31 2003 06:58
CTD: ctd037 Date and Time: Jul 31 2003 08:04
CTD: ctd038 Date and Time: Jul 31 2003 08:59
CTD: ctd039 Date and Time: Jul 31 2003 10:02
CTD: ctd040 Date and Time: Jul 31 2003 11:05
CTD: ctd041 Date and Time: Jul 31 2003 12:03
CTD: ctd042 Date and Time: Jul 31 2003 13:03
CTD: ctd043 Date and Time: Jul 31 2003 14:07
CTD: ctd044 Date and Time: Jul 31 2003 15:07
CTD: ctd045 Date and Time: Jul 31 2003 16:01
CTD: ctd046 Date and Time: Jul 31 2003 16:58
CTD: ctd047 Date and Time: Jul 31 2003 18:09
CTD: ctd048 Date and Time: Jul 31 2003 21:05
CTD: ctd049 Date and Time: Jul 31 2003 22:06
CTD: ctd050 Date and Time: Aug 1 2003 01:10
CTD: ctd051 Date and Time: Aug 1 2003 03:37

CS1

CTD: ctd052 Date and Time: Aug 1 2003 10:51
CTD: ctd053 Date and Time: Aug 1 2003 13:07
CTD: ctd054 Date and Time: Aug 1 2003 20:31

CS3b
CS3c (mooring)
IS1 (test for mixed)

CTD: ctd055 Date and Time: Aug 2 2003 02:57
CTD: ctd056 Date and Time: Aug 2 2003 03:58
CTD: ctd057 Date and Time: Aug 2 2003 04:57
CTD: ctd058 Date and Time: Aug 2 2003 05:59
CTD: ctd059 Date and Time: Aug 2 2003 07:02
CTD: ctd060 Date and Time: Aug 2 2003 08:02
CTD: ctd061 Date and Time: Aug 2 2003 09:01
CTD: ctd062 Date and Time: Aug 2 2003 10:11
CTD: ctd063 Date and Time: Aug 2 2003 11:03
CTD: ctd064 Date and Time: Aug 2 2003 12:10
CTD: ctd065 Date and Time: Aug 2 2003 13:09
CTD: ctd066 Date and Time: Aug 2 2003 14:03
CTD: ctd067 Date and Time: Aug 2 2003 15:01
CTD: ctd068 Date and Time: Aug 2 2003 16:03
CTD: ctd069 Date and Time: Aug 2 2003 17:06

IS1 (mixed)

CTD: ctd070 Date and Time: Aug 2 2003 18:02
CTD: ctd071 Date and Time: Aug 2 2003 19:00
CTD: ctd072 Date and Time: Aug 2 2003 19:59
CTD: ctd073 Date and Time: Aug 2 2003 20:59
CTD: ctd074 Date and Time: Aug 2 2003 22:00
CTD: ctd075 Date and Time: Aug 2 2003 22:59
CTD: ctd076 Date and Time: Aug 2 2003 23:58
CTD: ctd077 Date and Time: Aug 3 2003 00:57
CTD: ctd078 Date and Time: Aug 3 2003 01:56
CTD: ctd079 Date and Time: Aug 3 2003 02:57
CTD: ctd080 Date and Time: Aug 3 2003 03:57

IS1 (mixed)

CTD: ctd081 Date and Time: Aug 3 2003 05:42
CTD: ctd082 Date and Time: Aug 3 2003 07:18
CTD: ctd083 Date and Time: Aug 3 2003 08:39
CTD: ctd084 Date and Time: Aug 3 2003 10:09
CTD: ctd085 Date and Time: Aug 3 2003 12:01
CTD: ctd086 Date and Time: Aug 3 2003 12:59
CTD: ctd087 Date and Time: Aug 3 2003 14:11
CTD: ctd088 Date and Time: Aug 3 2003 15:22
CTD: ctd089 Date and Time: Aug 3 2003 16:32
CTD: ctd090 Date and Time: Aug 3 2003 17:57

**Cross-front
X1-X11**

CTD: ctd091 Date and Time: Aug 3 2003 20:13
CTD: ctd092 Date and Time: Aug 3 2003 21:33
CTD: ctd093 Date and Time: Aug 3 2003 22:44
CTD: ctd094 Date and Time: Aug 4 2003 00:00
CTD: ctd095 Date and Time: Aug 4 2003 01:36

**Along-front
Y1-Y5**

CTD: ctd096 Date and Time: Aug 4 2003 11:26 (with optics)

CTD: ctd097 Date and Time: Aug 5 2003 03:00
CTD: ctd098 Date and Time: Aug 5 2003 03:55
CTD: ctd099 Date and Time: Aug 5 2003 05:07
CTD: ctd100 Date and Time: Aug 5 2003 06:03
CTD: ctd101 Date and Time: Aug 5 2003 06:57
CTD: ctd102 Date and Time: Aug 5 2003 08:14
CTD: ctd103 Date and Time: Aug 5 2003 09:09
CTD: ctd104 Date and Time: Aug 5 2003 10:01
CTD: ctd105 Date and Time: Aug 5 2003 11:02
CTD: ctd106 Date and Time: Aug 5 2003 12:02
CTD: ctd107 Date and Time: Aug 5 2003 13:01
CTD: ctd108 Date and Time: Aug 5 2003 14:00
CTD: ctd109 Date and Time: Aug 5 2003 15:03
CTD: ctd110 Date and Time: Aug 5 2003 16:00
CTD: ctd111 Date and Time: Aug 5 2003 17:02
CTD: ctd112 Date and Time: Aug 5 2003 18:02
CTD: ctd113 Date and Time: Aug 5 2003 18:59
CTD: ctd114 Date and Time: Aug 5 2003 19:59
CTD: ctd115 Date and Time: Aug 5 2003 21:02
CTD: ctd116 Date and Time: Aug 5 2003 21:58
CTD: ctd117 Date and Time: Aug 5 2003 22:58
CTD: ctd118 Date and Time: Aug 5 2003 23:57
CTD: ctd119 Date and Time: Aug 6 2003 00:58

CS3 (1)

CTD: ctd120 Date and Time: Aug 6 2003 01:58
CTD: ctd121 Date and Time: Aug 6 2003 02:56
CTD: ctd122 Date and Time: Aug 6 2003 04:06



CS3 (1)

CTD: ctd123 – aborted.
CTD: ctd124 Date and Time: Aug 6 2003 16:28

U2

CTD: ctd125 Date and Time: Aug 7 2003 13:54
CTD: ctd126 Date and Time: Aug 7 2003 15:49
CTD: ctd127 Date and Time: Aug 7 2003 17:42
CTD: ctd128 Date and Time: Aug 7 2003 19:46
CTD: ctd129 Date and Time: Aug 7 2003 21:30
CTD: ctd130 Date and Time: Aug 7 2003 23:24
CTD: ctd131 Date and Time: Aug 8 2003 02:38
CTD: ctd132 Date and Time: Aug 8 2003 06:32
CTD: ctd133 Date and Time: Aug 8 2003 11:03



Line N

CTD: ctd134 Date and Time: Aug 10 2003 02:56
CTD: ctd135 Date and Time: Aug 10 2003 03:56
CTD: ctd136 Date and Time: Aug 10 2003 04:58
CTD: ctd137 Date and Time: Aug 10 2003 05:57
CTD: ctd138 Date and Time: Aug 10 2003 06:57
CTD: ctd139 Date and Time: Aug 10 2003 08:11
CTD: ctd140 Date and Time: Aug 10 2003 09:22
CTD: ctd141 Date and Time: Aug 10 2003 10:15
CTD: ctd142 Date and Time: Aug 10 2003 11:02
CTD: ctd143 Date and Time: Aug 10 2003 12:07
CTD: ctd144 Date and Time: Aug 10 2003 13:09
CTD: ctd145 Date and Time: Aug 10 2003 14:02
CTD: ctd146 Date and Time: Aug 10 2003 15:05
CTD: ctd147 Date and Time: Aug 10 2003 16:10
CTD: ctd148 Date and Time: Aug 10 2003 17:03
CTD: ctd149 Date and Time: Aug 10 2003 18:22
CTD: ctd150 Date and Time: Aug 10 2003 18:55
CTD: ctd151 Date and Time: Aug 10 2003 19:47
CTD: ctd152 Date and Time: Aug 10 2003 21:01
CTD: ctd153 Date and Time: Aug 10 2003 21:58
CTD: ctd154 Date and Time: Aug 10 2003 22:56
CTD: ctd155 Date and Time: Aug 10 2003 23:57
CTD: ctd156 Date and Time: Aug 11 2003 00:56
CTD: ctd157 Date and Time: Aug 11 2003 01:55
CTD: ctd158 Date and Time: Aug 11 2003 02:56
CTD: ctd159 Date and Time: Aug 11 2003 03:53



CS3 (2)

CTD: ctd160 Date and Time: Aug 11 2003 06:13
CTD: ctd161 Date and Time: Aug 11 2003 07:55
CTD: ctd162 Date and Time: Aug 11 2003 09:59
CTD: ctd163 Date and Time: Aug 11 2003 12:36
CTD: ctd164 Date and Time: Aug 11 2003 14:39
CTD: ctd165 Date and Time: Aug 11 2003 16:11
CTD: ctd166 Date and Time: Aug 11 2003 17:59
CTD: ctd167 Date and Time: Aug 11 2003 20:50
CTD: ctd168 Date and Time: Aug 11 2003 23:47
CTD: ctd169 Date and Time: Aug 12 2003 03:39
CTD: ctd170 Date and Time: Aug 12 2003 06:47

D1
D2
D3
D4
CS1
CS1b
A3
A6
A9
A13
CS2

CTD: ctd171 Date and Time: Aug 12 2003 11:25

CS2 (optics)

CTD: ctd172 Date and Time: Aug 12 2003 13:59

CS2 (fixed depth time series)

CTD Problems:

Slip ring problems on the CTD winch caused problems during the cruise, particularly during the latter part of station CS1. While the problems were largely fixed after CS1, there is some spiking in the raw data that needs to be removed.

Full list of all station positions.

Deg N	min N	Deg W	min W	Decimal N	Decimal W	
50	52.0	8	21.0	50.867	8.350	A1/CS1
50	35.5	8	30.0	50.592	8.500	A3
50	7.6	8	43.5	50.127	8.725	A6
49	39.7	8	57.0	49.662	8.950	A9
49	2.0	9	15.2	49.033	9.253	A13
48	33.0	9	30.0	48.550	9.500	A16/CS2
48	38.3	9	6.7	48.638	9.112	N1
48	34.8	9	17.5	48.580	9.292	N2
48	31.2	9	29.6	48.520	9.493	N3
48	30.1	9	33	48.502	9.550	N4
48	29.1	9	36	48.485	9.600	N5
48	26.9	9	42.9	48.448	9.715	N6
48	23.8	9	53	48.397	9.883	N7
48	21.3	10	1.6	48.355	10.027	N8
48	17	10	13	48.283	10.217	N9
52	34.01	5	28.02	52.567	5.467	IS1b
50	52	8	21	50.867	8.350	CS1
48	31.9	9	27.8	48.532	9.463	CS2
51	28.4	6	25.8	51.473	6.430	CS3c
49	14	6	10	49.233	6.167	U2
52	34.01	5	28.02	52.567	5.467	IS1b/X1
52	20.0	5	40.0	52.333	5.667	X2
52	6.8	5	52.0	52.113	5.867	X3
52	0.7	6	4.7	52.012	6.078	X4
51	54.4	6	17.8	51.907	6.297	X5
51	51.2	6	24.0	51.853	6.400	X6
51	49.0	6	28.3	51.817	6.472	X7
51	43.8	6	39.1	51.730	6.652	X8
51	38.8	6	49.5	51.647	6.825	X9
51	33.7	7	0.0	51.562	7.000	X10
51	28.5	7	10.8	51.475	7.180	X11
51	49.0	7	12.2	51.817	7.203	Y1
51	43.3	7	0.0	51.722	7.000	Y2
51	38.8	6	49.5	51.647	6.825	Y3
51	33.3	6	37.5	51.555	6.625	Y4
51	28.4	6	25.8	51.473	6.430	CS3c/Y5
51	21.0	6	48.0	51.350	6.800	D1
51	14.0	7	8.0	51.233	7.133	D2
51	7.0	7	32.0	51.117	7.533	D3
50	59.0	7	58.0	50.983	7.967	D4
50	50.0	8	21.0	50.833	8.350	CS1b

4.2 Mooring deployments.

Ian Waddington & Chris Crowe – UKORS, SOC.

There were three moorings and 2 landers deployed at site CS2 28th July 2003 - Day 209

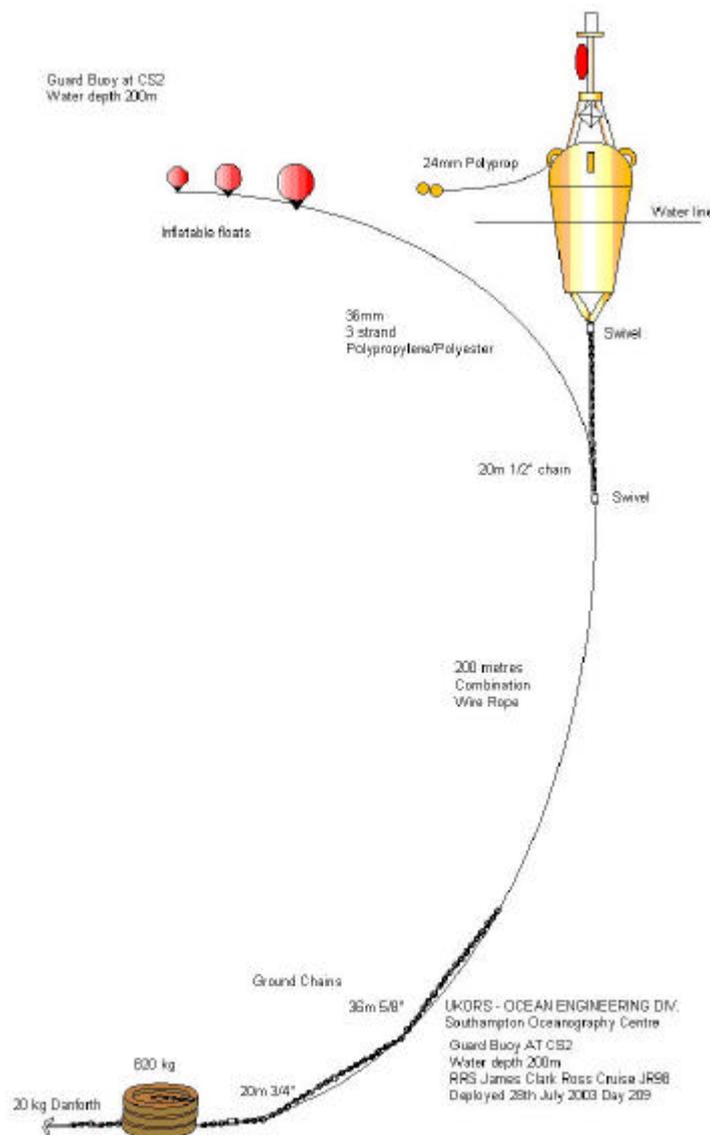
In order of deployment :-

1. Guard Buoy
2. Temperature Logger Mooring - VEMCO Mooring
3. SUBS buoy mooring
4. 150 khz ADCP lander
5. 300 khz ADCP lander

Recovery of all the moorings and landers took place on the 12th August 2003 – Day 224

MOORING 1 – Guard Buoy at CS2

The Guard buoy is deployed as its name implies to provide a large surface marker with navigation aids to provide protection for the mooring and lander array. The buoy type is an all steel construction pear shape buoy with a 2 metre mast . The mast has a conventional radar



reflector and Firdell blipper radar reflector along with a solar powered navigation light .

Deployment – 28th July 2003 - Day 209

The buoy mooring is deployed buoy first with all the heavy chains flaked down on deck and the combination wire rope wound onto the 5 tonne portable winch.

The buoy is lifted overside on a release toggle and at the same time the ballast chain is heaved over such that there is weight beneath the buoy to stabilise it as it enters the water . All the chain is then slipped away to the combination wire, which is then paid out by winch along the deck. At the end of the combination wire is a 5 tonne cut off rope , this enables the wire to be connected to the ground chain and to disconnect the winch wire quickly. As this line is cut the ground chain is slipped away to the railway wheel anchor and Danforth anchor.

The mooring is slowly towed to position and the railway wheel anchor released to freefall to the seabed. The buoy pulls towards the ship as the anchor sinks and gradually stabilises as the mooring settles in position .

The buoy was observed during the 25 hour ctd station and appeared to be performing correctly with the navigation light operating through the dark hours .

Recovery

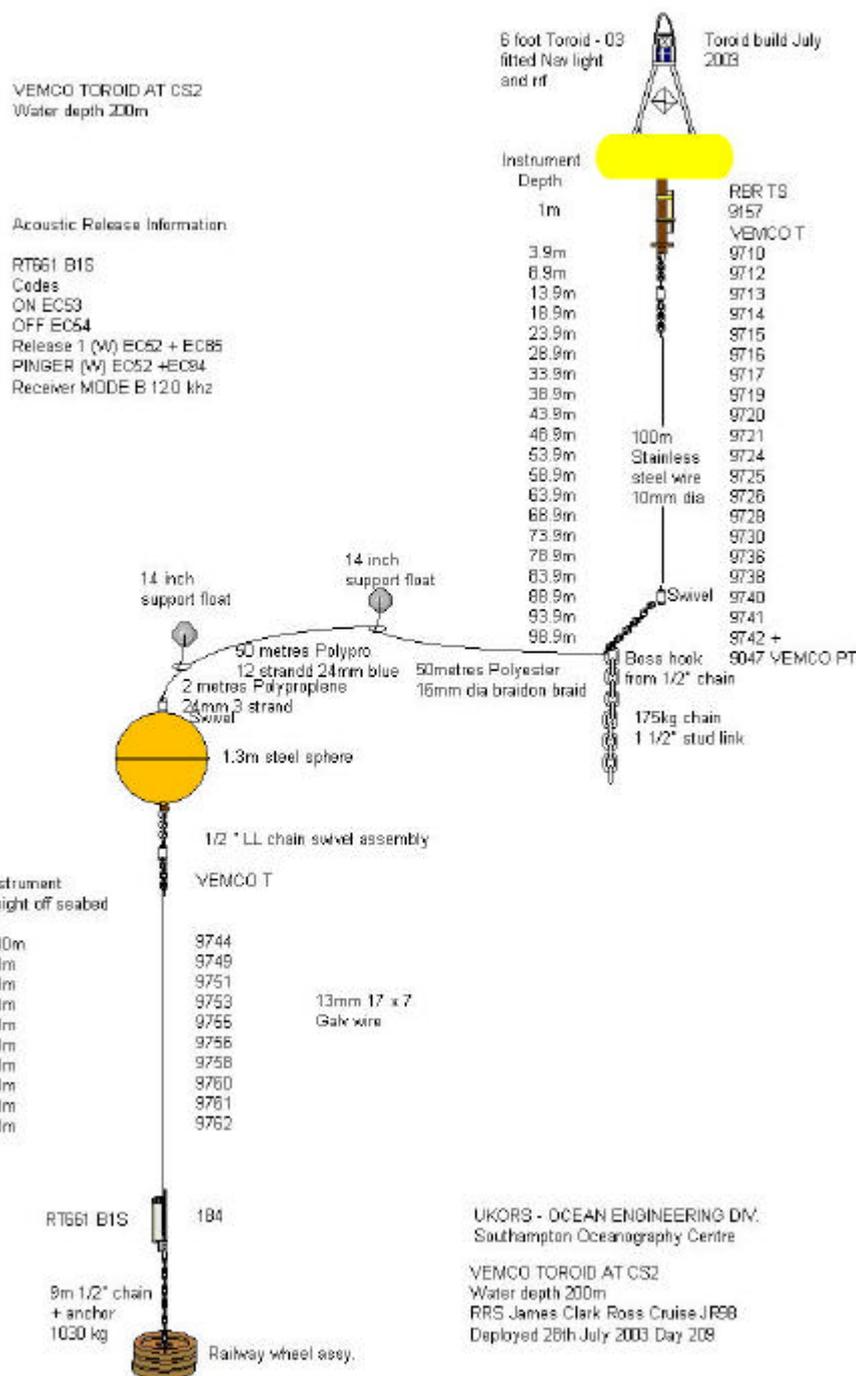
The mooring was recovered on the 12th August 2003 . Recovery line from top of buoy fouled around chain beneath buoy. Grappled at deep line and held in control until top line could be freed by hauling.

Recovery then proceeded as normal with the anchor being hauled onboard tangled with the ground chains .

MOORING 2 – Temperature Logger Mooring - VEMCO Mooring

The mooring is an S tether mooring which comprises a surface string of temperature loggers , Vemco Mini logger 12 , coupled to a subsurface mooring , again carrying temperature loggers. The mooring technique was evolved for VAESAT current and ADCP buoys in the South Western Approaches (IOS W) and is here modified to provide near vertical mooring components for the measurement of temperature . In 2002 a similar shallow water ,100 metre depth , mooring was deployed for near surface temperature measurements and from this and the previous designs the present mooring was evolved.

The surface buoy is a toroidal hull with relatively low hydrodynamic drag and high buoyancy return. In order to provide increased uplift at the surface toroidal buoy a new design of keel with reduced buoy ballast was prepared . This allows the pendulum weight to be increased which improves verticality of the upper temperature string . The downside of this is that weather and seastate conditions must be less than the previous design as the buoy without its keel ballast weight is more prone to capsize during deployment . When in position the buoy stability is as previous designs. The connecting line of the S tether to the subsurface mooring buoy provides a compliant linkage which is of two differing line types . The upper line type is braided polyester which naturally sinks , this keeps the line clear of the upper mooring at all times . The lower line type to the subsurface buoy is a buoyant polypropylene 12 plait this thus floats well above the subsurface buoy and mooring. Additional buoyancy is provided above the subsurface to hold the swivel up clear of the subsurface buoy . Again at the joint of the polypropylene 12 plait and polyester braid a float is positioned to support the line connection shackles and hard eyes , this also assists the line to float up clear of the subsurface rig at slack water conditions. The subsurface mooring is a conventional shallow seas mooring with a low drag steel support buoy , swivels and acoustic release , anchored to the seabed by a deadweight anchor comprised of railway wheels . The subsurface mooring is overly taught for a conventional shallow seas subsurface mooring but is a requirement when coupled to the S



tether to create a stable mooring with optimised knockdown in high current and wave conditions. The mooring is swivelled throughout its length to permit free rotation of the major components.

Deployment – 28th July 2003 - Day 209

The mooring was deployed as buoy first - anchor freefall . Deployment commenced by lowering the 6 foot Toroid over the stern on a slip line from the ships Gilson wire. The upper 4 (20 metres) Vemco min-loggers were pre-attached to the mooring wire before commencing deployment such that paying out the upper wire was quickly achieved as the toroid in this unballasted state can overturn.

The stainless steel wire was then paid out from the 5 tonne winch and VEMCO mini-loggers attached at pre-marked intervals using cable ties and bright coloured pvc tape , this to aid sighting during recovery phase.

At the mooring connection between the stainless wire and the polyester braid a length of 1/2" chain with oval link was placed such that the 175kg pendulum chain was Boss hooked into the oval link ensuring quick smooth attaching.

The polyester and polypropylene lines were then paid out from the 5 tonne crane with the support floats added by looping through the large hard eyes as the line connections were paid overside.

The 1.3m steel sphere was positioned on its pallet on deck with chain and swivel pre-connected , the mooring line overside stopped off by rope to enable transfer of load through the sphere. The 1.3m sphere was then lifted overside using the ships Gilson wire and release . The upper 10metre Vemco logger being positioned before lowering the sphere.

As the wire was paid out from the 5 tonne winch the surge on the mooring was quite considerable and attaching the Vemcos was achieved with some difficulty , one logger being lost overside .

The RT661 B1S was pre-attached to the anchor by the anchor chain , such that the transfer to the mooring wire could be achieved quickly using a cut off rope on the winch tail wire .

The anchor was then swung over the stern on the starboard aft crane using a cut off line . As the ship towed slowly onto position the mooring streamed well astern . As the ship came onto position the anchor was cut away to freefall to the seabed. The steel sphere being observed to submerge and the toroid buoy to approach the ship. The toroid buoy stabilised over a period of several minutes as the mooring settled and the pendulum weight took up its position beneath the buoy .

A CTD was undertaken shortly after deployment and attempts to range on the acoustic release made . This was not entirely successful as experienced on previous occasions (April 2003) with the ships thrusters running . Replies were detected but not with any consistent range due to noise.

Recovery

The mooring was recovered on the 12th of August , by pop up of the subsurface section , then grappled midships at the toroid buoy and transferred aft where hauling was commenced on the winch. The steel 4 foot sphere was quite deep in the water and was a cause for concern.

As the stainless steel wire was hauled the VEMCO loggers were removed , at the 68.9 metre position the logger was missing with the securing tape and cable tie ripped down one side . At succeeding depths loggers were missing with similar evidence . The stainless wire was damaged and some strands had broken .

At the position of the pendulum chain , this chain was missing entirely and the mooring polyester very damaged . Just 5 metres from this the SUBS float was entangled with the polyester line . There was a sever load on the line as the SUBS mooring still had its anchor obviously attached. The SUBS release was immediately fired and the mooring rose to the surface close alongside the VEMCO mooring then in tow. By hauling the SUBS onboard and stopping off the SUBS buoy was removed , the lines untangled and the SUBS mooring then allowed to drift astern tied off with a stopper rope.

The VEMCO mooring was then hauled onboard and all equipment recovered .

The SUBS mooring then was hauled onboard and all equipment recovered.

It would appear that the moorings had become entangled either during recovery or possibly by fishing activity moving the moorings. The damage to the VEMCO mooring was not caused by entangling as this would be inconsistent with the soft materials used on the SUBS mooring.

Instrumentation

RBR TS logger - SOES

9157

Time interval 1 minute

RBR XL-210 3.0 009157 jr98 rbr toroid buoy

Host time 03/08/13 15:32:15

Logger time 03/08/13 15:32:21

Logging start 03/07/28 10:00:00

Logging end 03/08/11 12:00:00

Sample period 00:01:00

Number of channels = 2, number of samples = 13939, mode : 4

XL4.2: Calibration file is 009157.CAL :

Drawing 1334-801, created 17mar00 for logger XL-210. #9157

D01%8.2f%8.2f

1 1 15.1233 0.0051516 0 0 0 0 0 Degrees_C

2 1 -0.20792 0.0128368 0 0 0 0 0 mS/cm

Start 1000+00 gmt 28th July 2003

VEMCO Minilog-T

Miniature data logger recording temperature at user defined intervals. 5 years battery life.

ALL VEMCO Minilog - T set as ;

Time interval set to 1 minute

No pre cruise temp cal.

Start 0800 + 00 gmt 28th July 2003

VEMCO Minilog PT 9047 set as ;

Time interval set to 2 minutes

Range T = -4.1 to +20.6C Range P = 0 to 150.3m

Temp cal 9th October 2002

Start 0800 + 00 gmt 28th July 2003

Mooring allocation

Instrument depth from surface

9710-3.9m	9717-33.9m	9726-63.9m	9741-93.9m
9712-8.9m	9719-38.9m	9728-68.9m	9742-98.9m
9713-13.9m	9720-43.9m	9730-73.9m	PT9047-98.9m
9714-18.9m	9721-48.9m	9736-78.9m	
9715-23.9m	9724-53.9m	9738-83.9m	
9716-28.9m	9725-58.9m	9740-88.9m	
9744 100mab	9749 90mab	9751 80 mab	9753 70mab
9755 60mab	9756 50mab	9758 40mab	9760 30mab
9761 20 mab	9762 10mab		

Data download

All recovered loggers downloaded using VEMCO software and converted to ASCII file.s.

Acoustic Release

RT661 B1S

Serial number 184

ON EC53 12 khz Mode B

OFF EC54

REL 1 (W) EC52 + EC85

PINGER (W) EC52 + EC94

Recovery

Mooring allocation

Instrument depth from surface

9710-3.9m REC	9717-33.9m REC	9726-63.9m REC
9741-93.9m LOST	9712-8.9m REC	9719-38.9m REC
9728-68.9m LOST	9742-98.9m LOST	9713-13.9m REC
9720-43.9m REC	9730-73.9m REC	PT9047-98.9m LOST
9714-18.9m REC	9721-48.9m REC	9736-78.9m LOST
9715-23.9m REC	9724-53.9m REC	9738-83.9m LOST
9716-28.9m REC	9725-58.9m REC	9740-88.9m LOST
9744 100mab REC	9749 90mab REC	9751 80 mab REC
9753 70mab REC	9755 60mab REC	9756 50mab REC
9758 40mab REC	9760 30mab REC	9761 20 mab REC
9762 10mab REC		

MOORING 3 – SUBS BUOY MOORING

The SUBS buoy mooring comprises of a streamlined SUBS buoy with 600 khz Sentinel ADCP and temperature logger to provide a stable platform for the ADCP measurements . The mooring comprises of low drag mooring wires with some near SUBS fairing to reduce strumming. In line buoyancy is added beneath the SUBS buoy to provide adequate support and stiffness to the mooring line. An Aanderaa RCM7 is fitted near seabed to provide deep ctd measurements.

The mooring is entirely subsurface and is equipped with an acoustic release AR361 for recovery. The mooring hydrodynamic s were modelled at SOC to optimise the mooring layout for various possible line and buoyancy configurations which might be applied at sea. Lines and components measured onboard to locate 600 khz ADCP at 90 metres water depth.

Deployment.

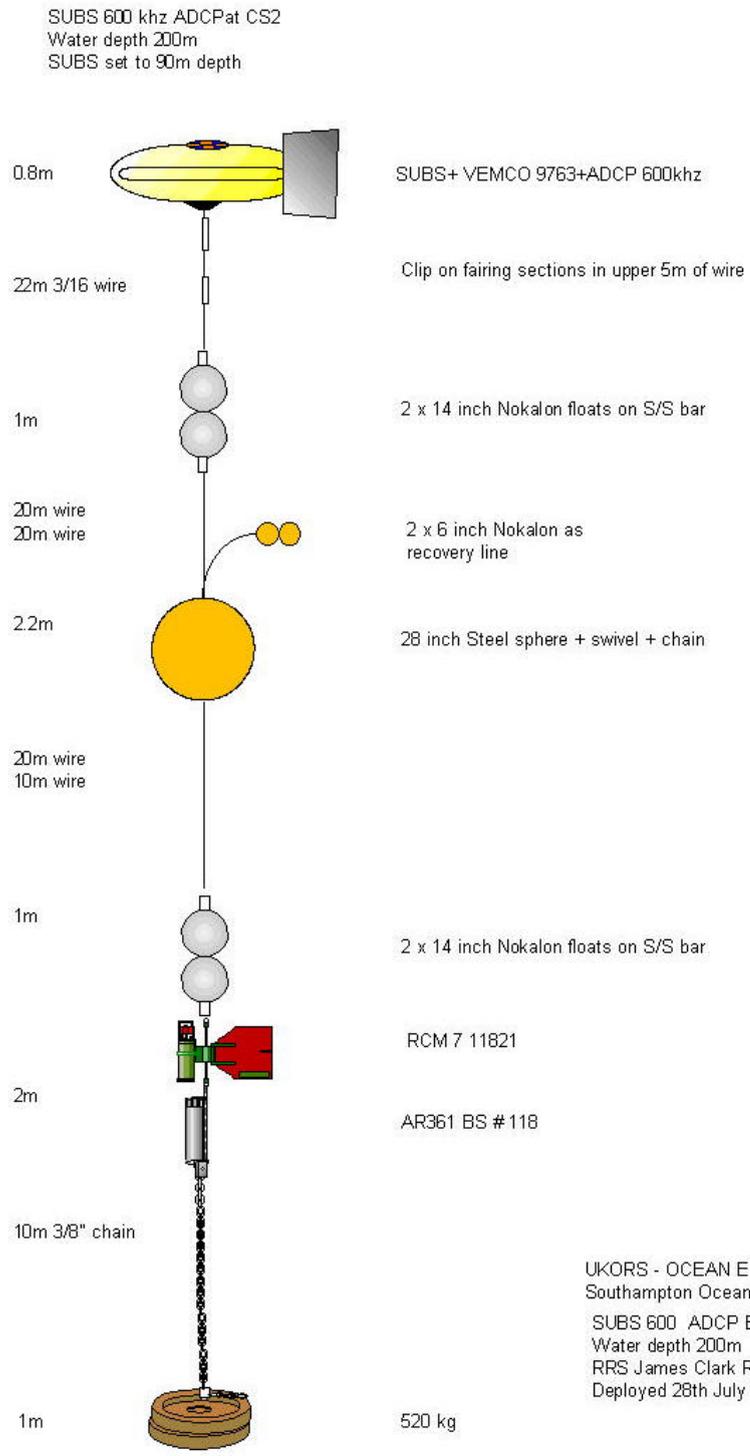
The mooring was all prepared on deck for buoy first deployment . All mooring lines and components connected together with the buoyancy and instruments. The lower line being connected to a cut off / transfer line attached to the 5 tonne portable deck winch wire.

All lines were carefully coiled down to ensure free running during deployment .

Deployment commenced with the SUBS buoy being lifted overside using a slip pole attached to the ships Gilson wire. As the Subs entered the water the line was freed and with the ship going slowly ahead the mooring components were then deployed by hand . The 28 inch steel sphere was lowered by hand over the roller on the ships stern.

As the line tension increased at the RCM7 and acoustic release the 5 tonne winch was used to control the deployment along the deck were the anchor riser chain could be connected to the acoustic release link . The cut off/transfer line was then cut away to allow the mooring tension to be tranferred to the anchor which was secured to the starboard aft crane by a 5 tonne cut away line. The anchor was then swung outboard as the ship proceeded to drop point. On arrival at the drop point the anchor was cut away to freefall to the seabed. Visual observation

of the mooring descent from the buoys at the surface and SUBS buoy indicated a relatively gentle descent rate.



UKORS - OCEAN ENGINEERING DIV.
Southampton Oceanography Centre
SUBS 600 ADCP Buoy AT CS2
Water depth 200m
RRS James Clark Ross Cruise JR98
Deployed 28th July 2003 Day 209



Instrumentation

VEMCO Minilog-T

Miniature data logger recording temperature at user defined intervals. 5 years battery life.

VEMCO 9763

Time interval set to 1 minute

Start 0800 + 00 gmt 28th July 2003

Installed in tail assembly of SUBS buoy secured by cable ties.

Aanderaa RCM 7

Rotor / vane instrument fitted with temperature , conductivity sensors for the JR98 experiment , pressure remains installed from previous experiment .

Calibration of temperature and check value of conductivity carried out at OED Calibration laboratory , July 2003.

CRUISE / SHIP: JR80 JCR
USER/PROJECT: Sharples

RCM Serial No: 11821
RCM TYPE:RCM7

SENSORS and SET UP

Electronics board S/N : 30455

Data storage unit S/N : 8184

Type : 2990

Channel No.	SENSOR	SERIAL No.	Range/Comment
1	Ref	no	value 412
2	Temp	no	low cal16/07/2003
3	Conductivity	2565	check 17/07/2003
4	Pressure	1116	0-3000 psi no cal
5	Compass	20844	no pre cruise cal
6	Rotor	2608	no pre cruise cal

Battery Type :Leclanche
 Temp Range Select : LOW
 63ohm=620

Open Loop Volts:
 Check values on Ch3 cond
 77ohm =509

100ohm Load Volts:
 50ohm=781
 100ohm=390

Time Interval Select : 1 **Time Interval: 1 min**
DSU Erased : YES
DSU Clock Set : YES 2142+00 gmt 27-07-2003

FIRST MEASUREMENT (GMT): 2145+ 00s gmt 27th July 2003 - day 208
SECOND MEASUREMENT : 2147 + 00s

RECOVERY PHASE

LAST MEASUREMENT (GMT) : NONE DSU full – check dsu 1753 + 17secs at 1753 gmt ships time. Recovered 12th August 2003
NUMBER OF DSU WORDS 65520 :
Condition of Recording Unit : GOOD . Time on interval – 1736 + 12 sec gmt
Data Downloaded to : cd JR98 and filed to SOC S drive
Filed as : 11821

ACTIONS REQUIRED AT LABORATORY :

Calibration of sensors

600 Khz Sentinel ADCP

The unit was set up on board to use the command parameters provided by Dr Tom Rippeth , these were input to the 600khz ADCP and consequences and set up checked against the provided parameters.

Set up

CF11101 FLOW CONTROL
EA0 HEADING ALIGNMENT
EB0 HEADING BIAS
ED800 TRANSDUCER DEPTH (dm)
ES35 SALINITY (parts per thousand)
EX00000 COORD TRANSFORM
EZ11111111 SENSOR SOURCE (C;D;H;P;R;S;T)
WD111000000 DATA OUT (Vel;Cor;Amp PG ; St ; P0 P1 ; P2 ; P3)
WF88 BLANK AFTER TRANSIT (0-9999cm)
WM12 MODE 12
WN45 NUMBER OF DEPTH CELLS
WP1 PINGS PER ENSEMBLE
WS100 DEPTH CELL SIZE (0-9999cm)
WO6 , 6
WV130 AMBIGUITY VELOCITY (cm/s radial)
TE:00:02:00 Time per ensemble (hours;minutes;seconds;hundredths of seconds)
TP00:02,00 Time between pings (minutes,seconds,hundredths of seconds)
CK Keep parameters as USER DEFAULTS
CS START PINGING - This set just prior to deployment at known time
Instrument Workhorse Monitor
Frequency 614400
Beam Angle 20
Temperature 10
Deployment hours 360
Battery packs 0
Automatic TP NO
Memory size MB 996

Consequences

First cell range = 2.19m
Last cell range = 46.19m
Max range = 45.77m
Standard deviation = 2.18cm/s
Ensemble size = 864 bytes
Storage required = 559.87 MB
Power usage = 451.65 Wh

TS Time set onboard 03/07/28 14:36:29 as GMT

RN = Sharp
CR0 = PARAMETERS SET TO USER DEFAULTS
Internal battery packs = 2
Memory available =

CS START PINGING at 1440+00 GMT 28th July 2003 Day 209
Data downloaded , datadownload time taking 36 hours.

Acoustic Release

Acoustic release type AR361 BS . Fitted Alkaline battery set .
Serial number 118 Manufacturers service date March 01
AR3X1 Board Ser.no. 27 Soft AR3X1 - 3
INT/RANGE EA22 FT0 8.0 khz Mode A
RELEASE EA21 FT0 8.0 khz Mode A

Recovery – See Vemco mooring recovery.

MOORING 4 – 150 Khz BBADCP Lander - RED

The lander used to house the 150 khz BBADCP is a modified 150 khz Narrow band ADCP framework. Modifications are to the buoyancy where the previous glass buoyancy is replaced with 14" Nokalon floatation to provide improved buoyancy and lower drag . This is to create a more stable lander platform. The BBADCP is mounted within the framework and attached by rigid clamps along its length. The ballast frame is steel with additional lead weights added to ensure the lander sinks quickly and in the vertical as it freefalls through the water column . The ballast weight is located onto the framework by steel pegs into polypropylene bushes within the lander framework.Held in place by tensioning the framework to the acoustic release using a dynamo bolt through the ballast frame which is pulled down against the release chain. To ensure that the release chain does not foul the frame on release a length of bungee is attached near the release which is then tensioned to the ballast frame. Thus as when the release is triggered the chain is pulled rapidly down to the ballast clear of the framework.

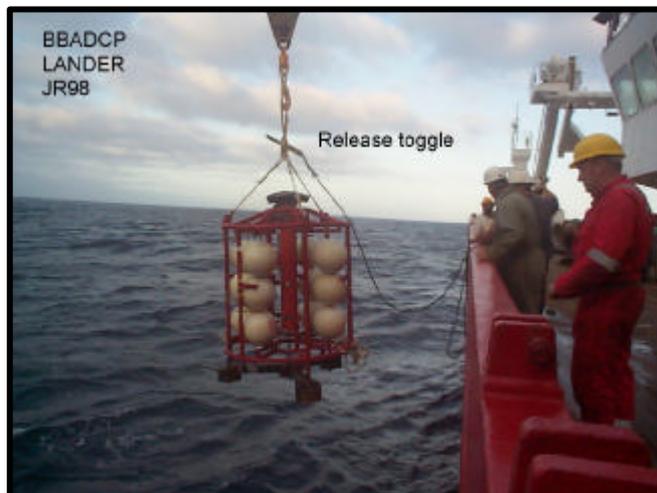


Ballasting trials were carried out in the dock at SOC to ensure correct hold down with ballast frame attached and buoyancy of the framework when the ballast is removed. The frame floats at the surface inverted with the BBADCP transducers downward and with the acoustic transducer 1.5 metres underwater. No recovery line is fitted above the lander to minimise possible interference to the beams of the 150khz.

It was originally planned to recover the lander by using a ships boat but as this was not possible recovery break off lines were added at the base of the frame such that the lines could be grappled from the ship to permit craning onboard.

Deployment

The lander was lifted overside using the ships crane with the lander attached to the release toggle by three polypropylene rope strops at the top of the lander .
As the lander submerged the toggle was pulled and the lander then went into freefall to the seabed. As the lander sank away it could be seen that the descent appeared stable and vertical.



Recovery

Lander release triggered, confirmation imprecise due to ship acoustic noise , sighted from bridge. Instrument surfaced inverted as expected and pull off recovery line hooked with pole and grapnel . Lander recovered onboard midships using crane.

Instrumentation

VEMCO Mini logger T

Attached within the framework of the lander.

Ser. No 9764

VEMCO Minilog - T set as ;

Time interval set to 1 minute

No pre cruise temp cal.

Start 0800 + 00 gmt 28th July 2003

Acoustic release

RT 361 BS

ON EA54 FT0 = 12Khz Mode B

OFF EA55

RELEASE EA56

150 khz SCBBADCP

The 150 KHz BBADCP was set up as below -

JR98 .CMD

SHAR .CMD

```

PINGS PER ENSEMBLE  10
DEPTH CELL SIZE      4.00M
NUMBER OF DEPTH CELLS  50
BLANK AFTER TRANSMIT  4.00M
PROFILING MODE       4
AMBIGUITY VELOCITY   200CM/S
BOTTOM TRACK
PINGS PER ENSEMBLE  0
DATA COLLECTION SET UP
TIME BTWN PING GROUPS  0.00S
```

TIME PER ENSEMBLE 00:01:00:00
 DEPLOYMENT LENGTH 18 DAYS 19DAYS
 VELOCITY YES
 COORDINATE SYSTEM EARTH
 CORRELATION YES
 INTENSITY YES
 PERCENT GOOD YES
 STATUS YES
 ENABLE RECORDER YES
 ENABLE SERIAL OUTPUT YES
 BAUD RATE 38400
 FREQUENCY 150KHZ
 BEAM ANGLE 20
 FIRMWARE VERSION 3.xx/4.xx
 SYSTEM POWER LOW
 WATER TEMP 5.00C
 DEPTH OF TRANSDUCER 200M
 FIRST DEPTH CELL 10M
 LAST DEPTH CELL 206.00M
 PREDICTED MAX RANGE 259.47M
 MIN PING TIME 0.83S
 VELOCITY STD DEV 1.37CM/S
 DATA COLLECTION PREDICTIONS
 ENSEMBLE SIZE 1312B 1312B
 MIN TIME PER ENSEMBLE 9.11S 9.11S
 TOTAL SPACE NEEDED 34.01MB 35.9MB
 ENERGY REQUIRED 440.33WH 464.79WH
 RECORDING ON AT :- 1757+00s GMT 27th July 2003 Day 208
 Data downloaded onboard taking 24 hours .

MOORING 5 – 300 khz ADCP lander

In order to provide a near seabed 300 khz ADCP a pop up lander frame was built at SOC to house a fully gimballed 300 khz ADCP, acoustic release and Vemco Minilogger T. Minimising magnetic influence had to be considered . The framework is all welded aluminium alloy with stainless steel fasteners to secure sensors and buoyancy . The ballast weight is clean cast lead . Titanium parts are used for the release mechanism and the acoustic release is housed in an anodised aluminium pressure housing.

The ADCP is mounted into a Flotation Technologies Type AL-200 Gimbal assembly , this was purchased for a shallow (200m rated) ADCP and had to be modified to house the full ocean depth WorkHorse 300 . Additional work had to be undertaken to add lead ballast in a framework beneath the ADCP to stabilise it vertically , as the natural orientation of the WorkHorse in the gimbal is inverted . The gimballed adcp is then mounted within a polyethylene housing to prevent tidal current moving the adcp in the gimbals.



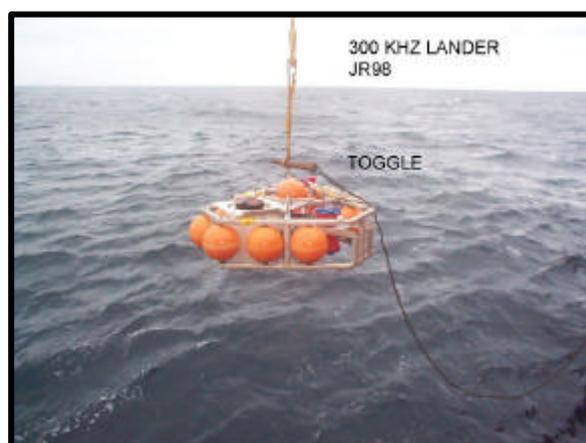
The acoustic release is an SOC / MORS pyro firer mounted horizontally within the framework , the pyro release mechanism being centrally positioned and suspended from the top of the framework in a custom fitting to prevent rotation . Pyro leads are clipped around the framework from the acoustic release to the pyros on the mechanism. The lead ballast weight is housed in an aluminium frame and then tensioned to the release mechanism using a dynamo bolt .On release the lead falls clear of the aluminium frame. The Minilogger is clipped to the upper framework adjacent to the ADCP.

The complete assembly was dock tested at SOC to ensure correct ballasting of the lander and to ensure support buoyancy was adequate for recovery . The frame floated with the acoustic release uppermost as the framework rotated through 90 degrees to sit on its edge when surfaced. Additional buoyancy was added to ensure the framework had sufficient reserve buoyancy when surfaced.

Recovery break off lines and a flag were added at sea for recovery by grapnel from the ship.

Deployment

The lander was lifted by crane from short stainless steel lift strops coupled to a release ring



through which a release toggle was placed. As the lander reached the sea surface the toggle was freed and the lander sank away quickly. In the few moments it could be observed sinking the lander was seen to be descending quite vertically with the framing horizontal. No acoustic tests were made due to ships noise on station .

Recovery

Acoustic release triggered , but no positive confirmation on pyrotechnic channel . Repeat firing on REL 1 , positive ranges at 850 metres . Lander sighted from bridge. Lander floated upside down and recovery break off line picked up by pole and grapnel. Lander recovered midships by crane.

Instrumentation

The 300khz Workhorse is powered by a two battery packs housed in a 500 metre battery pressure housing. To enable the gimbal to operate correctly an extension lead is used to connect to the battery pack and for communications. The unit was set up on board to use the command parameters provided by Dr Tom Rippeth , these were input to the 300khz ADCP and consequences and set up checked against the provided parameters.

Ser.No.3726

Set up

CR1
CF11101 FLOW CONTROL
EA0 HEADING ALIGNMENT
EB0 HEADING BIAS
ED2000 TRANSDUCER DEPTH (dm)

4.3 Seasoar transects.

Seasoar was planned to be a pivotal component of JR98, as a means to map large areas of the shelf sea, provide high-resolution information on the structures of chlorophyll within the subsurface maximum, and to provide information on spatial variability around the time series stations occupied with the CTD and turbulence sensors.

Two Seasoar systems were taken. The primary system was the recently-developed Penguin Seasoar, with a Chelsea Instruments Minipack (CTD, chlorophyll fluorescence) and a Fastracka FRRF connected to the onboard Penguin data acquisition and control computer. The back-up system was the old Neil Brown based Seasoar, with a Neil Brown CTD transmitting CTD data to the ship via the tow cable, and a FRRF powered by the CTD but recording data internally.

Significant problems were experienced with Seasoar. Most of these problems arose from the very poor state of the slip rings on both of the Seasoar winches. It took considerable effort by the UKORS technical support to rebuild a working slip ring from bits salvaged from the two bad units. Problems were also experienced with the Penguin system; it is thought most of these arose from a faulty hard drive aboard the Penguin pc on Seasoar.

One Seasoar run was attempted on July 30th, using the back-up Neil Brown system with the rebuilt slip ring. While the run was successful, analysis of the CTD data was not possible because a software “dongle” required to run the processing software was not available.

The first successful Seasoar run with the primary Penguin system was on August 4th, from almost completely mixed water in the Irish Sea, across the Celtic Sea front, and through to the CS3 mooring site (Fig. 4.3.1).

The main frontal position seems to have been crossed at about 2000 GMT on August 4th. With spring tides having occurred on August 2nd the weak stratification seen between about 1700 and 2000 GMT is possibly residual stratification left from the earlier neap tide and not completely mixed by the August 2nd spring tide. Alternatively, it could be new stratification developing after the peak in spring tidal mixing; assessment of the required heat input is required to check this.

The second successful Seasoar run was conducted on August 6th and 7th between positions U2 (well-stratified site NW of France) and N1 (close to the shelf edge) (Fig. 4.3.2).

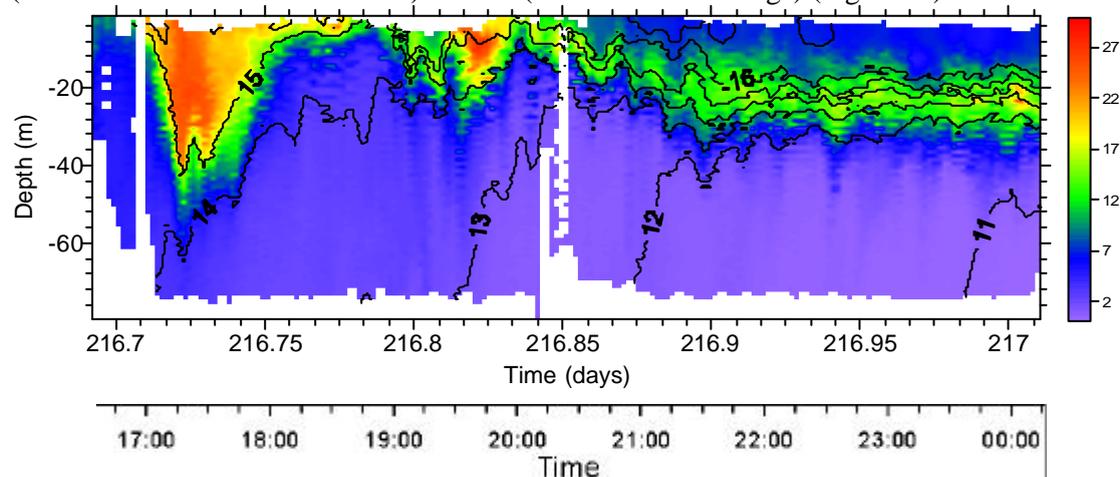


Figure 4.3.1

Cross-front Seasoar section August 4th to 5th. Lines are temperature (°C), colours are chlorophyll fluorescence (arbitrary units). Interpolation is onto a 500m x 1m grid. The CS3 mooring site is at the far left of the plot. Time is GMT.

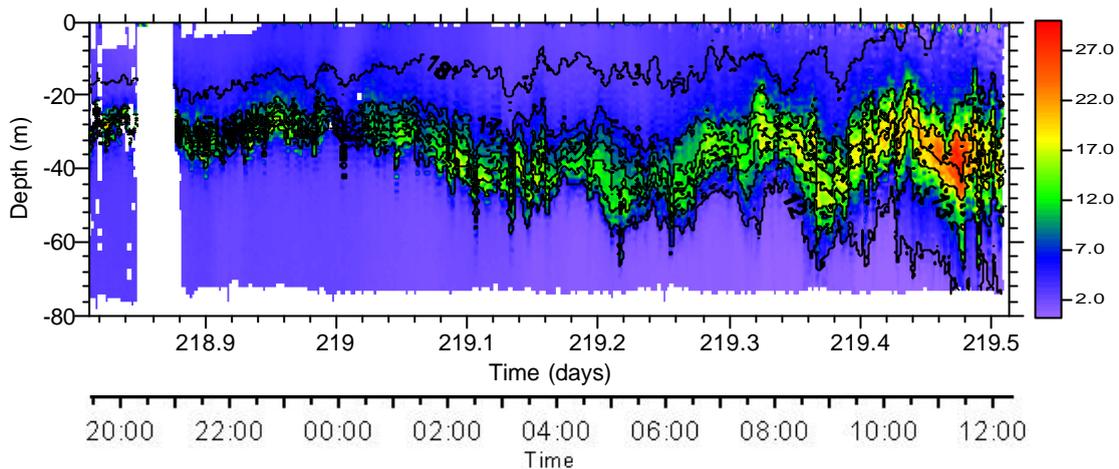


Figure 4.3.2

Seasoar run between U2 (left of panel) to N1 (right of panel) on August 6th to 7th. Lines are temperature (°C), colours are chlorophyll fluorescence (arbitrary units). The blank area at about 2030 to 2100 GMT was caused by Seasoar being recovered briefly to investigate data dropouts.

The section appears to show a series of 2 or 3 large waves across the shelf, apparently dissipating towards U2 (the amplitude of the wave decreases towards U2, while the thermocline becomes sharper). Taking a vessel speed of 3.5 m s^{-1} , the wavelength of the waves towards N1 is about 35 km. If this is an internal tidal wave with a 12.42 hr period, then the wave speed is about 0.8 m s^{-1} . This of course assumes that the vessel travelled orthogonal to the wave direction, which is unlikely. Thus the wavelength and wave speed are the maximum possible.

The 3rd successful Seasoar run took place on August 8th to 10th, from the station furthest seaward off the shelf edge (N9), through the CS2 shelf edge mooring site, through CS1, and to CS3 – a total run of 35.5 hours (Fig. 4.3.3).

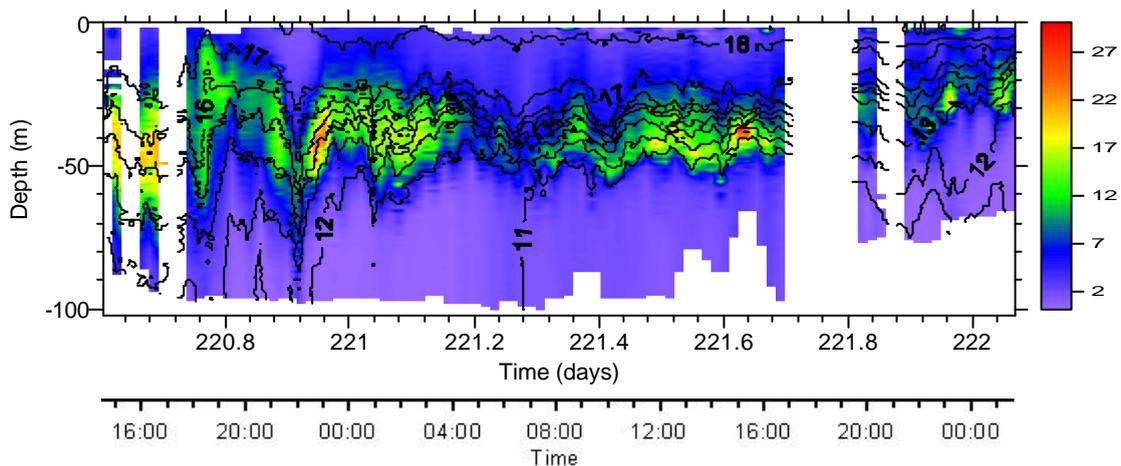


Figure 4.3.3

Seasoar run from N9 (left of panel), through CS2 (2030 August 8th), through CS1 (1630 August 9th), to the CS3 mooring site (right of panel). Lines are temperature (°C), colours are chlorophyll fluorescence (arbitrary units). Blank areas were caused by data problems from Seasoar, requiring recovery. Times are GMT.

At the shelf edge (from the start of the run to about 2100 GMT) there is clear evidence of considerable internal tidal mixing, with peak-to-trough amplitudes of isotherm movement

reaching 50 metres. Chlorophyll concentrations are clearly patchy, with significant holes in the subsurface maximum.

The Seasoar work successfully carried out was less than 50% of that planned. In particular, repeat box surveys over tidal cycles at the shelf edge were not completed, and Seasoar work in the earlier part of the cruise (which would have allowed much better knowledge of conditions for mooring sites) was not possible. However, after the hard work of Jon Short (UKORS) the Penguin system worked very well and should be regarded as the only way to run Seasoar on research cruises. The rapid and easy access to both the Minipack and FRRF data, via FTP directly from the slave pc connected to Seasoar, is remarkably useful and to be recommended on any cruise where the cruise track is dependent on the observed conditions.

4.4 Vessel ADCP.

The Acoustic Doppler Current Profiler (ADCP) mounted in the hull of the RRS *James Clark Ross* is an early model narrowband 150 kHz RDI instrument. The software available for running the ADCP is an early version of the narrowband software. Both instrument and software are in need of significant upgrading. Data quality from the ADCP was adequate for basic measurements of coarsely-resolved current profiles. However, for more useful research the system is not capable of collecting useful high-sample rate data (e.g. for measurements of mean shear in the water column) and measurements with vertical resolution less than the 8 metre bin size used during JR98 are too noisy to be of much value. The decision was taken during JR98 to concentrate on acquiring good profiles of the main currents, and utilise the moorings and the RV *Prince Madog* ADCP data for more detailed investigations.

After experimenting with the set-up commands for the ADCP, and some apparent confusion concerning where data was being written to, useful ADCP data began to be collected on Julian Day 211 (July 30th). Data is thus available for all of the 25 hour stations apart from the shelf edge station at CS2. At the time of writing this report the data from station CS3(2) on August 10th is incomplete; the BAS IT support (Doug Willis) has been requested to investigate an apparently corrupted data file.

The ADCP was configured to collect data with a 8 metre depth bin and 2 minute averaging (approximately ** pings per profile). Summaries of the ADCP data collected during the 3 complete 25 hour stations are shown in Fig 4.4.1 (CS1), Fig. 4.4.2 (IS1), Fig. 4.4.3 (CS3(1)).

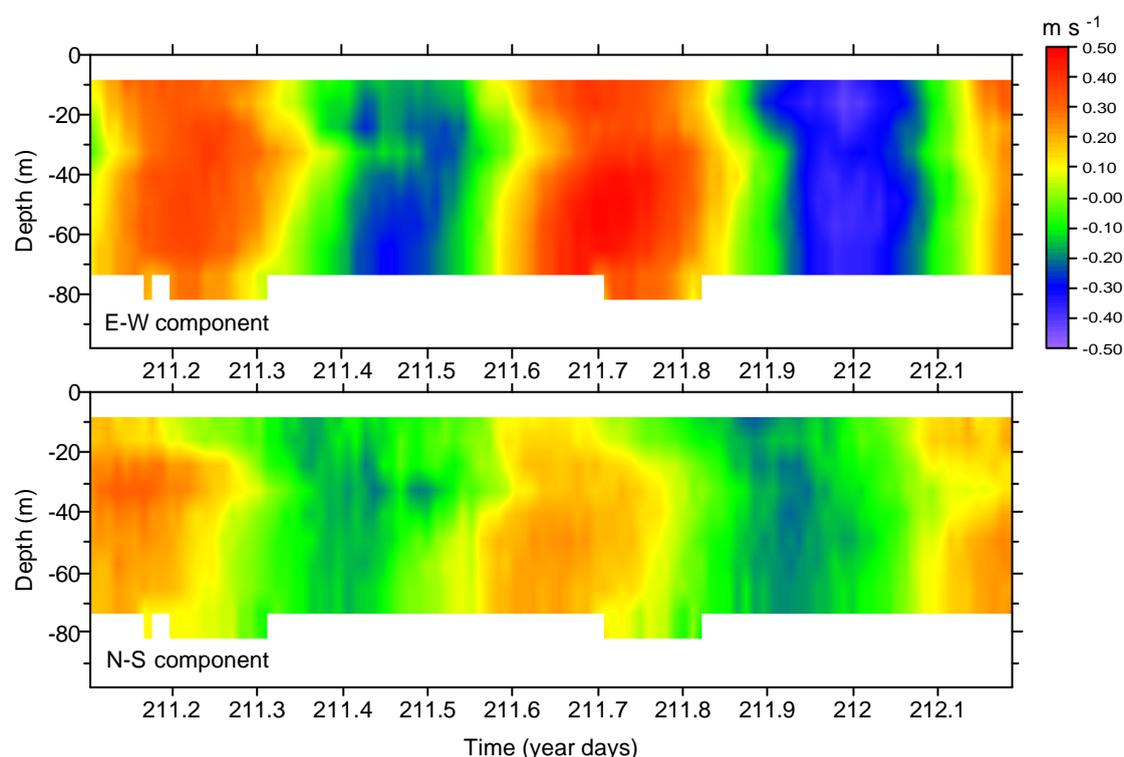


Figure 4.4.1.
Summary plot of EW and NS current velocities over station CS1
(JD=212 – 213; 31st July – 1st August).

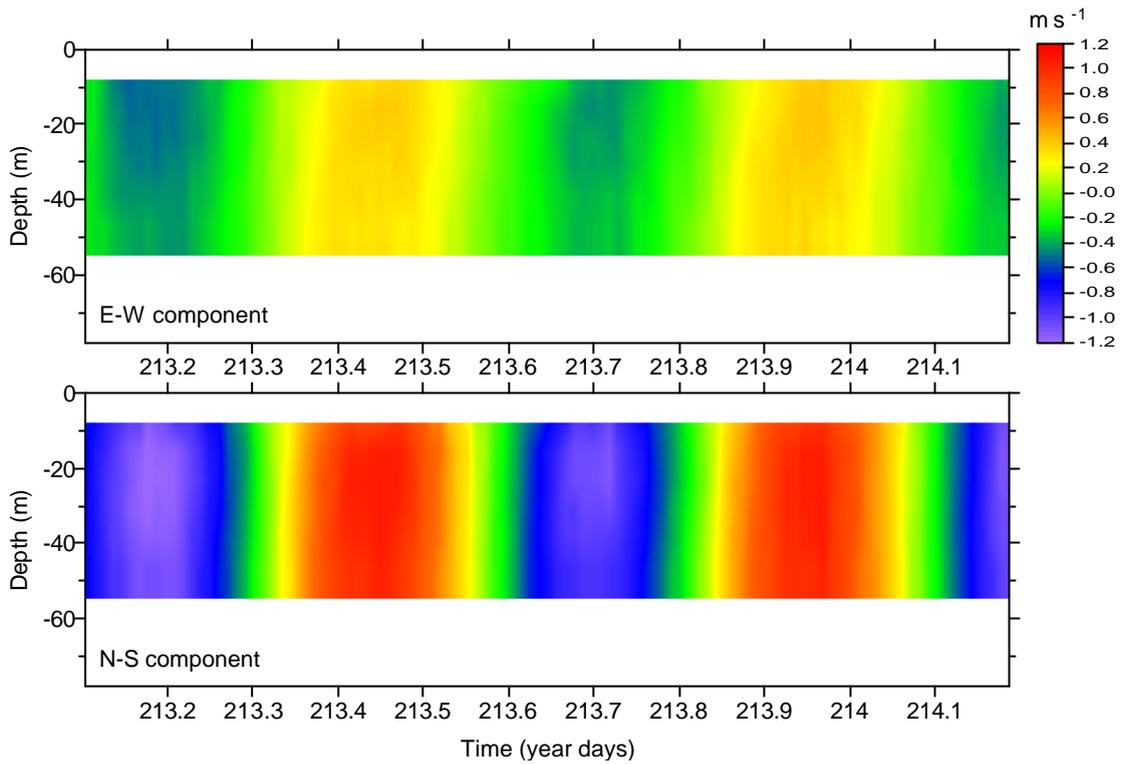


Figure 4.4.2.
Summary plot of EW and NS current velocities over station IS1
(JD=214 – 215; 2nd – 3rd August).

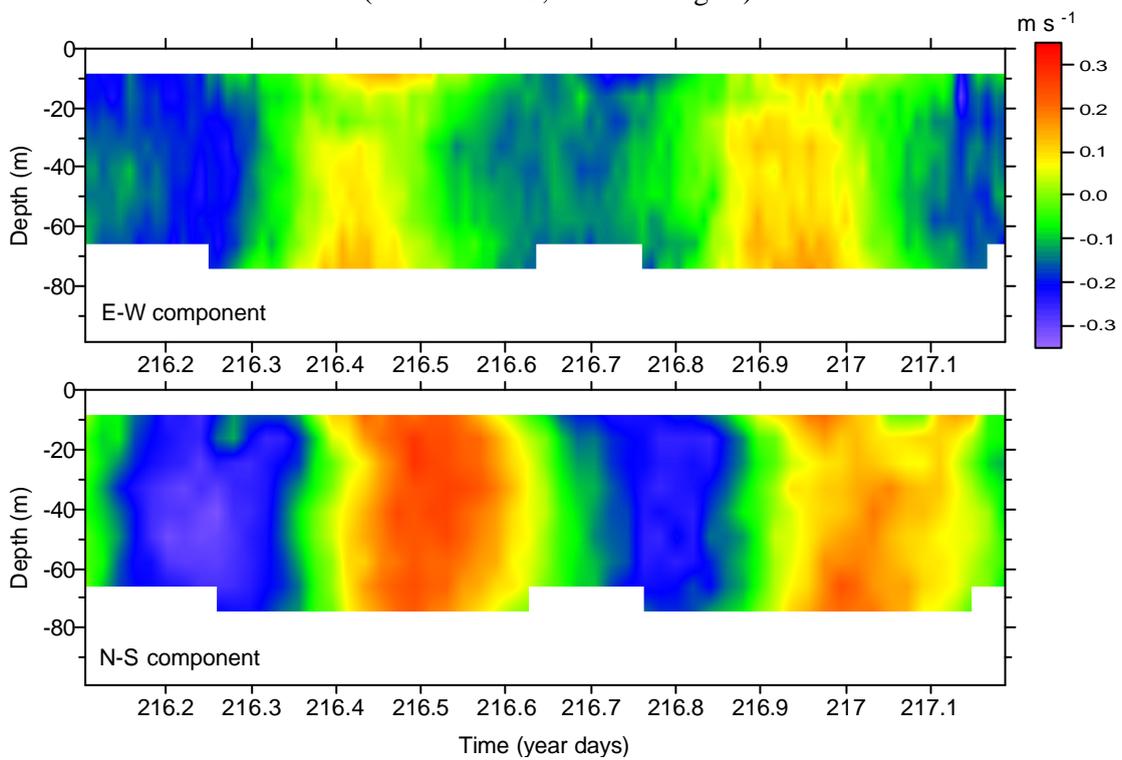
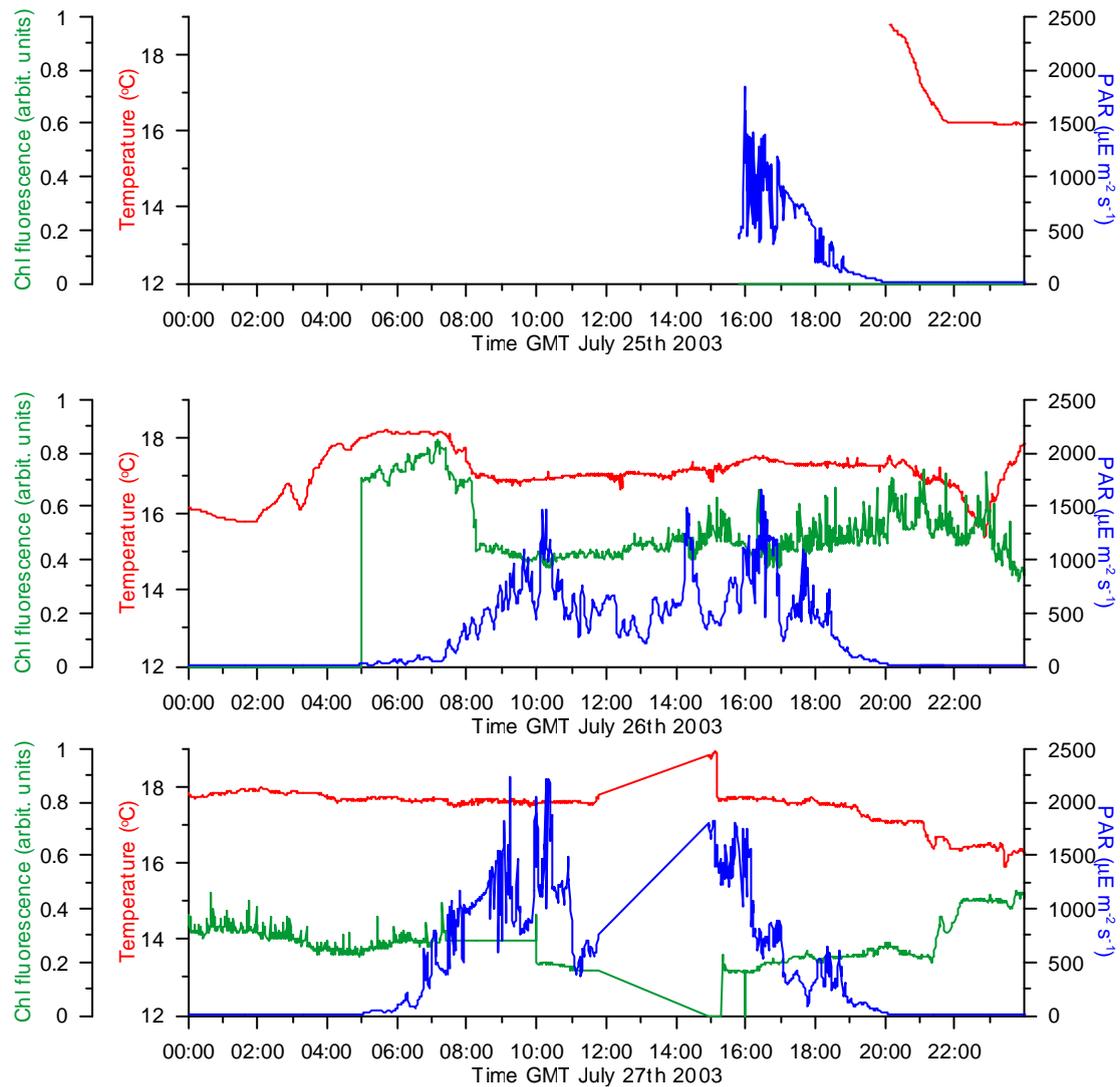


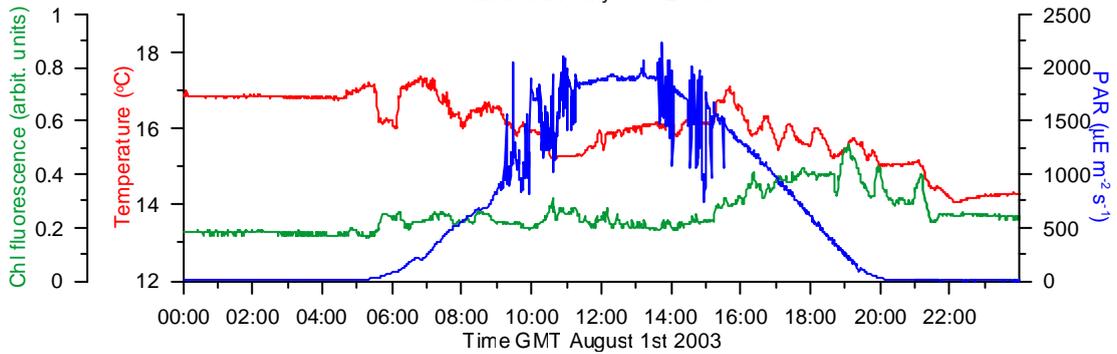
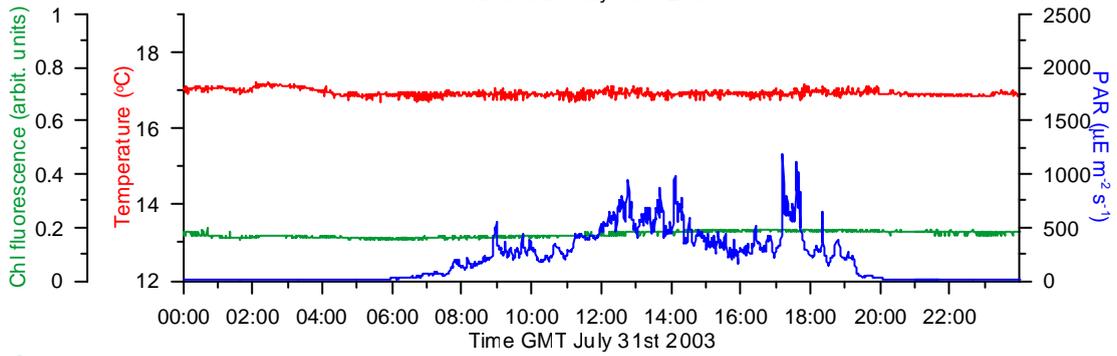
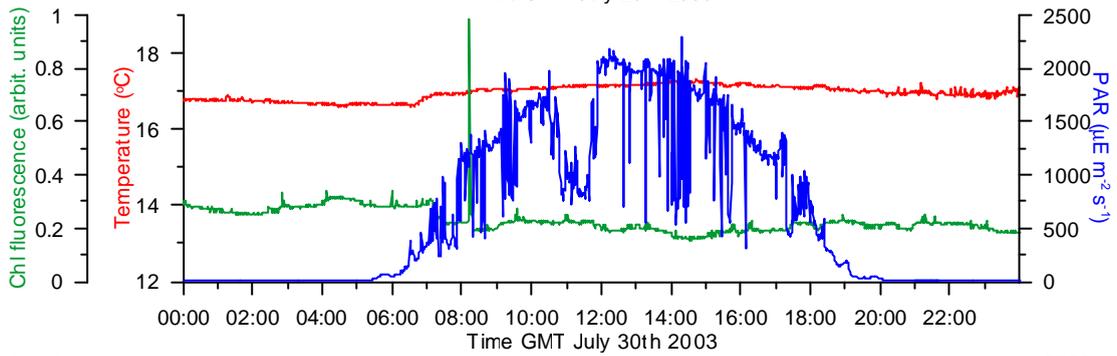
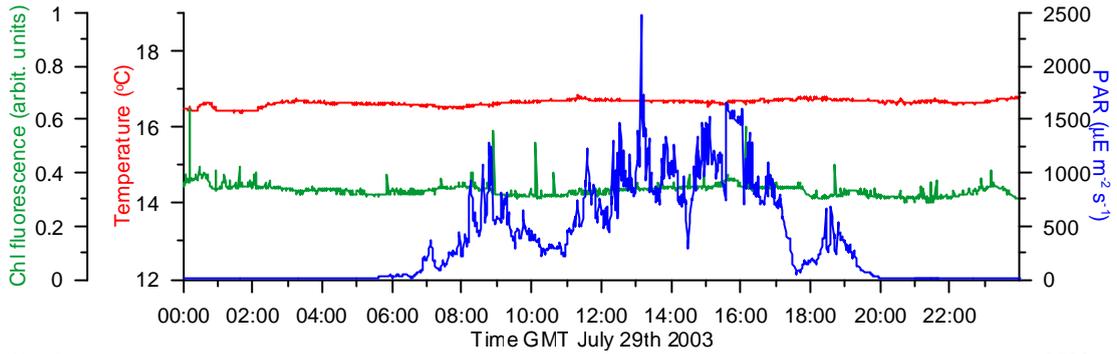
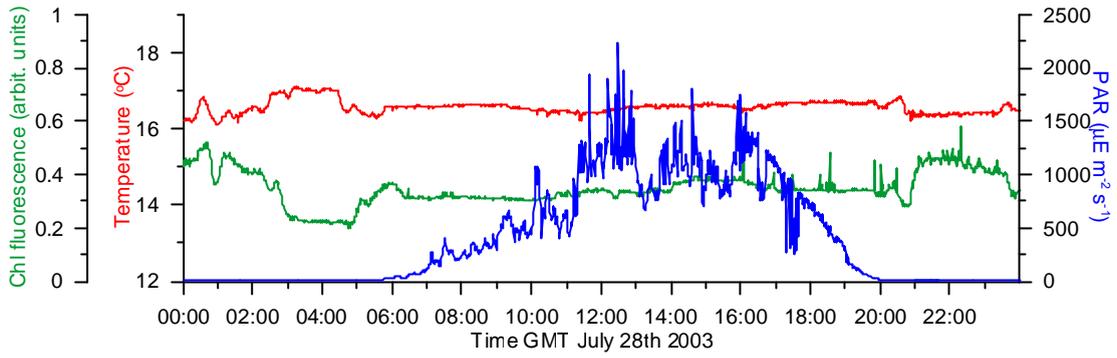
Figure 4.4.3.
Summary plot of EW and NS current velocities over station CS3(1)
(JD=217 – 218; 5th – 6th August).

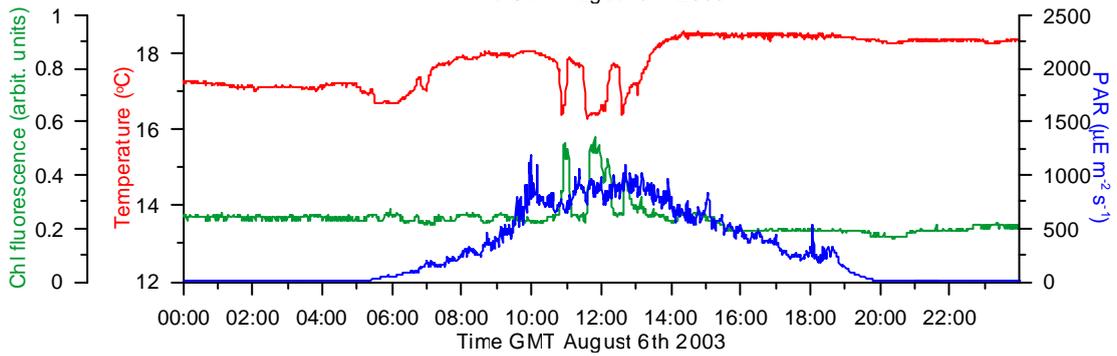
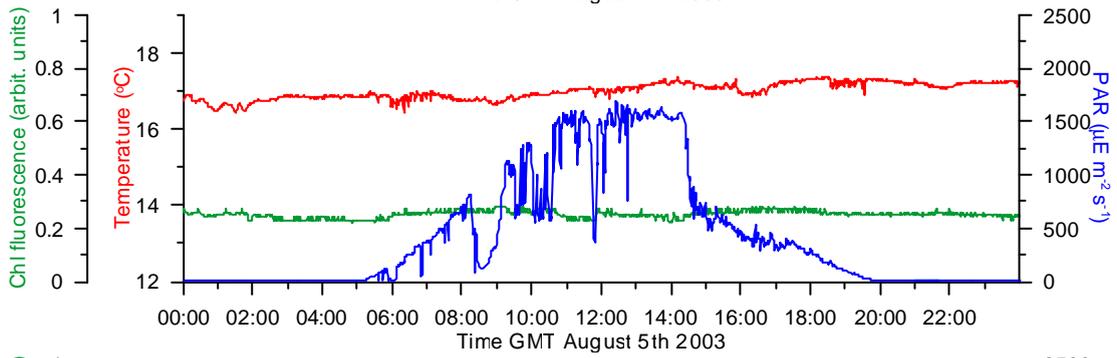
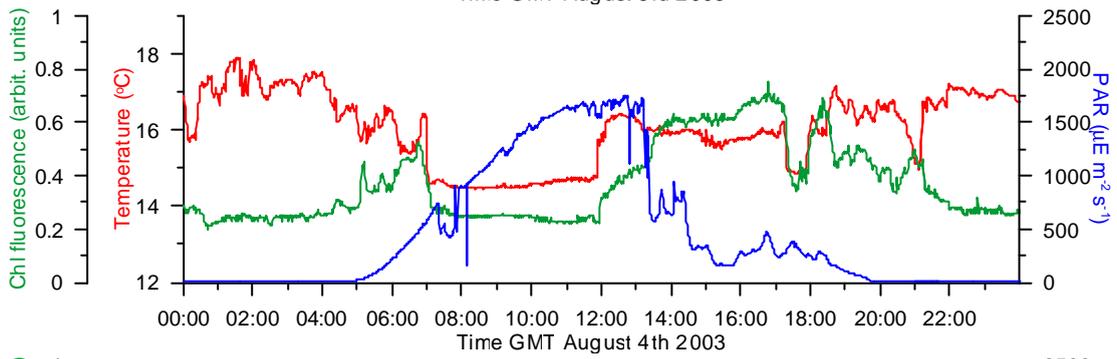
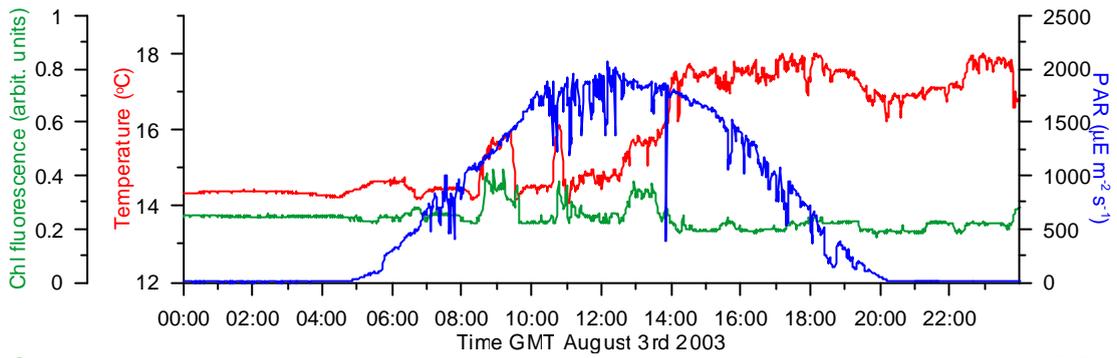
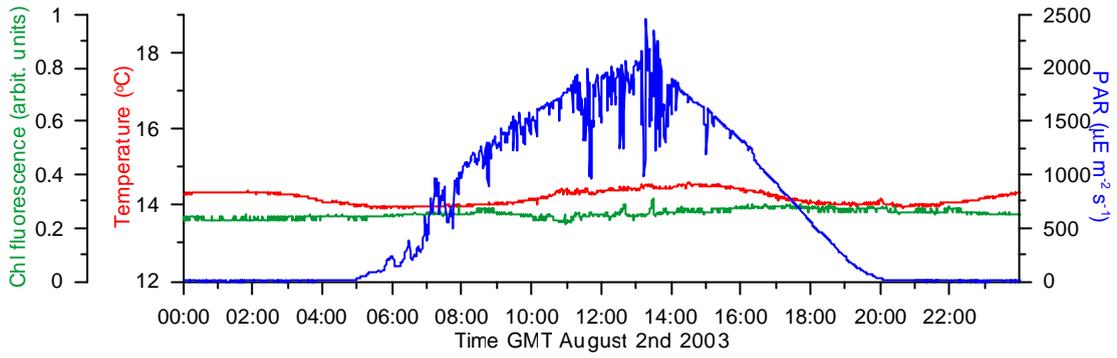
4.5 Sea surface and meteorological information.

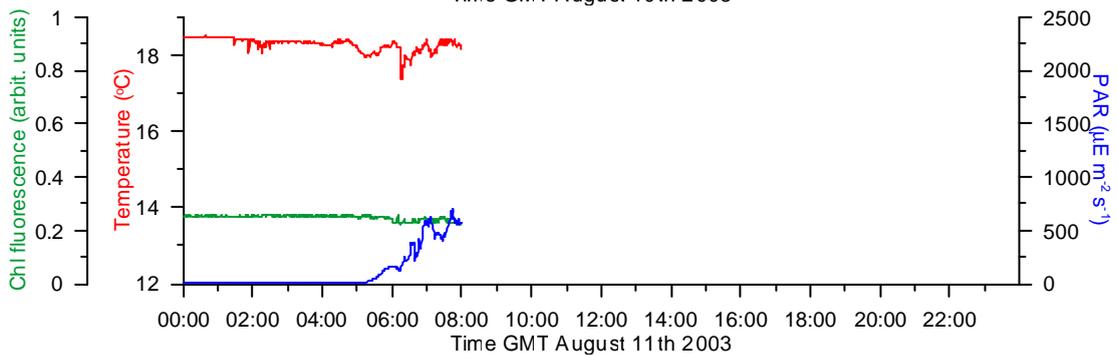
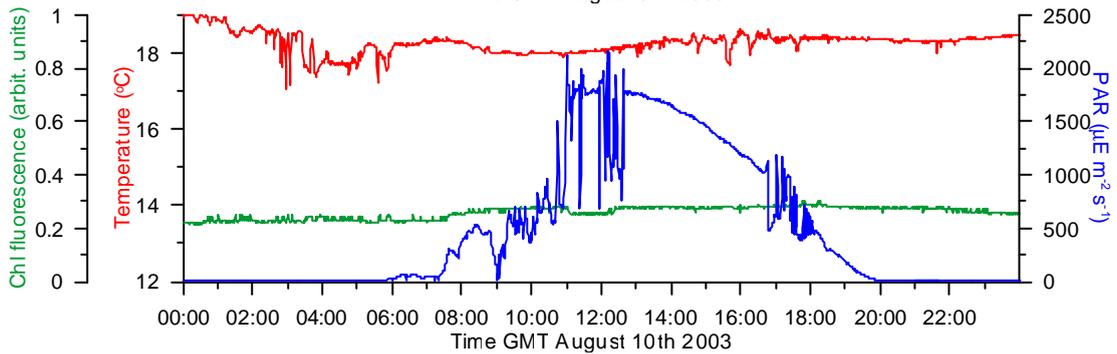
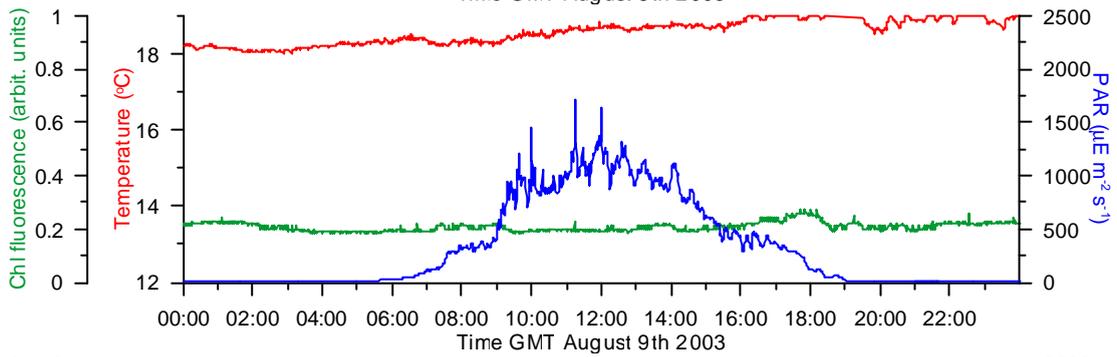
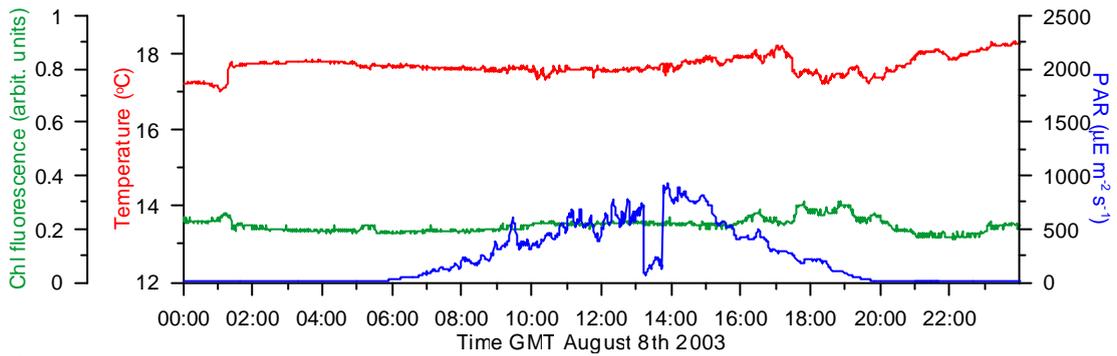
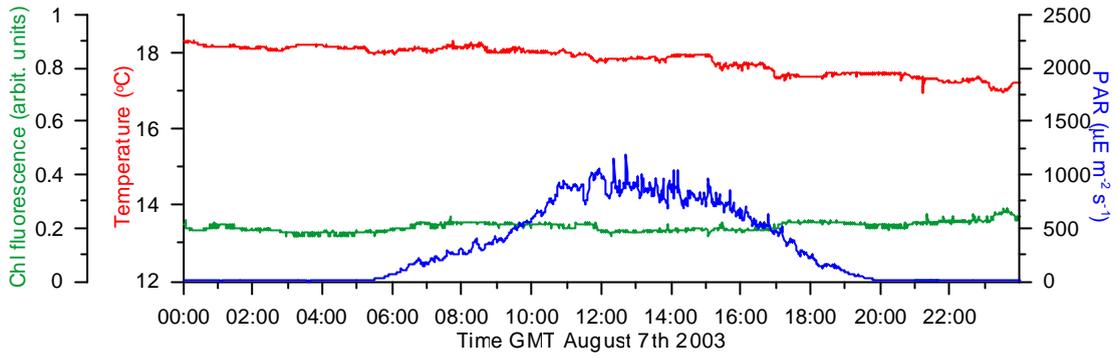
The SURFMET system was switched on following the vessel clearing Portsmouth Harbour and reaching deeper water in the English Channel. Good meteorological data began to be collected at about 1600 GMT July 25th, and good surface oceanographic data from about 2200 GMT on July 26th. Note that the chlorophyll fluorometer in the SURFMET system was cleaned on July 27th, so only data after 1600 GMT on July 27th should be considered. Data ceased at 0800 GMT August 11th. The only significant gaps in the SURFMET data occurred on July 27th.

The following plots summarise the surface temperature, chlorophyll and incident solar irradiance (PAR) information for each of the days at sea.









4.6 Primary production experiments (¹⁴C) – P vs E. Anna Hickman, SOC.

Experiment no.	Date	Time GMT	CTD no.	Station	Depth	Incubation Duration	Notes
1	28/07/2003	13.40	3		20 60	2hr	
2	29/07/2003	3.58	5	CS2	20	4hr30min	
3		12.29	13		50 20	2hr	
4	30/07/2003	3.59	29		10 20	2hr	
5	31/07/2003	4.01	33	CS1	10	2hr8min	
6		13.03	42		40 2 31 39	2hr	
7	01/08/2003	3.37	51		40	2hr30min	Thermocline sample incubated at insitu and surface temperature
8	02/08/2003	8.02	60	IS1(mixed)	20	4hr	
9		12.10	64		2 50	4hr05min	
10	03/08/2003	3.57	80		20	2hr	
11		12.59	86	Front	15	2hr48min	
12	04/08/2003	12.59	86	Front	15	2hr	Water after experiment see Dave and Mark (check depth had2in notes)
13	05/08/2003	3.55	98	CS3	2	4hr	
14		12.02	106		22 2 22	2hr 4hr	
15		14.00	108		2	2hr	
16	06/08/2003	16.30	124	U2	2 26	2hr	
17	07/08/2003	13.54	125	shelf LINE N1	2 27	2hr8min	T's left in 10mins??
18	08/08/2003	11.03	133	oceanic N9	2 27	2hr	
09/08/2003							
19	10/08/2003	7.00	138	CS3	2	2hr	
20		12.00	143		20 2 18	2hr2min	

21		17.00	148		2	2hr1min
					20	
22	11/08/2003	8.07	161	D2	2	2hr
					36	
23		14.00	164	CS1	2	2hr4min
					32	2hr4min

¹⁴C PE Incubation Protocol

Working Stock Solution

1mCi of ¹⁴C as buffered NaOH (0.5ml) was diluted in 9.5mls of 0.2µm filtered sea water to provide a working stock solution. The activity of each 100µl 'spike' added to the sample bottles is therefore 10uCi.

Standards

In order to check the true activity of the spike, sea water standards were taken for each sample. In addition standards were taken directly from the working stock. For this, 100µl of working stock was added to 10mls Carbosorb and from this 5 replicates of 100µl were placed in 6ml pony vials to which 5mls Permafluor E+ scintillation cocktail was added.

Another method of making standards was also carried out for some Working Stock solutions. Sea water standards from five bottles of surface sea water blanks of a precisely measured volume (73ml) were taken to represent the activity of the spike added and the consistency of spiking.

Protocol

1. 1µCi was added to 73ml (roughly) water samples
2. 15 light bottles, 3 dark and 3 time zero samples were taken for each depth
3. The light and dark samples were incubated for 2hrs - 4hrs (depending on the possible oxygen evolution experiment). Chlorophyll maximum samples were incubated at in situ temperature
4. Sea water standards and filtration were carried out for 'time zero' samples as soon as incubation was underway
5. After incubation, sea water standards were taken for all sample bottles. 200µl of sample was removed and placed in a 6ml pony vial to which 1ml Carbosorb and 3ml Permafluor E+ scintillation cocktail were added. Therefore giving the total activity of each sample bottle prior to filtration.
6. Samples were then filtered onto 25mm 0.2µm polycarbonate filters
7. Filters were then fumed with concentrated HCl to remove dissolved ¹⁴C for 30mins and placed in 6ml pony vials into which 5ml Opti-Phase HiSafe was added
8. All standards and samples were counted using the scintillation counter on the ship

Light levels

Light levels were measured periodically during the cruise using a PAR sensor.

4.7 Primary production experiments (¹⁴C) – simulated in situ. Pedro Cermeño & Valesca Pérez, Universidad de Vigo.

Three different variables were measured during the cruise mainly in the 25h CTD stations: size fractionated primary production (size POCp), size fractionated chlorophyll-a (size Chl-a) and dissolved organic carbon production (DOCp). The measurement of DOCp provides, at the same time, data of the total particulate organic carbon production (POCp).

At each cast, samples were collected from four to six depths and sequentially filtered through 20, 5, 2 and 0.2 µm pore size polycarbonate filters in order to measure Chl-a. Primary production was measured at the same depths by conducting on deck simulated *in situ* (SIS) incubations with ¹⁴C from dawn to dusk. After incubations size POCp samples were sequentially filtered through 20, 5, 2 and 0.2 µm pore size polycarbonate filters.

Sampling stations, depths and measured variables are shown in the following table:

CAST	STATION	DATE	DEPTH	sizePOCp	DOCp & POCp	sizeChl-a
002	CS2	7/27/03	2	x	x	x
			15	x	x	x
			30	x	x	x
			60	x	x	x
005	CS2	7/29/03	2	x	x	x
			10	x	x	x
			20	x		x
			30	x	x	x
			40	x		x
			50	x	x	x
029	CS2	7/30/03	2	x	x	x
			10	x	x	x
			20	x		x
			30	x	x	x
			40	x		x
			50	x	x	x
033	CS1	7/31/03	2	x	x	x
			10	x	x	x
			20	x		x
			30	x		x
			35	x	x	x
			50	x	x	x
051	CS1	8/01/03	2	x	x	x
			10	x		x
			20	x	x	x
			30	x		x
			40	x	x	x
			50	x	x	x
056	IS1	8/02/03	2	x	x	x
			20	x	x	x
			40	x	x	x
			60	x	x	x

CAST	STATION	DATE	DEPTH	sizePOCp	DOCp & POCp	sizeChl-a
080	IS1	8/03/03	2	x	x	x
			10	x	x	x
			20	x		x
			30	x	x	x
			55	x	x	x
098	CS3(1)	8/05/03	2	x	x	x
			10	x	x	x
			17	x	x	x
			22	x		x
			30	x		x
			38	x	x	x
121	CS3(1)	8/06/03	2	x	x	x
			13	x	x	x
			22	x	x	x
			25	x		x
			40	x	x	x
124	U2	8/06/03	2	x	x	x
			20	x	x	x
			26	x	x	x
			40	x	x	x
133	N9	8/08/03	2	x	x	x
			20	x	x	x
			27	x	x	x
			50	x	x	x
135	CS3(2)	8/10/03	2	x	x	x
			10	x	x	x
			20	x	x	x
			40	x		x
			60	x	x	x
158	CS3(2)	8/11/03	2	x	x	x
			20	x	x	x
			30	x	x	x
			40	x		x
			60	x	x	x

Preliminary results:

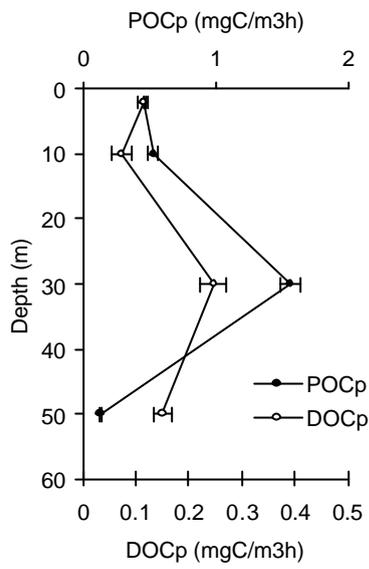
1.- DOCp & POCp:

Ranges of euphotic layer integrated primary production rates:
(min-max and average value in parenthesis)

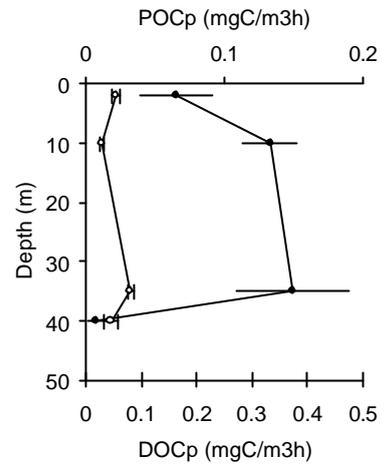
DOCp: 40-384 (127) mg C m⁻² d⁻¹ (min at CS2 and CS1 and max at CS3)

POCp: 68-1549 (410) mg C m⁻² d⁻¹ (min at CS1 and max at CS3)

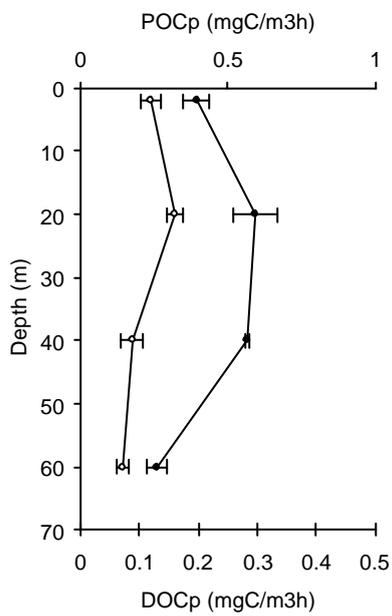
Shelf edge (CS2)



Shelf (CS1, strongly stratified)

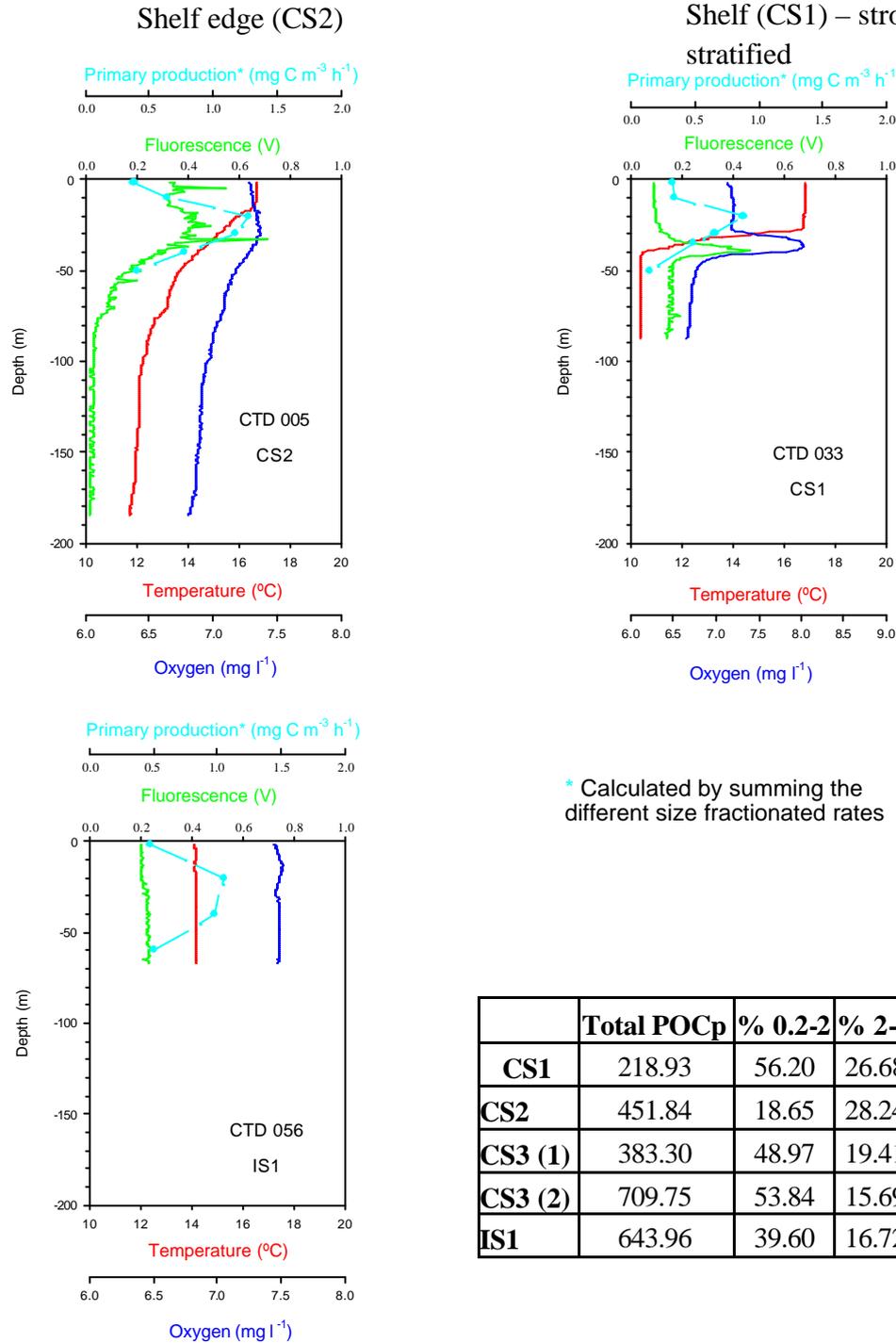


Irish Sea (IS1, Mixed)



2.-Size POCp:

Mean values of euphotic layer (1% I_0) Total POCp ($\text{mg C m}^{-2} \text{d}^{-1}$), determining by summing the size fractionated rates, and phytoplankton sizes contribution to total POCp (expressed as percentage) at each station are shown in the following figures and table:



	Total POCp	% 0.2-2	% 2-5	% 5-20	% >20
CS1	218.93	56.20	26.68	13.18	3.95
CS2	451.84	18.65	28.24	15.89	37.22
CS3 (1)	383.30	48.97	19.41	28.25	3.37
CS3 (2)	709.75	53.84	15.69	26.60	3.87
IS1	643.96	39.60	16.72	22.57	21.11

4.8 Active fluorescence measurements (FRRF). Mark Moore, Young Nam Kim and Jacqui Tweddle – SOC.

In situ active fluorescence measurements

In situ FRR (Fast Repetition Rate) fluorometry was performed using two Chelsea Scientific instruments FASTtracka™ FRRs attached to the CTD rosette frame. The instruments were located at the top of the frame on extensions which minimised the shading to the instrument sample areas by the CTD package. However shading of the whole package in the near surface by the ship was frequently observed and a record of the sun's position relative to the ship orientation during each cast was therefore kept. Besides the problems with ship's shading of the instrument package, the generic problem with the current version of the FASTtracka instrument which causes loss of the fluorescence signal due to ambient red light interference in the near surface region, was also apparent. Thus much of the data from the very high light near surface regions had to be discarded in post processing due to shading and loss of signal.

Two instruments were used on the CTD frame in order to accommodate two different gain settings. The auto ranging option on the instrument was known to be inadequate for the rapid changes in absolute fluorescence levels associated with the sharp deep chlorophyll maxima which were previously observed in the region during CH145, August 1999. The instruments were typically set to gains of 1 and 4. In practice the absence of any very large increases of chlorophyll at the thermocline during JR98 meant that one instrument would probably have been sufficient. However the opportunity to compare the two instruments was useful, as the possibility of artefacts being introduced due by variable gain settings could be eliminated.

Both instruments were set up using identical saturation protocols. Variable chlorophyll fluorescence was stimulated using 100 flashlets of 1.1 μ s duration with a 2.3 μ s repetition rate. Relaxation flashlets were also performed, although the spacing of these was set to a minimal time in order to maximise the depth resolution of the saturation data. The timing of flashlets that would be required in order to measure accurate Q_a relaxation times would be incompatible with *in situ* measurements.

Fluorescence transients following 16 saturation sequences were averaged then stored internally for download once the CTD package was recovered.

Both instruments were interfaced with CI 2π PAR sensors and power was provided by the CI battery packs. Unfortunately two of these battery packs were flooded during the cruise as a result of inadequate sealing of the O-rings on the base cap following re-charging. This highlights a weakness of instrument design, where the battery seal has to be broken each time re-charging is performed (this could be daily with the intensity of sampling during JR98). However it also serves to illustrate that extreme care MUST be taken to ensure that the O-rings are clean and properly sealed.

Corrections for variability in fluorescence response within the saturation protocol and between instruments were corrected during post cruise processing using instrument response functions (IRFs) recorded at sea using extracts of chlorophyll *a*. Blanking for *in situ* profiling instruments is obviously problematic and the blanks run for correction of the laboratory instruments will initially be used to ascertain the potential magnitude of any blanking effects. Representative 24hr time series from the five sites are presented below (Fig. 1).

Laboratory FRR light response curves

Discrete samples were collected for laboratory FRR measurements of light responses. Such complimentary measurements were likely to be very important given the ambiguity in interpretation inherent with *in situ* FRR data, particularly when collected in stratified waters, where the vertical gradient in light may occur simultaneously to a vertical gradient in phytoplankton physiology.

Samples were collected from the CTD rosette and quickly transferred to a controlled temperature laboratory on the ship. Temperature within the laboratory was within 2°C of the *in situ* temperature for the majority of the experiments. Samples were allowed to dark acclimate for >30 minutes before being placed in a clear acrylic chamber connected to the optical head of an FRRf run in benchtop mode. Actinic light was initially provided using a slide projector, with a series of neutral density filters attenuating the projector bulb. However, following the early failure of the projector, a purpose built micro-processor controlled LED system was used to provide actinic light at a range of irradiances from 2-600 $\mu\text{mol photons m}^{-2} \text{s}^{-1}$. Relative changes in light levels were monitored using a CI 2 π PAR sensor placed beside the sample chamber. Absolute light levels were measured within the sample chamber using a Biospherical Instruments QSL-2000 4 π PAR sensor.

Instrument settings for the saturation protocol were the same as with the *in situ* instrument, whereas relaxation flashlets were provided at 98.8 μs spacing, giving a total relaxation protocol length of around 2ms. Such a protocol allowed adequate resolution of Q_a relaxation kinetics (Fig. 2).

Blanks for these experiments were generated by filtering the sample through a GF/F and then a 0.2 μm polycarbonate filter. The filtrate was then analysed using the FRRf set at the same gain as the sample run.

A total of 44 light response curves were collected spanning the environmental gradients sampled during the cruise. Data representative of the light response of phytoplankton from the surface and deep chlorophyll maximum at a stratified site are shown in Figure 2. The distinct difference in light response between the surface and deep samples is clear and would not be resolvable using *in situ* FRRf data. A preliminary synthesis of the light response curve data is presented in Fig. 3. The increase in σ_{PSII} from the mixed to stratified waters is clear and vertical variability in σ_{PSII} is only minor in the stratified waters. Conversely E_k is high in the mixed water and in the front and remains relatively high in the surface waters on the stratified side. Low values are found within the thermocline, this is caused by increasing turnover times (τ_{Qa}).

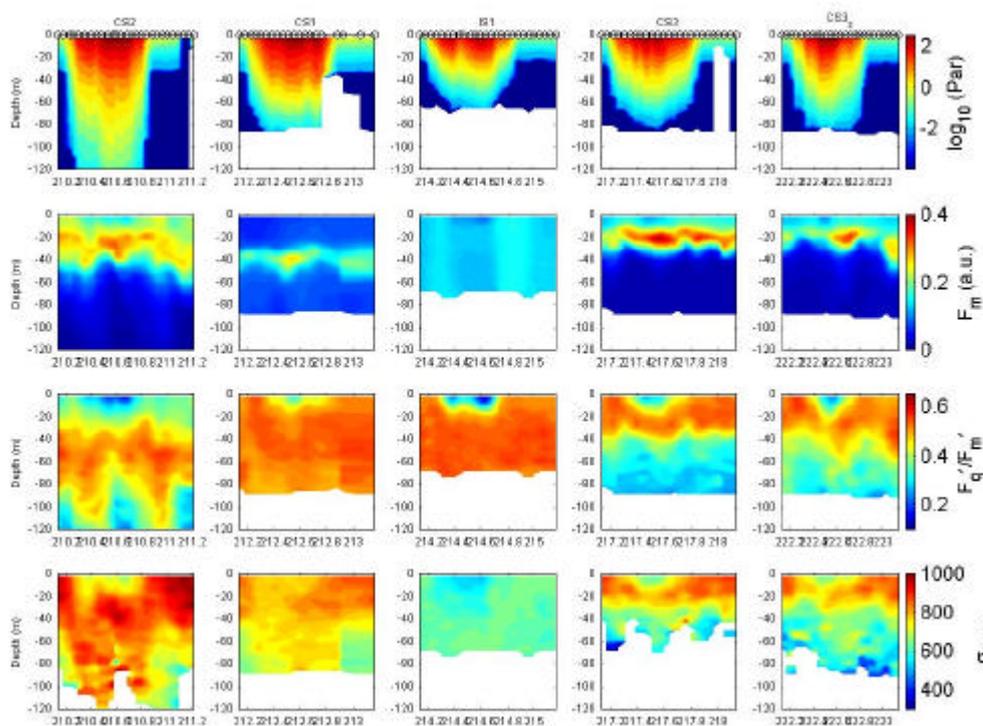


FIGURE 1 (previous page): 24 Hour time series of parameters measured using the *in situ* FRRf instruments on the CTD frame. No strong gradients in F_v/F_m (taken as the night-time values of F_q'/F_m') were observed with the exception of slightly depressed values for the surface at CS2. Lateral gradients in σ_{PSII} are pronounced with markedly lower values in the mixed water column (IS1). Conversely the values of σ_{PSII} are relative uniform throughout much of the stratified shelf region.

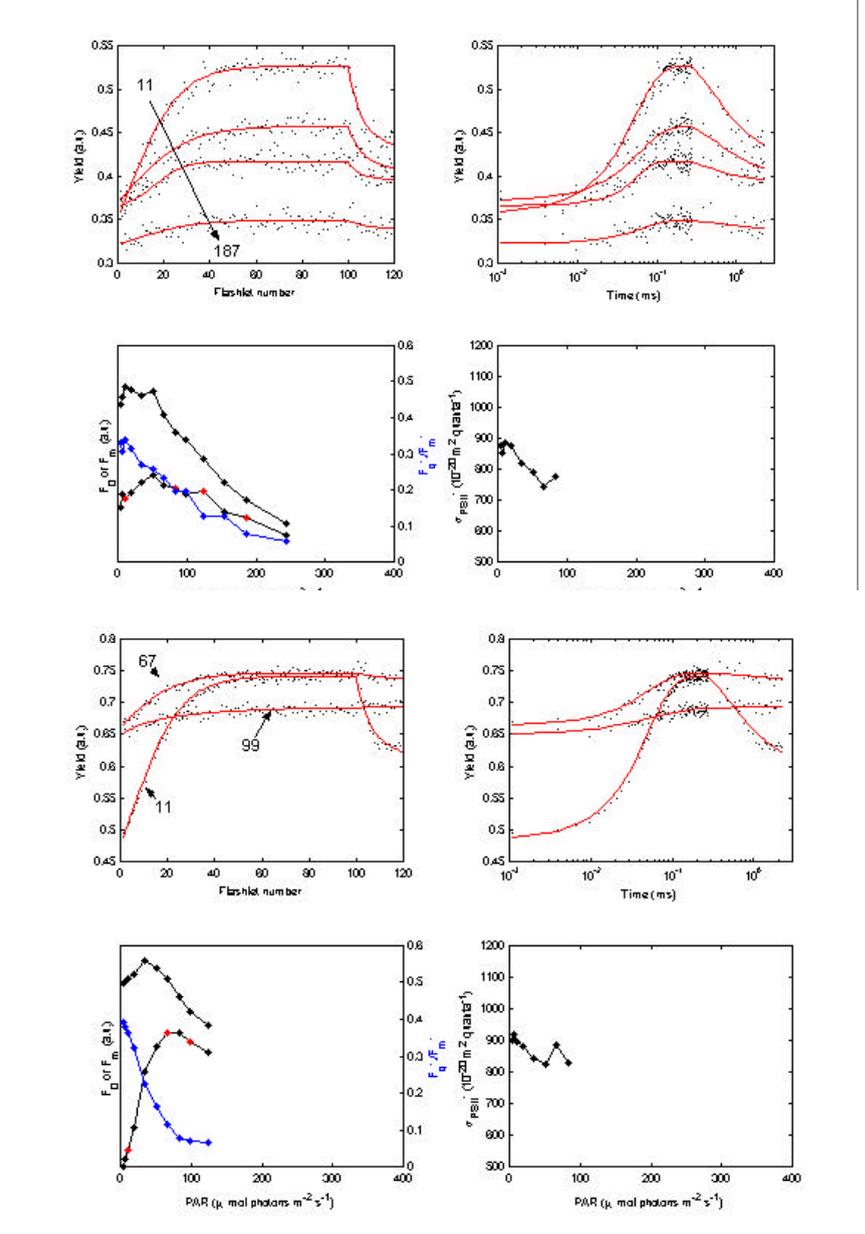


FIGURE 2: Representative data from two FRRf light response curve experiments run on samples collected from the near surface (Top) and sub-surface chlorophyll maximum (Bottom) at the stratified CS1 site. The four panels for each curve display: Top left, example FRR fluorescence transients and fits for a number of irradiances (labelled). Top right, as top left against flashlet time. Bottom left, light responses of F_q , F_m and F_q'/F_m' red symbols indicate corresponding curves in top left. Bottom right, the values of σ_{PSII} at irradiances where this parameter could be accurately measured.

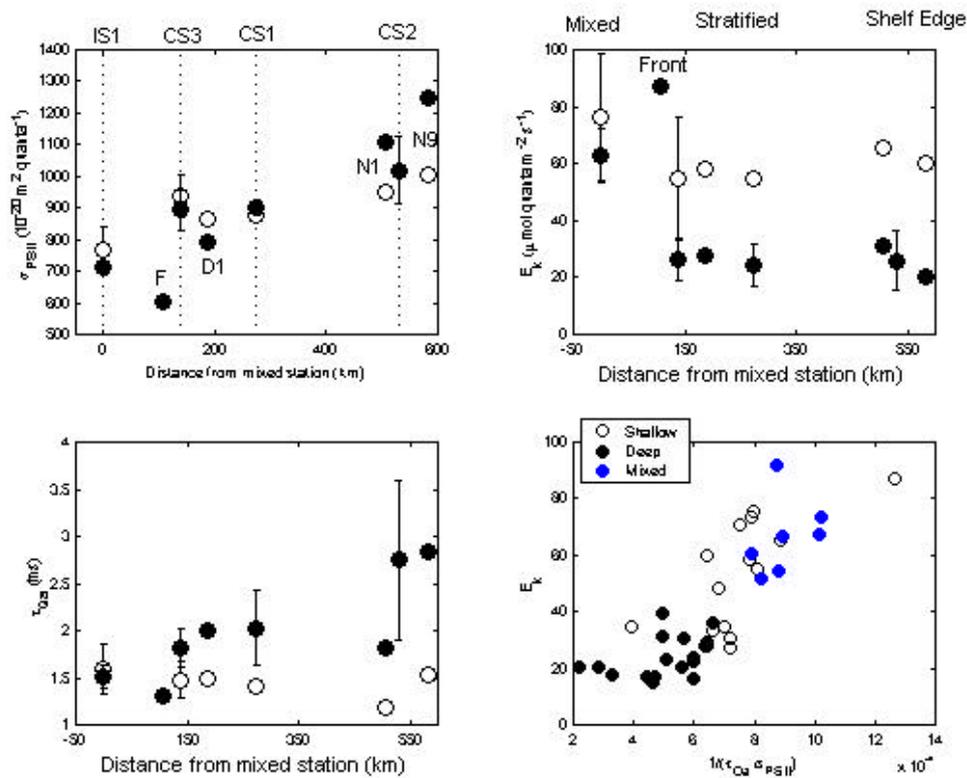


FIGURE 3 Preliminary synthesis of FRR fluorescence light response curve data. Vertical variability in the light saturation parameter (E_k , top right) is clear within the stratified water, with lower values for the thermocline likely to result from an increase in the chlorophyll:carbon ratio and hence the ratio of PSII reaction centres to Calvin Cycle capacity. This is consistent with the higher PSII turnover times found within the thermocline (bottom left). The data conforms well to theory predicting the relationship between E_k and $(\sigma_{PSII} \tau_{PSII})^{-1}$, with all three parameters being independently measured using the FRR technique (bottom right). This gives confidence both in terms of the underlying theory and the protocols employed in the light response curve measurements. For phytoplankton within the mixed water column, photosystem II appears to be acclimated to high light.

4.9 Nutrients (autoanalyser – nitrate, phosphate, silicate). David J. Hydes, SOC.

24 July

Portsmouth.

On board from 10:30. Analyser bolted down in Bio-lab.

25 July

Portsmouth.

Analyser was running by 10:00.

Sample changer failed about 10:15 – replacement delivered from SOC plus extra storage boxes to freeze samples in if necessary.

About 13:00 glass tube into phosphate heating bath broke. Repaired with plastic tubing collar and Araldite support.

Methods used are standard “Grasshoff” AA-II methods with the de-bubbler removed from the nitrate manifold. Details of methods, manifolds and set up in lab are given in the Appendix (A*).

Sailed 18:00. Hourly underway samples collected on route to shelf break station CS2 (Fig. 1).

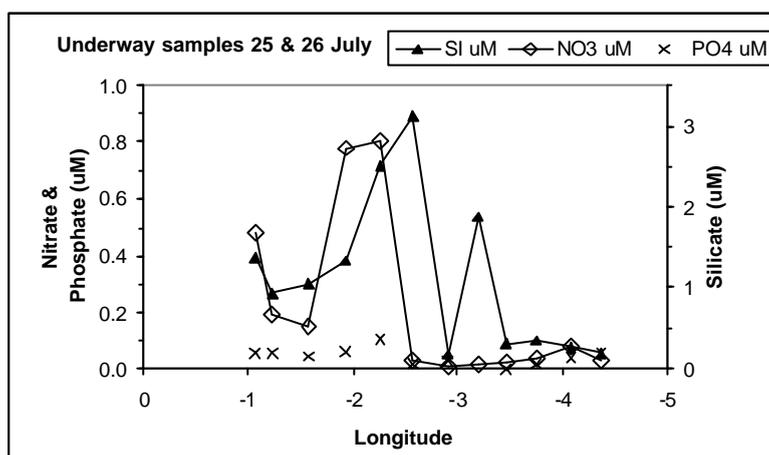


Figure 1.

Underway samples collected at start of cruise.

Note Silicate values look high for time of year

29 July

Start of 1st 25 hour station CS2 at shelf break. Detailed CTD 10 taken at 09:30 sampling at 2 m intervals through chlorophyll maximum. This worked well due to stability of ship.

Interesting minimum in P profile at 56m where there is an inflection in the NO3 and Si profiles. N:P ratio generally 15.3 in this deeper water (Fig. 2).

30 July

End of CS2 shelf break station.

CTD 31 first SUV-6 profile (30/07/2003 17:16)

This profile shows the significant drift that has tended to characterise use of the SUV-6 in the past on 2 of the 3 channels. First CTD deck unit version of profile (Fig. 3) shows the drift on Channel 5 the 220nm “nitrate” channel is less than the other two channels and less than seen previously.

31 July

Start of CS1 time series.

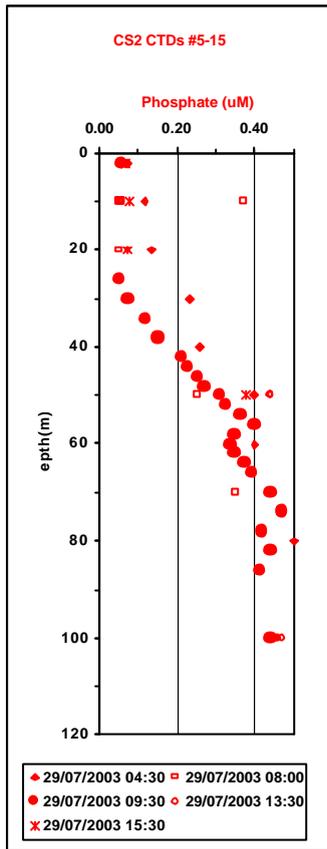


Figure 2.

Phosphate data from CS2 stations 5 to 15.
 Note detail obtained by close sampling across thermocline, and particularly structure in the phosphate profile

1 August

End of CS1 time series. Time series incomplete because of problems with the CTD cable over night. SUV-6 battery was disconnected between each cast at CS1. Figure 4 shows a comparison of the absorbance measured on the 220nm channel of the SUV-6 with the bottle data collected on the 3 detailed casts done at CS1. These were from CTD casts 34, 43 and 50. At this station the nutricline could not be distinguished from the thermocline and halocline.

3 August

Start of IS1 mixed site work.
 SUV-6 was left connected to battery all time at this site and also in to the sampling of the X and Y sections. Battery failed during section Y sampling.
 Nutrient concentrations were well mixed at this site. Concentrations changed though the tidal cycle changes were relatively greatest from Silicate then Nitrate then Phosphate the change follows changes in salinity closely but is the reverse of what would be expected from a simple fresh water source of nutrients. Variation is shown in Figure 5.

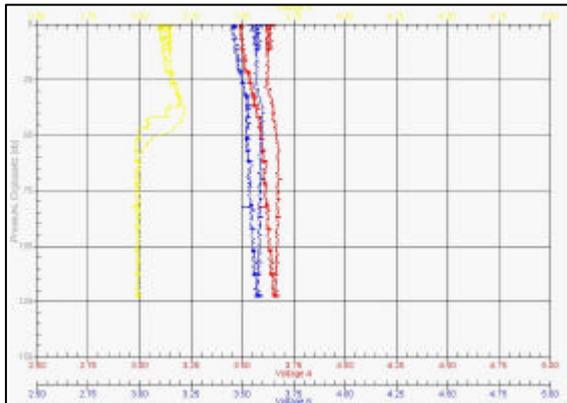


Figure 3.

First SUV-6 cast profile at Station CS3b August 1.

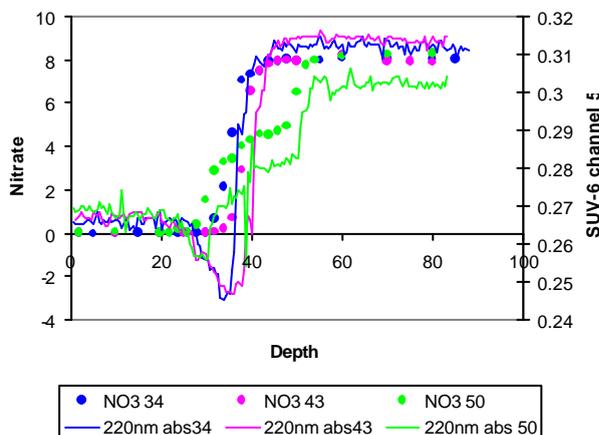


Figure 4.

Comparison of the absorbance on the 220nm channel with nutrient data measured in water samples from CTD casts 34, 43, and 50.

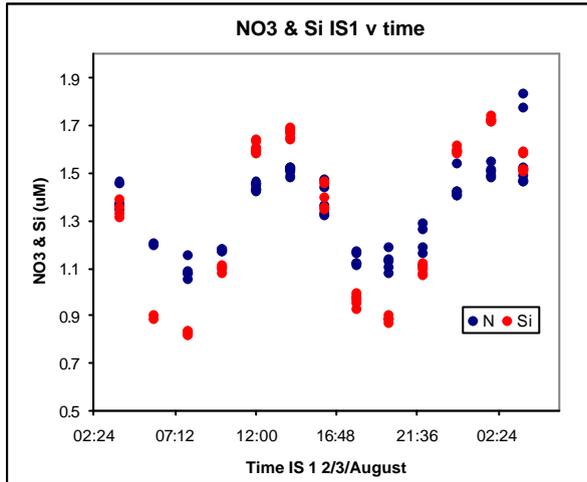


Figure 5.

Variation in nutrient concentrations through the tidal cycle as station IS1.

The signals recorded from the SUV-6 show close agreement between the up and down cast in these well mixed waters (Fig. 6) suggesting any off sets seen between up and down cast was not due to temperature or pressure changes. (This might be due to the air temperature being close to the water temperature during sampling at this site due to the poor weather).

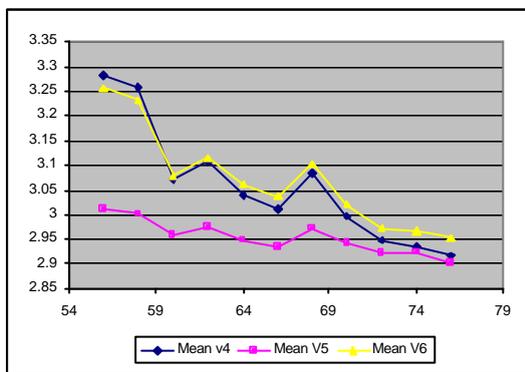


Figure 6.

Variation in mean voltages on each of the recorded SUV6 detector channels.

4 August

End of station IS1 and start of section X and Y sampling.

Problem with Skalar sample changer stopping spontaneously twice during morning. No samples lost but delayed finish to 17:30. All analyser tubes replaced.

A series of plots for data collected at Station X9 on CTD 88 show that at this site the nutricline was distinct from the thermocline and the halocline (**Figures 7 a, b, c 7 d**)

5 August

Started 25h station CS3 at 0400. Detailed 22 bottle cast taken at 07:00. New battery put on SUV-6 at 03:00 at start of CS3 (1) sampling. On cast 101 up and down SUV-6 channels are still drifting by CTD 104 up and down casts are only showing divergences due to water carried by frame which are in line with those of the other sensors on the frame. Figure 8 shows the drift in the overall voltage signal on the 250nm channel, Figure 9 shows that the 235 and 250 nm channels seem to be responding in the same way both with respect to drift and composition of the water.

Two detailed nutrient profile were collected at CS3(1) in Figure 10 the nitrate determined in the bottle samples second of these casts CTD 166 are compared with the “nitrate” estimated by the SUV-6. (The earlier profile CTD 101 was taken when the instrument was still settling down. It is interesting in that the bottle data show a nutricline significantly shallower than on any of the other casts. The SUV-6 data appear to confirm this shallow nutricline.

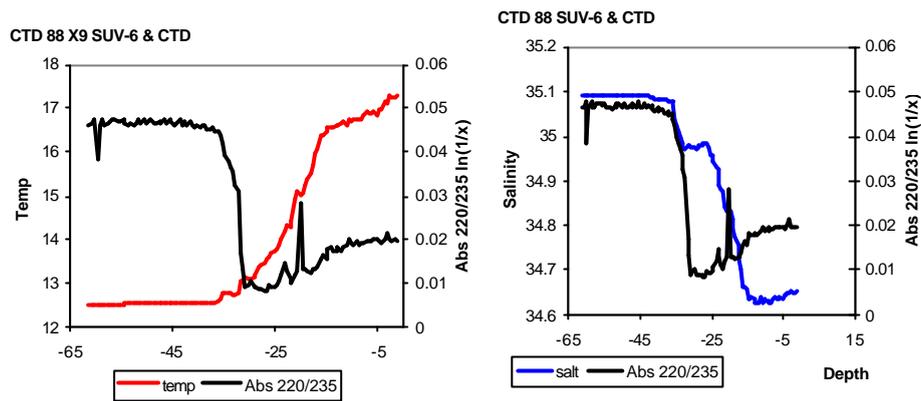
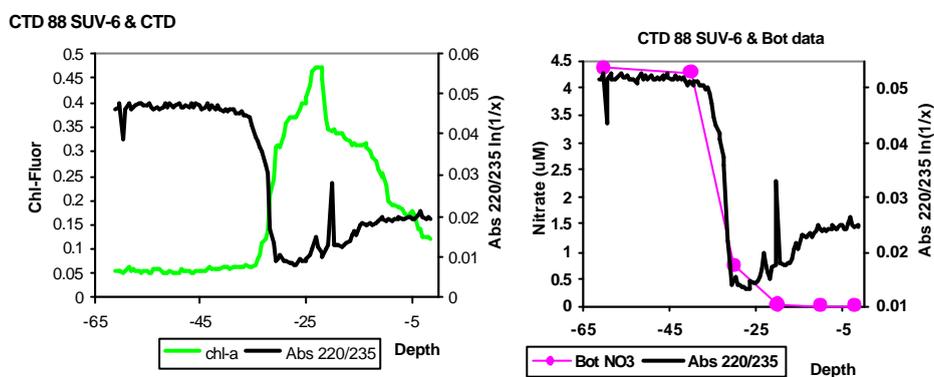


Figure 7
Four plots comparing the SUV-6 absorbance measured on the 220nm channel “corrected” by reference to the absorbance on the 235nm channel.



6 August

End of CS3 station. Mostly sampled 2 hourly with 2 detailed profiles. First at 0700GMT shows a very sharp nutricline. Processing samples finished 16:00. Cd repacked. SUV- moved from diverging up and down casts at start to giving as good agreement as other sensors through most of casts on 5 August. Last cast at 04:00 shows big divergence. Terry reported frame came back oily from one cast could get oil washing off.

8 August

Shelf break section samples on Ti rosette No SUV-6 measurements. Deep water samples had high concentrations, so analytical runs 030808c and 030808d were done with higher concentration range standards. Deeper samples from CTD N8 were diluted 1 + 2 no nutrient sea water to get them on scale. The plot of Si:N ratio with depth (Fig. 11) suggest stronger Antarctic Bottom Water may be present in deep water than during any of the OMEX sampling. This needs checking against the OMEX data. The increase is indicated by the increase in the silicate to nitrate ratio at depth. I think it shows a relatively higher concentration of silicate in the deeper water than was seen in the same location in 1995.

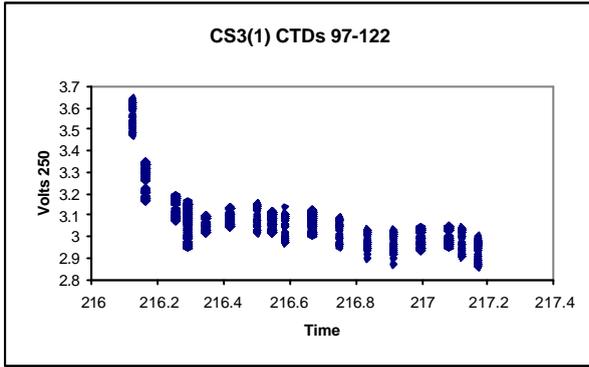


Figure 8.
Plots of all voltage data from the 250 nm channel on all of the CTD casts as CS3(1), showing the initial drift of the instrument at the start of the station.

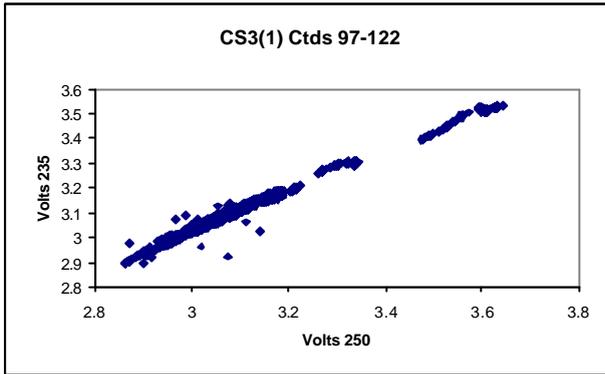


Figure 9.
Plots of voltages recorded on the 235 and 250 nm channels of the SUV-6, showing that they responded in the same way with respect to drift and signals detected..

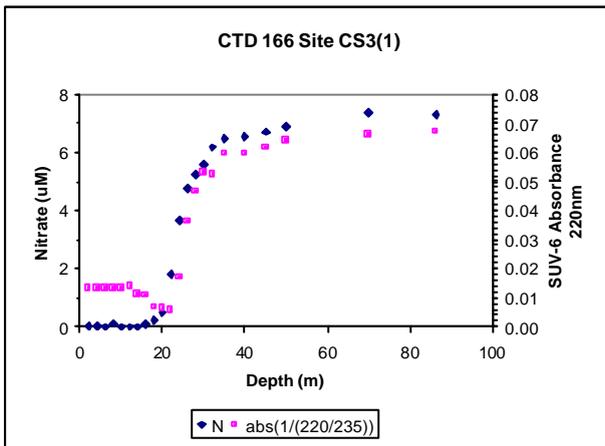


Figure 10
Comparison of nitrate determined in bottle samples with “nitrate” determined by SUV-6 from the second of 2 detailed profile collected at site CS3(1).

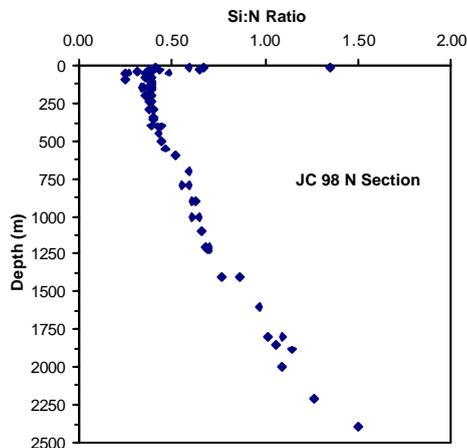


Figure 11.
Section N. Plot of Si:N ratio measured in all the samples collected on section N.

9 August

A closer look at N section data shows that as in the OMEX data a change in the N:P ratio with depth can be detected, as was the case in the OMEX data.

The concentrations of nitrate below the nutricline in the shallow shelf break stations N1 and N2 are higher than encountered previously in this region. The concentration was 9.3 μM NO_3 as opposed to 8 μM NO_3 . The inflection in depth profile suggest a deep winter mixing depth of the order of 400 m deeper than the OMEX data. This may be the cause of the higher values.

10 August

Up to this point 763 samples from CTD rosette bottles had been analysed.

When Skalar sampler turned on it was dead. After awhile it came back to the state of sample turntable moving round sporadically slowly and jerkily – identical symptoms to the one returned from ship to Skalar at the start of the cruise. Taking top of and spaying boards with contact cleaner and lubricant had no effect.

Measurement of samples is therefore at an end. Analyser not stripped down just in case it is a “humidity effect” and it comes back to life tomorrow.

Samples still collected but when 36 tube sample tray is full these are transferred to the -20°C freezer.

11 August

End of CS3(2) 25 hour station. Skalar sample-changer was checked it was still dead. Collect samples on section to CS1. At CTD station 161 voltages on screen from SUV-6 were low. Checked last cast at CS3 – V4 was reading zero through out cast other voltages were zero at end of cast. Battery voltage checked reading 14.3 volts instead of 24 volts. Cast at midnight checked that looks good showing a strong nutricline at depth consistent with advection of colder water,.

An incursions of colder deep water are seen periodically at this station CS3(2) these water contain a high absorbance on both the 220 and 235nm channels of the SUV-6 so this water is not associated with a significant change in the concentration of nitrate

12 August

Last nutrient samples collected and stored in freezer.

JC 98 Skalar Nutrient Analyser Methods

Nitrate

Reagents

Ammonium Chloride Stock 250g/2l

Working Ammonium Chloride Stock diluted 1+ 4 distilled water

Stock Hydrochloric Acid 250 ml conc diluted to 1 litre

Sulphanilimide 5g/l plus 200 stock Hydrochloric Acid to 500ml with distilled water

Naphthylethylenedihydrochloride (NED) 0.5 g/500ml distilled water.

Working sulphanilamide/NED mixed 1:1 plus 1ml Brij 35 (30% solution) /l

Tubes

Working Ammonium Chloride Blue/Yellow 1.2 ml/min

Sample Black/Black 0.3 ml/min.

Air Black/Black 0.3 ml/min.

Mixed Sulphanilimide/NED Orange/Yellow 0.2 ml/min

Waste from Cell Red/Red 0.8 ml/min

Phosphate

Reagents

Ammonium Molybdate 30g/l
Ascorbic Acid 50 g/l
Potassium Antimony Tartrate 1.4g/l
Stock Sulphuric Acid 140ml conc diluted to 1 litre
Sodium Dodecyl Sulphate (SDS) 50 g/l
Working Molybdate Solution – 200 ml Stock Molybdate, 500 ml dilute sulphuric acid, 100 ml Tartrate 200 ml distilled water.
Working Ascorbic Acid Solution – 75 ml Ascorbic Acid stock, 20 ml SDS Stock Distilled water to 1l.

Tubes

Working Molybdate Orange/White 0.2 ml/min
Working Ascorbic Acid Red/Red 0.8 ml/min
Air – Skalar injector
Sample Red/Red 0.8 ml/min
Waste from Cell Red/Red 0.8 ml/min

Silicate

Reagents

Ammonium Molybdate 30g/l
Oxalic Acid 25 g/l
Ascorbic Acid 18 g/l
Stock Sulphuric Acid 140ml conc diluted to 1 litre
Sodium Dodecyl Sulphate (SDS) 50 g/l
Working Molybdate Solution – 320 ml Stock Molybdate, 40 ml dilute sulphuric acid, 100 ml SDS

Tubes

Working Molybdate Orange/Orange 0.4 ml/min
Air – Skalar injector
Sample Orange/Orange 0.4 ml/min
Oxalic Acid Black/Black 0.3 ml/min
Ascorbic Acid Orange/Orange 0.4 ml/min
Waste from Cell Red/Red 0.8 ml/min

Standards

Primary Standards

Separate primary standards were prepared from dry (110° C overnight) salts on 24 July 2003 and stored on 125 ml Nalgene polycarbonate bottles in refrigerator.

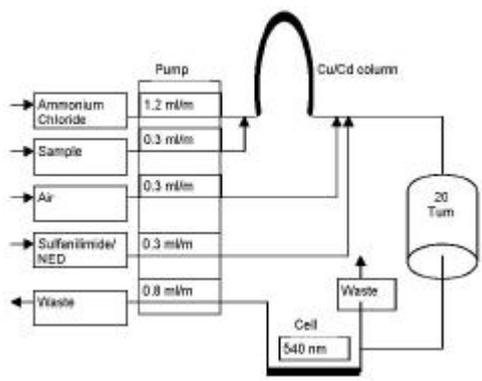
Weights in 500ml distilled water
Silicate 0.96g sodium fluorosilicate
Phosphate 0.681g Potassium hydrogen phosphate
Nitrate 0.510g Potassium Nitrate
Nitrite 0.345g Sodium Nitrate

Secondary Standard

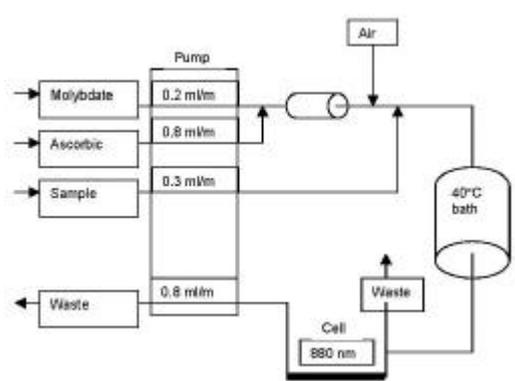
A combined Silicate, Phosphate and Nitrate Standard was prepared from 25 ml of primary silicate and nitrate and 5 ml primary phosphate diluted to 100ml.
1ml of this standard gave a top concentration working standard of 10 uM Si and NO₃ and 2uM PO₄ when diluted in 250ml of 40g/l sodium chloride solution.

Manifold Diagrams

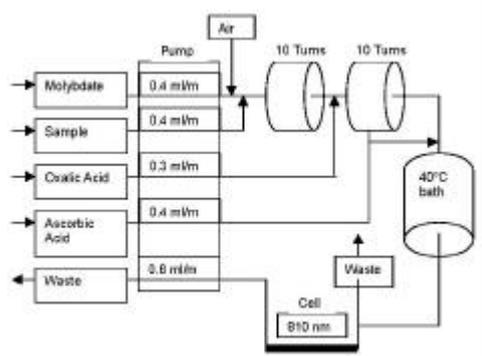
Nitrate



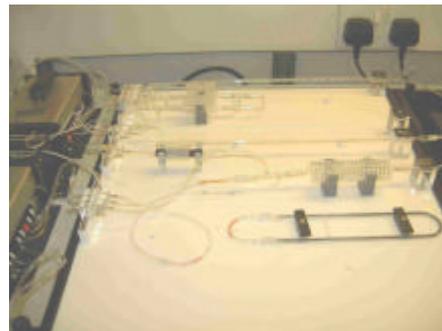
Phosphate



Silicate



Laboratory Pictures JC98 – Skalar Autoanalyser set out



4.10 Nutrients (ammonium). Sinhué Torres-Valdés, SOC.

Ammonium concentration in seawater samples was measured according to the method described by Holmes *et al.* (1999), which is an adaptation of the continuous-flow fluorometric technique developed by K erouel and Aminot (1997). The method involves *i*) the addition of a mixture of reagents (working reagent) to the seawater samples, *ii*) incubation of the samples for 3-8 h in the dark and *iii*) measurement of fluorescence of the samples. During the cruise fluorescence was measured with a Turner Designs TD-700 Fluorometer.

Seawater collection for ammonium analysis

In order to minimise contamination, seawater was collected from the Niskin bottle tap using a rubber tube directly into small containers (either 50 mL centrifuge tubes or 20 mL diluvials) and prior to any other water collection (*e.g.* water collection for oxygen measurements, chlorophyll, etc.). The tubes/diluvials were rinsed several times before the water was collected and were then sealed with solid caps to avoid contact with air. Caps were only opened when adding the working reagent and when the fluorescence measurement was done. Samples were collected and analysed in three or four replicates (see daily summary below for reference).

Calibration

Fluorometer calibrations were done daily whenever it was possible. Five points calibration curves were prepared by addition of different volumes of a 50 μM ammonium chloride (NH_4Cl) standard solution (working standard) into 25, 20 or 10 mL of Milli-Q water (see daily summary for reference). The working standard was prepared by diluting 1 mL of a 5000 μM NH_4Cl solution (mid standard) to 100 mL of Milli-Q water using a Pyrex volumetric flask. The mid standard was in turn prepared by diluting 1 mL of a 0.5 M NH_4Cl solution (stock standard) to 100 mL of Milli-Q water as above. The fluorometer is calibrated by setting a standard assumed to be in the middle of the range of concentrations expected to be measured. The fluorometer then assigns 500 arbitrary units to the fluorescence measured. This value is thus the main reference value. During this cruise two calibration ranges were used; up to 2 $\mu\text{mol L}^{-1}$ and up to 1 $\mu\text{mol L}^{-1}$ (see daily summary for reference).

Working reagent

Sodium sulphite solution: 1 g of sodium sulphite in 125 mL of Milli-Q water.

Disodium tetraborate solution (buffer): 80 g of disodium tetraborate in 2 L of Milli-Q water.

OPA solution: 4 g of ortho-phthalaldehyde in 100 mL of reagent-grade ethanol.

NB: The reaction of ammonium with OPA produces an intense fluorescent product.

Working reagent: 2 L of tetraborate buffer, 10 mL of sodium sulphite solution and 100 mL of OPA solution (mixed and stored in a dark container).

References

Holmes RM, A Aminot, R K erouel, BA Hooker and BJ Peterson (1999) A simple and precise method for measuring ammonium in marine and freshwater ecosystems. *Can. J. Fish. Aquat. Sci.*, 56:1801-1808

K erouel R and A Aminot (1997) Fluorometric determination of ammonia in sea and estuarine waters by direct segmented flow analysis. *Mar. Chem.*, 57:265-275.

Daily summary

24-25/07/03

All equipment and materials needed for ammonium analysis were unpacked, set up and prepared.

26/07/03

Testing the method and the fluorometer; preparation of two calibration curves with Milli-Q water (range up to 2 $\mu\text{mol L}^{-1}$). Analysis carried out in triplicate samples (25 mL of sample + 2 mL of reagent in 50 mL centrifuge tubes). Satisfactory results obtained.

Table 1. 1st Calibration curve (prepared by diluting the amount of STD added to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD diluted (mL)</i>
BLK	0.00	0.000
STD 1	0.25	0.125
STD 2	0.50	0.250
STD 3	1.00	0.500
STD 4	1.50	0.750
STD 5	2.00	1.000

Table 2. 2nd Calibration curve (done by adding STD to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD addition (mL)</i>
BLK	0.00	0.000
STD 1	0.04	0.020
STD 2	0.10	0.050
STD 3	0.20	0.100
STD 4	1.00	0.500
STD 5	2.00	1.000

NB: Tubes were washed with Milli-Q water and left to dry on the lab bench.

27/07/03

Testing the method for salt effects; preparation of two calibration curves with Seawater from the ship's non-toxic supply (range up to 2 $\mu\text{mol L}^{-1}$). Analysis carried out in triplicates (25 mL of sample + 2 mL of reagent in 50 mL centrifuge tubes). Satisfactory results obtained. Readings only slightly different from calibration curves prepared with Milli-Q water, likely within the analytical error (*e.g.* variability between replicates and calibration curves prepared).

Table 3. 3rd Calibration curve (prepared by diluting the amount of STD added to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD diluted (mL)</i>
BLK	0.00	0.000
STD 1	0.25	0.125
STD 2	0.50	0.250
STD 3	1.00	0.500
STD 4	1.50	0.750
STD 5	2.00	1.000

Table 4. 4th Calibration curve (prepared by adding STD to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD addition (mL)</i>
BLK	0.00	0.000
BLK 2*	0.00	0.000
STD 1	0.04	0.020
STD 2	0.10	0.050

STD 3	0.20	0.100
STD 4	1.00	0.500
STD 5	2.00	1.000

*Blank with twice the amount of reagent added.

NB: The blank with double addition of reagent was done in order to investigate the effect in the sample fluorescence by the reagent. The results showed an increase in the fluorometer reading of BLK 2, however a complete calibration curve with double reagent addition should have been done in order to investigate whether the effect was proportional in all standards.

28/07/03

5th Calibration curve prepared (range up to 2 $\mu\text{mol L}^{-1}$).

First ammonium analysis carried out for CTD cast 002 (21:58 h GMT of the previous day).

Fluorescence readings of the first analysis suggest very low ammonium concentrations. It was thus decided to reduce the range of the calibration up to 1 $\mu\text{mol L}^{-1}$ instead.

A 6th calibration curve with a range up to 1 $\mu\text{mol L}^{-1}$ was prepared before the following CTD cast.

Ammonium analysed for CTD cast 003 (13:40).

Table 5. 5th Calibration curve (prepared by adding STD to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD addition (mL)</i>
BLK	0.00	0.000
STD 1	0.25	0.125
STD 2	0.50	0.250
STD 3	1.00	0.500
STD 4	1.50	0.750
STD 5	2.00	1.000

Table 6. 6th Calibration curve (prepared by adding STD to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD addition (mL)</i>
BLK	0.00	0.000
STD 1	0.05	0.025
STD 2	0.25	0.125
STD 3	0.50	0.250
STD 4	1.00	0.500

NB: A higher degree of variability was noted with this calibration range between replicate samples. It also seemed to have higher blanks, although this may be also due to the change in the calibration range.

29/07/03 Station CS2 starts.

7th Calibration curve prepared (range up to 1 $\mu\text{mol L}^{-1}$). Calibration curve was prepared with Milli-Q water kept in clean polycarbonate bottles from the previous day.

Ammonium analysed for cast 005 (03:58) and Time 0 ammonium for ¹⁵N-incubations (e.g. initial conditions of incubation).

Table 7. 7th Calibration curve (prepared by adding STD to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD addition (mL)</i>
BLK	0.00	0.000
STD 1	0.05	0.025
STD 2	0.10	0.050

STD 3	0.25	0.125
STD 4	0.50	0.250
STD 5	1.00	0.500

NB: Calibration curve 7th went completely wrong, very likely contaminated (first time the calibration curve is not prepared with fresh Milli-Q water). The previous calibration settings in the fluorometer are kept (6th calibration curve) and 7th calibration is rejected. 8th calibration curve prepared. Analysis for CTD 018 (17:01) and ΔT ammonium (end of ¹⁵N incubations).

Table 8. 8th Calibration curve (prepared by adding STD to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD addition (mL)</i>
BLK	0.00	0.000
STD 1	0.05	0.025
STD 2	0.10	0.050
STD 3	0.25	0.125
STD 4	0.50	0.250
STD 5	1.00	0.500

NB: 8th calibration curve highly variable and one standard point contaminated. Leaving the tubes open to dry with tiny water droplets inside is the possible source of variation and contamination, as these droplets may trap ammonium from the air (Hydes, personal communication). The problem may not affect the seawater samples as the tubes used to collect them are rinsed several times with sampled water. From now onwards the tubes used for calibrations will be left closed at all times and will be carefully rinsed with fresh Milli-Q water just before the calibration curve is prepared. Fluorometer left with previous calibration settings, therefore ammonium concentrations from CTD cast 018 and concentration for ¹⁵N experiment calculated with 6th calibration curve.

30/07/03

Analysis for CTD 029 (03:59), T0 and ΔT ammonium for ¹⁵N-incubations.

Fluorometer readings still show some variability. 40 m sample replicates highly variable (a unique value, similar to those from the neighbouring depths, out of three replicates was considered to calculate the concentration).

31/07/03 Station CS1 starts .

It was decided to try diluvials instead of tubes (diluvials may be cleaner and are disposable). It was also decided to increase the number of replicates to four.

A 9th and a 10th calibration curves were prepared; first one using centrifuge tubes (25 mL of sample + 2 mL of reagent), and a second one using diluvials (20 mL of sample + 1.8 mL of reagent). Reagent addition was reduced proportionally.

Ammonium analysed for CTD cast 033 was carried out using tubes and diluvia ls as well.

Table 9. 9th Calibration curve (prepared by adding STD to 25 mL of Milli-Q water).

<i>Standard (STD) / Blank (BLK)</i>	<i>Concentration ($\mu\text{mol L}^{-1}$)</i>	<i>Volume of 50 $\mu\text{mol L}^{-1}$ STD addition (mL)</i>
BLK	0.00	0.000
STD 1	0.05	0.025
STD 2	0.10	0.050
STD 3	0.25	0.125
STD 4	0.50	0.250
STD 5	1.00	0.500

Table 10. 10th Calibration curve (prepared by adding STD to 20 mL of Milli-Q water).

Standard (STD)/ Blank (BLK)	Concentration (mmol L^{-1})	Volume of 50 mmol L^{-1} STD addition (mL)
BLK	0.00	0.000
STD 1	0.05	0.020
STD 2	0.10	0.040
STD 3	0.25	0.100
STD 4	0.50	0.200
STD 5	1.00	0.400

NB: The fluorometer readings showed a slight difference between the two calibration curves and the CTD cast analysed, however within the analytical error (see figure 1).

Analysis carried out in diluvials for CTD casts 039 (10:02), 042 (13:03), 043 (14:07), 045 (16:01) and 047 (18:09), and also for T0 and ΔT ammonium for ¹⁵N-incubations.

NB: Very satisfactory results obtained. Variability problems very much improved. Fluorometer thus calibrated with the calibration curve prepared using centrifuge tubes.

01/08/03

Analysis done for T0 ammonium for ¹⁵N-incubations.

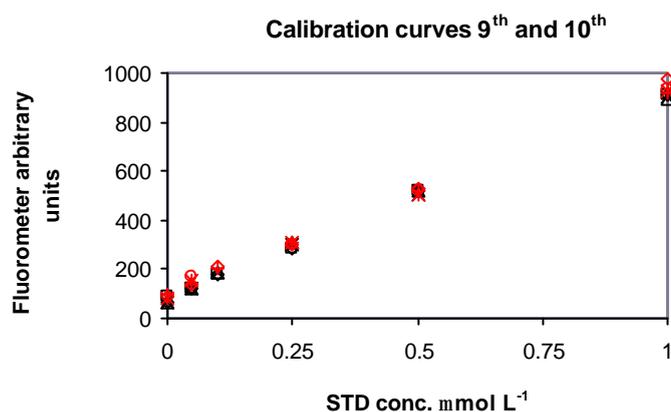


Figure 1.

Calibration curves 9th (dark symbols) and 10th (red symbols). The four replicate fluorescence values are shown (with the exception of four values of contaminated samples).

02/08/03 Station IS1 (mixed) starts.

In order to investigate the effect of double addition of working reagent, calibration 11 was prepared as usual and calibration curve 12 with twice the amount of reagent. Fluorescence values of samples with double reagent addition were slightly higher than those with normal dose, however within the analytical error (see figure 2 below).

Table 11. 11th and 12th Calibration curves (prepared by adding STD to 20 mL of Milli-Q water).

Standard (STD)/ Blank (BLK)	Concentration (mmol L^{-1})	Volume of 50 mmol L^{-1} STD addition (mL)
BLK	0.00	0.000
STD 1	0.05	0.020
STD 2	0.10	0.040
STD 3	0.25	0.100
STD 4	0.50	0.200
STD 5	1.00	0.400

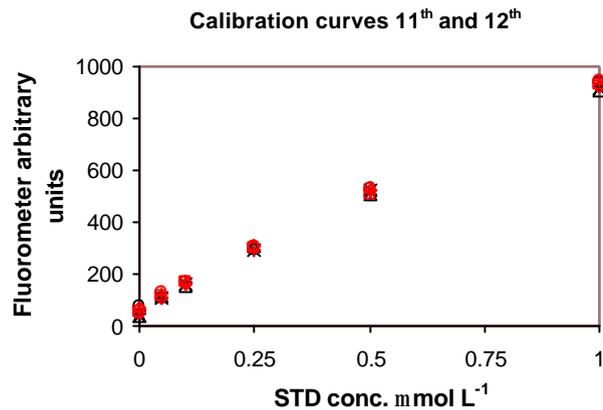


Figure 2.

Calibration curves 11th (dark symbols) with 0.8 mL reagent addition, and 12th (red symbols) with 1.6 mL of reagent addition. The four replicate fluorescence values are shown

NB: Fluorometer calibrated with the 11th calibration curve.

Ammonium analysed for CTD casts 056 (03:58), 062 (10:11), 064 (12:10), 069 (17:06), 070 (18:02), and for T0 and ΔT ammonium for ¹⁵N-incubations.

NB: Fluorometer readings showed this station presented the higher ammonium concentrations measured so far.

03/08/03 Transect X (cross-front).

Previous calibration settings kept.

Due to the increasing shortage of diluvalia ls it was decided to further use the same set of tubes to prepare calibration curves, and three sets of diluvalia to collect and analyse samples.

Analysis done for CTD casts 083 (08:39) X3, 084 (10:09) X4, 085 (12:01) X5, 086 (12:59) X6, 087 (14:11) X7, 088 (15:22) X8, 089 (16:32) X9 and 090 (17:57) X10.

NB: Very satisfactory results.

04/08/03

Computer work; ammonium concentrations calculated and profiles produced.

05-06/08/03 Station CS3c (1).

Due to rapid shortage of working reagent the amount of sample was reduced to 10 mL. The working reagent addition was therefore proportionally reduced to 0.8 mL.

13th calibration curve prepared and fluorometer calibration setting updated.

Analysis carried out for casts 098 (03:55), 100 (06:03), 102 (08:14); 104 (10:01*^{NB}), 106 (12:02), 108 (14:00), 110 (16:00), 112 (18:02); 114 (19:59), 116 (21:58), 118 (23:57), 120 (01:58) and 121 (02:56).

***NB:** New chemical supplies arrive.

In order to investigate whether a change in the ammonium concentration occurred with time, an improvised small experiment was carried out with 22 m depth water (Chl max) from CTD cast 117 (22:58). Six sets of four diluvalia (*e.g.* 4 replicates) were filled with seawater. One set was 'fixed' with working reagent just after the water was collected. The diluvalia were then placed in a dark place at room temperature. A second set was 'fixed' one hour later and so on. The 6th set was 'fixed' after ~5 h.

NB: Fluorescence readings of this improvised experiment showed no change in ammonium concentration with time. Likely not the best way to carry out an experiment of this sort. Readings suggest concentrations below the limit of detection.

Ammonium analysis was also done for the P vs. E ¹⁵N-experiments.

NB: Good results. Ammonium concentrations mainly detectable in sub-surface samples. Apart from cast 114 (19:59), concentrations only detectable in night CTD casts; 098 (03:55), 118 (23:57), 120 (01:58) and 121 (02:56).

NB: The water from CTD cast 121 (03:30 GMT) was collected in carboys. Carboys were sub-sampled for ambient ammonium concentration at about 06:00 GMT. Additions of reagent for 'Ro or T0' (¹⁵N incubations) were done at about 10:00 GMT and fluorometer readings at about 17:30 GMT.

06/08/03 Station U2.

Analysis done for CTD 124 (16:28).

07/08/03

Computer work; ammonium concentrations calculated and profiles produced (updated).

08/08/03 Line N.

Analysis done for CTD cast 133 (11:03).

New working reagent prepared.

10-11/08/03 Station CS3c (2).

14th calibration curve prepared; fluorometer calibration settings updated.

Analysis carried out for CTD casts 135 (03:56), 137 (05:57), 139 (08:11); 141 (10:15), 142 (11:02), 143 (12:07), 145 (14:02), 147 (16:10), 150 (18:55), 152 (21:01), 154 (22:56), 156 (00:56), and 158 (02:56). Analysis also done for T0 and ΔT ammonium for ¹⁵N-incubations.

NB: Very good results. Higher (or detectable) concentrations were expected in the night CTD casts, as it was observed in the CS3c (1). However, higher fluorometer readings were observed in the morning CTD casts 135 (03:56), 137 (05:57), 139 (08:11), 141 (10:15), 142 (11:02), and 143 (12:07).

11/08/03 Station CS1.

Analysis done for cast 164 (14:40).

12/08/03 Station CS2.

Analysis done for CTD cast 170 (only from the depth at which the chlorophyll maximum was observed).

Analysis also done of the stock ¹⁵N-ammonium solution and ammonium carrier. Last analysis carried out.

4.11 Iron and Trace Metal Studies

Florence Nédélec - Southampton Oceanography Centre

Background

Iron has been demonstrated to be an essential nutrient element for phytoplankton in marine systems and this is particularly important in high nutrient low chlorophyll (HNLC) areas where the element can limit primary production. However, the accurate determination of iron at picomolar concentrations in seawater is a difficult analytical task and the amount of reliable information on this element in ocean waters is very limited. The JR98 cruise within the Celtic and Irish Seas provide an excellent opportunity to sample in shelf waters where the mixing processes normally occurring in the surface mixed layer allows the re-suspension of sediments. This particulate material which is susceptible to be brought to the surface, is thought to be a major source of iron in these shelf waters. This cruise will thus significantly add to our knowledge on the quantification of the iron inputs to surface waters, on the composition of the particulate phase, on the distribution of iron within the water column in relation to the biota and its concentration gradient across the shelf. An additional major advantage to doing the Fe and trace metal work on this cruise is the large ancillary database to be produced on biology, suspended particulate material size fractionation and concentration, and light in the system that can be used to help interpret the Fe and trace metal data.

Sample collection

At the end of each 25h stations, a cast at 5am was done for the iron work and two transects were performed throughout this cruise. The titanium rosette normally used for trace metal work consists of 24 10L OTE water-sampling bottles that have been adapted to minimise metallic components and potential contamination. The bottles are deployed on a titanium rosette-CTD system with the instruments all being housed in titanium cases. There are no zinc sacrificial electrodes on the frame, which have caused considerable problems with contamination for this element when such electrodes have been used. As this Titanium rosette was not working for about half the cruise and for practical reasons, several casts were performed with the stainless steel rosette. The table below describes the samples taken over this cruise with which rosette:

Station	Day (of the year)	CTD number	Bottom depth (m)	Rosette used
CS2	30/07 (211)	30	200	Stainless steel
CS1	01/08 (213)	51	97	Stainless steel
IS1b	03/08 (215)	80	76	Stainless steel
CS3c	06/08 (218)	122	96	Stainless steel
N1	07/08 (219)	125	157	Titanium
N2	07/08 (219)	126	165	Titanium
N3	07/08 (219)	127	250	Titanium
N4	07/08 (219)	128	365	Titanium
N5	07/08 (219)	129	542	Titanium
N6	07/08 (219)	130	1238	Titanium
N7	08/08 (220)	131	1893	Titanium
N8	08/08 (220)	132	2411	Titanium
N9	08/08 (220)	133	2953	Titanium
CS3c	11/08 (223)	158	99	Stainless steel
CS3c	11/08 (223)	159	100	Titanium
D2	11/08 (223)	161	103	Stainless steel
A3	11/08 (223)	166	101	Stainless steel
A6	11/08 (223)	167	120	Stainless steel
A9	11/08 (223)	168	123	Stainless steel
A13	12/08 (224)	169	155	Stainless steel

CS2	12/08 (224)	170	198	Stainless steel
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Filtration of the samples

Bottles were fired at least in duplicate at each depth (that included the chlorophyll maximum) to provide adequate water for all samples required. After arrival on deck, the bottles dedicated to the iron work were carried to a clean container laboratory. This container laboratory has been substantially modified for trace metal work, and has a small anteroom and a main working space. The walls are coved and lined with plastic, and exposed metallic components have been minimised through choice of materials and appropriate coatings. The air supply is air conditioned and primary filtered, and there is a laminar flow hood for critical handling steps. The OTE or Niskin bottles (depending on which rosette was used) containing samples were held on a rack in the container, a Teflon external frame was used to clamp top and bottom valves shut, and the bottle was pressurised with (filtered) air to 1 atmosphere using a compressor. Samples were directly passed through filters (normally 0.4 or 0.1 μm pore size cleaned polycarbonate membranes) held in a Teflon inline filter holders into acid cleaned low-density polyethylene storage bottles. Samples were acidified with 1mL of quartz-distilled hydrochloric acid per litre to stabilise the contained dissolved metals.

Sample treatment

For each cast 6 to 12 depths were sampled, depending on the bottom depth and features observed with the transmissometer during the downward cast. For each depth, the sample was filtered through 0.4 μm pore size filter to collect the conventionally defined “dissolved” fraction ($< 0.4 \mu\text{m}$).

Recent research has indicated that a substantial fraction of the Fe in seawater can be present as colloidal phase. To test this for the environment studied here, two filtrations were done for all the casts performed at the end of a 25h station; i.e. through 0.4 μm and then a separate filtration through 0.1 μm filters. The intention is to investigate the distribution of colloids with respect to biological activity and biomass in the water column and the potential relationship between the colloidal concentration and particulate inputs from the sediments. In shelf waters, typical particulate concentrations vary between 0.5 and 1.5 mg/L throughout the water column (Sarah Jones, personal communication). To study the iron inputs from the sediments, several litres of the deepest sample(s) (from 4 to 8L depending on how fast the seawater was going through), were filtered through 0.4 μm pore size filters, the filter was then rinsed with MQ-water and stored in a sterilised box. Back in the laboratory, some iron release experiments will be performed on the particles trapped on the filters to determine the total iron concentration in the particulate phase and to study the release of iron from this fraction in seawater in natural conditions during incubation experiments.

In order to check for any contamination of the samples collected with the stainless steel rosette, two casts at CS3c were performed in a row on the 11th August. At 4am, samples were collected at 8 depths with the stainless steel rosette and filtered through 0.4 μm pore size filters, and the bottom one being kept. At 5am, samples were collected at 10 depths with the titanium rosette, filtered through 0.4 μm and then 0.1 μm , and the four filters of the deepest samples kept. It will thus be possible to compare the results obtained for the 0.4 μm filtered fraction in order to check for any contamination.

Number of samples collected for Fe and other trace metal analyses:

Sampling system	Number of CTDs	Number of samples collected
Titanium rosette (0.4 μm filtered)	10	90
Titanium rosette (0.1 μm filtered)		29
Stainless steel rosette (0.4 μm)	11	76
Stainless steel rosette (0.1 μm)		66

Filters kept		33
Total number of events/samples	21	294

Shipboard Iron Analyser System

When samples were not collected, the cruise was also used as an opportunity to optimise a new Fe analyser system built at the SOC that is based on the system of Bowie et al. (Bowie, A.R. *et al.*, 1998. "Determination of sub-nanomolar levels of iron in seawater using flow injection with chemiluminescence detection". *Analytica Chimica Acta*, **361**(3): 189-200). The system uses a pre-concentration column to remove Fe(II) from the sample, and this collected metal is determined by chemiluminescence using a buffered luminol solution.

Significant improvements to the system were made, including:

- the optimisation of the chemistry and the reagents preparation,
- increasing the sensitivity to sub-nanomolar concentrations (best result was 142pM),
- modification of the software to have sequences of four analytical cycles to perform four replicates for each blank/standard/sample analysed,
- addition of a switching valve to minimise the contribution of the previous solution analysed and avoid any carrier effect,
- optimisation of the first loading time to improve the precision,
- addition of a 8-hydroxyquinoline column on the eluent stream to lower the baseline, due to the suspected presence of organic compounds in the water used to prepare the diluted acid eluent.

The precision of the measurements was significantly improved as for the best calibration curve (500pM to 5nM) it was between 5.3 and 11.6% ($n=4$) calculated on corrected peak areas. However as this result is still not systematic, it means that the system still has to be optimised. Although an extensive series of experiments was done to improve the precision and mainly to minimise the carrier effect between each solution, work is also needed to stabilise the system response between each batch of reagents and to have stabilised standards.

Acknowledgements

I would like to thank the PSO for personally keeping me updated of the latest changes in the cruise program, as well as Huw Thomas, Young Nam Kim and Sinhue Torres for helping me carrying the CTD bottles to the container all over the cruise and over night during the two transects. All the UKORS and BAS ship staff were also very helpful throughout the cruise; Terry and Jon (repairing the Titanium CTD, OED), Kevin (set up of the clean container, OED) and Doug (deck engineer, BAS) are particularly thanked for their efforts.

4.12 Phytoplankton 15N & 13C Uptake Rates. Mike Lucas – SOC.

RATIONALE

The vertical structure of the Celtic Sea in August is typically dominated by a strong thermocline and associated deep chlorophyll maximum (DCM). Surface waters are nutrient impoverished. Phytoplankton within the DCM have access to limited nutrients injected from below the thermocline by tidal and internal wave mixing but experience a low ambient light field. Phytoplankton community structure (diatoms / flagellates), productivity and physiological status will depend on relative light and nutrient availability. The major goal of the 15N & 13C tracer studies was to simultaneously measure phytoplankton production (13C fixation) and “new” and “regenerated” production. The relative contribution of new and regenerated production, represented by the f-ratio, will depend not only on ambient nutrient concentrations and supply rates, but also on the available light to drive NO₃ assimilation in particular. It is therefore also important to measure NO₃ assimilation relative to variable light.

RESEARCH APPROACH

1. On-Deck Incubations

Standard on-deck 15N (& 13C) dawn-to-dusk (~5/6am to ~7/8pm) measurements of NO₃, NH₄ & urea uptake (in 2.0L bottles) were conducted at a number of light depths (6 max., chosen from 97%, 55%, 33%, 14%, 7%, 4.5%, 1% and 0.1% irradiances), but concentrating on the DCM (usually 4.5 to 1% irradiance). Dark bottles corrected for potential dark uptake. Ammonium regeneration was also measured by isotopic dilution at each of the light depths. Some size-fractionated (SF) 15N uptake experiments for each of the three nitrogen resources (6L total; 2L x intact community, 2L x <10µm, 2L x <2µm) were performed at the DCM to demonstrate the relative significance of the different phytoplankton communities. The DCM (low-light) incubations were cooled to ambient temperatures (11-13°C) with an on-deck (K3) chiller. All other incubations were maintained at SST. Nutrient additions were made at approximately 10% of the ambient concentration. At the end of the experiments, phytoplankton were recovered onto 25mm Whatman GF/F filters which were stored frozen prior to analysis on a Mass Spec at SOC.

2. P vs E Measurements

To properly understand how the community at the DCM is maintained and how it partitions NO₃ & NH₄ in particular, control by light needs to be evaluated through P vs E response curves for NO₃ and NH₄ uptake. Previous work by Joint et al, 2001 DSR II (48): 3049-3081) has demonstrated the higher light dependence of NO₃ uptake relative to NH₄ (& urea) uptake. The P vs E experiments were designed to determine the irradiance at which NO₃ uptake (rather than NH₄ uptake) is likely to become light limited. If we find (or calculate) significant NO₃ flux across the thermocline, but no (or little) NO₃ uptake from the on-deck incubations within the DCM, P vs E responses ought to explain this. Similarly, the frequent observation of a declining f-ratio with depth could also be explained by a higher light dependency for NO₃ assimilation relative to reduced nitrogen sources.

For these (NO₃, NH₄ & 13C) incubations, 12 x 1.0L bottles for each nutrient were incubated in a cooled light box for 34 hours. Light was provided by a 500W halogen lamp and the spectral quality was corrected to remove the red light with a “Misty Blue” (061) Lee filter. Light attenuation within the light box ranged from approx. 500µE to 8µE. Nutrient additions were made at approximately 10% of the ambient nutrient concentration.

At the end, phytoplankton were recovered onto 25mm Whatman GF/F filters which were stored frozen prior to analysis on a Mass Spec at SOC.

MEASUREMENTS

Date	Station	CTD No	Depths	% Light tubes	Measurements
29/07	CS2	5	2	97	On-deck:
			10	55	ρNO_3 , ρNH_4 , purea +13C & rNH4
			20	14	
			40	4.5	
			50	1	
30/07	CS2	30	2	97	On-deck:
			10	55	ρNO_3 , ρNH_4 , purea +13C & rNH4
			20	14	
			40	4.5	
			50	1	
31/07	CS1	33	2	97	On-deck:
			10	55	ρNO_3 , ρNH_4 , purea +13C & rNH4
			20	14	
			40	1	
			50	0.1	
1/08	CS1	51	2	97	On-deck:
			10	55	ρNO_3 , ρNH_4 , purea +13C & rNH4
			20	14	
			40	1	
			50	0.1	
Date	Station	CTD No	Depths	% Light tubes	Measurements
2/08	IS 1	56	2	55	On-deck:
			20	24	ρNO_3 , ρNH_4 , purea +13C & rNH4
			40	4.5	SF ρNO_3 , ρNH_4 , purea +13C
			60	0.1	
3/08	Front X7	86	13	Chl. max	P vs E ρNO_3 , ρNH_4 , +13C
5/08	CS3 c	106	22	Chl. max	P vs E ρNO_3 , ρNH_4 , +13C
6/08	CS3 c	121	2	33	On-deck:
			13	7	ρNO_3 , ρNH_4 , purea +13C & rNH4
			25	4.5	
			40	1	
6/08	U2	124	26	Chl. max	P vs E ρNO_3 , ρNH_4 , +13C
8/08	N9	133	26?	Chl. max	P vs E ρNO_3 , ρNH_4 , +13C
10/08	CS3	135	2	33	On-deck:
			10	14	ρNO_3 , ρNH_4 , purea +13C & rNH4
			20	4.5	

			40	1	
10/08	CS3	138	30?	Chl. max	P vs E ρNO_3 +13C @ SST 18°C
		143	30?	Chl. max	P vs E ρNO_3 +13C @ SST 18°C
		148	30?	Chl. max	P vs E ρNO_3 +13C @ 11°C
		148	30?	Chl. max	P vs E ρNO_3 +13C @ 11°C - repeat
11/08	CS3	158	30	Chl. max	P vs E ρNH_4 +13C @ 11°C
11/08	CS1	164	32	Chl. max	P vs E ρNO_3 , ρNH_4 , +13C
		164	32	Chl. max	P vs E ρNO_3 +13C - repeat
12/08	CS2	170	31	Chl. max	P vs E ρNO_3 , ρNH_4 , +13C

Sample Analyses

It is anticipated that I will be able to begin the 15N & 13C sample analyses in mid- to late October (2003) once the SOC Mass Spec is up and running.

4.13 Algal photophysiological measurements.

David Suggett, Gayle Harris & Emily Le Floc'h, University of Essex.

Various photophysiological measurements were made to support the routine determinations of algal productivity/biomass:

1. Photosynthetic unit size of photosystem II (n_{PSII})? Fast Repetition Rate (FRR) fluorometry can be used to estimate the gross O_2 evolution by PSII *in situ*. Such estimations require knowledge of the ratio of PSII reaction centres to chlorophyll *a* (n_{PSII}) in order to generate chlorophyll *a*-specific values of gross O_2 productivity (P^{chl}). The n_{PSII} has only been measured on laboratory cultures and *in situ* values of P^{chl} have previously relied upon an assumed value of n_{PSII} ; therefore, we attempted to measure n_{PSII} directly throughout the cruise using a technique modified from Suggett *et al.* (2003). Algal material was pre-concentrated by resuspension following gentle vacuum filtration across 0.2 μm polycarbonate filters. Changes in RCII activity were determined from the O_2 evolution of each suspension exposed to various single-turnover flash frequencies. A total of 15 n_{PSII} experiments were successfully obtained. The highest and lowest RCII: *chl a* were observed at the Celtic-Irish Sea front and CS2, respectively. All *in situ* values were within the range observed from a wide variety of algal cultures (Suggett *et al.*, in prep.). These n_{PSII} measurements are the first to be made *in situ* and will be fundamental to more accurate estimates of P^{chl} .

2. Spectral absorption and fluorescence? Optical chlorophyll *a*-specific absorption measurements (a^{chl}) describe the pigment array employed by phytoplankton for absorbing light but can also enable the estimation of photosynthetic quantum yields from productivity measurements. a^{chl} was routinely measured following the protocols of Mitchell *et al.* (2000). Particulate material from a known volume of water was loaded onto 25mm GFFs and measured for absorption using a Hitachi U-3000 fitted with an integrating sphere ($\approx 60^\circ$). The particulates were measured before and after bleaching in order to determine the proportion of total absorption attributable to algae and detritus. Example spectra from each 25 hour site are given in Fig. 1. Highest and lowest values of a^{chl} were observed at CS2 and IS1, respectively, and a^{chl} was always higher in surface than in subsurface waters. These trends are indicative of changes in cell size, pigment concentration and the ability of cells to package pigments. An obvious loss in phycobilin absorption ($\sim 550\text{nm}$) can be observed from 16m to 2m at CS3 suggesting a strong presence of cyanobacteria or cryptomonads at this site. In a separate set of experiments, complimentary measurements of a^{chl} and spectral fluorescence (using a Perkin Elmer LS50B) were performed on each n_{PSII} concentrate. These data will be used in conjunction with HPLC for attempting to validate a relationship that exists in laboratory cultures between optical (a^{chl}) and biophysical (FRRF) absorption (Suggett *et al.*, 2003, in prep.).

3. Single-cell active fluorescence imaging? Routine FRR fluorometry provides a description of the photosynthetic capacity from the algal community. Fluorescence imaging enables high-resolution variable fluorescence measurements of individual cells within the community and, therefore, a more detailed description of algal 'health' *in situ*. The imaging system has been previously used for higher plants (Baker *et al.* 2001), microphytobenthos and Baltic Sea algal populations (unpublished) but not for the widespread assessment of marine phytoplankton. Multiple turnover determinations of the maximum photochemical efficiency ($F_v/F_{m\text{MT}}$) were made from all sites (eg. Fig 2). Differences in both $F_v/F_{m\text{MT}}$ and the predominant cell size class could be distinguished within and between sites. Corresponding measures of community variable fluorescence using single-turnover FRR fluorometry ($F_v/F_{m\text{ST}}$) were also made. These measurements should enable a more accurate interpretation of the routine FRR fluorometry of community response to environmental variability.

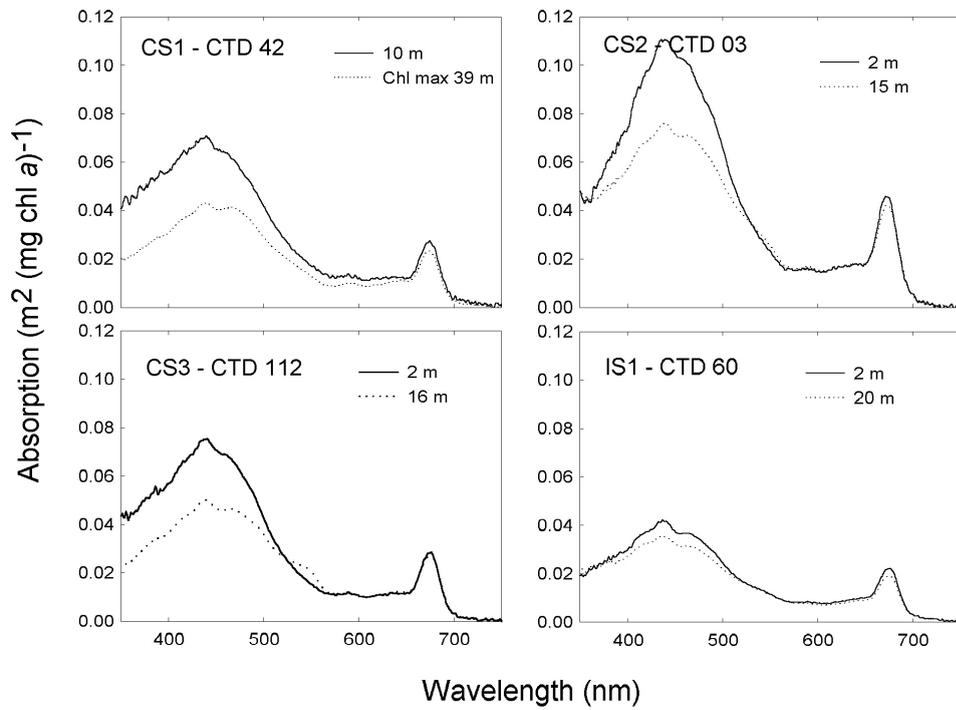


Figure 1. Example chlorophyll a-specific absorption spectra (a^{chl} , $\text{m}^2 (\text{mg chl a})^{-1}$) from each of the 25 hour stations.

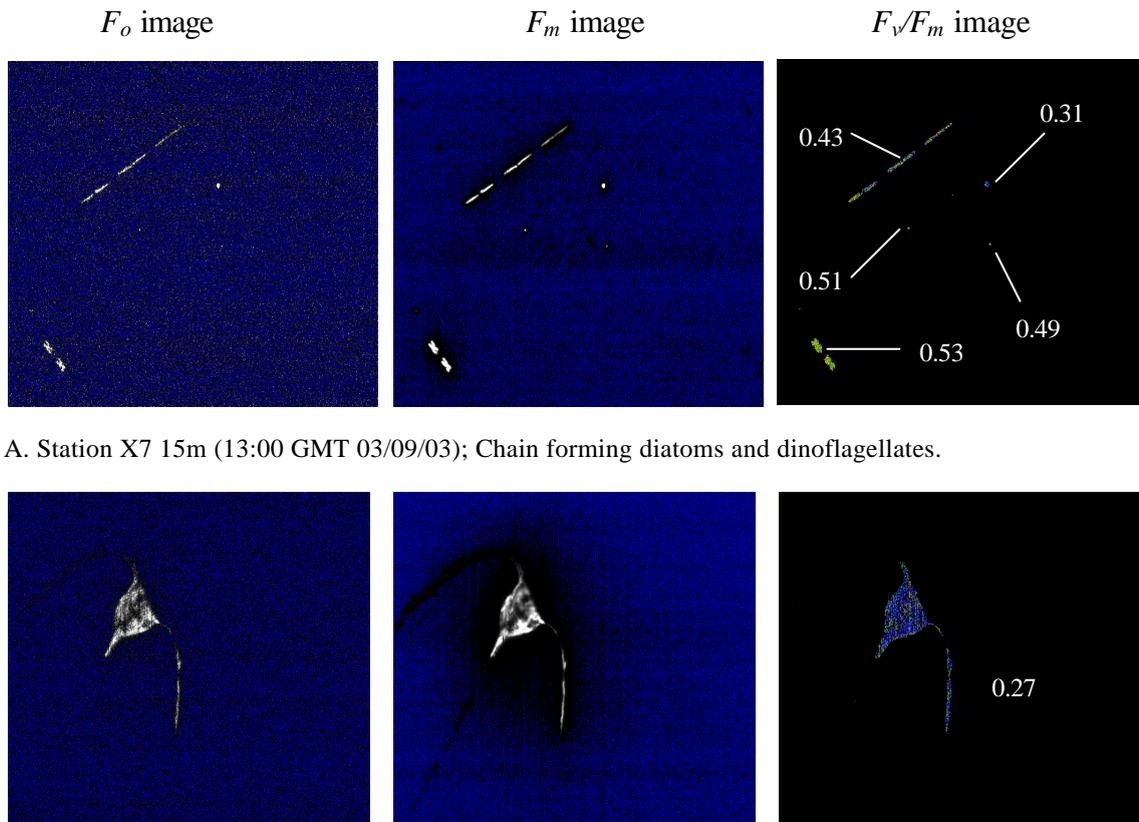


Figure 2. Example images of background (F_0), maximum (F_m) fluorescence and PSII photochemical efficiencies (F_v/F_m) determined using the MT imaging technique.

Baker NR, Oxborough K, Lawson T, Morison JIL. 2001. High resolution imaging of photosynthetic activities of tissues, cells and chloroplasts of leaves. *J. Exp. Bot.* 52:615-621.

Mitchell GB, Bricaud A, *et al.* Determination of spectral absorption coefficients of particles, dissolved material and phytoplankton for discrete water samples. NASA Tech. Memo. 209966: 125-153 in GS Fargion & JL Mueller, *Ocean Optics Protocols for Satellite Ocean Colour Sensor Validation, Revision 2.*

Suggett DJ, MacIntyre HL, Geider RJ. Biophysical and optical determinations of light absorption for fluorometric estimates of PSII productivity in phytoplankton. *In prep.*

Suggett DJ, Oxborough K, Baker NR, MacIntyre HL, Kana TM, Geider RJ. 2003. Fast Repetition Rate and Pulse Amplitude Modulation chlorophyll *a* fluorescence measurements for assessment of photosynthetic electron transport in marine phytoplankton. *Eur.J.Phycol.* *In press.*

4.14 Oxygen measurements.

Tim Adey - SOC

Methodology

Oxygen measurements were made using an automated Winkler titration system with a photometric endpoint detector.

Three types of O₂ measurements were undertaken:

- (i) Simulated in-situ incubations (ISI) were performed in on-deck incubators for approximately 12 hours (dawn to dusk)
- (ii) P vs. E incubations (PvsE) were performed in a photosynthetron in the laboratory and lasted approximately 4 hours.
- (iii) Oxygen profiles were measured at up to 23 depths, between 2 and 200m to calibrate the O₂ sensor on the CTD.

Samples were collected in calibrated borosilicate glass bottles (120ml for in-situ incubations, and 50ml for P vs. E incubations and O₂ profiles) ensuring that no bubbles were present. For oxygen profiles the samples were taken directly from the CTD niskin bottles, while for incubations water was taken from pooled carboys.

The dissolved oxygen in the water samples was “fixed” by addition of manganous chloride and alkaline iodide reagents. The samples were then acidified (addition of 1 or 0.5ml of 10N sulphuric acid) just prior to analysis by Winkler titration. The addition of acid released iodine, which is stoichiometrically equivalent to the dissolved oxygen. The sample was titrated with 0.2N sodium thiosulphate using an automated burette connected to a photometric endpoint detector. The sodium thiosulphate solution was frequently calibrated against a potassium iodate standard.

Results of Dissolved Oxygen Measurements

The following measurements were successfully made and data listed below:

29/7/03 CS2/05: In situ experiment: Water from 50, 40, 30, 20, and 10 m incubated at 1%, 4.5%, 14%, 55%, and 97% light respectively. Temp 18°C. Duration 11.5 hours.

31/7/03 CS1/34 and CS1/46: O₂ profiles from two casts 12 hours apart.

2/8/03 IS1/56: In situ experiment: Water from 2m incubated at 4 light levels, 1%, 4.5%, 14%, and 55%. Temp 14°C. Duration 14.5 hours.

3/8/03 CTD/86: PE experiment: Water from 13 m. Temp SST = 18°C. Duration 2.45 hours.

5/8/03 CS2/100: In situ experiment: Water from 40, 22, 15, 10, and 2 m incubated at 1%, 4.5%, 7%, 14%, and 33% light respectively. Temp 17°C. Duration 12 hours.

6/8/03 U2/124: O₂ profile

7/8/03 N1/125: PE experiment: Thermocline sample. Temp 12°C. Duration 4 hours.

10/8/03 CS3/135: In situ experiment: Water from 40, 20, 10, and 2 m incubated at 1%, 4.5%, 14%, and 33% light respectively. Temp 33 & 14% SST = 18.2°C, 4.5 & 1 % = 12°C. Duration 7.5 hours.

10/8/03 CS3/139: O₂ profile

10/8/03 CS3/145: O₂ profile

11/8/03 CS1/164: PE experiment: Water from 32m. Temp 12°C. Duration 3.5 hours.

12/8/03 CS2/171: O₂ profile

Additional measurements/incubations were made as follows but data not included due to either analytical problems or changes in O₂ concentration being below the precision of the method.

26/7/03 O₂ Profile: Software problems led to data loss

28/7/03 O₂ Profile: O₂ data very variable so not included

28/7/03 CD3 PE: Changes in O₂ conc. below precision of method- no trend in data when plotted

29/7/03 PE: Changes in O₂ conc. below precision of method- no trend in data when plotted

31/7/03 CS1/33 IN: No change in oxygen during incubation.

2/8/03 IS1/60 PE: Changes in O₂ conc. below precision of method- no trend in data when plotted

5/8/03 PE: Changes in O₂ conc. below precision of method- no trend in data when plotted

Results

1) Simulated in-situ Incubation results:

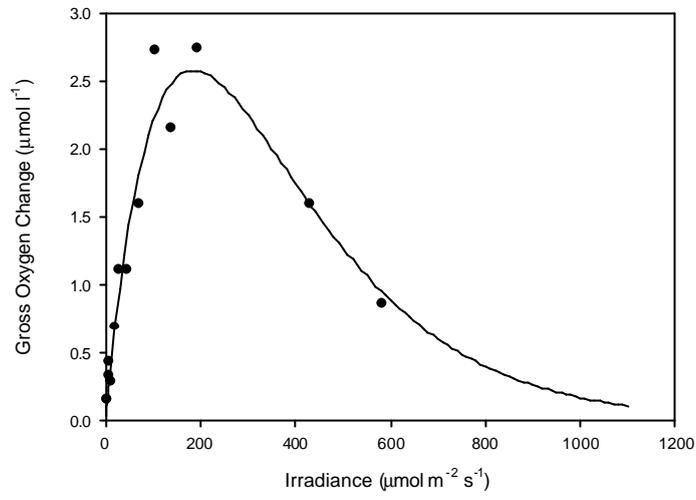
Date	Station	Inc. (hrs)	Depth (m)	% Irradiance	GPP*	+/-	NPP*	+/-	Resp*	+/-
29/07/03	CS2/005	11.5	10	97	0.91	0.59	0.16	0.65	0.75	0.36
			20	55	2.27	0.34	0.84	0.24	1.42	0.41
			30	14	5.91	0.93	4.9	0.68	1.01	1.13
			40	4.5	-0.08	0.55	-0.4	0.4	0.32	0.39
			50	1	-0.37	0.45	-0.84	0.41	0.47	0.2
02/08/03	IS1/056	14.5	2	55	3.13	0.96	2.4	0.97	0.73	0.3
			2	14	3.4	0.36	2.67	0.36	0.73	0.3
			2	4.5	1.9	1.21	1.17	1.21	0.73	0.3
			2	1	1.05	0.23	0.32	0.23	0.73	0.3
05/08/03	CS2/100	12	2	1	2.38	0.32	1.13	0.31	1.26	0.1
			10	4.5	4.67	0.36	3.21	0.41	1.46	0.22
			15	7	1.89	0.28	1.61	0.56	4.25	0.49
			22	14	5.91	0.67	3.57	0.51	2.34	0.48
10/08/03	CS3/135	7.5	40	33	0.7	0.57	1.27	0.16	1.97	0.55
			2	33	2.64	0.21	0.95	0.09	1.69	0.22
			10	14	3	0.27	1.97	0.23	1.04	0.18
			20	4.5	3.5	0.33	2.77	0.35	0.73	0.15
			40	1	0.54	0.17	0.02	0.25	0.56	0.21

*Oxygen change umol/l

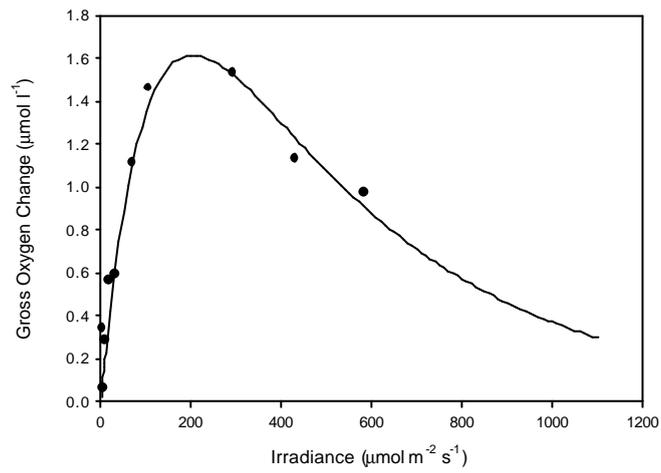
2) P vs E incubations:

<i>Station/Date</i>	<i>Light Level</i>	<i>GP</i>	<i>NP</i>	<i>Resp</i>
CS1/164 11/8/03	584.2	0.86	1.06	-0.20 ± 0.28
	429.9	1.60	1.80	-0.20 ± 0.28
	291.2	0.83	1.03	-0.20 ± 0.28
	192.2	2.74	2.94	-0.20 ± 0.28
	138.3	2.15	2.35	-0.20 ± 0.28
	106.0	2.72	2.92	-0.20 ± 0.28
	70.2	1.59	1.79	-0.20 ± 0.28
	45.2	1.11	1.31	-0.20 ± 0.28
	30.5	1.11	1.31	-0.20 ± 0.28
	19.6	0.69	0.89	-0.20 ± 0.28
	12.8	0.29	0.49	-0.20 ± 0.28
	9.3	-0.29	-0.09	-0.20 ± 0.28
	7.6	0.43	0.63	-0.20 ± 0.28
	5.9	0.33	0.53	-0.20 ± 0.28
	4.4	0.16	0.36	-0.20 ± 0.28
3.2	0.15	0.35	-0.20 ± 0.28	
N1 7/8/03	584.2	0.97	1.40	-0.43 ± 0.84
	429.9	1.13	1.56	-0.43 ± 0.84
	291.2	1.53	1.96	-0.43 ± 0.84
	192.2	0.46	0.89	-0.43 ± 0.84
	138.3	0.95	1.38	-0.43 ± 0.84
	106.0	1.46	1.89	-0.43 ± 0.84
	70.2	1.11	1.54	-0.43 ± 0.84
	45.2	0.19	0.62	-0.43 ± 0.84
	30.5	0.59	1.02	-0.43 ± 0.84
	19.6	0.56	0.99	-0.43 ± 0.84
	12.8	-0.04	0.39	-0.43 ± 0.84
	9.3	0.28	0.71	-0.43 ± 0.84
	7.6	-0.07	0.36	-0.43 ± 0.84
	5.9	-0.02	0.41	-0.43 ± 0.84
	4.4	0.06	0.49	-0.43 ± 0.84
3.2	0.34	0.77	-0.43 ± 0.84	
CTD/86 3/8/03	715.5	7.32	7.07	0.25 ± 0.13
	578.7	7.95	7.70	0.25 ± 0.13
	365.7	6.04	5.79	0.25 ± 0.13
	250.9	4.98	4.73	0.25 ± 0.13
	172.8	3.88	3.63	0.25 ± 0.13
	124.7	2.51	2.26	0.25 ± 0.13
	90.4	1.43	1.18	0.25 ± 0.13
	66.6	1.34	1.09	0.25 ± 0.13
	40.1	0.53	0.28	0.25 ± 0.13
	30.0	0.34	0.09	0.25 ± 0.13
	22.9	0.09	-0.16	0.25 ± 0.13
	13.7	-0.20	-0.45	0.25 ± 0.13
	9.5	-0.61	-0.86	0.25 ± 0.13
	7.0	0.04	-0.21	0.25 ± 0.13

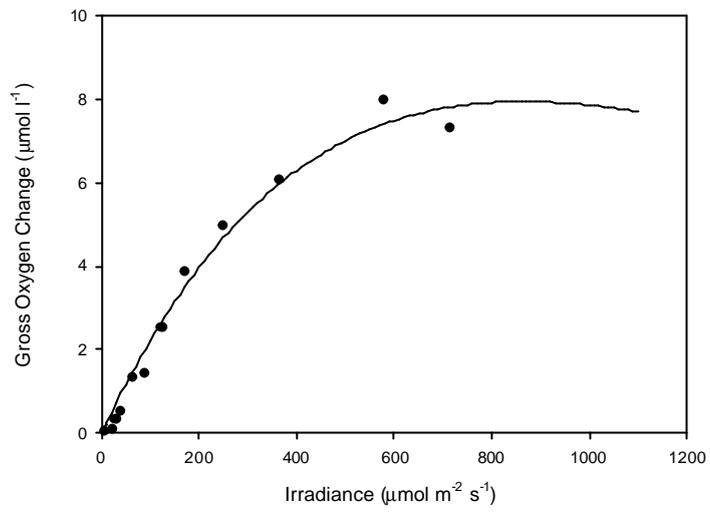
CS1/164 11/8/03



N1: 7/08/03



CTD/86 3/8/03



3) Oxygen Profiles:

(± indicates standard difference where two replicates measured)

CS1/34		CS1/46		U2/124		CS3/139		CS3/145		CS2/171	
Depth (m)	O2 umol/l	Depth (m)	O2 umol/l	Depth (m)	O2 umol/l	Depth (m)	O2 umol/l	Depth (m)	O2 umol/l	Depth (m)	O2 umol/l
85	241.43	83	235.58	100	233.17 ± 0.16	85	216.22 ± 0.75	85	213.87	200	241.62 ± 0.45
80	235.98	80	235.63	60	233.44 ± 0.49	83	218.46	70	216.60	100	242.65 ± 0.09
70	237.32	70	235.3	40	232.61 ± 0.09	81	215.46 ± 0.23	60	218.78	60	248.48
55	235.32	60	235.25	32	234.90 ± 0.09	73	216.10 ± 0.41	45	218.90	26	259.04 ± 0.08
50	237.28	55	235.42	28	234.03 ± 0.05	60	216.20	40	218.06	20	259.04 ± 0.51
48	235.66	50	235.53	26	236.19 ± 0.44	50	216.26	36	218.19	10	260.34 ± 0.20
46	235.54	48	236.46	24	238.84 ± 0.03	40	216.21	34	217.59	2	253.54 ± 0.31
44	236.55	46	236.78	20	245.11 ± 0.39	30	217.67	32	217.80		
42	239.26	44	236.94	10	247.28 ± 0.11	25	217.94 ± 0.03	30	218.40		
40	239.52	42	236.28	2	247.47 ± 0.24	23	217.92	28	220.63		
38	241.62	40	237.56			21	231.59	26	225.71		
36	254.16	38	237.93			20	223.88	24	237.73		
34	268.14	36	246.76			19	220.12	22	242.39		
32	276.75	34	254.29			17	240.33	20	252.25		
30	277.43	32	269.51			15	266.06	18	262.96		
28	272.64	30	274.17			13	263.96	16	267.10		
26	264.57	28	270.91			10	261.98	14	268.53		
24	253.01	26	256.95			5	256.27	12	268.27		
20	252.26	24	252.46			2	256.52	10	266.70		
15	251.63	20	251.95					8	266.43		
10	251.66	15	250.67					6	265.62		
5	251.73	10	250.94					4	264.22		
2	251.74	5	250.69					2	264.82		
		2	251.41								

4.15 Particle profiles.

**S Jones, C Jago, R Delahunty – School of Ocean Sciences,
Univeristy of Wales, Bangor.**

Objectives.

- 1) To measure in situ particle size distributions and size fractionated volume concentrations over tidal cycles at sites in the Celtic Sea encompassing mixed water, the frontal region, mid shelf and shelf edge. This is the first time that particle size has been measured at this vertical resolution over such a range of sites.
- 2) To measure suspended particle mass concentrations, organic carbon content and size distribution on water samples from surface, thermocline and near bed regions at these sites.
- 3) To interpret observed variations in particle size in terms of physical and biological processes including turbulence, tidal resuspension and advection, primary production and biologically mediated aggregation.

Instrumentation.

- 1) A LISST 100C laser diffraction in situ particle size analyser was mounted onto the base frame of the CTD. This is battery operated and logs autonomously with a recording capacity of 26,000 scans. Each scan represents an average of 3 samples at one second intervals and comprises light intensity received at 32 concentric ring detectors and a light transmission reading. Depth and temperature are also logged, although the temperature sensor was found to have a slow response time resulting in strong differences between down and up casts. The optical data are subsequently inverted to obtain volume concentrations of particles over 32 size classes from 2.5 – 500 microns.
- 2) A Galai Cis 100 laser analyser/videomicroscope was used to measure size distribution of discrete samples, for inter-comparison with the LISST and to allow direct visualisation of the particles. Samples were initially obtained from standard CTD water bottles: later on a smaller bottle was used and samples were extracted using a specially designed sleeve sampler to minimise physical disturbance of the particles. Video recordings of selected samples were also made.
- 3) Water samples were collected (2-10 litres) and filtered through washed, dried, ashed and pre-weighed GFF filters for gravimetric determination of particle mass concentration and organic carbon content.

Cruise diary.

25 July.

Performed background scattering calibration on LISST 100C using shipboard MilliQ supply. This was essential as low concentrations were expected, especially out on the shelf edge. Lower background values than the factory calibration coefficients were in fact obtained, so these were used for subsequent data processing.

26 July

Changed battery of LISST 100C (connectors were found to be reversed in the new battery packs and had to be resoldered) and mounted it on the CTD frame. Background scattering calibration was repeated with the new battery as a check.

28 July

At CS2. First LISST profile obtained on cast C003. Data processed and examined.

29/30 July.

25 hour tidal cycle station at CS2.

LISST profiles obtained for casts C004 – C030.

17 water samples obtained for gravimetric analysis at surface, thermocline (including chlorophyll maximum) and near bed

LISST profile obtained for cast C031.

LISST data processed and examined.

31 July/01 August

25 hour tidal cycle station at CS1.

LISST profiles obtained for casts C032 – C051

23 water samples obtained for gravimetric analysis at surface, thermocline (including chlorophyll maximum) and near bed.

22 samples obtained for analysis of particle size distribution using Galai Cis 100 (using standard water bottle samples).

LISST data processed and examined.

LISST profiles obtained for casts C052, C053, C054 (CS3b, CS3c, IS1a)

02/03 August

25 hour tidal cycle station at IS1.

LISST profiles obtained for casts C055– C059, C064–C080. (Logging program failed to start for casts C060–C063).

33 water samples obtained for gravimetric analysis at surface, thermocline (including chlorophyll maximum) and near bed.

18 samples obtained for analysis of particle size distribution using Galai Cis 100 (using special sampler to minimise sample disturbance).

LISST data processed and examined.

03 August.

LISST profiles obtained for **cross-frontal survey** Sites X1/IS1 – X11 (Casts C080–C083). 7 samples obtained for analysis of particle size distribution using Galai Cis 100 (using special sampler to minimise sample disturbance).

04 August.

LISST profiles obtained for **along front survey** sites Y1–Y5 (Casts C091–C095).

Changed LISST battery. Redid background scattering calibration with MilliQ water. Mounted LISST on CTD frame.

05/06 August.

First 25 hour tidal cycle station at CS3c.

LISST profiles obtained for casts C097– C112.

30 water samples obtained for gravimetric analysis at surface, thermocline (including chlorophyll maximum) and near bed.

15 samples obtained for analysis of particle size distribution using Galai Cis 100 (using special sampler to minimise sample disturbance).

LISST data processed and examined.

Some Galai data processed.

LISST profiles obtained at U2 (Casts C123, C124).

07-09 August.

Developed procedures and strategies for processing, despiking and visualising LISST data.

10/11 August

Second 25 hour tidal cycle station at CS3c.

LISST profiles obtained for casts C134– C159.

37 water samples obtained for gravimetric analysis at surface, thermocline (including chlorophyll maximum) and near bed.

19 samples obtained for analysis of particle size distribution using Galai Cis 100 (using special sampler to minimise sample disturbance).

Experiment with Mike Lucas to investigate whether incubated phytoplankton samples aggregated under dark conditions: 2.0litre samples collected from chlorophyll maximum at dawn (Cast C135) were incubated under dark and light conditions for ~ 12 hours. These were then analysed using the Galai Cis 100. A further sample collected at dusk (C153) was left in the dark overnight in the cold room and analysed the following morning.

11/12 August.

CTD survey from CS3 to the shelf edge.

LISST profiles obtained at sites D1, D2, D3, D4, CS1, CS1b, A3, A6,A9, A13, and CS2 (Casts C160 – C171).

LISST data also obtained at chlorophyll maximum over 105 minutes (Cast C172)

Preliminary results.

Initial examination of the in situ particle size data has indicated significant variability in suspended particle size, with variation occurring vertically, over tidal and spring/neap cycles and between sites. Considerable further analysis and integration with physical and biological observations is required before a full interpretation can be made. For example some interesting differences were identified in size distribution in the surface mixed layer at the different sites which may reflect differences in phytoplankton species distribution.

At the mixed site IS1 a combination of resuspension and advection of suspended particles was observed, with both concentrations and particle size generally increasing towards the bed and varying at semi-diurnal and quarter diurnal frequency.

There was a distinct layer of large particles (ranging from 80 – 500 micron) situated within the thermocline at all of the stratified sites, producing a maximum in mean particle diameter (e.g at sites CS1 and CS3c, Figure 1). The maximum was most pronounced at the mid shelf and frontal sites. This did not necessarily correspond with the chlorophyll maximum, and may comprise aggregated detritus and zooplankton (although there was no clear reason why zooplankton should concentrate at the levels indicated by the size maximum).

Fine particle concentrations (less than 80 microns) were at their highest in the surface mixed layer (SML) at the shelf edge site CS2. At CS3 there were also elevated concentrations of fine particles (this time predominantly less than 10 microns) in the SML (Figures 2 & 3) with a pronounced minimum in this fraction at the base of the thermocline. This corresponded to a maximum in transmission recorded by the CTD transmissometer, which would be expected as the transmissometer is most sensitive to particles finer than ~ 80 microns and so increases as their concentration reduces. At this site there was a further increase in concentration of all size classes in the near bed region, with significantly higher concentrations near the bed on the second time series (Figure 3), but higher concentrations of particles finer than 80 microns in midwater beneath the thermocline on the first time series (Figure 2). There may have been settlement of this material into the bottom layer over the neap tide period between the two series. At the mid shelf site CS1 concentrations were generally lower and there was no minimum in fine particle concentration at the thermocline (Figure 4): concentrations gradually increased from the SML towards the bed. Further, elevated concentrations of larger particles (80-250 microns) appeared in the bottom mixed layer (BML) at times corresponding

to mixing of phytoplankton into the BML from the chlorophyll maximum. This suggests that there was some connection between the BML water and the thermocline region during this time, preventing formation of a fine particle minimum and entraining some of the large aggregates into the BML. This process also appears to have been initiating at CS3c on the second visit, with higher concentrations of 80-250 micron particles appearing beneath the main thermocline layer (Figures 1 and 3) just after noon and midnight.

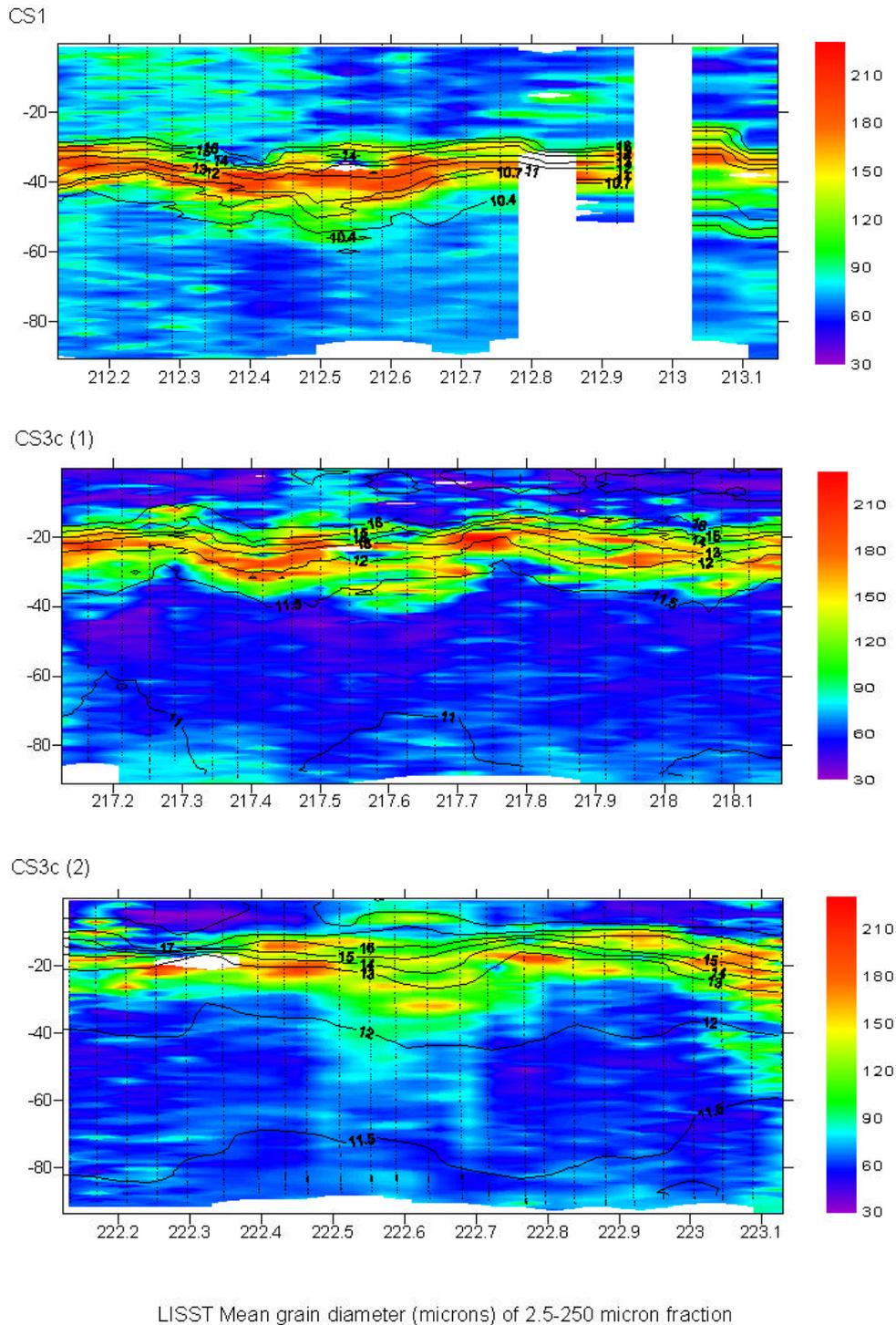
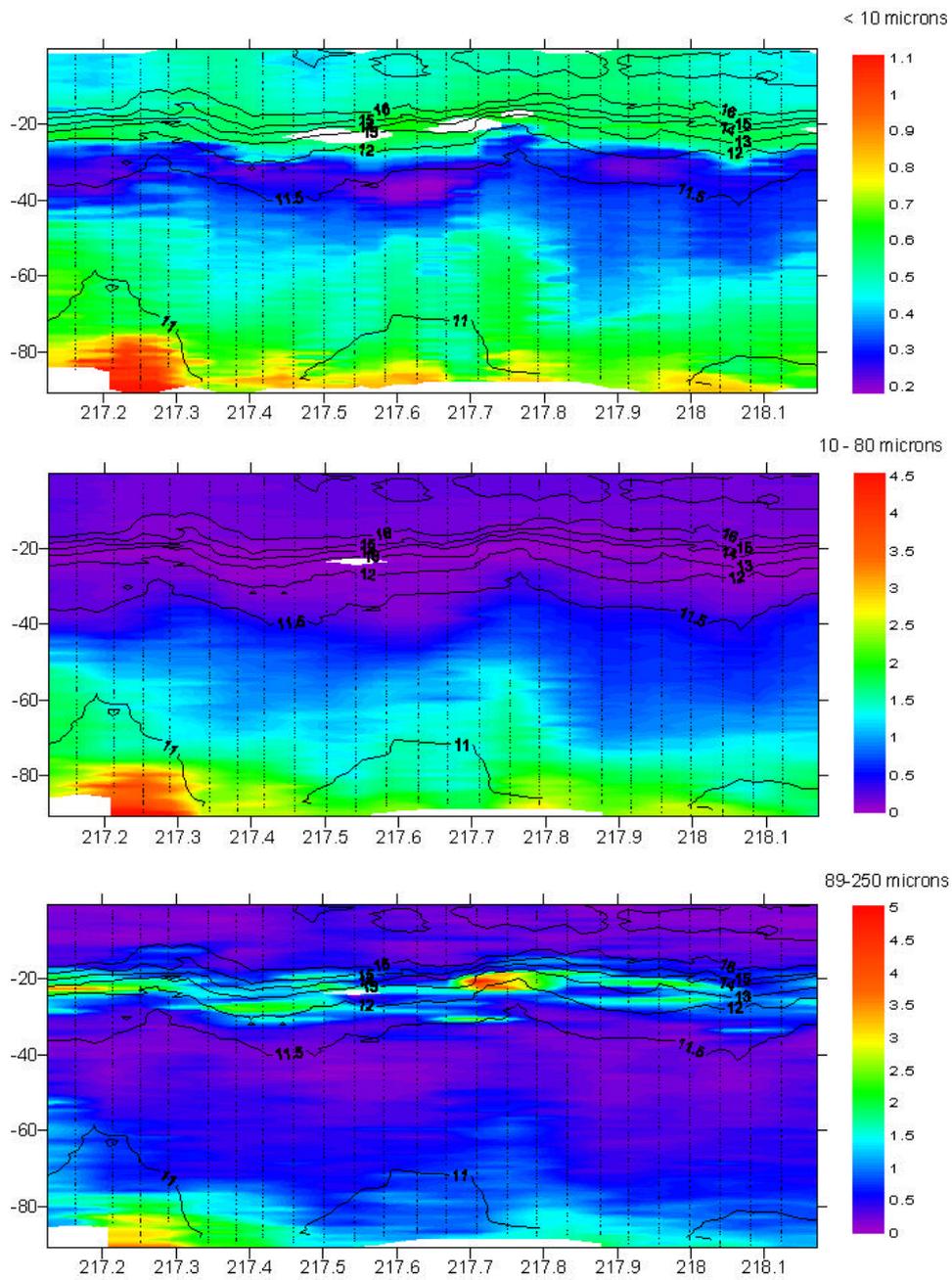
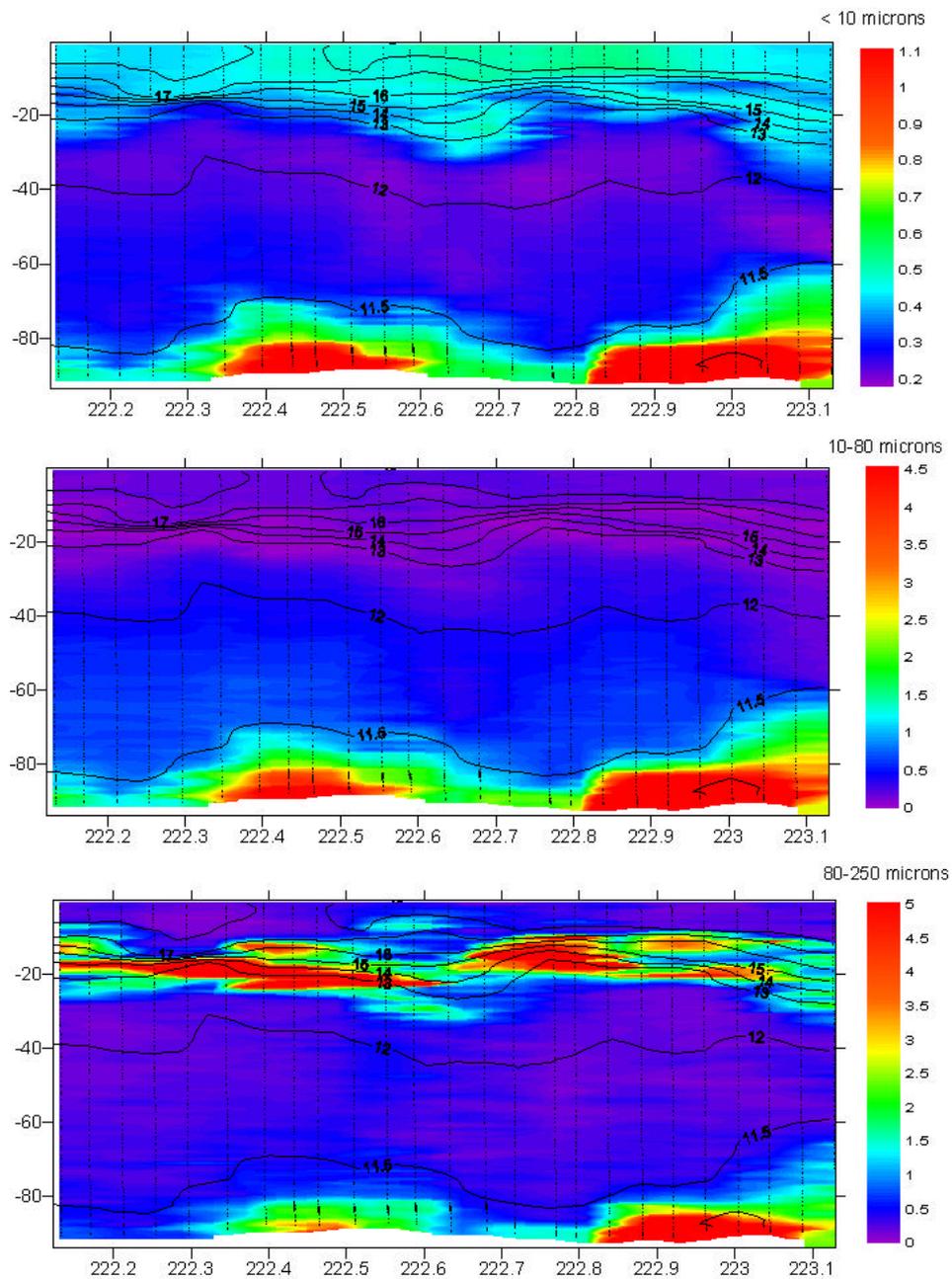


Figure 1. Variation in mean particle diameter at sites CS1, CS3c (first visit) and CS3c (second visit).



CS3c Time series 1
 LISST volume concentrations ppm

Figure 2. Volume concentrations of 3 size fractions at CS3c (first visit).



CS3c Time series 2
 (NB contour levels restricted to same as TS1)
 LISST volume concentration data ppm

Figure 3. Volume concentrations of 3 size fractions at CS3c (second visit).

4.16 Water column optics.

Gavin Tilstone – Plymouth Marine Laboratory.

Date: July 26th 2003.

Summary:

Bio-optics – inherent and apparent optical property of the water column.
Shakedown test station – Eddystone.
CTD 001, Optics cast 001.
Lat – 50 02.01
Long – 04 22.40
Optics rig deployed to 40 m
Backscatter meter deployed to 40 m.

Comments:

Optics001: Optics logger failed. No backscatter data recorded.
Sea Colour – Blue / green
Visibility – 10 km
Cloud Cover – 80% cumulus; clear on western horizon.
Sea state – slight 0.5 to 1.25 m

Date: July 28th 2003.

Summary:

Bio-optics – inherent and apparent optical property of the water column.
Station – CS2.
CTD 003, Optics cast 002.
Lat – 48 31.09
Long – 09 27.43
Time – 14:07 GMT
Optics rig deployed to 60 m
Backscatter meter deployed to 60 m.
Deck cell air spectral irradiance.
Discrete samples taken at 2, 30 & 60 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

Comments:

Optics 002: Optics logger failed. CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Blue
Visibility – 10 - 20 km
Cloud Cover – Totally overcast.
Sea state – moderate 1.25 to 2.50 m.

Date: July 29th 2003.

Summary:

Bio-optics – inherent and apparent optical property of the water column.
Station – CS2.
CTD 008, Optics cast 003.

Lat – 48 32.29
Long – 09 27.35
Time – 7:35 GMT
Optics rig deployed to 50 m
Backscatter meter deployed to 50 m.
Deck cell - air spectral irradiance.
Air spectral irradiance also logged from 8:15 to 11:45 GMT.

Bio-optics – inherent and apparent optical property of the water column.
Station – CS2.
CTD 010, Optics cast 004.
Lat – 48 32.27
Long – 09 27.84
Time – 12:00 GMT
Optics rig deployed to 50 m
Backscatter meter deployed to 50 m.
Deck cell - air spectral irradiance.
Discrete samples taken at 2, 20 & 50 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

Comments:

Optic 003: Optics, CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Blue
Visibility – 200 - 500 m
Cloud Cover – Totally overcast.
Sea state – moderate 1.25 to 2.50 m

Optics 004: Optics logger failed.
CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Blue
Visibility – 200 - 500 m
Cloud Cover – Totally overcast.
Sea state – moderate 1.25 to 2.50 m

Date: July 31st 2003.

Summary:

Bio-optics – inherent and apparent optical property of the water column.
Station – CS1.
CTD 034, Optics cast 006.
Lat – 50 52.12
Long – 08 20.619
Time – 05:42 GMT
Optics rig deployed to 50 m
Backscatter meter deployed to 50 m.
Deck cell - air spectral irradiance.

Bio-optics – inherent and apparent optical property of the water column.
Station – CS1.
CTD 038, Optics cast 007.
Lat – 50 52.12
Long – 08 20.62

Time – 09:18 GMT
Optics rig deployed to 50 m
Backscatter meter deployed to 50 m.
Deck cell - air spectral irradiance.

Bio-optics – inherent and apparent optical property of the water column.
Station – CS1.
CTD 041, Optics cast 008.
Lat – 50 52.12
Long – 08 20.62
Time – 11:22 GMT
Optics rig deployed to 60 m
Backscatter meter deployed to 60 m.
Deck cell - air spectral irradiance.
Discrete samples taken at 2, 40 & 60 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

Bio-optics – inherent and apparent optical property of the water column.
Station – CS1.
CTD 044, Optics cast 009.
Lat – 50 52.12
Long – 08 20.62
Time – 15:33 GMT
Optics rig deployed to 60 m
Backscatter meter deployed to 60 m.
Deck cell - air spectral irradiance.

Comments:

Optics 006: Optics, CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Blue
Visibility – 500 - 1000 m
Cloud Cover – Totally overcast.
Sea state – moderate 1.25 to 2.50 m

Optics 007: Optics, CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Blue
Visibility – 4 - 10 km
Cloud Cover – Totally overcast.
Sea state – Rough 4 to 6 m

Optics 008: Optics, CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Blue
Visibility – 2 - 4 km
Cloud Cover – Totally overcast.
Sea state – Rough 6 to 9 m

Optics 009: Optics, CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Blue
Visibility – 1 - 2 km
Cloud Cover – Totally overcast.
Sea state – Rough 4 to 6 m

Date: August 1st 2003.

Summary:

Bio-optics – inherent and apparent optical property of the water column.
Station – CS3.
CTD 053, Optics cast 010.
Lat – 51 32.19
Long – 06 26.13
Time – 12:23 GMT
Optics rig deployed to 50 m
Backscatter meter deployed to 50 m.
Deck cell - air spectral irradiance.
Discrete samples taken at 2, 20 & 40 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

Comments:

Optics 010: Optics, CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Blue / green
Visibility – 20 - 50 km
Cloud Cover – Clear skies.
Sea state – moderate 1.25 to 2.50 m
MERIS overpass 11:00 GMT – 'MATCH UP'

Date: August 2nd 2003.

Summary:

Bio-optics – inherent and apparent optical property of the water column.
Station – IS1.
CTD 058, Optics cast 011.
Lat – 50 52.12
Long – 08 20.619
Time – 05:42 GMT
Optics rig deployed to 50 m
Backscatter meter deployed to 50 m.
Deck cell - air spectral irradiance.

Bio-optics – inherent and apparent optical property of the water column.
Station – IS1.
CTD 059, Optics cast 012.
Lat – 52 34.01
Long – 5 28.02
Time – 07:22 GMT
Optics rig deployed to 50 m
Backscatter meter deployed to 50 m.
Deck cell - air spectral irradiance.

Bio-optics – inherent and apparent optical property of the water column.
Station – IS1.
CTD 061, Optics cast 013.
Lat – 52 38.01
Long – 5 28.02
Time – 09:19 GMT

Optics rig deployed to 50 m
Backscatter meter deployed to 50 m.
Deck cell - air spectral irradiance.

Bio-optics – inherent and apparent optical property of the water column.
Station – IS1.

CTD 064, Optics cast 014.

Lat – 52 34.07

Long – 5 27.96

Time – 11:28 GMT

Optics rig deployed to 60 m

Backscatter meter deployed to 60 m.

Deck cell - air spectral irradiance.

Discrete samples taken at 2, 20 & 40 m for determination of:

HPLC pigments

Phytoplankton absorption coefficient

Absorption spectra of Coloured Dissolved organic material

Total suspended particulate material.

Bio-optics – inherent and apparent optical property of the water column.

Station – IS1.

CTD 067, Optics cast 015.

Lat – 52 38.01

Long – 5 28.02

Time – 15:22 GMT

Optics rig deployed to 50 m

Backscatter meter deployed to 50 m.

Deck cell - air spectral irradiance.

Comments:

Optics 011: Optics, CTD, ac9, vsf, Bb6 logged OK.

Sea Colour – Green

Visibility – 10 - 20 m

Cloud Cover – Totally overcast.

Sea state – calm 0.1 to 0.5 m

Optics 012: Optics, CTD, ac9, vsf, Bb6 logged OK.

Sea Colour – Green

Visibility – 20 - 50 km

Cloud Cover – Mostly overcast, but sun partially visible.

Sea state – Rough 0.1 to 0.5 m

Optics 013: Optics, CTD, ac9, vsf, Bb6 logged OK.

Sea Colour – Green

Visibility – 10 - 20 km

Cloud Cover – Thin cirrus, sun visible.

Sea state – Moderate 0.5 to 1.25 m

Optics 014: Optics, CTD, ac9, vsf, Bb6 logged OK.

Sea Colour – Green

Visibility – 10 - 20 km

Cloud Cover – Thin cirrus, sun visible.

Sea state – Moderate 0.5 to 1.25 m

Optics 015: Optics, CTD, ac9, vsf, Bb6 logged OK.

Sea Colour – Green
Visibility – 10 - 20 km
Cloud Cover – Thin cirrus, sun visible.
Sea state – Moderate 0.5 to 1.25 m

Date: August 3rd 2003.

Summary:

Station – X6.
CTD 085, Optics cast 016.
Lat – 51 51.25
Long – 6 23.86
Time – 11:09 GMT
Optics rig deployed to 60 m
Backscatter meter deployed to 60 m.
Deck cell - air spectral irradiance.
Discrete samples taken at 2, 15 & 50 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

Comments:

Optics 016: Optics, CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Green
Visibility – 20 - 50 km
Cloud Cover – Patchy thin Cirrus, sun visible overhead.
Sea state – moderate 0.1 m
MERIS overpass 11:39 GMT – POSSIBLE 'MATCH UP'

Date: August 4th 2003.

Summary:

Station – ??.
CTD 096, Optics cast 017.
Lat – 52 06.76
Long – 05 51.97
Time – 10:06 GMT
Optics rig deployed to 70 m
Backscatter meter deployed to 70 m.
Deck cell - air spectral irradiance.
Discrete samples taken at 2, 20 & 50 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

Comments:

Optics 017: Optics, CTD, ac9, vsf, Bb6 logged OK.
Sea Colour – Green
Visibility – 10 - 20 km
Cloud Cover – Patchy thin Cirrus, sun visible overhead.
Sea state – moderate 0.1 m
MERIS overpass 11:08 GMT – POSSIBLE 'MATCH UP'

Date: August 5th 2003.

Summary:

Station – CS3.

CTD 099, Optics cast 018.

Lat – 51 28.16

Long – 6 25.42

Time – 05:28 GMT

Optics rig deployed to 70 m

Backscatter meter deployed to 70 m.

Deck cell - air spectral irradiance.

Station – CS3.

CTD 103, Optics cast 019.

Lat – 51 28.16

Long – 6 25.42

Time – 08:50 GMT

Backscatter meter deployed to 70 m.

Deck cell - air spectral irradiance.

Station – CS3.

CTD 105, Optics cast 020.

Lat – 51 28.16

Long – 6 25.42

Time – 10:17 GMT

Optics rig deployed to 70 m

Backscatter meter deployed to 70 m.

Deck cell - air spectral irradiance.

Discrete samples taken at 2, 22 & 40 m for determination of:

HPLC pigments

Phytoplankton absorption coefficient

Absorption spectra of Coloured Dissolved organic material

Total suspended particulate material.

Station – CS3.

CTD 108, Optics cast 021.

Lat – 51 28.16

Long – 6 25.42

Time – 14:30 GMT

Backscatter meter deployed to 70 m.

Deck cell - air spectral irradiance.

Station – CS3.

CTD 112, Optics cast 022.

Lat – 51 28.16

Long – 6 25.42

Time – 17:16 GMT

Backscatter meter deployed to 75 m.

Deck cell - air spectral irradiance.

Comments:

Optics 018: Optics, CTD, ac9, vsf, Bb6 logged OK.

Sea Colour – Green

Visibility – 4 - 10 m

Cloud Cover – Thin cirrus, sun visible.
Sea state – moderate 1.25 to 2.5 m

Optics 019: ac9 failed – optics rig not deployed,
Bb6 logged OK.
Sea Colour – Green
Visibility – 20 - 50 km
Cloud Cover – Mostly overcast, but sun partially visible.
Sea state – Rough 0.1 to 0.5 m

Optics 020: AC9 failed.
Optics, CTD, vsf, Bb6 logged OK.
Sea Colour – Blue / Green
Visibility – 4 - 10 km
Cloud Cover – Scattered clouds but area clear overhead.
Sea state – Moderate 0.5 to 1.25 m
MERIS overpass at 10:38 GMT – POSSIBLE 'MATCH UP'

Optics 021: ac9 failed trying to fix it. Optics rig not deployed.
Bb6 logged OK.
Sea Colour – Green
Visibility – 1 - 2 km
Cloud Cover – Thin cirrus, sun visible.
Sea state – Smooth wavelet 0.1 to 0.5 m

Optics 022: ac9 failed trying to fix it. Optics rig not deployed.
Bb6 logged OK.
Sea Colour – Green
Visibility – 1 - 2 km
Cloud Cover – Totally overcast.
Sea state – Calm 0.1 m

Date: August 6th 2003.

Summary:

11:00 GMT Used Backscatter meter in underway mode to track coccolithophore bloom; no bloom found.

Station – U2.
CTD 124, Optics cast 023.
Lat – 49 14:00
Long – 06 10.01
Time – 17:02 GMT
Optics rig deployed to 75 m
Backscatter meter deployed to 75 m.
Deck cell - air spectral irradiance.
Discrete samples taken at 2, 26 & 40 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

Comments:

Optics 023: Ac9 failed
Optics, CTD, vsf, Bb6 logged OK.

Sea Colour – Blue
Visibility – 1 - 2 km
Cloud Cover – Totally overcast, thick mist.
Sea state – Smooth wavelt 0.1 to 0.5 m

Date: August 7th 2003.

Summary:

Station – N1.
CTD 125, Optics cast 023.
Lat – 48 38.31
Long – 9 06.69
Time – 13:25 GMT
Backscatter meter deployed to 75 m.
Deck cell - air spectral irradiance.

Discrete samples taken at 2, 26 & 40 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

Coments:

Optics 024: Trying to fix ac9, optics rig not deployed.
Bb6 logged OK.
Sea Colour – Blue
Visibility – 50 - 200 m
Cloud Cover – Totally overcast, thick mist.
Sea state – Calm 0.1 m

Date: August 8th 2003.

Summary:

Station – N9.
CTD 133, Optics cast 024.
Lat – 48 16.99
Long – 10 12.98
Time – 10:17 GMT
Optics rig deployed to 100 m
Backscatter meter deployed to 100 m.
Deck cell - air spectral irradiance.
Discrete samples taken at 2, 27 & 60 m for determination of:
HPLC pigments
Phytoplankton absorption coefficient
Absorption spectra of Coloured Dissolved organic material
Total suspended particulate material.

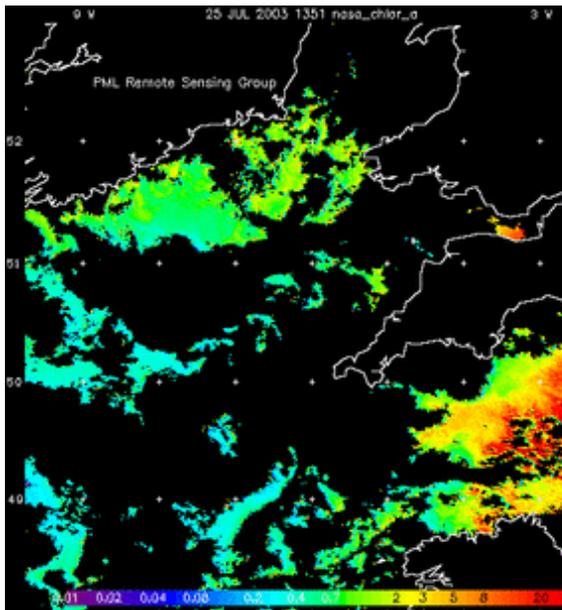
Coments:

Optics 024: ac9 failed.
Optics, CTD, VSF, Bb6 logged OK.
Sea Colour – Blue
Visibility – 1 - 2 km
Cloud Cover – Totally overcast, thick mist.
Sea state – Slight 0.5 to 1.25 m

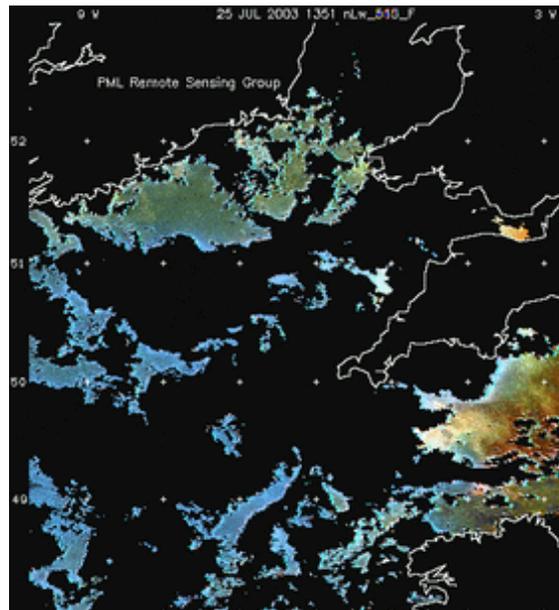
4.17 Satellite imagery. Jonathan Sharples – SOC

Satellite imagery for the Irish and Celtic Seas and the Goban Spur area of the shelf edge were received aboard the ship from the Remote Sensing Group, Plymouth Marine Laboratory. All useable images are shown here. The latter half of the cruise was severely hampered by cloud cover (despite the record-breaking heatwave that the UK was experiencing at the time).

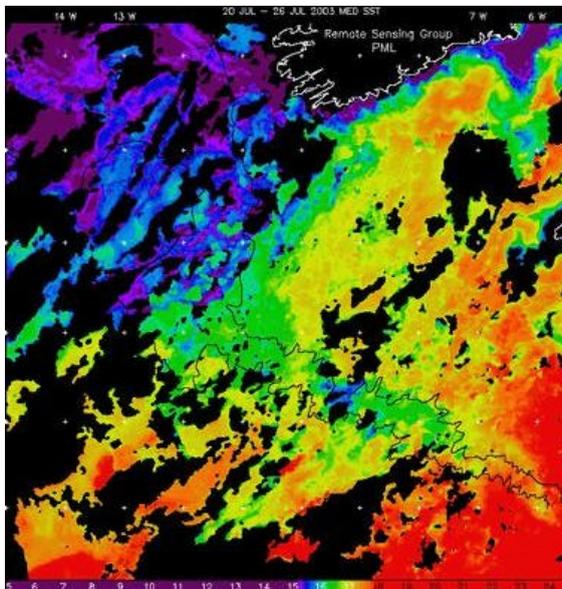
Images received July 27th 2003.



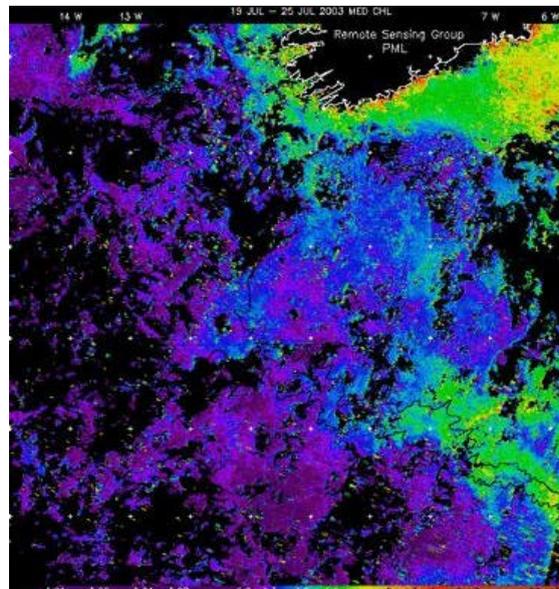
Celtic Sea chl July 25th



Celtic Sea true colour July 25th



Goban Spur SST 20 – 26 July

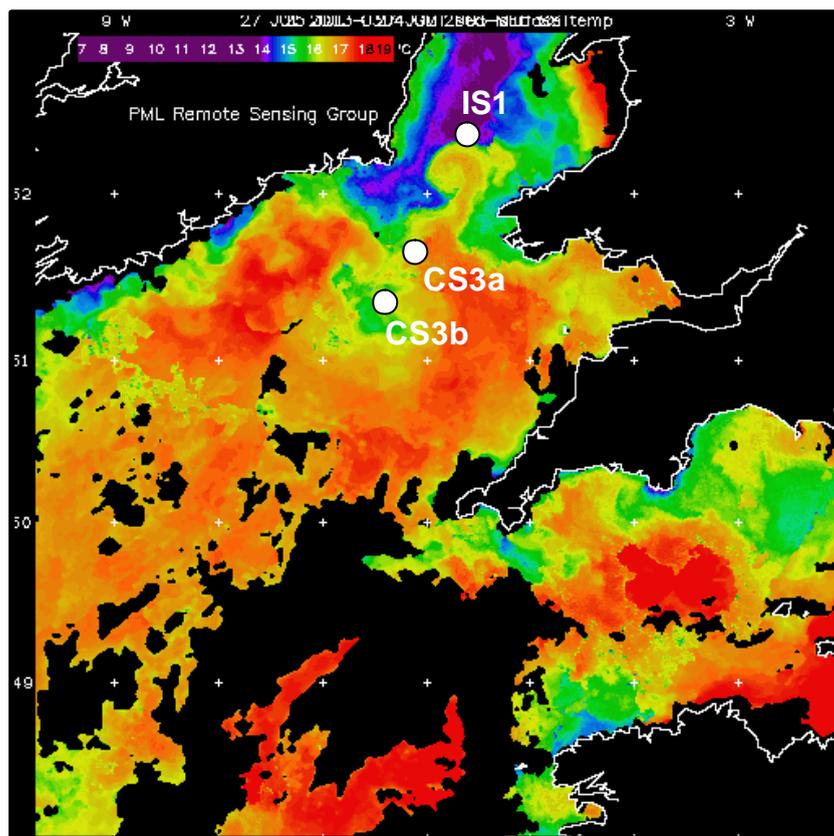


Goban Spur chl 19 – 25 July

Cloud cover was a problem with these images for the study area. However, there is a clear signal in chlorophyll and reflectance (true colour) of the dense *Gyrodinium* bloom in the west of the English Channel.

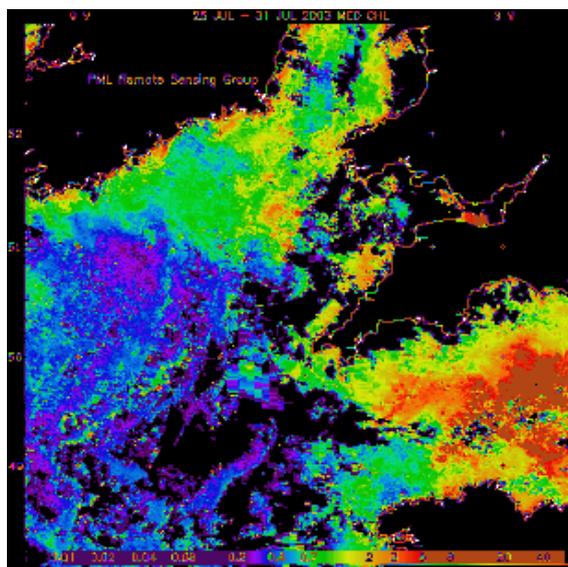
Image received July 28th 2003.

Celtic Sea SST July 27th superimposed on 25th – 27th composite.



The positions of 2 possible CS3 sites (CS3a, b) and the possible mixed site (IS1) are shown in the image. The often-seen tongue of warm water jutting northward from the Celtic Sea front is very clear. There is also evidence of a patch of possibly recently-transported cooler water on the stratified side of the front (CS3b). Based on this image, it was thought that IS1 may not be fully mixed.

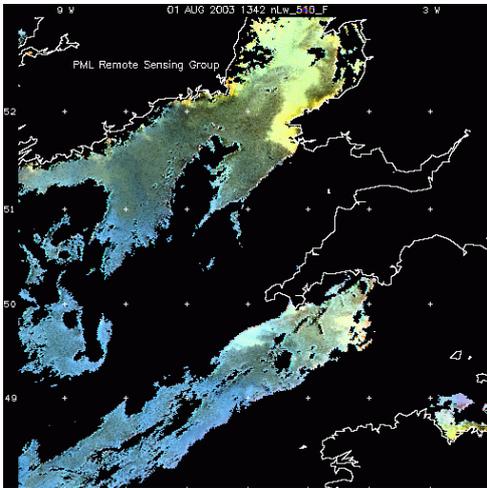
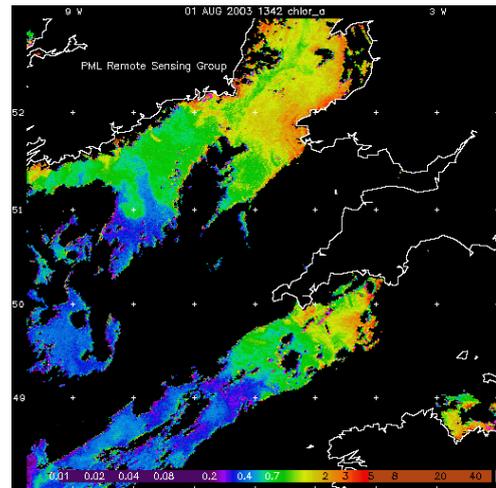
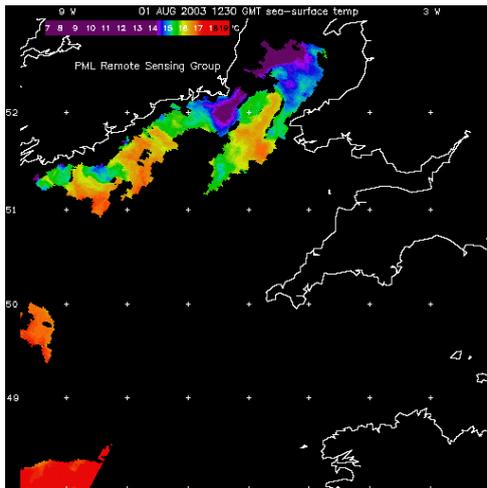
Image received July 31st 2003.



Celtic Sea 7 day composite of chl: 25th – 31st July.

Cloud cover prevented any good snapshots. There is apparently little evidence of higher chlorophyll associated with the Celtic Sea front. The high chlorophyll in the Gyrodinium bloom in the Western Channel is still very clear.

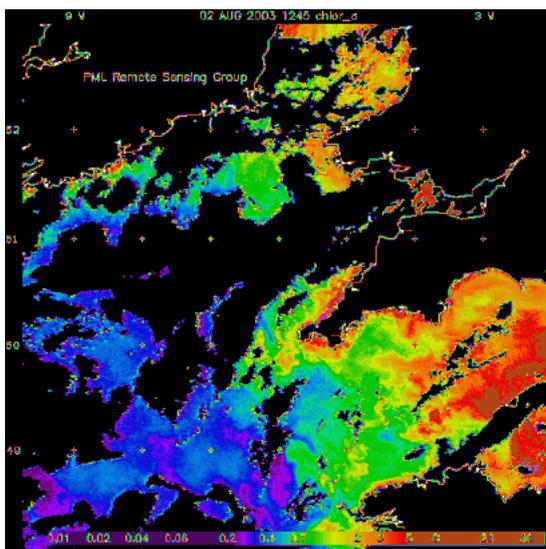
Images received August 1st 2003.



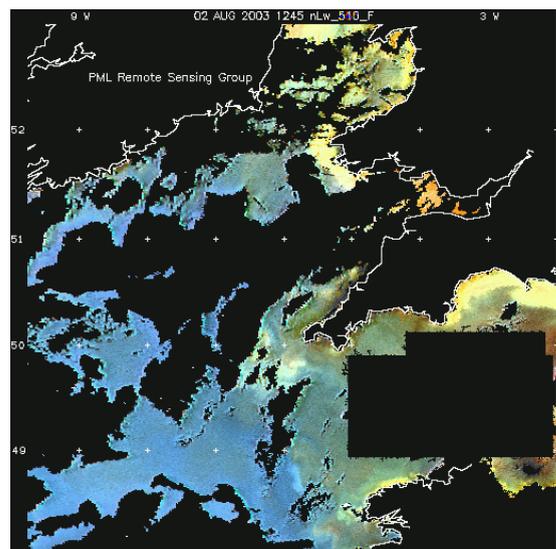
Top left: Sea Surface Temperature
Top right: Sea Surface Chlorophyll
Left: True Colour.

All images are snapshots, August 1st.

Images received August 2nd 2003.

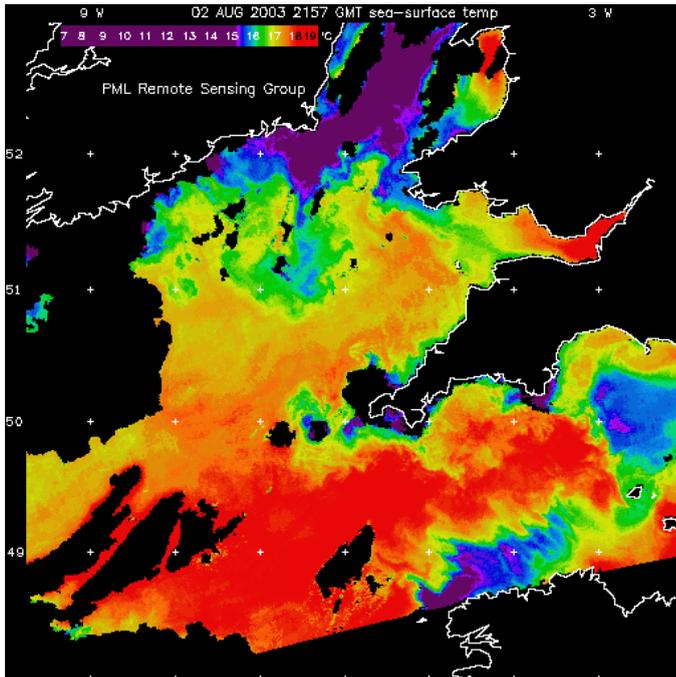


Sea Surface Chlorophyll



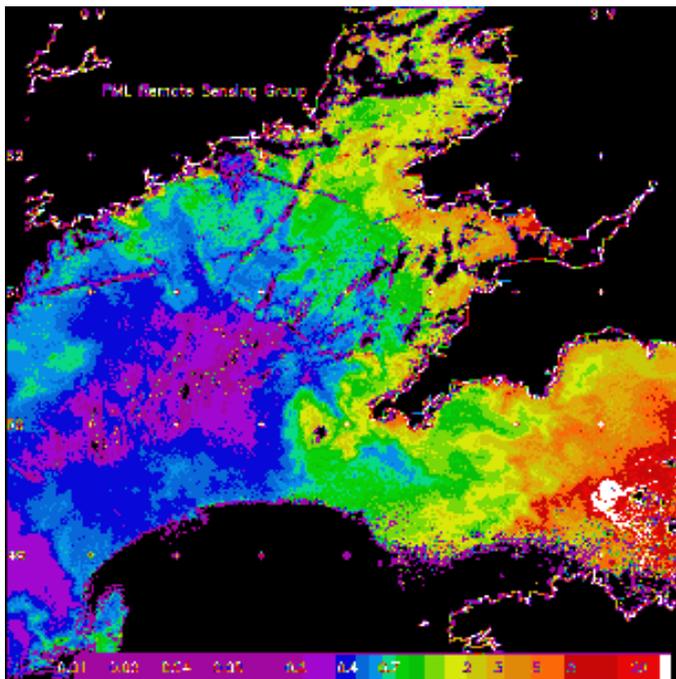
True Colour

Images received August 3rd 2003.



Sea Surface Temperature.

Still evidence of cooler water just south of the Celtic Sea front.

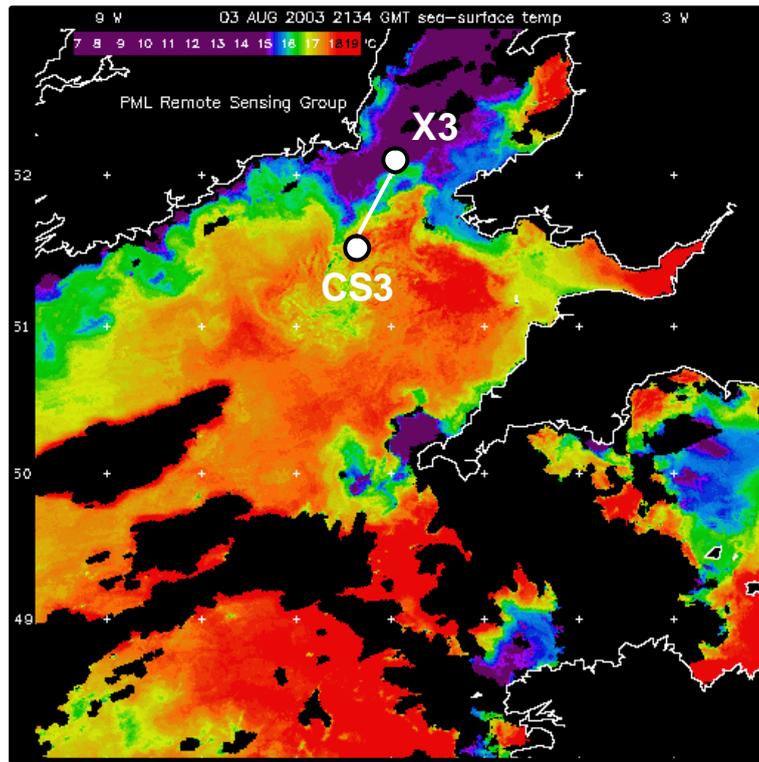


Sea Surface Chlorophyll.

High chlorophyll is seen along the Celtic Sea front, and very high chlorophyll still in the English Channel.

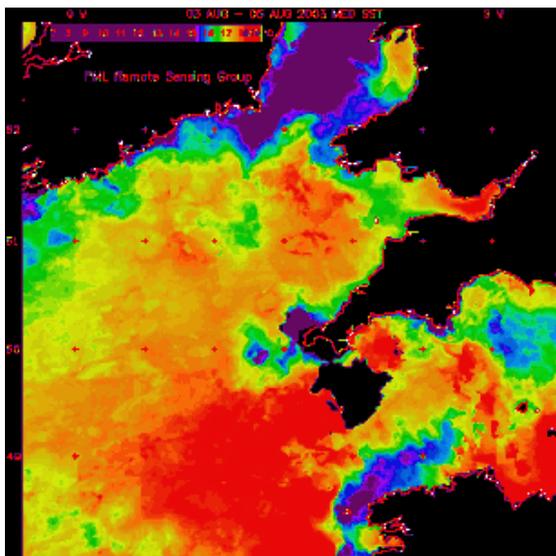
The straight lines are aircraft vapour trails.

Images received August 4th 2003.

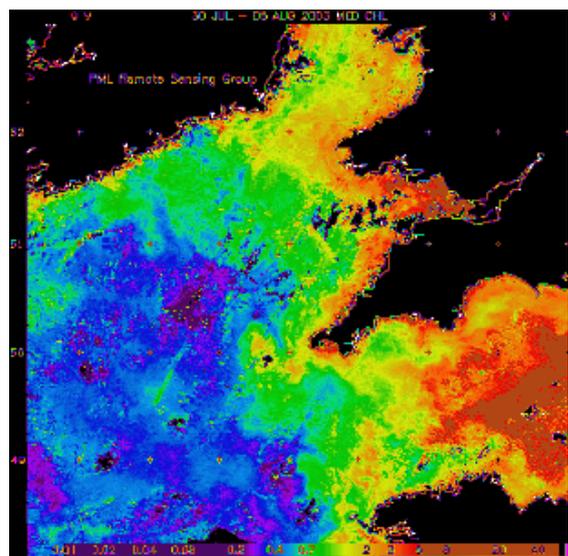


August 3rd SST. The line between X3 and CS3 was used for a Seasoar transect on August 4th. The image was used in determining the line for the cross-front turbulence surveys conducted from the RV *Prince Madog*.

Images received August 6th 2003.

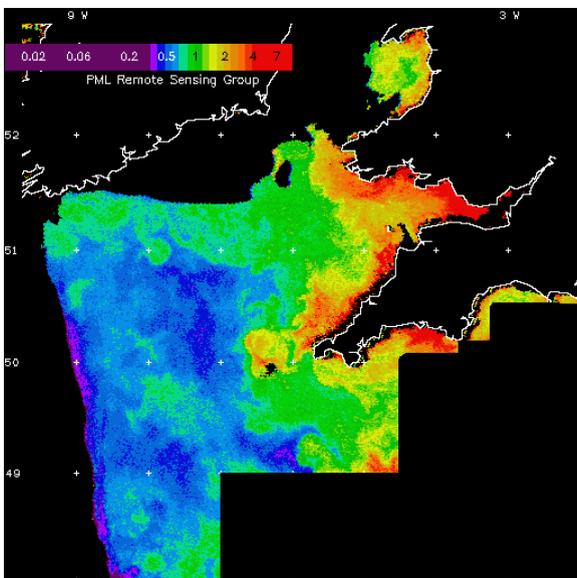


August 3rd - August 5th SST composite.

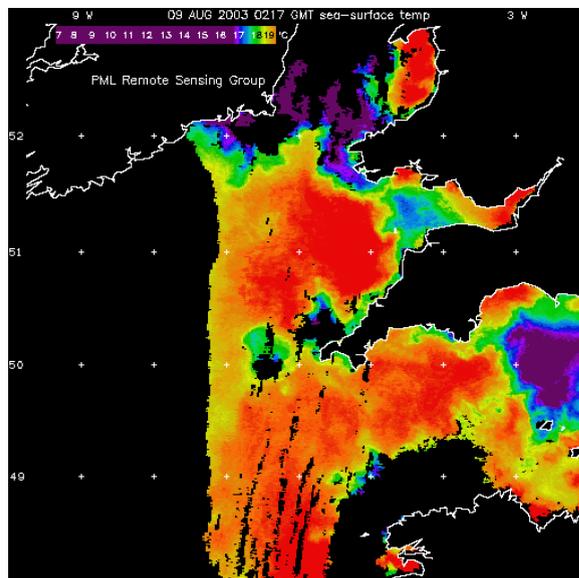


July 30th to August 5th chl composite.

Images received August 8th - 9th 2003.



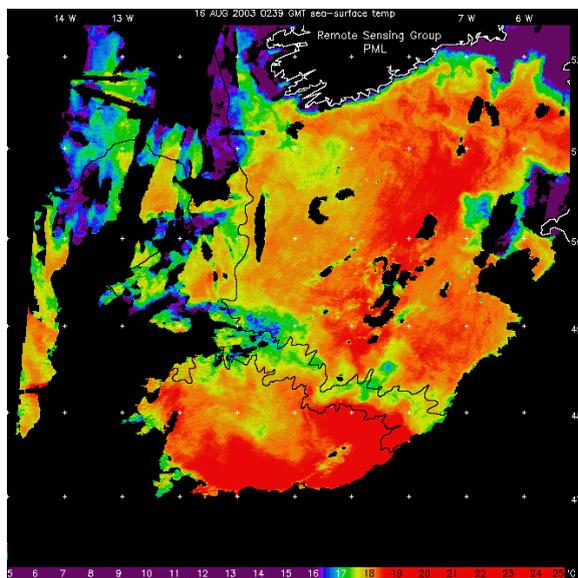
Sea Surface Chlorophyll, August 8th.



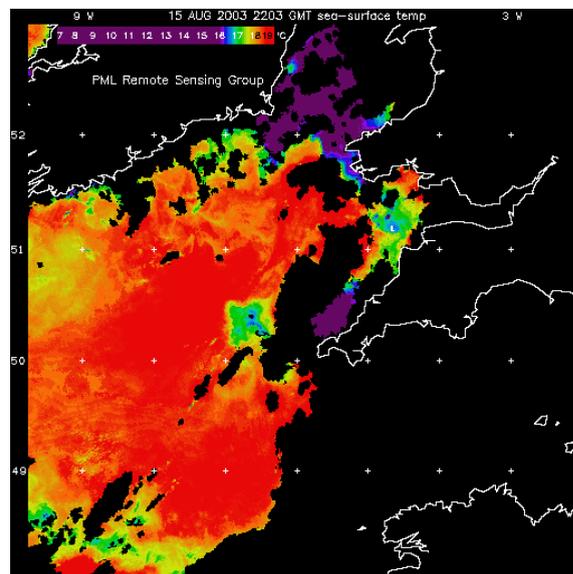
Sea Surface Temperature, August 9th.

Post-cruise images.

The Celtic Sea front and the cooling along the shelf edge is clear in both images.



August 16th Sea Surface Temperature – Goban Spur



August 15th Sea Surface Temperature – Celtic Sea

5. Post-Cruise Assessment Feedback.

The following was provided to the ship, BAS and NERC as part of the post-cruise assessment of JR98.

Success of Scientific Objectives.

Scientific objectives involving CTD operations were largely met, particularly the 25 hour fixed stations conducted alongside the RV *Prince Madog*. Some slip ring problems with the ship's CTD winch caused poor data collection and some data loss on one of the 25 hour stations. The problems were rapidly fixed by the ship's staff. Problems were also experienced with the titanium CTD, leading to a reduction in clean chemistry CTD transects from 3 to 1.

Scientific objectives involving the ship's laboratories were met.

Scientific objectives involving Seasoar were substantially hampered. Only 3 successful Seasoar transects were carried out, from a planned total of approximately 6 transects and 3 box surveys. Some of these problems were the result of a faulty hard drive in the Seasoar Penguin system, but most were caused by Seasoar winch slip rings being in a very poor condition.

Number of lost days.

A total of approximately 1.5 days were lost, mainly associated with efforts to fix and test Seasoar.

Changes suggested.

Safety procedures were very good. Points that need to be considered are:

(i) The handrail leading down into the scientific hold is slightly bent against the bulkhead near the top of the stairs. This makes it difficult to hold the rail, which is a particular issue when carry loads up and down the stairs.

Pre-cruise planning etc.

Due to the rushed nature of our cruise aboard the JCR, caused by the winch refit problems of RRS Discovery, the pre-cruise planning was unavoidably hectic. We did feel that there were communication problems within BAS (i.e. between BAS departments), and also between BAS HQ and the vessel (e.g. information sent to BAS did not always make it through to the ship, and vice versa).

Partially as a result of the late shift to the JCR, and the JCR being in refit, it was often very difficult to get firm dates and details of mobilisation. In particular, the late shift to Portsmouth as the mobilisation port (an understandable result of excessive fees charged by ABP Southampton) did cause some stress in the last days prior to the cruise. Working through the security of Portsmouth Naval Dockyard made things more complicated, but the help of the ship's Purser was much appreciated in organising passes for both the scientific group and other help from the SOC.

Ship's operation, equipment, personnel etc.

The operation of the ship was highly efficient, and proved to be as flexible as we hoped for when conducting work in such a dynamic and changeable oceanographic environment. We have nothing but praise for the professionalism, attitude, and humour of the ship's staff.

The shipboard BAS technical support was good. Being used to the UKORS system from previous cruises, with all technical support being carried out by UKORS staff and liaison through the UKORS TLO, I am sure that we did not utilise the BAS support as much as we

could have done. We now know better for next time! With illness preventing one of the planned UKORS support staff from joining the ship, the BAS technical support helped considerably in taking a turn at looking after the CTD during the intensive 25 hour stations. This was particularly useful as it freed our UKORS support to work on fixing Seasoar. The dedicated Deck Officer and Deck Engineer, again something not experienced before, were excellent and invaluable.

We have some recommendations regarding ship's scientific facilities:

- (i) The ship's ADCP, and the software controlling ADCP operation and data collection, are very outdated. Visualisation of collected data, required in real time during our CTD stations, is inadequate with the present version of the software. The type of data collected is limited compared to later software versions (i.e. no ability to collect raw and averaged data at the same time). The ADCP data quality is not as good as that produced by more recent models. We recommend an immediate upgrade of software and firmware as far as is achievable with the installed instrument, and an upgrade of the ADCP as soon as practically possible.
 - (ii) Much of our work required regular knowledge of changes in surface ocean conditions. The only readout of this data is on a pc in the UIC. Slave readouts in other laboratory space (particularly the main laboratory and/or the wet laboratory) would be extremely useful.
 - (iii) The ship's radioisotope laboratory would benefit from an extracting fume hood (similar to the fume hood in the UKORS radioisotope container laboratory). A drain in the stainless steel worktop is also requested.
 - (iv) With more UKORS equipment likely to be used aboard the JCR in the future, some effort needs to be put into connecting non-BAS equipment into the ship's network. This worked well with the Penguin Seasoar system, but our only method of transferring CTD data was by 1.4MB floppy disks.
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6. Summary and Future Plans.

The primary aims of the cruise were to conduct detailed tidal cycle surveys at positions covering a range of thermocline and mixing environments through the Celtic Sea and to the shelf edge. Our goals here were to investigate the growth rates of phytoplankton within the subsurface chlorophyll maximum, and to assess how these growth rates are controlled by the physical mixing regime (i.e. via the control of nutrient fluxes, light, and the interaction with photo-acclimation). We aimed to employ new methods for quantifying turbulence at these stations (i.e. measurements of Reynolds stresses using moored ADCPs). It was also a requirement to map the detailed structure of the subsurface chlorophyll maximum at high horizontal (approximately 300 – 500 metres) and vertical (approximately 1 metre) resolution, and use these maps to investigate the phytoplankton species community changes over the shelf.

A total of five 25 hour stations were occupied, four of them alongside the RV *Prince Madog*. These five stations ranged from strongly stratified (CS1), intermediate stratification (CS3, once between neap and spring tides, and once between spring and neap), weak stratification (CS2, influenced by the internal tidal mixing at the shelf edge), and fully mixed (IS1). The biochemical experiments carried out aboard the RRS *James Clark Ross* were broadly very successful, with only some minor problems encountered during one station (CS1) caused by a dirty CTD winch slip ring. The largest failure at these stations now appears to have been the CS2 mooring. In addition to the instrumentation lost as a result of fishing activity, neither of the key ADCPs configured for Reynolds stress measurements worked; at the time of writing the reasons for this are not yet known. These failures are a major drawback for the physics component of the project.

Mapping of the cross-shelf thermocline and subsurface chlorophyll structure was hampered significantly by the considerable difficulties experienced with Seasoar. While we knew that taking the Penguin system as our primary Seasoar vehicle was always going to be a risk, it is exasperating that the main problems experienced were simply the result of poor maintenance of the Seasoar winch slip rings.

The transmission of satellite data to the vessel during the cruise was very successful, and very useful (particularly when trying to plan without any reliable Seasoar data). In particular the enhanced Java Browser, provided by PML-RSDAS, was of great benefit when planning mooring positions and the RV *Prince Madog* cross-front turbulence work.

The combined operations with the RV *Prince Madog* went very smoothly, with easy communication via fax, email, and VHF.

As a part of this NERC project, we have another cruise scheduled aboard RRS *Discovery* in summer 2004. This next cruise will be a single-ship experiment, focussed on spring-neap variability at the shelf edge (in the vicinity of CS2), including the role of the canyons in determining the mixing and enhanced productivity apparent in this region.

7. Acknowledgements.

Our thanks go first to the British Antarctic Survey, who were able to provide the RRS *James Clark Ross*, immediately out of annual refit, in response to the problems caused by the winch refit on RRS *Discovery*. Without the availability of the RRS *James Clark Ross*, this work would not have been carried out.

The officers and crew of the RRS *James Clark Ross* were a pleasure to work with; their professionalism, dedication, and great humour were superb.

This cruise was one of the most challenging any of us had experienced with the vast array of different disciplines working together towards the same goals. Organising the logistics of the large amount of equipment involved was a far from easy task, and we have UKORS (Colin Day as Marine Equipment Pool manager, and Jon Short as JR98 Mobilisation Officer) and our own Mark Moore to be very grateful to for all that.

We are also grateful to the Plymouth Marine Laboratory Remote Sensing Data Analysis Service for the efficient provision of satellite imagery to the ship, which was invaluable in the planning of day-to-day operations during the cruise.

Finally a word of thanks and great appreciation to our colleagues working aboard the RV *Prince Madog*. At station CS2 in particular, we all felt very sympathetic as we watched the heavy pitching in seas that had very little effect on the RRS *James Clark Ross* (though, as we said at the time, not sympathetic enough to want to swap ships).



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