National
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National Oceanography Centre

Cruise Report No. 27

RRS *James Cook* Cruise 87

31 MAY - 18 JUN 2013

The Twilight Cruise to the Porcupine Abyssal Plain

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2014

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DOCUMENT DATA SHEET

AUTHOR	*PUBLICATION DATE*
LAMPITT, R S et al	2014

TITLE

RRS *James Cook* Cruise 87, 31 May - 18 Jun 2013. The Twilight Cruise to the Porcupine Abyssal Plain.

REFERENCE

Southampton, UK: National Oceanography Centre, Southampton, 104pp.
(National Oceanography Centre Cruise Report, No. 27)

ABSTRACT

The Twilight Zone is that depth zone in the ocean between 100 and 1000m depth where a tremendous amount of activity takes place. Much of the material containing carbon which sinks out of the upper sunlit or "Euphotic" zone is broken down in the twilight zone and then mixes back up to the surface in the winter. If it manages to sink further, this carbon is lost for periods of centuries.

The main factor that affects this sedimentation process and the rate of destruction of the sinking particles is the structure and function of the biological community living near the sea surface and in the twilight zone beneath. This is because the planktonic plants and animals living there both generate and destroy particles. The Porcupine Abyssal Plain sustained observatory (PAP) is a heavily instrumented area of the open ocean 350 miles southwest of Ireland and in a water depth of 4800m. The instruments measure a wide variety of properties of the environment above the water, within it and on the seabed and much of the data is transmitted in real time to land via satellite.

KEYWORDS

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23	PIPER	CARL	A/Stwd

1 Itinerary

RRS *James Cook* slipped her moorings in the Port of Glasgow at 0815h BST on 31st May 2013. A request to rescue a flooded glider to the north of Ireland meant a detour was carried out on passage to PAP but this successful recovery did set the tone for the rest of the cruise. Downtime due to bad weather or faults of shipboard or overside equipment was minimal and did not affect the outcome of the cruise in any major way.

A location was selected within the OSMOSIS mooring array at PAP for the most intensive sampling in order to provide a very much better physical context than is usually possible. This was certainly the best ever achieved at PAP and possibly anywhere for a cruise which had the primary focus of biology and biogeochemistry. This location, termed "The Twilight Station" was more than 4km from any of the OSMOSIS moorings to ensure there was no entanglement with them.

A feature of the site was that in contrast to previous years, there was a strong and persistent westerly current over the top few hundred meters of the water column. The effect of this was that the PELAGRA drifting sediment traps which were intended to provide a direct measure of downward particle flux at the twilight station rapidly exited the region after every deployment.

Most aspects of the sampling and experimentation during JC087 were highly successful although almost continuous cloud cover removed the possibility of satellite remote sensing data which was to provide the spatial context for our work.

RRS *James Cook* left PAP at 1645h GMT on 14th June 2013, 13 hours earlier than planned due to the possibility of poor weather on the return passage. The ship reached the Port of Glasgow in the early evening of 17th June, the day before that expected.

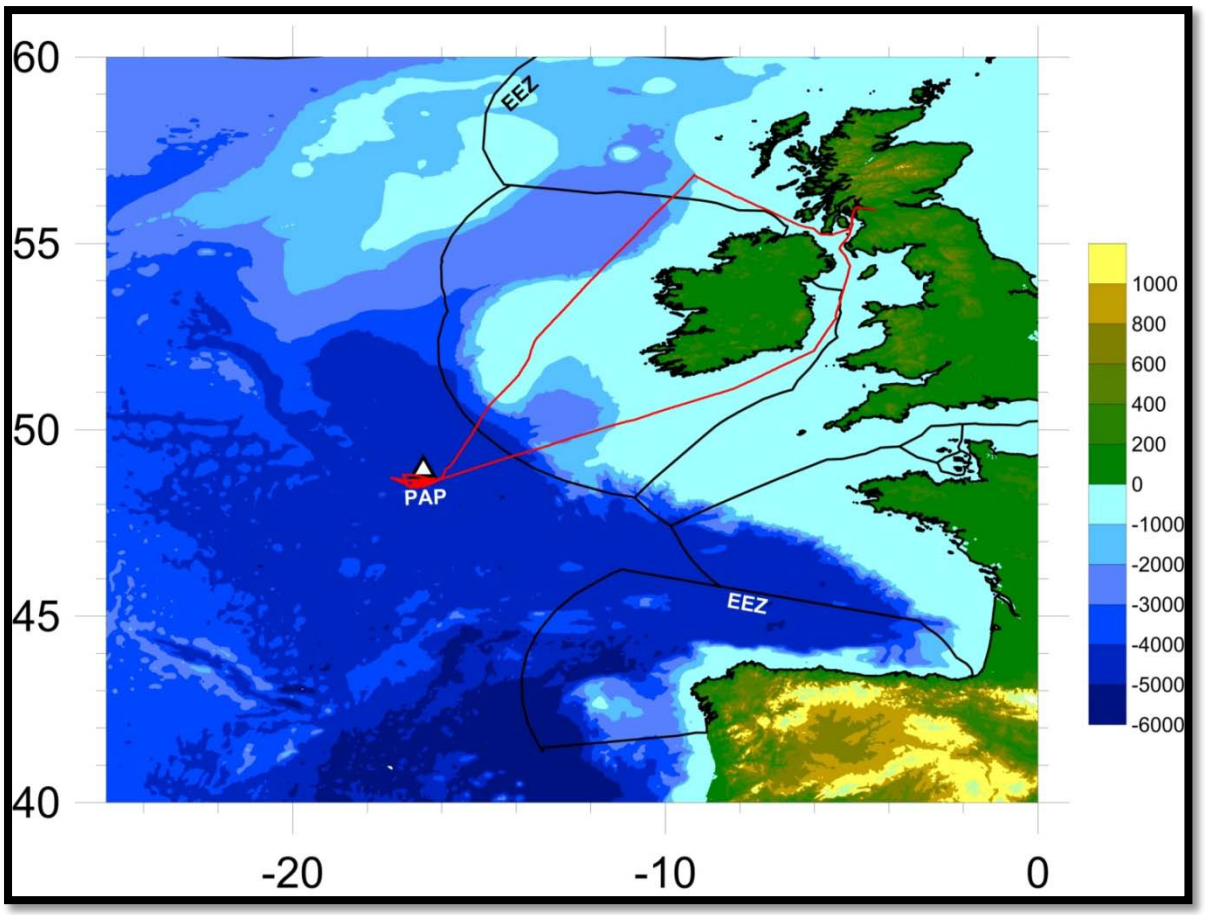


Fig. 1 Cruise Track (red) and Exclusive Economic Zone Boundaries (black).

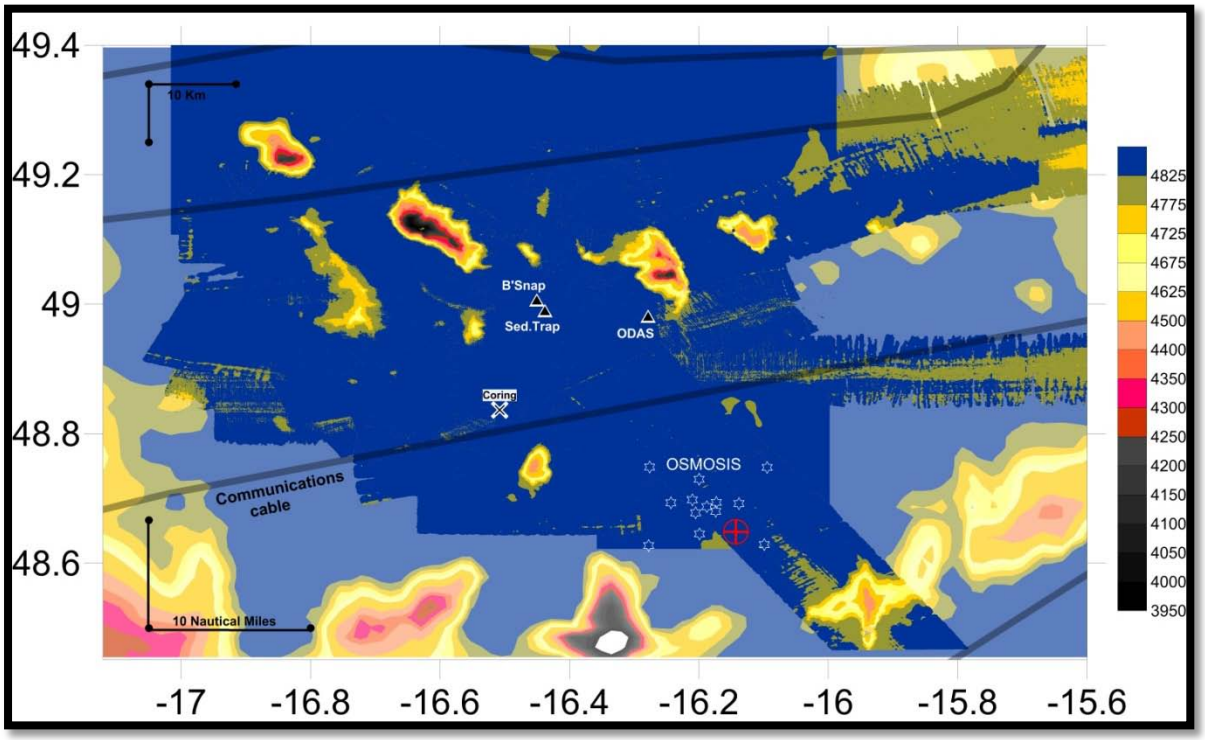


Fig. 2 Key features of the PAP observatory region. The "Twilight station is identified (red)). Pale colours outside central area are areas with no multibeam data and bathymetry is provided by other means.

2 Background & Objectives

The twilight zone is that depth zone in the ocean between 100 and 1000m depth where a tremendous amount of activity takes place. Much of the material containing carbon which sinks out of the upper sunlit or "Euphotic" zone is broken down in the twilight zone and then mixes back up to the surface in the winter. If it manages to sink further, this carbon is lost for periods of centuries.

The main factor that affects this sedimentation process and the rate of destruction of the sinking particles is the structure and function of the biological community living near the sea surface and in the twilight zone beneath. This is because the planktonic plants and animals living there both generate and destroy particles. The Porcupine Abyssal Plain sustained observatory (PAP) is a heavily instrumented area of the open ocean 350 miles southwest of Ireland and in a water depth of 4800m. The instruments measure a wide variety of properties of the environment above the water, within it and on the seabed and much of the data is transmitted in real time to land via satellite.
http://www.eurosites.info/pap/data.php

Although most of these data concern the biology and chemistry of the water column and seabed, for this particular year there is also a major physical oceanography programme at the site. This programme called OSMOSIS aims to examine the processes of mixing in the upper Ocean and employs an array of moorings and two permanent gliders which cruise around them undulating over the top 1000m.

This cruise involves 19 research scientists from 7 European nations bringing together a very wide range of expertise including chemists, biologists, physicists and biogeochemical modellers. Many of these individuals are involved with the EU programme EuroBASIN. EuroBASIN is part of the trans-Atlantic BASIN initiative. This involves scientists from US, Canada and EU who are investigating how climatic and human activity affects the North Atlantic ecosystem.
The objective of the cruise is to use a wide variety of approaches to characterise the biological communities in the Euphotic and Twilight zones using water bottles, nets and video systems. We then characterise the chemical and physical environment and examine the sinking particles and the rate of downward flux of material using water samples, photographic approaches and the free drifting sediment trap PELAGRA.

3 Activity Reports

3.1 Ocean Acidification Experiment

Valeria Ibello

Objective

The aim of the ocean acidification experiment is to evaluate the effect of decrease of pH on nitrifying bacteria in the ocean upper layer.

It has been observed that decrease of pH can strongly inhibit nitrifying bacteria, because in lower pH conditions, the NH_3/NH_4^+ ratio tends to decrease and the substrate for nitrifying bacteria (NH_3) disappears (Huesemann et al. 2002, Beman et al. 2011).

The ultimate objective, therefore, is to understand how changes of nitrate production can impact on primary production during the summer season where stratification limits the uplifting of deep nitrate and the only nitrate available is produced by nitrification processes.

Method

Ocean acidification experiment was carried on 14/06/2013 (ctd # 24). Seawater was collected from one single depth at 40 m corresponding to 1% of PAR, where highest nitrification rates were generally observed.

Samples for dissolved inorganic carbon (DIC) and total alkalinity (TA) were immediately collected in 250 ml Duran Schott glass bottles, poisoned with 50µl of $HgCl_2$ saturated solution, sealed and stored till analysis at home laboratory, accordingly with the procedure recommended by Dickson et al. (2007).

Samples for acidification experiments were immediately added with ^{15}N-NH_4^+ and incubated for 30 minutes to homogenize the sample. 3 samples were manipulated with opportune addition of HCl and $NaHCO_3$ to reach approximately pCO_2 450, 600 and 750 µatm. One sample was not pH altered to be used as control. All bottles were sealed avoiding any air bubble inside. After 24 h incubation at controlled light and temperature, DIC, TA and nitrification rates were sub-sampled. Samples for nitrification rates were stored in 100 ml HDPE Nalgene bottles and immediately frozen till analyses in home laboratory. All samples were collected in triplicates. During all operations, samples were in contact with the atmosphere for very limited time to avoid CO_2 exchange.

Nutrients were sub-samples at the beginning and at the end of the experiment.

In addition, single samples for DIC and TA were collected from the deep cast along all water column (depths: 2, 5, 10, 15, 25, 35, 40, 65, 100, 150, 200, 400, 600, 800, 1000, 1500, 2000, 2250, 2500, 2750, 3000, 3250, 3500, 3750, 4000, 4500, 4800 m).

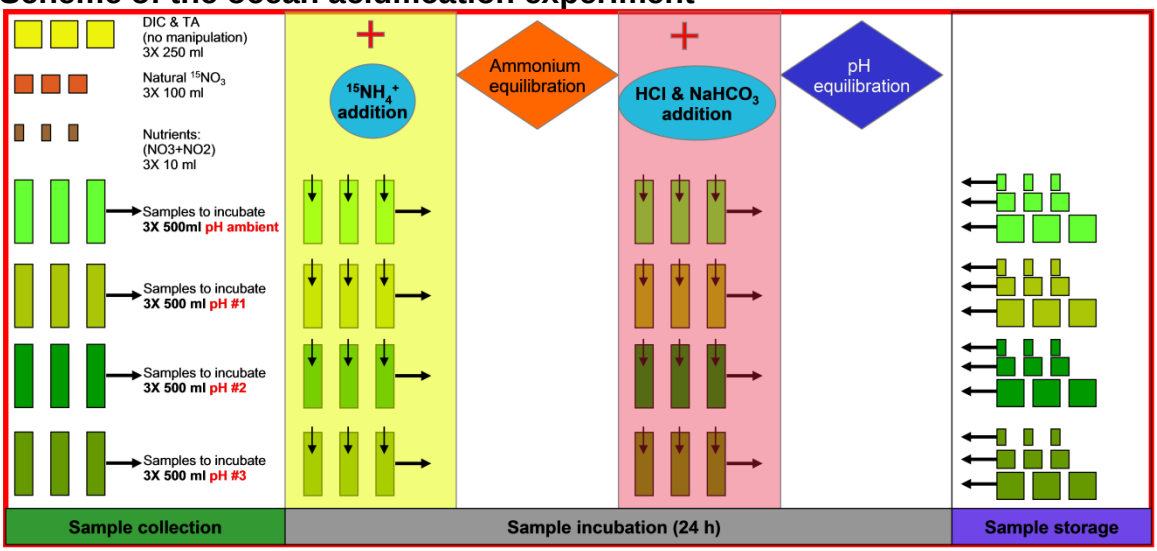
Nitrification Rates

Nitrification rates will be determined with the tracer addition method. Briefly, samples were added with about 10% of NH_4^+ ambient concentration nM of 99 atom percent (at%) stable isotope tracer ($^{15}NH_4^+$). Nitrification rates will be calculated by measuring the accumulation of ^{15}N label in the oxidized NO_2 + NO_3^- pool following incubation for 24h. The method that will be used to determine ^{15}N produced by nitrification is the so called 'denitrifier method' using denitryfying bacteria to convert NO_2^- and NO_3^- in N_2O (Sigman et al. 2001).

Carbonate System

Seawater CO_2 parameters will be determined by measurement of two carbonate system parameters: total TA and DIC concentration. pH will be calculated. DIC and TA measurements will be undertaken using a VINDTA 3C (Marianda, Germany) at NOC. DIC will be determined using a coulometric titration (coulometer 5011, UIC, USA) and TA will be determined using a closed-cell titration procedure (Dickson et al. 2007).

Scheme of the ocean acidification experiment



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Huesemann MH, Skillman AD, Crecelius EA (2002) The inhibition of marine nitrification by ocean disposal of carbon dioxide. Mar Pollut Bull 44:142–148.

Sigman DM, et al. (2001) A bacterial method for the nitrogen isotopic analysis of nitrate in seawater and freshwater. Anal Chem 73:4145–4153.

3.2 Atmospheric Deposition

Anthony Birchill, Caglar V. Yumruktepe and Valeria Ibello

Objective

Aerosol samples was collected to i) estimate aerosol deposition rates at PAP, ii) evaluate the bioavailability of aerosol in surface seawater, and iii) explore the impact of the ocean acidification on the aerosol availability in surface seawater.

The nutrient/metals investigated are - NO_3^-, NH_4^+, PO_4^{3-}, Zn, Cu, Pb, Cd.

Methods

Atmospheric sampling was conducted on the RRS *James Cook*'s monkey island, at more of 20 m distant from the chimney flue. In order to avoid contamination from the ship's stacks, the air sampling system incorporated an automatic switch connecting a wind vane to the air pump engine to activate/deactivate air sampling accordingly with wind direction.

A total of 9 bulk aerosol filter samples were collected using a low volume air sampling system (flow rates approximately 10 l min^{-1}) on a 0.2 µm polycarbonate filter (45 mm diameter), for typically 24 h. Due to an initial problem occurred at the air pump, the aerosol sampling started 3 days later the start of water measurements. Details of the sampling log are reported in Table 1 below.

Sampling Day (mm-dd-yy)			Air Volume	Time (GMT)	Weather	Coordinates (LAT / LON)	Jul Day
	From	06-06-13	20768247	21:00:00	partly cloudy	48.38.915N / 16.08.571W	157
ATM01	To	06-07-13	20784512	20:00:00	Cloudy	48.38.917N / 16.08.571W	158
	From	06-07-13	20784512	20:32:00	partly cloudy	48.38.916N / 16.08.571W	158
ATM02	To	06-08-13	20797970	19:40:00	partly cloudy	48.29.317N / 16.41.05W	159
	From	06-08-13	20803673	20:00:00	Clear	48.29.317N / 16.41.05W	159
ATM03	To	06-09-13	20803899	09:51:00	Rainy	48.38.916N / 16.08.573W	160
	From	06-09-13	20803899	10:28:00	rainy	48.38.916N / 16.08.573W	160
ATM04	To	06-10-13	20810920	10:00:00	overcast	48.38.549N / 16.08.344W	161
	From	06-10-13	20810920	10:25:00	overcast	48.38.550N / 16.08.344W	161
ATM05	To	06-11-13	20820782	12:48:00	cloudy	48.46.382N / 16.39.943W	162
	From	06-11-13	20820782	13:09:00	cloudy	48.46.371N / 16.40.103W	162
ATM06	To	06-12-13	20830328	18:53:00	storm	48.30.011N / 16.53.712W	163
	From	06-12-13	20830328	19:09:00	clear/windy	48.30.012N / 16.52.28W	163
ATM07	To	06-13-13	20840694	18:23:00	cloudy/windy	48.38.918N / 16.08.5748W	164
	From	06-13-13	20840694	18:47:00	cloudy/windy	48.38.914N / 16.08.573W	164
ATM08	To	06-14-13	20852248	19:57:00	clear/windy	48.52.719N / 15.23.569W	165
	From	06-14-13	20852268	20:19:00	clear/windy	48.52.743N / 15.08.617W	165
ATM09	To	06-15-13	20853069	19:06:00	cloudy	50.35.812W / 09.48.421W	166

Table 1 Summary of Atmospheric Samples Collected.

All subsequent analysis will take place at home laboratories. In the case of ammonia analyses it will be required to determine if the system has the sensitivity to measure ambient concentrations over blanks. Tests on nutrients bioavailability will be done on filtered surface seawater collected at PAP. pH manipulation and carbonate system analysis will follow the same procedure/methods of the ocean acidification experiment described in the N cycle measurements section.
Analysis will be carried out using Ion Chromatography and Auto-analyzer. For experiments on nutrient bioavailability, sea-water will be purified by Chelex-100.

3.3 N Cycle Measurements

Anthony Birchill, Oliver Wilmott, Caglar V. Yumruktepe and Valeria Ibello

Objective

The main objective of the JC87 cruise was to estimate new and regenerated primary production and nitrification rates Different processes of the N cycle will be tackled (ammonium and nitrate assimilation rates, ammonium regeneration and nitrification rates) in order to obtain estimates of *f* ratio. New primary production rates will be used to calculate C export from the euphotic zone.
Furthermore, natural abundance of the stable ^{15}N isotope in particulate organic nitrogen (PON) and in nitrate at the base of the euphotic zone will be determined to evaluate the origin of N sources (N deposition, N_2 fixation, deep nitrate) used by phytoplankton.

Methods

1. Determination of ammonium and nitrate assimilation rates

Seawater was collected around 8.30 a.m. for 9 days from the surface ocean at 6 optical depths: 100% 55%, 33%, 14%, 4.5% and 1% of surface radiation. PAR profile was determined from the same CTD during the down cast deployment. Samples were collected in triplicates in 670 ml acid washed, 3 times milliQ rinsed, polycarbonate clear bottles screened with combination of neutral and blue light filters.
Assimilation rates for NO_3^- and NH_4^+ will be determined following the incorporation of the stable isotope $^{15}N\text{-}NH_4^+$ and $^{15}N\text{-}NO_3^-$ in PON.
Ideally, addition of enriched daily-prepared standard was within 10% of nutrient ambient concentration, calculated on the base of nutrients vertical profile of the day before. In oligotrophic conditions, the minimum addition was 5 nmol/l.
After $^{15}N\text{-}NH_4^+$ and $^{15}N\text{-}NO_3^-$ addition, samples were incubated for 4-6 hours. Incubations were made in an on-deck incubator cooled with at surface seawater (temperature was maximum 2° C warmer than the in situ

temperature). After incubation, samples were filtered (<40 mHg vacuum) on ashed GF/F filters.
^{15}N abundance in PON will be determined by continuous flow stable isotope mass spectrometry using techniques described by Barrie et al. (1989) and Owens and Rees (1989).

2. Determination of ammonium regeneration and nitrification rates

Approximately 5 L of seawater were collected around 8.30 am from the surface ocean at 4 optical depths (55%, 14%, 1% and the last 30m below 1% of PAR). The bottles were screened as done for N uptake samples.
Soon after collection, ^{15}N tracer was added to the whole sample. The amount of added tracer was between 10-25% of the ambient NH_4^+ concentration. After 30 minutes, the samples was equally divided in two parts: one part was incubated for 24h at the proper light and another part was immediately filtered on GF/G pre-combusted filters and processes for development of indophenol and sudan-l accordingly to the procedure described by Clark et al. (2006, 2007).

3. Determination of ^{15}N-PON natural abundance and ^{15}N-NO_3^-

Samples for ^{15}N-PON (particulate organic nitrogen) determinations were collected at the same depths of N uptake samples (100% 55%, 33%, 14%, 4.5% and 1% of PAR) on pre-combusted GF/F filters. 4–9 liters of seawater were filtered.
^{15}N-NO_3^- was collected at the base of the euphotic zone in 100 ml HDPE bottles and immediately frozen for later analyses according to Sigman et al. (2001).

N assimilation rates sampling (NH_4^+ and NO_3^-)

Date	Julian Day	CTD #	Station #	LD (%)	LD (m)	NB #	Time
05-Jun	156	4	37	100	2	22,23	8:55:00
				55	6	18,19,20	9:05:00
				33	10	15,16	9:15:00
				14	25	11,12,13	9:25:00
				4.5	40	8,9,10	9:35:00
				1	60	3,4,5,6	9:45:00
06-Jun	*157*	*8*	*55*	100	*2*	*22,23,24*	*9:15:00*
				55	*6*	*18,19,20,21*	*9:25:00*
				33	*10*	*15,16,17*	*9:35:00*
				14	*20*	*11,12,13,14*	*9:45:00*
				4.5	*30*	*8,9,10*	*9:55:00*
				1	*50*	3,4,5,6,7	*10:05:00*
07-Jun	158	10	67	100	2	22,23,24	9:25:00
				55	4	18,19,20,21	9:35:00
				33	5	15,16,17	9:45:00
				14	11	11,12,13,14	9:55:00

				4.5	25	8,9,10	10:05:00
				1	40	3,4,5,6,	10:15:00
08-Jun	*159*	*12*	*75*	100	*2*	*22,23,24*	*11:10:00*
				55	*4*	*18,19,20,21*	*11:20:00*
				33	*7*	*15,16,17*	*11:30:00*
				14	*15*	*11,12,13,14*	*11:40:00*
				4.5	*25*	*8,9,10*	*11:50:00*
				1	*50*	3,4,5,6,	*12:00:00*
09-Jun	160	13	88	100	2	23,24	8:30:00
				55	4	20,21,22	8:40:00
				33	7	17,18,19	8:50:00
				14	15	13,14,15,16	9:00:00
				4.5	20	10,11,12	9:10:00
				1	40	7,8,9	9:20:00
10-Jun	*161*	*18*	*104*	*100*	*2*	*22,23,24*	*9:20:00*
				55	*7*	*18,19,20,21*	*9:30:00*
				33	*10*	*15,16,17*	*9:40:00*
				14	*15*	*11,12,13,14*	*9:50:00*
				4.5	*25*	*8,9,10*	*10:00:00*
				1	*45*	*3,4,5,6,*	*10:10:00*
N assimilation rates sampling (NH4+ and NO3-) *(continue)*							
Date	**Julian Day**	**CTD #**	**Station #**	**LD (%)**	**LD (m)**	**NB #**	**Time**
11-Jun	162	19	117	100	2	22,23,24	9:40:00
				55	4	18,19,20,21	9:50:00
				33	8	15,16,17	10:00:00
				14	15	11,12,13,14	10:10:00
				4.5	25	7,8,9	10:20:00
				1	45	3,4,5,6	10:30:00
13-Jun	*164*	*21*	*130*	*100*	*3*	*22,23,24*	*9:25:00*
				55	*5*	*18,19,20,21*	*9:35:00*
				33	*10*	*15,16,17*	*9:45:00*
				14	*15*	*11,12,13,14*	*9:55:00*
				4.5	*35*	*8,9,10*	*10:05:00*
				1	*60*	*3,4,5,6*	*10:15:00*
14-Jun	*165*	*23*	*149*	*100*	*2*	*22,23,24*	*9:25:00*
				55	*5*	*18,19,20,21*	*9:35:00*
				33	*10*	*15,16,17*	*9:45:00*
				14	*15*	*11,12,13,14*	*9:55:00*
				4.5	*25*	*7,8,9,10*	*10:05:00*
				1	*35*	*3,4,5,6*	*10:15:00*

bold: same optical depths sampled for 13C primary productivity

italic: same dates (but different CTD) of 13C primary productivity sampling

Ammonium regeneration and nitrification rates

Date	Julian Day	CTD #	Station #	LD (%)	LD (m)	NB #	Time
07-Jun	158	10	67	***55**	4	18,19,20,21	9:35:00
				*14	11	11,12,13,14	9:55:00
				***1**	40	3,4,5,6,	10:15:00
				1% -30 m	70	1,2	10:25:00
08-Jun	*159*	*12*	*75*	****55***	*4*	*18,19,20,21*	*11:20:00*
				**14*	*15*	*11,12,13,14*	*11:40:00*
				****1***	*50*	*3,4,5,6,*	*12:00:00*
				1% -30 m	*80*	*1,2*	*12:10:00*
09-Jun	160	13	88	***55**	4	20,21,22	8:40:00
				*14	15	13,14,15,16	9:00:00
				***1**	40	7,8,9	9:20:00
				1% -30 m	70	3,4,5,6	9:30:00
10-Jun	*161*	*18*	*104*	****55***	*7*	*18,19,20,21*	*9:30:00*
				**14*	*15*	*11,12,13,14*	*9:50:00*
				****1***	*45*	*3,4,5,6,*	*10:10:00*
				1% -30 m	*75*	*1,2*	*10:20:00*

Ammonium regeneration and nitrification rates *(continue)*

Date	Julian Day	CTD #	Station #	LD (%)	LD (m)	NB #	Time
11-Jun	162	19	117	***55**	4	18,19,20,21	9:50:00
				*14	15	11,12,13,14	10:10:00
				***1**	45	3,4,5,6	10:30:00
				1% -30 m	75	2	10:40:00
13-Jun	*164*	*21*	*130*	****55***	*5*	*18,19,20,21*	*9:35:00*
				**14*	*15*	*11,12,13,14*	*9:55:00*
				****1***	*60*	*3,4,5,6*	*10:15:00*
				1% -30 m	*90*	*1,2*	*10:25:00*

bold: same optical depths sampled for 13C primary productivity

italic: same dates (but different CTD) of 13C primary productivity sampling

* same depths and CTD of N assimilation rates sampling

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3.4 Small Zooplankton

Marja Koski and Bellineth Valencia

Particle-colonising Zooplankton

Background and Methods

Zooplankton and bacteria have recently been estimated to be approximately equally important for the degradation of sinking flux (Steinberg et al. 2008), although we know very little about what regulates their aggregate consumption rates. Zooplankton species / groups which could be expected to be relevant for flux degradation include small copepod species from genus *Microsetella* and *Oncaea*. These copepods can at times be extremely abundant, and are known to colonise and feed on sinking particles.

We wanted to quantify the consumption rates of *Microsetella* / *Oncaea* on diverse types of marine snow particles, which, together with their vertical distribution, can be used to estimate their effect on flux degradation. In addition, we estimated their respiration rates as an indication of minimum metabolic carbon requirement, and their gut chlorophyll content as an indication of the importance of phytoplankton in the diet of these species. The experiments, samples and measurements are listed in Table 2.

Measurement	Gear	Frequency	Collection depth
Vertical distribution of small zooplankton	Multinet 50 µm mesh size	~Daily; day light hours	1000-500, 500-300, 300-100, 100-50, 50-0m
Microsetella and *Oncaea* respiration	WP2 90 µm, microrespirometer	2-3 stations	0-100m
Microsetella and *Oncaea* gut chlorophyll	WP2 90 µm	~Daily	0-100m
Microsetella, functional response of feeding on aggregates	WP2 90 µm; incubations	2 times	0-100m

Table 2 List of the measurements, gear, sampling frequency and the depth of the collection of samples.

Vertical zooplankton samples were collected using a Hydrobios Multinet, occupied with 50 µm nets and pressure sensor to determine the depth. The net was towed at the speed of a 0.5 m s^{-1}. The functional response of *Microsetella* feeding on aggregates was measured at 5 different

concentrations using *Trichodesmium* colonies and small aggregates collected with the marine snow catcher. The feeding was estimated based on the pellet production of *Microsetella* after 24-h starvation followed by a 12-h incubation with aggregates. *Microsetella* and *Oncaea* respiration was measured using Clarke-type oxygen electrodes and a microrespirometer. Gut chlorophyll was estimated based on 3 x 50 individuals collected from the WP2 net directly after sampling, and extracted in acetone.

Preliminary Results

Based on the collection of live zooplankton for experiments (WP2 nets), *Microsetella* spp. were always abundant and frequently dominated the zooplankton community. *Oncaea* spp. were also abundant at most stations. Other abundant small copepod species included *Oithona* spp., *Acartia* sp. and *Centropages* sp., among other species. The 50 µm Multinet samples will be sent to a plankton sorting center in Poland for analysis of the species composition, stage distribution and biomass (based on the size measurements).

Microsetella ingestion (pellet production) increased in increasing concentration of aggregates, both when *Trichodesmium* colonies and marine snow catcher aggregates were used as food (Fig. 1). By fitting the function of hyperbola to the observations, we can estimate the encounter rate kernel (ß) which indicates the volume of water that *Microsetella* can search for aggregates, as well as the handling time and maximum ingestion of the aggregates. These rates can be combined with the vertical distribution and abundance of *Microsetella* and *Oncaea*, to estimate where and how many of the sinking particles can be cleared from the water due to the activity of these two copepods.

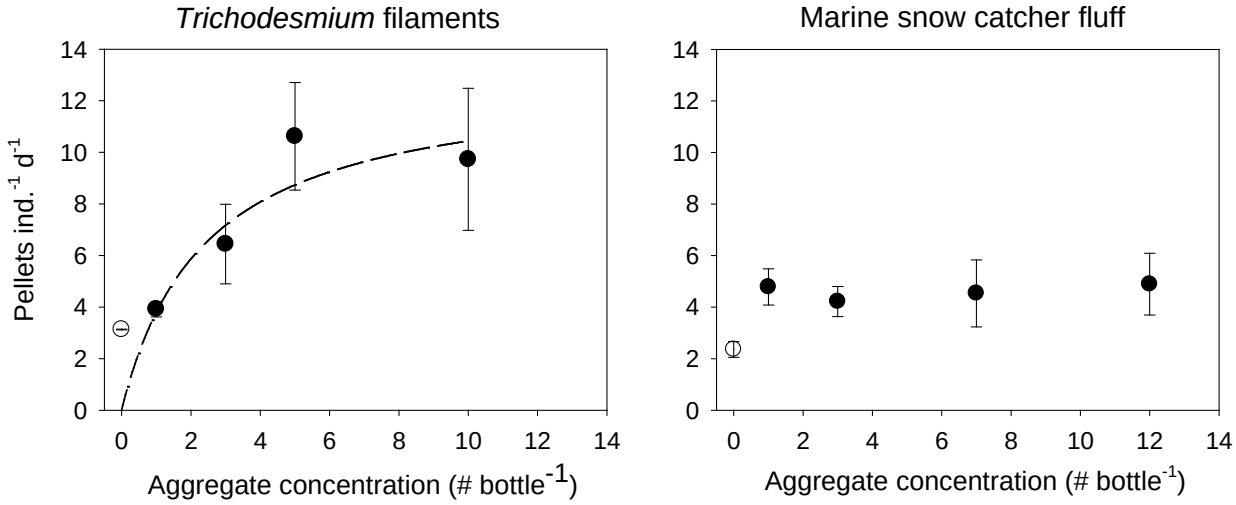


Fig. 3 Functional response of *Microsetella* sp. pellet production (pellets ind.$^{-1}$ d^{-1}) on *Trichodesmium* filaments and small marine snow aggregates (mean ± SD). The line indicates the function of hyperbola (R^2 0.44, $p < 0.05$).

***Centropages* sp. as a representative of small calanoids**

Background and Methods

Many calanoid copepods feed in the surface layer at night, and migrate to deeper waters during the daylight hours. By feeding at one depth and respiring and producing fecal pellets and eggs at another depth they therefore actively transport carbon from the surface to the deeper parts of the water column. Calanoid copepods are also major contributors to zooplankton secondary production, which makes them an important food source for e.g., larval fish.

We wanted to investigate the active carbon transport and secondary production of one of the abundant calanoid species *Centropages* sp. by measuring its egg production and hatching success, fecal pellet production, grazing, gut evacuation rate and respiration. Egg and pellet production were measured both in daily 24-h incubations, and once during the cruise using 6-h intervals, to investigate the dial feeding rhythms. Copepods for incubations were collected using the WP2 net from 100 m to the surface. Egg and pellet production and hatching success were measured in incubations using standard techniques; in addition females were collected for later determination of the gonad maturation. Respiration was measured using the microelectrodes (see above) at two stations. Grazing was measured at two stations in 24-h incubations based on the disappearance of chlorophyll-*a* and microzooplankton (lugol-preserved samples) in the bottles containing copepods compared to controls (Frost 1972) and one microzooplankton dilution experiment was conducted to correct for the microzooplankton grazing (Table 3).

Measurement	**Gear**	**Frequency**	**Collection depth**
Vertical distribution of small zooplankton	Multinet 50 µm mesh size	~Daily; day light hours	1000-500, 500-300, 300-100, 100-50, 50-0m
Centropages respiration	WP2 90 µm, microrespirometer	2 stations	0-100m
Centropages gut evacuation rate	WP2 90 µm	1 station	0-100m
Centropages grazing	WP2 90 µm; incubations	2 stations	0-100m
Microzooplankton dilution experiment	Water from CTD	1 station	Chl-max and below
Centropages egg production	WP2 90 µm; incubations	Daily	0-100m
Centropages pellet production	WP2 90 µm; incubations	Daily	0-100m

Table 3 List of the measurements, gear, sampling frequency and the depth of the collection of samples.

Preliminary Results

The egg production of *Centropages* sp. was relatively high although variable between the days, with a mean rate of 24 ± 23 eggs f^{-1} d^{-1} and maximum and minimum of 98 and 0 eggs f^{-1} d^{-1}, respectively (Fig. 2). Hatching success was constantly relatively high (70-99%). In contrast, pellet production was low throughout the cruise, both in 24-h (Fig. 2) and in 6-h incubations, indicating relatively low feeding rate. The pellet production was highest during the night and early morning (from midnight to 6 am and from 6 to 12 am).

After all the data has been analysed, we will be able to calculate the individual carbon budget (ingestion, reproduction, egestion and respiration) for *Centropages* sp., and based on the diurnal rates and gut clearance rate, to estimate at what time of the day feeding takes place and how long will it take from the ingestion of the food items to the production of the fecal pellets. When this information is combined with the vertical day / night distribution of *Centropages* sp. (Multinet samples), we will be able to estimate its contribution to the active carbon transport. The egg production and hatching success can be compared to the environmental variables such as temperature, food concentration (chl-*a* in different size fractions, POC) and food quality (PON, POP), which might give an indication of the factors controlling *Centropages* production at the PAP site.

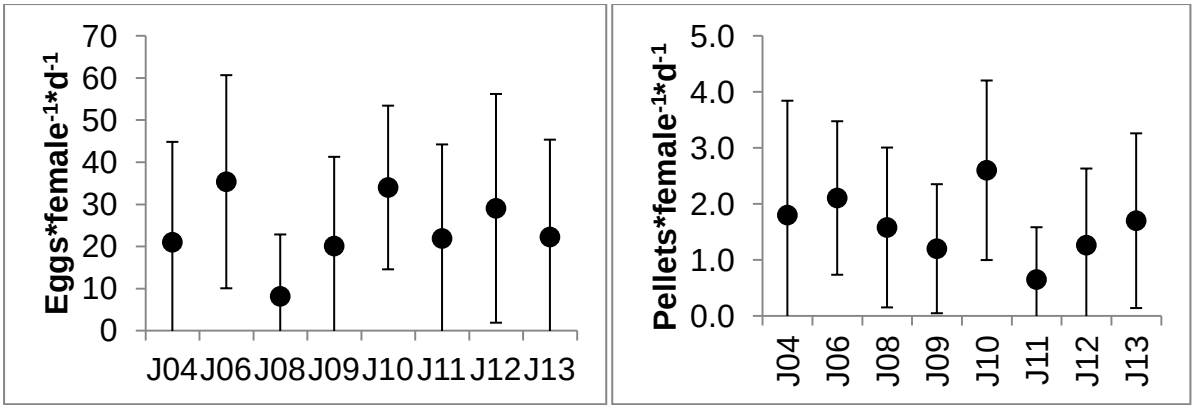


Fig. 4 Egg (eggs f^{-1} d^{-1}) and pellet (pellets f^{-1} d^{-1}) production of *Centropages* sp. in 24-incubations (mean ± SD).

3.5 Community Oxygen Dynamics (Consumption/Production)

Christian Lindemann

Aim & Background

The overall aim of this study is attempting to identify the oxygen adaptation dynamics in the plankton community in the upper part of the ocean.

Community respiration can serve as an indicator of heterotrophic activity. As such it can help to indicate the strength of regenerate production, especially in combination with primary production estimates, from for example carbon based estimates.
In modeling studies respiratory rates are often given a fixed (sometimes arbitrary value), like for example 5% per day. To improve this very simple parameter studies about changing community respiration rates can of great use.
Phytoplankton dark respiration depends not only changes on temperature and life stage, but a linear relationship between light and dark respiration has also been shown. Together with carbon or nitrogen based primary production rates there is the potential of accessing variability in phytoplankton dark respiration rates.
During the RRS *James Cook* JC 087 two different setups where used. Setup I was designed to test the adaptation response of community respiratory rates towards different light levels. In Setup II 24 hour incubations were measured contentiously to in order to investigate the dial cycle of oxygen dynamics.
A closer description of the setup can be found under Material and Method.

Material and Methods

General Method
Water samples were taken using Niskins bottles from 'pre-dawn' CTD casts (unless indicated differently in Table 4). To estimate community respiration rates, water from different depth was incubated in 500 ml glass bottles. The bottles were kept in a flow-through water bath (incubator) on deck with a constant inflow of surface water, thus ensuring realistic temperature and preventing the incubation from heating. The oxygen concentration was measured using the oxygen microsensor system (UNISENSE).
All samples where filtered through a 200 µm mesh size net before the incubation, so that potential biases from larger zooplankton were excluded.

Method Setup I
Water from 200 m depth, within the mixed layer and the surface was incubated into bottles which were either completely darkened (simulating large depth, in this case 200 m), covered with (simulating 20% surface light level) and without any cover (simulating surface water). A list of the CTD's used is presented in Table 1. Water from each depth was incubated in each of the three different treatments, thus all three by three combinations were accounted for. For each of the nine combinations triplicates were made. It was found during the second CTD that was used, that the workload was has

been underestimated. Consequently the intermediate light intensity incubation (20%) was excluded from the following incubations. For each of the measurements a subsample of approx. 2 µl was taken and measured under constant stirring in the vales provided by UNISENSE. Absolute oxygen concentration and rate of oxygen change were measured after zero, 12, 24 and 36 hours of incubation. Measurement intervals where set to 2 seconds.
Originally it was planned to test incubations With DCMU. DCMU blocks the electron transport in photosystem II and consequentially inhibits photosynthesis, which therefore allows to measure respiration even in light. However, during the first station it was observed that the treatment did not show the anticipated result. This was possibly due to the fact, that contrary to literature description, DCMU could not be well dissolved in water. It was therefore excluded form the following incubations.

Method Setup II

Surface water was incubated in 500 ml glass bottles and measured for at least 24 hours. The lid of the glass bottle was modified, so that the glass-lid provided by UNISENSE was fixed in the center of the lid (Figure 5). Also it was ensured that no air bubbles were in the bottle. Measurement intervals where set to 10 seconds.
Chlorophyll measurements were taken in the beginning and at the end of the incubation. During night time the incubation was covered with black plastic sacks to shield it from deck lights.

Fig. 5 Lid of a bottle used in the long incubation.

Nr.	Station	date	daytime	CTD	Setup	depth [m]
1	11, 16	04/06/13	04:40:00/05:55	snowcatcher	I	15, 150
2	31	05/06/13	04:10:00	3	I	2, 25, 200
3	51	06/06/13	03:50:00	7	I	5, 200
4	74	08/06/13	03:43:00	11	I	5, 200
5	101	10/06/13	03:47:00	17	II	5
6	126	13/06/13	04:46:00	20	II	5
7	149	14/06/13	08:42:00	23	II	5

Table 4 Stations from which water has been used for incubations.

Preliminary results

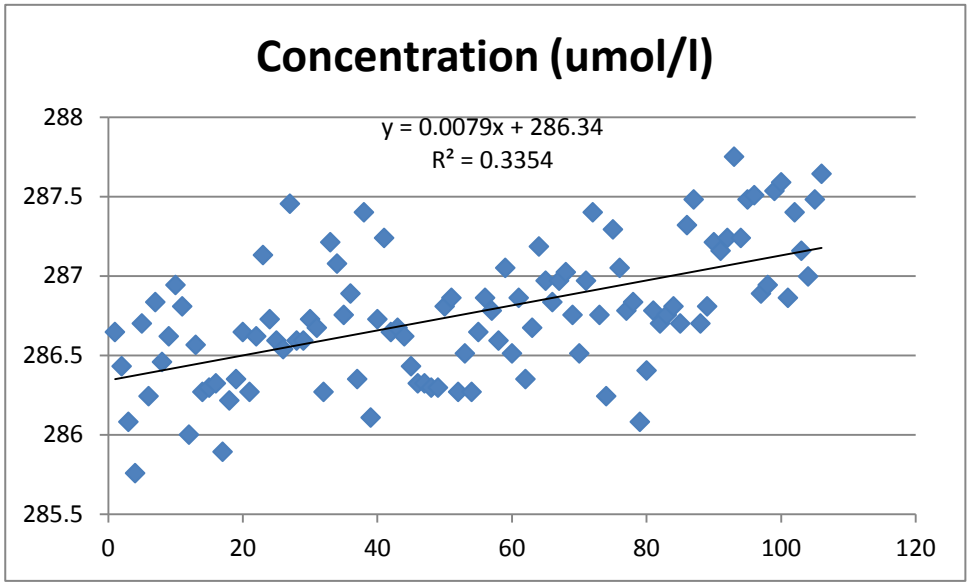


Fig. 6 Example of meaurement from Setup I. Uncorrected start concetration from CTD 11 at 5m depth.

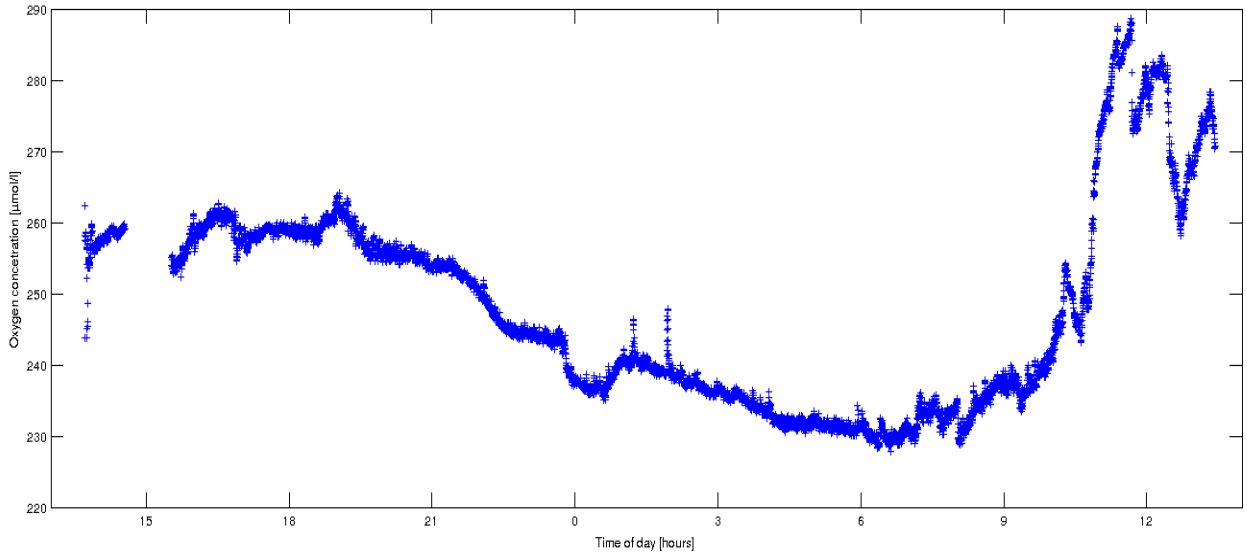


Fig. 7 Uncorrected oxygen concentration measured form setup II over the course of 24 hours. The gap around 15:00 is due to electrode problems.

3.6 Blog "Down to the Twilight Zone"

Christian Lindemann

http://downtothetwilightzone.noc.ac.uk/http://downtothetwilightzone.blogspot.com

Aim

The main objective of the blog is to communicate the science and life on-board the RRS *James Cook* during the JC087 cruise. It is meant to reach the general public, other researcher as well as friend and family of the people involved the cruise. Therefore all contributions are written in a language understandable to the general public. It includes (1) scientifically orientated contribution and (2) contribution about life and work on-board.

Blog Setup

The blog was set up prior to the cruise by the NOC communication department (Robert Curry, Kim Marshall-Brown) (hereafter referred to NOC comm.). The information in the categories "About", "Science" and "Equipment" was provided by Chief scientist Prof. Richard S. Lampitt prior to the cruise. Information in all other categories was provided by NOC comm.. The text on the site board was written by Ivo Grigorov (DTU Aqua, Charlottenlund, Denmark).

To facilitate engagement of scientist during the cruise the two-page document "DOWN to the TWILIGHT ZONE Cruise blog and iReports" (developed by Ivo Grigorov) was send to all participant via email and distributed in laminated copies around the laboratories on the ship. It included advice and suggestion on how to write a good story as well as instructions on how to make iReports.

A facebookfanpage ("Down to the Twilight Zone - Expedition") was set up, to increase outreach towards the facebook community. The facebookfanpage mirrored the blog. It was frequently updated by Antony Birchill.

Blog Structure

The blog is structured into different main categories as described below.

Home
The main category of the blog where the different contributions are posted; a list of all the post can be found in Table 5.

About
General introduction about the twilight zone and the cruise, including a link to the Eurosites page of the PAP site (http://www.eurosites.info/pap/data.php).
This information was provided by Chief scientist Prof Richard S Lampitt prior to the cruise.

People
A list of all the Scientists who participated in the JC087 cruise; it includes a Photo and a short description, written by the respective scientist, about their background and their work during the cruise.

Location
Information and about the PAP site.

Science
An overview about the science which takes place during the cruise; this information was provided by Chief scientist Prof Richard S Lampitt prior to the cruise.

Equipment
A short description of the main scientific tools employed during this cruise. This information was provided by Chief scientist Prof Richard S Lampitt prior to the cruise.

Media
An account of the different media, related to this expedition.

- twitter (hashtags #planktonpoo; #MarineSnow)
  media coverage of the cruise; livescience.com and nbcnews.com have reported on the cruise (as of 17/06/2013 10:15AM)link to the blog of the related EURO-BASIN deep convection cruise (http://deepconvectioncruise.wordpress.com/)
  Flickr count of the National Oceanographic Centre (NOC)
  http://www.flickr.com/photos/nationaloceanographycentre/sets/72157633911702526/
- Bathysnap movie of activity at the PAP site during 2011/2012
- link to the EURO-BASIN cruise campaign calendar

Ship
Information about the RRS *James Cook.*

Contact Us
Contact Information.

Nr.	Title	Date	Author	Keywords
1	Getting ready!	30/05/2013	Christian Lindemann, Antony Birchill	Introduction to the blog
2	Setting up a lab at sea- a nutrient chemist's perspective	06/02/13	Mark Stinchcombe	Nutrients
3	The thrill of anticipation	06/03/13	Richard Lampitt	preparations aboard
4	Interview with the captain	06/06/13	John Leask; Interviewer: Christian Lindemann	captains perspective, interview
5	Being “whale watched”	06/06/13	Christian Lindemann	pilot whales sighting
6	Catching the Ocean's Snow	06/07/13	Anna Belcher	marine snow, marine snow catcher
7	Under Pressure	06/08/13	Stephanie Wilson	pressure at depth
8	Life's Limits	06/10/13	Adrian Martin	effects of physics on life
9	IT at sea	06/11/13	Mark Maltby; Interviewer: Christian Lindemann	IT and communication on-board, interview
10	Small plants in the ocean	06/12/13	GayatriDudeja	phytoplankton
11	Sun and Sea	14/06/2013	Christian Lindemann	pictures
12	Listening for whales	14/06/2013	Adrian Martin	whale sounds, PELAGRA
13	The galley	15/06/2013	Christian Lindemann	galley, food on-board
14	On marine snow and copepod poo (#planktonpoo)	16/06/2013	Richard Lampitt	marine snow, faecal pellets, PELAGRA
15	Imaging twilight critters	16/06/13	FredrikaNorrbin	VPR, zooplankton
16	The scoop of the poop	17/06/2013	Stephanie Wilson	faecel pellets, zooplankton

Table 5 List of Blog Contribution

Work Flow
It was the responsibility of the on-board coordination to ensure a steady flow of contributions from a diverse range of participant. The contributions were sent to the NOC comm. who then updated the blog. To get scientist involved in the blog, that is to write a short contribution, they were engaged personally. In the majority of the cases the blog entries were quickly screened and any potential changes were discussed with the author before sending it off to NOC coms.

Photos to accompany the written part came from the coordination on-board as well as (in a few cases) from the author themselves.
For the contributions from non-scientist (the captain, sea service technicians, galley stuff) personal interviews were conducted. The notes were taken and written down in an interview form or a coherent text by the blog co-ordination. Approval of the text was ensured in all cases.

3.7 Particle Flux through the Twilight Zone

Morten Iversen, Kev Saw and Richard Lampitt

Background

The transport of organic matter from the surface ocean, through the twilight zone and into the deep ocean is dominated by two types of particles; marine snow and zooplankton faecal pellets (Fig. 8). However, every night a large part of the zooplankton migrates from depth of around 500 to 300 m to the surface to feed. Therefore, one would expect that the relative dominance of the two particle types is diurnal with a dominance of faecal pellets during night and early morning, while the marine snow may dominate during day and early evening when only few grazers are present in the upper ocean. The interactions between marine snow and zooplankton have a large influence on the efficiency of the biological pump, for example, grazing on marine snow by zooplankton can have several implications for the vertical flux; e.g. marine snow aggregates can be completely removed by ingestion of whole aggregates, their size can decrease due to fragmentation and partly ingestion, and the sinking particles can be repacked from marine snow to faecal pellets.

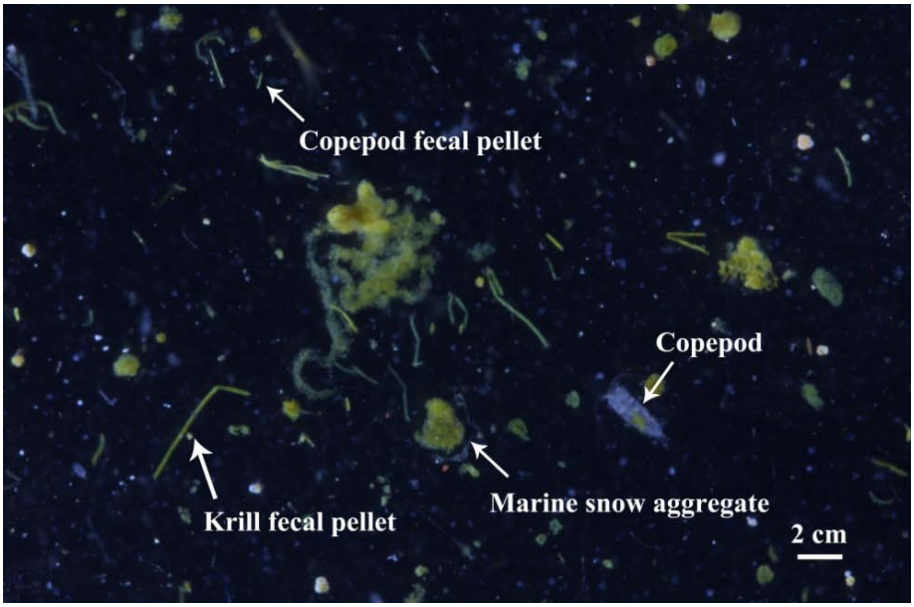


Fig. 8 Small section from a gel trap deployed at 100 m depth during the DF-6 deployment. The shape and structure of all particles collected in the gel is preserved and can be used to identify particle types and measure their sizes.

Both repackaging and changes in aggregate sizes will change the sinking speed of the aggregates, either to slower speeds in case of fragmentation and partly ingestion or potentially higher speeds when repackaged into dense faecal pellets. Hereby, the retention time of sinking particles in the upper water column may be strongly influenced by the presence of zooplankton. By investigating the composition of vertical fluxes at high time and depth resolution in the upper water column using a combination of bulk flux collectors and gel filled traps mounted on neutrally buoyant platforms (PELAGRAs – see JC087 PELAGRA Cruise Report), we seek to unravel the diurnal interactions between the vertical fluxes and the food web structure during the RRS *James Cook* 087 cruise.

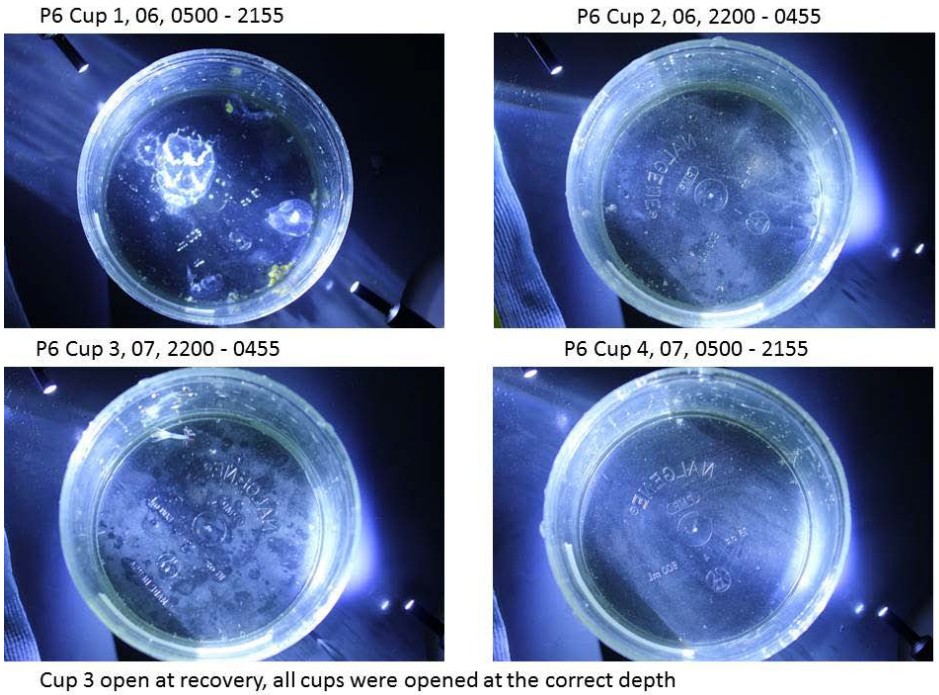
Work At Sea

The export fluxes in the upper 500 m of the water column were collected by the neutrally buoyant sediment traps (PELAGRA). We completed three deployments sessions during the cruise; one short deployment with 6 hours collection period to test the ballasting of the PELAGRAs and two long deployments allowing an 48 hours collection period - see position, trap depths, deployment, and recovery times in JC087 PELAGRA Cruise Report. The PELAGRAs equipped with gel traps were deployed at 100 and 400 meters which enabled us to follow the particle export and transformation from the base of mixed layer (100 m) and into the twilight zone (400 m). On those PELAGRAs two funnel-collectors captured biogeochemical mass

fluxes of carbon, nitrogen, biogenic opal, calcium carbonate and lithogenic material while the two traps without funnels were equipped with viscous gel which preserved the sinking material in its original shape. The different particle types collected in the gel were photographed on board using a digital camera and will be used to create particle size distribution and abundance of the flux. The combination of several deployments collecting either during a 24 h period or timed to only collect the night or day fluxes will hopefully provide quantitative and qualitative information on the origin of sinking particles and processes important for the flux attenuation on a diurnal time scale.

Preliminary Results

Fig. 9 shows the material collected during deployment 2 and 3. Unfortunately, many of the trap collectors had high abundances of the amphipod *Themisto compressa* whereby only a limited number of biogeochemical flux samples were obtained during the cruise. Therefore, further analysis in the laboratory back on land is needed before we can elaborate on the vertical fluxes.



Cup 3 open at recovery, all cups were opened at the correct depth

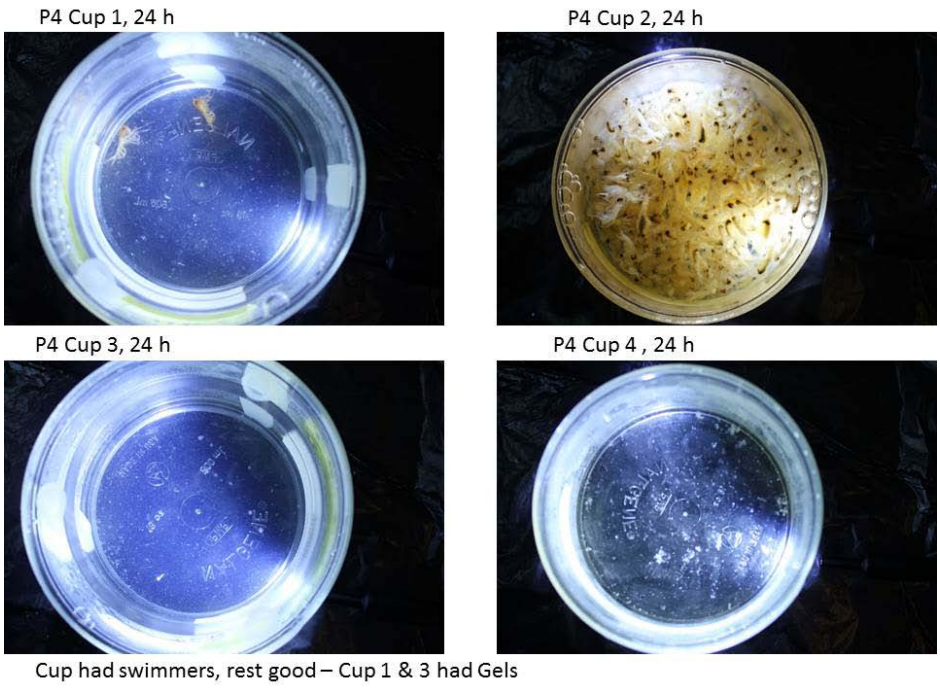


Fig. 9 Images of sediment trap collection from deployment 2 at 200 m(P6) and deployment 3 at 400 m (P4). The upper four images is from a night- and day collections, where P6 cup 1 and 2 were open during day and p6 cup 3 and 4 were open during night. The lower four images is from a deployment where a gel trap were open for 24 h simultaneously with a bulk trap. P4 cup 1 and 2 were open during the first 24 h and cup 3 and 4 were open during the following 24 h.

We could successfully distinguish between particle types in the gel trap collections and identify the contribution of fecal pellets and marine snow to the total flux (Fig. 10). This will be very useful in determining the influence from vertical migrating flux feeding on the day/night changes in both types and abundance of settling particles. To our knowledge, this is the first time gel traps have been deployed on a diurnal temporal resolution. Together with data on vertical distribution of zooplankton and settling particles (see cruise reports for VPR and Multinets) this will provide valuable information on the food web interactions with the vertical flux of particulate organic carbon.

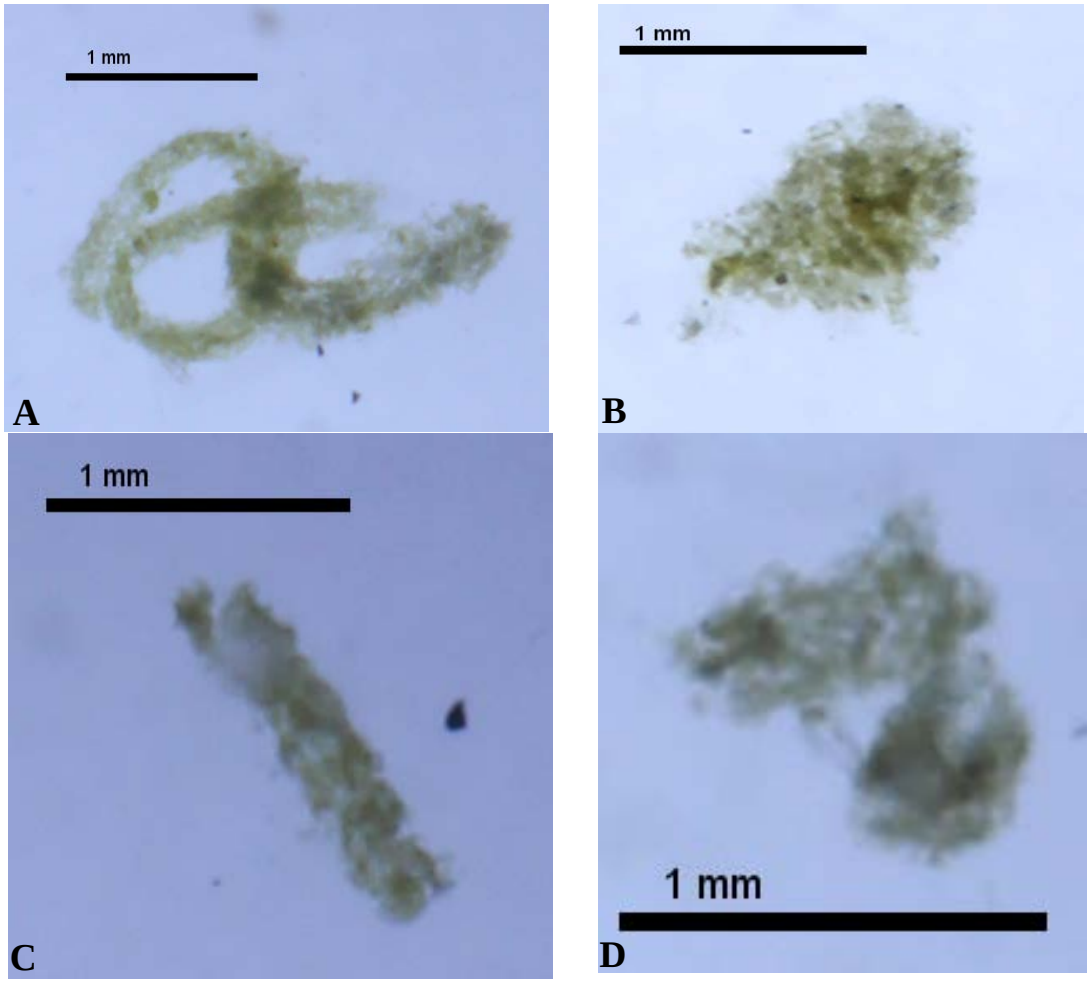


Fig. 10 Examples of particles collected with the gel traps. A) a Euphasiid fecal pellet, B) a marine snow aggregate, C) a copepod fecal pellet, and D) a small marine snow aggregates.

In Situ Measurements of Particle Sinking Velocities Using a Neutrally Buoyant Platform (PELAGRA)

The sinking of marine particles is the main downward transport of matter in the oceans. The amount of atmospheric CO_2 which can be taken up by the ocean is determined by the amount of organic matter that settles out of the upper ocean. This makes the sinking of particles the central component of the biological pump. During the past centuries, many researchers have attempted to measure in situ sinking velocities of settling particles. However, so far, no direct measurements of freely sinking particles have been at depths below the range of scuba diving (Alldredge and Gotschalk 1988). Several indirect estimates of sinking velocity have been made, such as deep water settling columns and video recordings (e.g. Asper 1987, Diercks and Asper 1997), relations between flux peaks at different depths (e.g. Berelson 2002, Fischer and Karakas 2009), and relations between camera estimated particle concentration spectra and gel traps

measurements of particle flux spectra (Mcdonell and Buesseler 2010, McDonnel and Buesseler 2012). During JC087, we attempted to obtain direct measurements of size-specific particle sinking velocities in situ by deploying two neutrally buoyant platforms (PELAGRAs) equipped with digital cameras and a collimated flash. The deployment depths were 100 m and 400 m. Every hour, a sequence of ten images where executed with two seconds intervals. This provided 20 seconds of images every hour during the entire deployment period of the PELAGRAs (see Fig. 11).

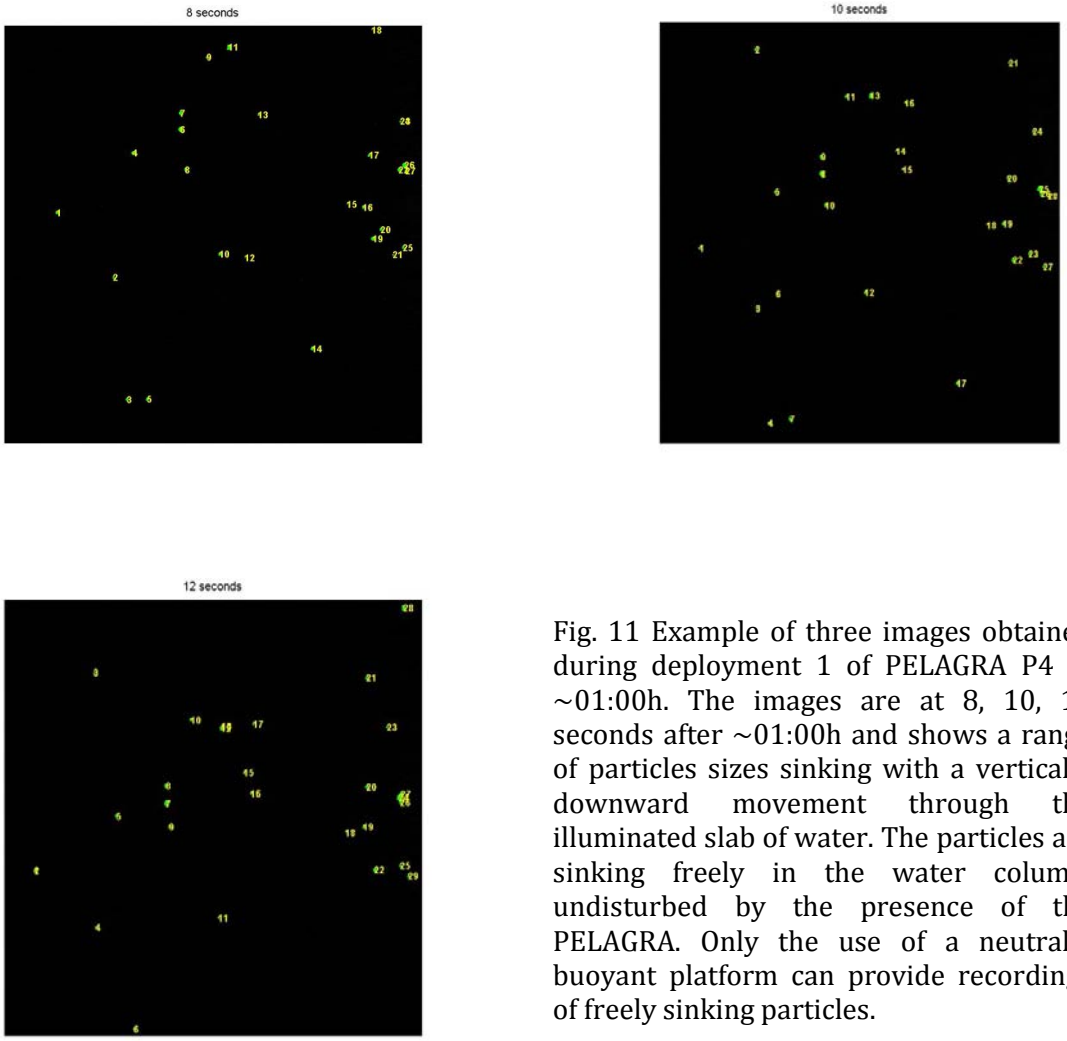


Fig. 11 Example of three images obtained during deployment 1 of PELAGRA P4 at ~01:00h. The images are at 8, 10, 12 seconds after ~01:00h and shows a range of particles sizes sinking with a vertically downward movement through the illuminated slab of water. The particles are sinking freely in the water column, undisturbed by the presence of the PELAGRA. Only the use of a neutrally buoyant platform can provide recordings of freely sinking particles.

A first glance at the image sequencing obtained with the trap mounted cameras indicate that we have several sequences where the PELAGRAs were flowing with the water, i.e. there is no relative current between the water movement and the movement of the PELAGRA. Hence, the method

for depth specific sinking speed measurements using the trap mounted cameras looks very promising. We performed a rapid calculation from one of the image sequences (deployment 1, P4) at 01:00 pm and found realistic size-specific sinking speeds for the settling particles (Fig. 12).

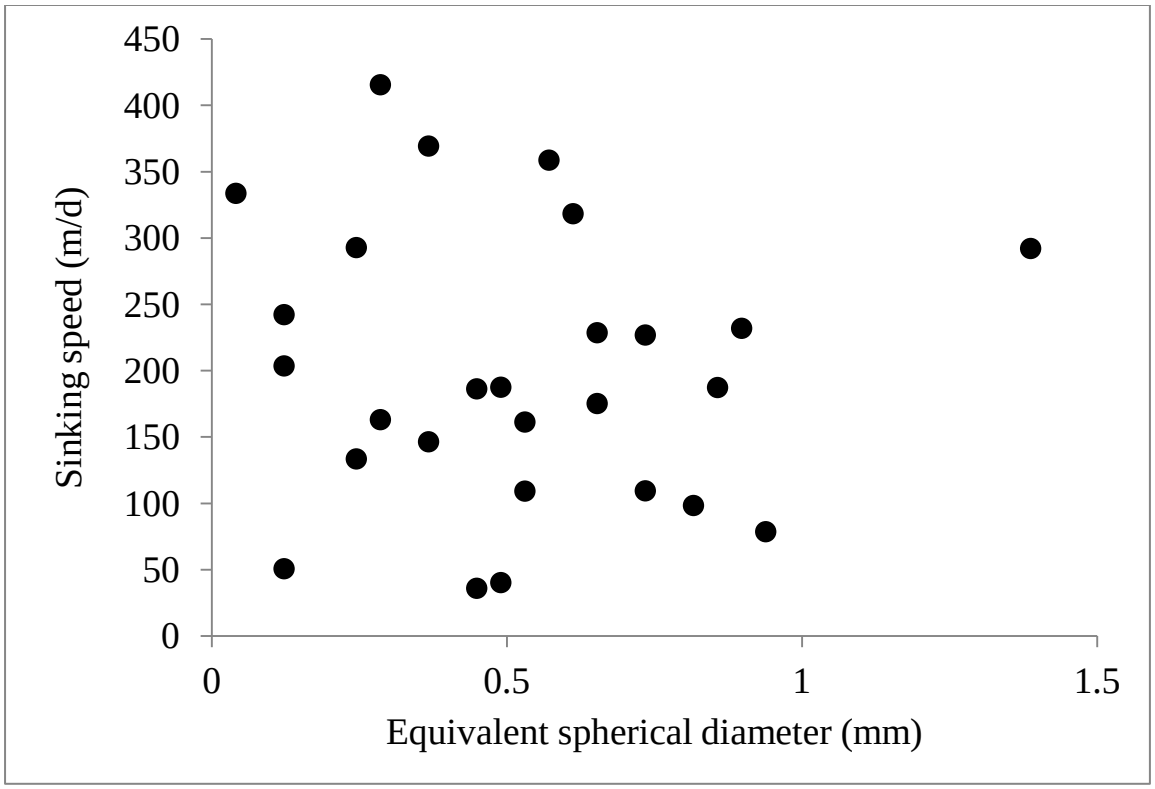


Fig. 12 Size-specific sinking speed for different particle types and sizes obtained from the image sequence recorded at ~01:00h during deployment 1 of PELAGRA P4.

It is not surprising that no clear relationship between size and sinking speed occur, since these particles consist of a heterogeneous pool of particles all with different densities. The high resolution of the images enables us to classify the individual particles into different types and thereby investigate the in situ sinking patterns of both different sizes and types of particles.

Vertical profiles of particle size-distribution and abundance were performed three times during the cruise; once as a wire test with the whole PELAGRA lowered through the water column to a depth of 1000 m and twice with the PELAGRA camera system and CTD mounted on a base (see PELAGRA Cruise Report) which was similarly lowered to 1000 m. These profiles provide high depth resolution of the particles through the water column, whereby we can identify depths of particle formation, transformation, and degradation. In combination with the chemical measurements from the PELAGRA collections and the information from the gel traps, these profiles will be valuable tool to identify important depth specific processes for the efficiency of the biological pump.

Direct measurements of sinking speed and microbial community respiration of different types of faecal pellets were performed on board to estimate the microbial degradation and export of faecal pellets from salps, *Themisto compressa*, and *Pleuromamma* sp.. We observed sinking speeds of salp pellets between 200 and 500 m d^{-1}, while *T. compressa* pellets on sank with an average speed of around 150 m d^{-1}. However, we cannot conclude from the sinking speed alone which pellet type is most likely to reach the deep ocean, since both the rate of microbial degradation and grazing from higher trophic levels have a large impact on the attenuation of their export fluxes.

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3.8 Molecular Variation of Lipids in Particles

Blazenka Gasparovic

Scientific Motivation

Lipids are essential for every living organism as they play vital roles in the membrane composition and the regulation of metabolic processes. They represent the carbon rich organic matter with very high energetic value, thus being an important metabolic fuel. Lipids differ in their chemical structure to a substantial degree and contain different functional groups influencing their reactivity. However, molecular structure is not the only factor relevant for organic matter reactivity, the fate of which also depends

on environmental conditions. The main origin of lipids is phytoplankton, as well as autotrophic bacteria and in much lesser extent heterotrophic bacteria. Plankton is constantly challenged with various abiotic stresses (light intensity, temperature, and nutrient availability) in their natural environment.

Characterization of marine lipids on a molecular level enables their use as good geochemical markers for the identification of different sources and processes of organic matter in the sea. For example, polar lipids are plankton biomembrane structure components, glycolipids are located predominantly in photosynthetic membranes and indicate on presence of autotrophs, triacylglycerols indicate plankton metabolic reserves, mono- and di-acylglycerides and free fatty acids breakdown products and characterize organic matter degradation level.

Sampling

Sampling was accommodated to follow temporal variability of lipid production in the surface productive layer. For this reason samples from six depths that corresponded to photosynthetic available radiation between 1-100% were taken every second day, while sample for 5 m depth was taken every day. Also, the changes of transferred primary photosynthate from the euphotic zone to depths will be investigated for samples taken from 100 m until 4800 m depth. Such sample distribution will allow to follow qualitative and quantitative changes of lipids until ocean bottom.

Sampling was performed for the depths and dates listed in Table 6.

Station	Depth (m)	Date sampled	Latitude (W)	Longitude (N)
JC087-05	4000	03/06/2013	016°08.56	48°41.99
	1000			
	600			
	400			
JC087-31	50	04/06/2013	016°08.57	48°38.91
	30			
	25			
	15			
non-toxic	5			
JC087-42	4800	05/06/2013	016°08.575	48°38.917
	4000			
	3000			
	2000			
	1000			
	600			
	400			
	300			
non-toxic	5			
JC087-51	200	06/06/2013	016°08.574	48°38.917
JC087-55	80		016°08.56	48°38.92
JC087-51	50		016°08.574	48°38.917
	30			
	25			
	15			
	5			
	surface			

non-toxic	5	07/06/2013	016°08.56	48°38.92
JC087-74	200	08/06/2013	016°08.604	48°38.919
	100			
	50			
	30			
	25			
	15			
	5			
JC087-75	surface		016°29.30	48°39.04
non-toxic	5	09/06/2013	016°08.56	48°38.92
JC087-101	200	10/06/2013	016°08.57	48°38.92
	100			
	50			
	30			
	25			
	15			
	5			
JC087-104	surface		016°08.57	48°38.91
non-toxic	5	11/06/2013	016°08.56	48°38.92
JC087-126	200	13/06/2013	016°08.57	48°38.91
	100			
	50			
	30			
	25			
	15			
	5			
JC087-130	surface		016°08.57	48°38.92
JC087-151	4800	14/06/2013	016°08.58	48°38.91
	4500			
	4000			
	3500			
	3000			
	2500			
	2000			
	1500			
	1000			
	800			
	600			
	400			
	300			
	5			

Table 6

Pre-treatment on Board

For particulate lipid determination seawater was filtered through 0.7 µm Whatman GF/F filters pre-burned at 450ºC/5 h. For the surface productive layer (depths 0-50 m) 4 to 5 l of seawater was filtered, while 9 to 11 l of deep seawater (depths 200-4800 m) was filtered. Filters are stored at -80°C until the particulate lipid extraction.

Further Work

Lipids from the collected particles will be extracted by a one-phase solvent mixture of dichloromethane-methanol-water. Ten micrograms of internal standard n-hexadecanone will be added to each sample before the extraction for the estimation of lipid recovery. Extracts will be concentrated under a nitrogen atmosphere and stored at -20 ºC until measurements.

The extracts will be analyzed for lipid classes by a thin-layer chromatography. Eighteen lipid classes (hydrocarbons, wax and steryl esters, fatty acid methyl esters, ketone, triacylglycerols, free fatty acids, alcohols, 1,3-diacylglycerols, sterols, 1,2-diacylglycerols, pigments, monoacylglycerols, mono- and di-galactosyldiacylglycerols, sulfoquinovosyldiacylglycerol, mono- and di-phosphatidylglycerols, phosphatidylethanolamines, and phosphatidylcholine) will be quantified. Also, intact polar diacylglycerolipids will be qualified and quentified by high performance liquid chromatography/electrospray ionization–mass spectrometry. This method determines three classes of phospholipids, three classes of betaine lipids and three classes of glycolipids. If we will have enough samples after first two analysis samples will be analyzed with Fourier transform ion cyclotron resonance mass spectrometry with electrospray ionization. This method distinguishes thousands of compounds of different elemental compositions.

Scientific Outcomes

Investigations of marine organic matter are becoming more popular since carbon capture and sequestration is a possible method of reducing the atmospheric carbon dioxide level. Therefore, studies of OM concentration, production, characterization, cycling and distribution, as well as influential factors, are important. Lipids are good candidates for such studies due to their stable nature compared to carbohydrates and proteins.

To contribute to this important issue several major questions were addressed for this cruise. First, what are the compositional changes in the particulate lipid pool in the surface productive layer during the investigated period? How varying environmental conditions influenced lipid production and composition? Which plankton group influenced the most lipid quantity? It is expected that at low nutrient conditions more glycolipids, molecules without nitrogen or phosphorus, would be synthesized instead of phospholipids representing N - or/and P - conserving mechanism. The distributions of intact polar diacylglycerolipids along the cruise transect should provide important new insights on lipid tentative planktonic sources.

Second, which are the magnitudes and compositional changes in the molecular characteristics of various lipid classes and individual compounds at various depths until bottom layer? Therefore it is aimed to appoint crucial depths at which N and P are removed from the certain lipid classes. Which are the most stable lipids that are surviving transfer from the euphotic zone to the benthic systems being as such good for CO_2 sequestration? It should be elucidated which environmental conditions are responsible for production of those stable lipids.

3.9 Video Plankton Recorder

Fredrika Norrbin

Introduction

The digital autonomous Video Plankton Recorder (daVPR) is a complimentary tool to the plankton nets and marine snow collecting systems used during this cruise. It is an underwater digital video camera with a macro lens and a Xenon strobe synchronized to the frame rate, ca. 20 images s^{-1}. It is also equipped with a Seabird SBE49 CTD and a Wetlabs Ecopuck (fluorometer/ turbidometer). It uses a 24 V Ni-Me-hydride rechargeable battery and stores the data on a detachable flash drive.

Fig. 13 Retrieval of the VPR

Images and environmental data are compressed and written to a zip-file, which has to be processed in the lab. The program Autodeck (Seascan, Inc., USA) extracts images of objects from the compressed file (regions of interest; ROIs) according the user's preferred settings, and simultaneously writes a file with the CTD and Ecopuck data. All data are identified by the time of day in milliseconds (UTC), and exact depth, temperature etc. can thus be interpolated for each ROI image.

3.9.1 Operation

During this cruise the VPR was deployed from the starboard side of the ship, and weighted with a 95 kg iron weight (Fig. 1). It was towed vertically to obtain repeated profiles, at a speed of 50 m min^{-1} (0.83 m s^{-1}). The S2 camera setting was used, giving image dimensions of ca. 22 x 32 mm (26.3 ml volume), each pixel representing ca. 22 µm.

The VPR was profiled either to a wire depth of 1000 m (resulting in a sampling depth of just under 900 m) or to 500 m (Table 1). Battery operation time was limited to ca. two h, so only two down-up profiles were made for the deep tows, and four or five for the 500 m tows.

Deployments were made just after Multinet-tows, and, on some occasions, at dusk and dawn to sample the ascent and descent of plankton layers previously observed by acoustic sensors.

For a few of the stations, images were sorted and data processed during the cruise. The rest of the material will be processed at the home institution. VPR ROI images in this document are all on the same scale.

The extraction settings in AutoDeck were: segmentation 0/142, sobel 30, sd 10, minimum blob size 50, minimum join distance 20, and growth 250%.

Date (VPR yearday)	**Ship station**	**Location**	**VPR #**	**Time start**	**Sampling details**
04.06.2013 d154	JC087-18	PAP-site	**VPR1**	08:19	200 m wire / 4 towyos Trial tow
05.06.2013 d155	JC087-41	PAP-site	**VPR2**	11:24	1000 m wire / 900 m / 2 towyos
05.06.2013 d155	JC087-45	PAP-site	**VPR3**	21:54	1000 m wire/900 m / 2 towyos
06.06.2013 d156	JC087-57	PAP-site	**VPR4**	12:16	1000 m wire/900 m / 2 towyos
07.06.2013 d157	JC087-72	PAP-site	**VPR5**	23:23	1000 m wire/900 m / 2 towyos
10.06.2013 d160	JC087-109	Pelagra location	**VPR6**	21:09	500 m wire / 5 towyos DUSK
11.06.2013 d161	JC087-111	Pelagra location	**VPR7**	03:30	500 m wire / 5 towyos DAWN
11.06.2013 d161	JC087-121	Pelagra location	**VPR8**	00:00	500 m wire / 4 towyos
12.06.2013 d162	JC087-123	Pelagra location	**VPR9**	00:47	500 m wire / 4 towyos
13.06.2013 d163	JC087-135	PAP-site	**VPR10**	20:43	500 m wire / 4 towyos DUSK

Table 7 Sampling Details for the Video Plankton Recorder

3.9.2 Results

The following taxa could be identified in the ROI images with relative ease (the list is not complete):

- Marine snow, including irregular aggregates (Fig. 14) and faecal pellets
- *Trichodesmium*
- Various protozooplankton (Fig 15.), including foraminiferans, radiolarians, sarcodines
- Siphonophores
- Chaetognaths
- Copepod genera, including *Rhincalanus*, *Calanus*, *Metridia*, *Pleuromamma*, *Pseudocalanus*, *Oithona*, *Microsetella*, *Macrosetella*, *Oncaea*
- *Tomopteris*
- Salps and doliolids
- Appendicularians (Fig. 14)

Some of these taxa will be checked for closer identification.

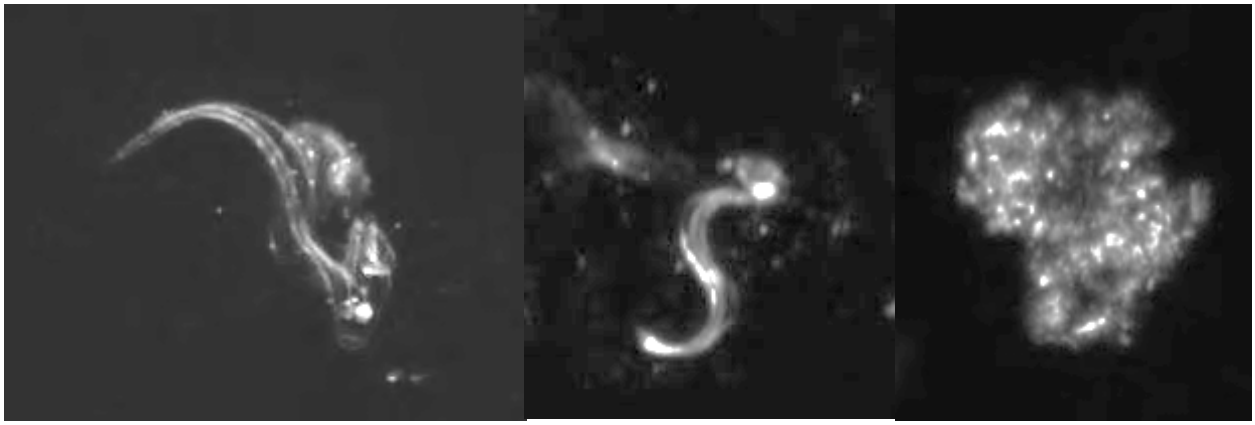

Fig. 14 Appendicularians and marine snow potentially derived from abandoned house.

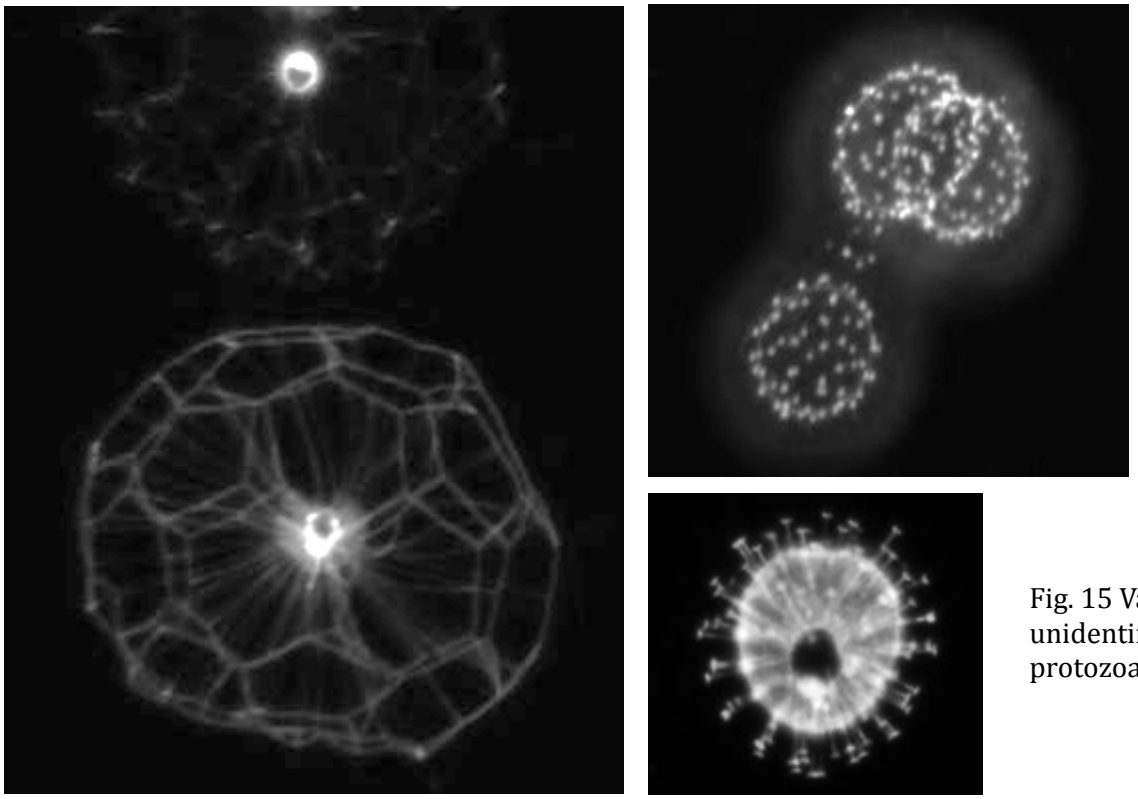

Fig. 15 Various unidentified protozoa

Small copepods of the genera *Microsetella* and *Oncaea* were sometimes observed on marine snow particles (Fig. 16).

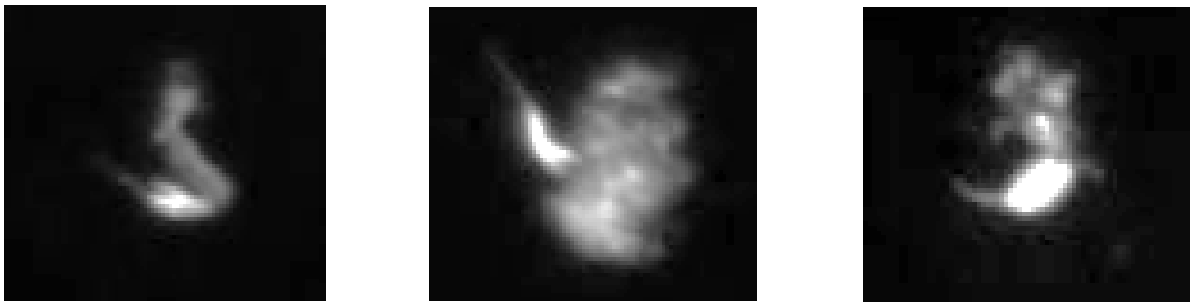

Fig. 16 Microsetella and Oncaea (far right) on particles

For two stations the ROIs were sorted completely, and raw profiles of individual observations were made for abundant plankton taxa and marine snow (Figs. 17 and 18). The marine snow images were divided into categories of image file size, rather than actual particle size. The particles extracted as ROIs are selected in boxes, and a 250% area increase is applied to the image box in order to make identification easier.
The points in the plankton distributions overlap, but it is notable that *Oithona* sp and appendicularians were quite concentrated in the upper 100 m in the noon tow (Fig. 16; *Pseudocalanus* is not sorted separately here), while *Pseudocalanus* sp was concentrated near the surface, but also spread throughout the water column in the night tow (Fig. 18).
It is possible to distinguish a zonation of marine snow in layers, with the large particles more concentrated at 200-300 m depth (deeper at night) and below 600 m (Figs. 17 and 18). Small particles were distributed more evenly in the water column. There was a tendency for fecal pellets to be observed deeper during the day tow than during the night tow, but the data set is quite limited.

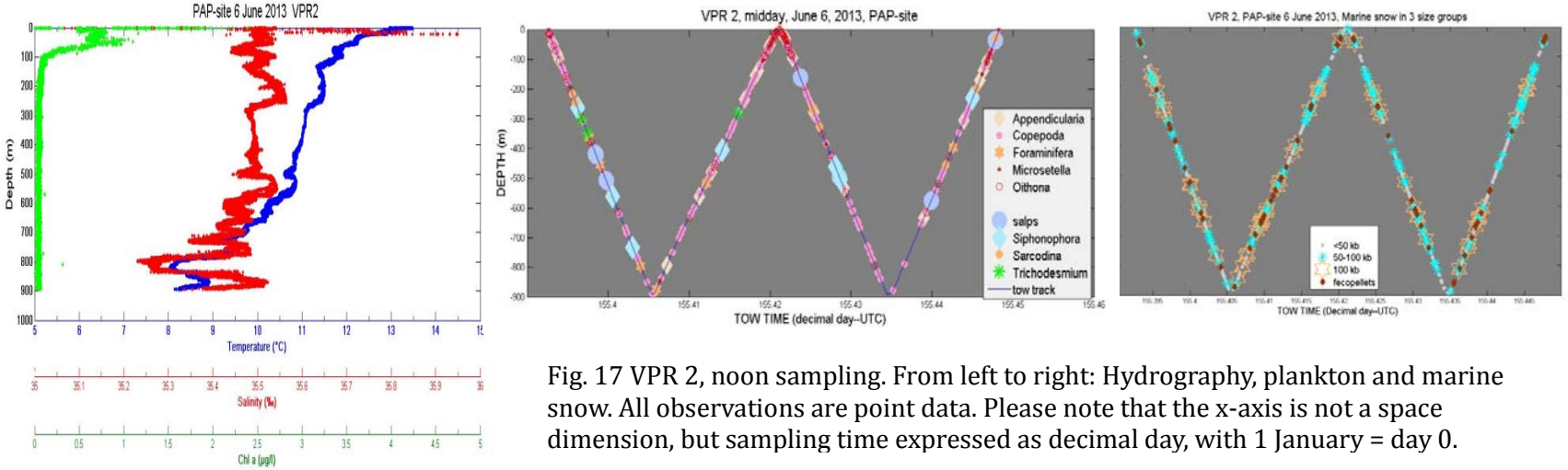

Fig. 17 VPR 2, noon sampling. From left to right: Hydrography, plankton and marine snow. All observations are point data. Please note that the x-axis is not a space dimension, but sampling time expressed as decimal day, with 1 January = day 0.

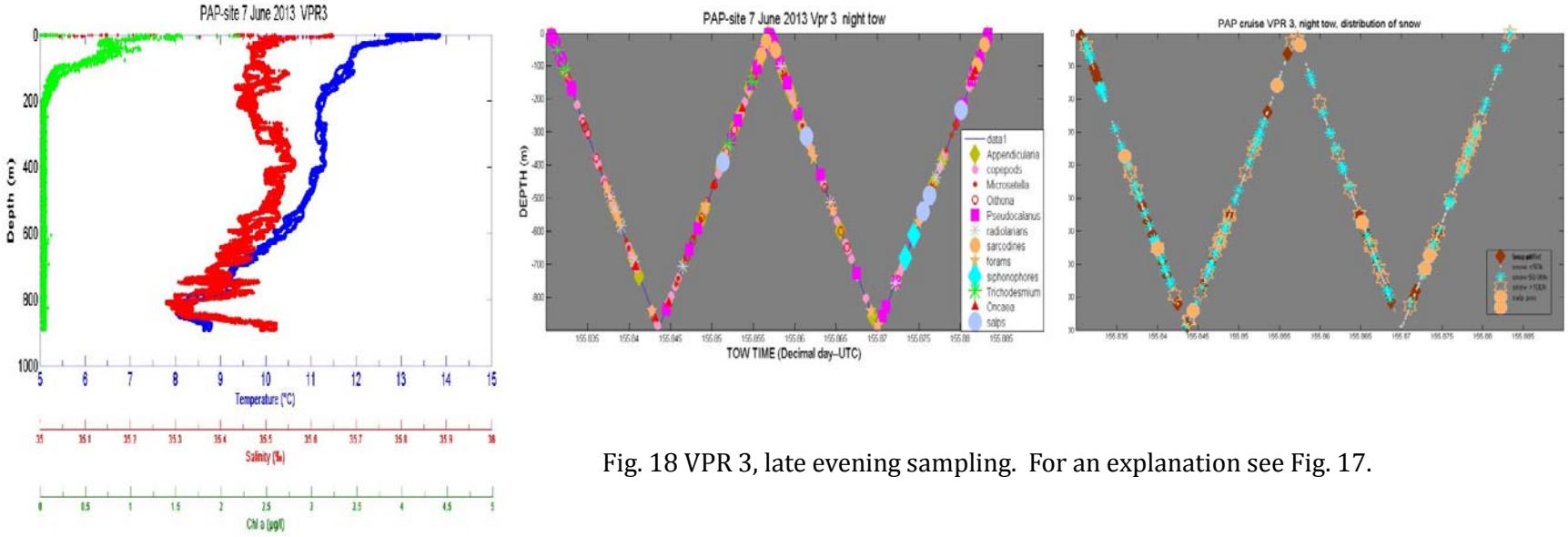

Fig. 18 VPR 3, late evening sampling. For an explanation see Fig. 17.

3.10 Marine Snow Analysis

Anna Belcher

Objectives and Aims

The aim of the cruise was to piece together surface and export processes, gathering simultaneous observations of the plankton community structure in the surface ocean, and the composition and magnitude of sinking particles at depth. The marine snow catcher (MSC) was utilised to collect marine snow particles from the water column and examine the size, composition and abundance of marine snow material at different depths and make estimates of particle flux. As such it was aimed to use the MSC to:

1) Measure any variation in the particle flux (in terms of magnitude, particle size and composition) with depth
2) Measure the sinking rates of particles to investigate any relationship with particle size
3) Collect water from the MSC to measure the particulate organic carbon (POC), particulate inorganic carbon (PIC), biogenic silica (BSi), and chlorophyll (Chl) in the suspended and slow sinking carbon pools
4) Identify composition of suspended and slow-sinking fluxes using organic geochemical (OC) analysis
5) Attempt to calculate POC export from the obtained data

Methods

95 litres of water were collected in each of two marine snow catchers (a PVC closing water bottle designed to minimise turbulence) at 10m and 110m below the mixed layer depth (determined from the most recent CTD profile). The two MSC's were deployed one after the other to provide a depth comparison for a particular station, with deployments were carried out at a range of times during the day. As soon as the MSCs were on deck, an initial two litre sample was taken from the bottom tap on the MSCs. The MSCs were then left upright for two hours to allow the marine snow particles to sink to the bottom and to be able to distinguish between suspended and sinking pools. One litre of the initial sample (Time zero - T_0 sample) was filtered immediately for POC and represents the homogenous water column. The remaining litre was left to stand for two hours before also being filtered for POC (T_2 sample).

After standing for two hours, a four litre sample was taken from the bottom tap of the MSC representing the suspended pool, before draining the remaining top 82 litres. The bottom section of the MSC containing 7 litres of water and settled particles was then removed. A four litre sample was siphoned out of the base section (representing the slow sinking pool) before carrying the bottom section to a 12°C temperature controlled

laboratory. Water samples collected from both the top and base sections of the MSC were filtered for analysis of POC. PIC, POC, BSi, Chl and OC analysis.

Particles that had settled to the base of the bottom chamber were removed using a wide-bore pipette and photographed using a Müller DCM310 microscope camera and Technico XE series microscope. These particles represent the fast sinking pool. In addition, sinking rate experiments using a flow chamber (Ploug and Jørgensen, 1999; Ploug et al., 2010) were carried out on 10-15 particles from each MSC. Each aggregate was carefully placed in a 10cm high Plexiglas tube (5cm diameter), on a net extended across middle of the tube. Flow is supplied from below the net, adjusted using a needle valve, resulting in a uniform flow field across the upper chamber. The flow was adjusted so that the particle is suspended one particle diameter above the net. At this point the sinking velocity is balanced by the upward flow velocity (Ploug et al., 2010), and can be calculated by dividing the flow rate by the area of the flow chamber. Three measurements of the sinking velocity were made for each particle and the x, y, and z dimensions measured using a horizontal dissection microscope with a calibrated ocular. The particles that were sunk were preserved individually in ependorf tubes and stored in a -20°C freezer.

Filter Sample Preparation, Preservation and Analysis:

POC: Each sample was filtered through a 0.7µm pore size, 25mm diameter, ashed GFF filter, rinsed with milliQ water, placed in a Petri dish, air dried and stored at room temperature for later analysis.

PIC: Each sample was filtered through a 0.8µm pore size, 25mm diameter, nucleopore polycarbonate membrane filter, rinsed with milliQ water, stored in a cryotube vial, air dried and stored at room temperature for later analysis.

BSi: Each sample was filtered through 0.8µm pore size, 25mm diameter, nucleopore polycarbonate membrane filter, rinsed with milliQ water, stored in a centrifuge tube, air dried and stored at room temperature for later analysis.

Chl: Each sample was filtered through at 0.7µm pore size, 25mm diameter, ashed GFF filter, rinsed with milliQ water and placed in a glass vial. 8ml 90% acetone was added and the vial stored in a fridge for 18-20 hours before onboard analysis on a fluorometer.

OC: Each sample was filtered through at 0.7µm pore size, 25mm diameter, pre-weighed ashed GFF filters, rinsed with milliQ water, placed foil and stored at -80 °C for later analysis.

Preliminary Results

During the cruise a total of 15 snow catcher deployments were made (Table 8), 14 of which were successful due to one messenger misfire.

Table 9 details the water samples taken from each MSC deployment. The slow sinking water and particles from the base of the MSC were lost from MSC B at station 83 due to a broken seal on the MSC.

Date	Julian Day	Station	Latitude	Longitude	MSC	Depth (m)	Time (GMT)
04/06/2013	155	10	48°38.69	016°08.42	A	30	00:08
		10	48°38.69	016°08.42	B	130	00:32
05/06/2013	156	38	48°38.92	016°08.58	B	70	09:10
		39	48°38.92	016°08.58	A	170	09:40
07/06/2013	158	63	48°38.91	016°08.57	A	45	04:45
		64	48°38.91	016°08.57	B	145	05:14
		70	48°38.92	016°08.75	A	45	21:08
		71	48°38.92	016°08.75	B	145	21:37
09/06/2013	160	82	48°38.94	016°08.58	A	45	05:48
		83	48°38.94	016°08.58	B	145	06:07
11/06/2013	162	112	48°38.91	016°08.58	A	Misfire	
		113	48°38.91	016°08.57	A	40	07:43
		114	48°38.91	016°08.57	B	140	08:05
13/06/2013	164	133	48°38.92	016°08.58	A	60	14:26
		133	48°38.92	016°08.52	B	160	14:56

Table 8 Details of MSC deployments at the 'Twilight Station'.

		Initial (T_0, T_2) (volume, ml)	Suspended (SP) (volume, ml)					Slow Sinking (SS) (volume, ml)				
Station	MSC	POC	POC	PIC	BSi	Chl	OC	POC	PIC	BSi	Chl	OC
10	A	1000	1000	500	500	250	1000	1000	500	500	250	1000
10	B	1000	1000	500	500	250	1000	1000	500	500	250	1000
38	B	1000	1000	500	500	250	1000	1000	500	500	250	1000
39	A	1000	1000	500	500	250	1000	1000	500	500	250	1000
63	A	1000	1000	500	500	250	1000	1000	500	500	250	1000
64	B	1000	1000	500	500	250	1000	1000	500	500	250	1000
70	A	1000	1000	500	500	250	1000	1000	500	500	225	1000
71	B	1000	1000	500	500	225	1000	1000	500	500	250	1000
82	A	1000	1000	500	500	260	1000	1000	500	500	250	1000
83	B	1000, (T_2 only 100)	1000	500	500	250	1000	Sample lost as seal on catcher damaged				
112	A	No sample due to messenger misfire										

113	A	1000	1000	500	500	250	1000	1000	500	500	250	1000
114	B	1000	1000	500	500	230	1000	1000	500	500	250	1000
133	A	1000	1000	500	500	250	1000	1000	500	500	250	1000
133	B	1000	1000	500	500	250	1000	1000	500	500	250	1000

Table 9 Summary of water samples and volumes taken from MSC.

The use of two MSC's allows for comparison of sinking material with depth at a particular station. It was noted for all stations that much less material was recorded in the deeper snow catcher. Both deep (110 m below the mixed layer) and shallow (10 m below the mixed layer) MSC samples consisted mostly of marine snow particles, with some faecal pellets and occasionally foraminifera, copepods or diatom tests (Fig. 19).

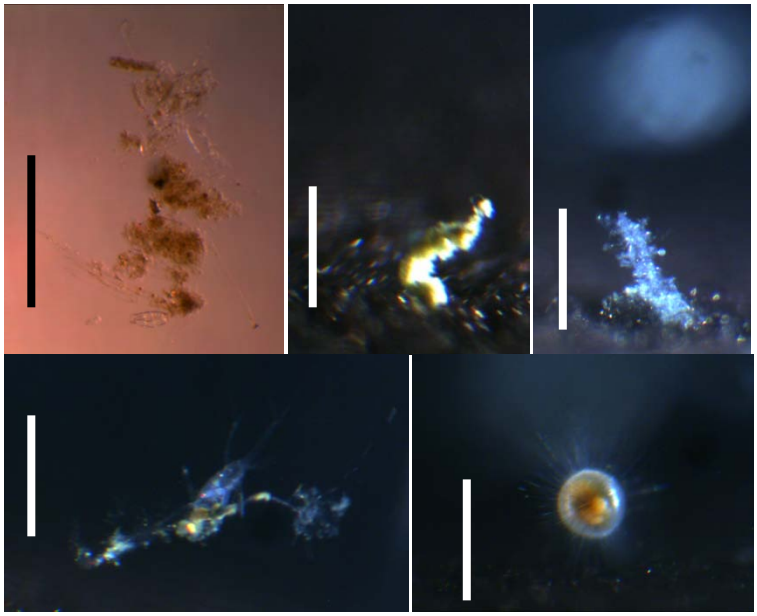

Fig. 19 Examples of particles recovered in marine snow catcher. Scale bar = 1mm

The results of on board sinking rate experiments revealed that typically, for a particular size, faecal pellets sank faster than marine snow particles. A preliminary look at measured data reveals a weak positive relationship between sinking rate and particle size, although there was much scatter. This is likely due to the complex structure of marine snow particles, with many irregularities that cannot be fully described by simple x, y, z measurements and volume calculations for an ellipse. Similarly it was visually evident that the composition of marine snow particles varied, resulting in density differences and hence influencing the sinking velocity.

Sinking velocities ranged from 5 – 379 m/day and equivalent spherical diameters ranged from 0.16 – 1.70mm.

Further results will be worked up following laboratory analysis of sample filters (POC, PIC, BSi, Chl and OC) to support the PhD thesis of Emma Cavan. It will then be possible to calculate the sinking rates and export of slow sinking material. An estimate of the fast sinking POC flux will be made based on microscope photographs and volume calculations of particles (Alldredge et al., 1998). Data from the MSC will be compared with other data collected from the cruise, such as CTD data, PELAGRA trap data and information on surface biological community structure from plankton net tows, to explain any variations and trends in particle size, composition and export.

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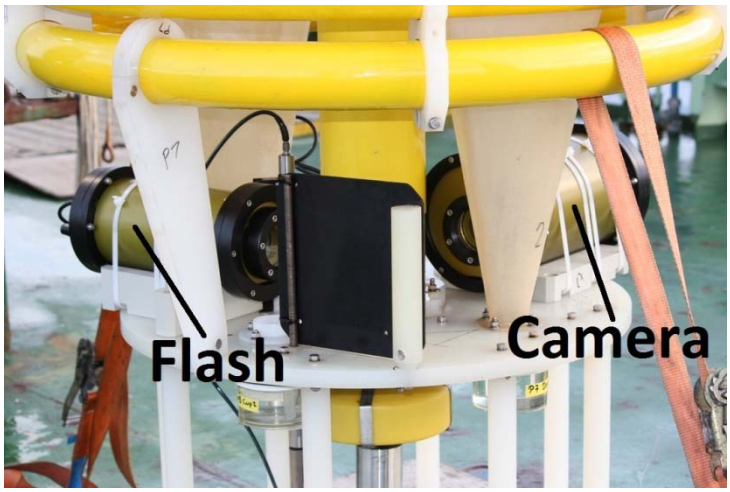
3.11 Pelagra

Kev Saw

Two Pelagra traps, P4 and P7, were modified to allow gel sampling and particle imaging as follows:

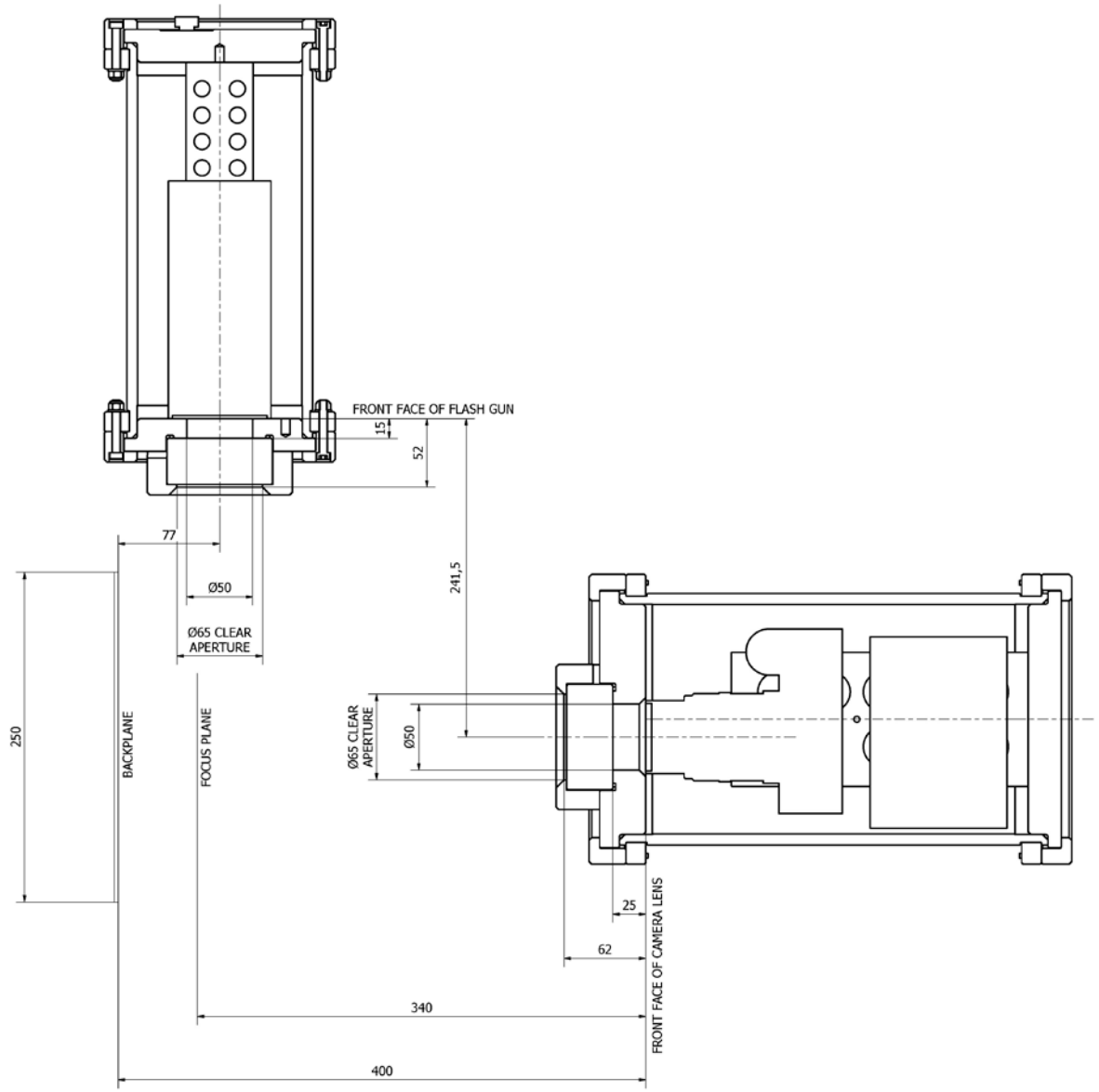
- Funnels 1 and 4 were removed to leave just the ~50mm diameter sample cup holes for collecting gel samples.
- The gel sample holes were fitted with 20mm high upstands to prevent particles that settle on the base plate being washed in.
- Both traps were fitted with newly designed and built camera and flash units for recording *in-situ* images of sinking particles
- The photographic setup consisted of the following components:
    - Canon EOS 6D digital SLR camera
    - Canon Speedlite 600EX-RT flash gun
    - Quantum Turbo 3 battery pack
    - Hahnel Giga T Pro II remote timer
- The camera, timer and battery pack were mounted in one pressure housing and the flash gun in another. The two housings were connected with cables to

provide power and signals to the flash gun. A black plastic back plane was fitted in front of the camera to contain the imaged volume.



The intention was to set the cameras to take groups of 10 repeated shots at 2 second intervals, every hour for at least 2 days. During two initial 'real-time' tests at NOC, the Quantum battery packs only lasted for 24 hours and 29 hours respectively. Further tests once on board produced similar results and it was concluded that whilst the Quantum batteries were very effective in recharging the flash gun rapidly, they were not suitable for providing long-term power. Further tests revealed that the flash guns' internal batteries (4 x AA cells) were sufficient for 2 days of images taken at the intended schedule. Consequently, the Quantum battery packs were used to power only the cameras and the flash guns were powered from their internal AA batteries.

Camera and flash geometry layout (plan view):



3.11.1 Camera Test

3.11.1.1 Station JC87-02

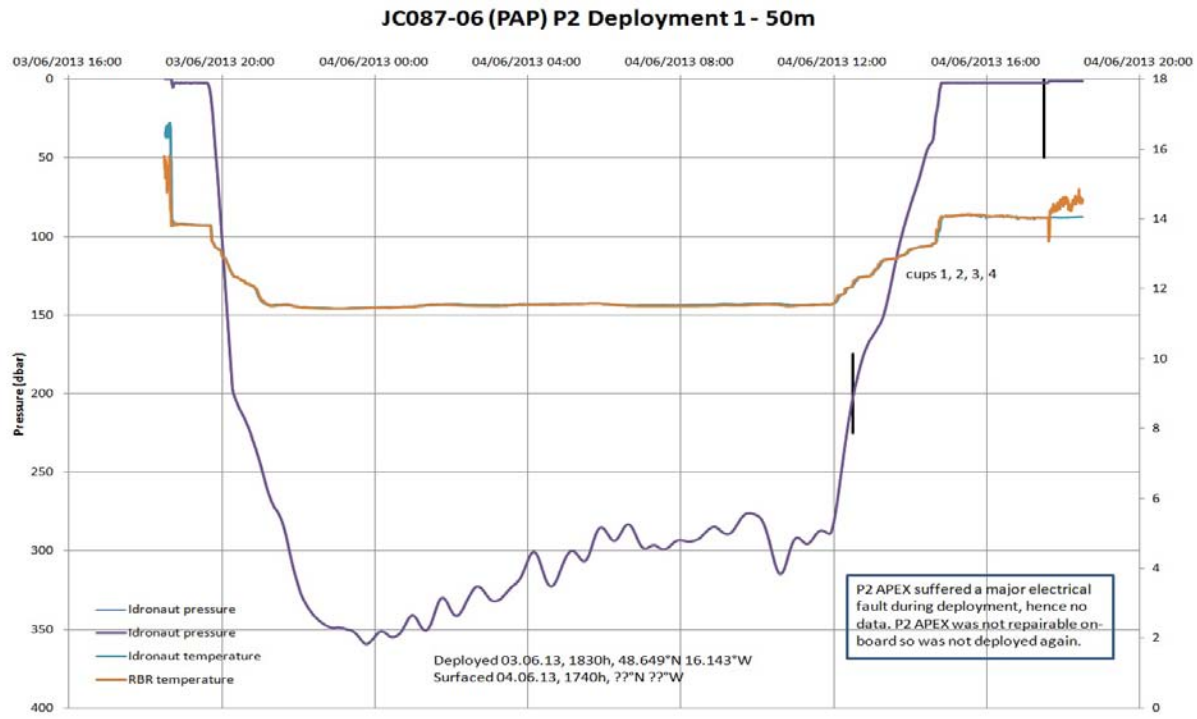
One camera system, fitted to a Pelagra trap, was deployed on a wire to 200m from the starboard gantry. This was to test the camera system *in-situ* and to gain a profile of particle abundance. This was a successful test.

3.11.2 Deployment 1 (Ballast Tests)

P4 and P7 had been fully re-ballasted at NOC as they had undergone major modifications. It was felt prudent that these traps should be deployed for a short mission to check that ballasting was correct. P2 and P5 were also to be checked as they had had fewer deployments on previous cruises and the ballasting was less certain. However, as the deployment over-ran its allotted time it was decided that P5 would not be deployed.

3.11.2.1 P2, Station JC87-06

Target depth: 50m
Duration: 24 hours
Added ballast: 3946g (this was 50g less than spreadsheet prediction based on previous cruise experience)
Sample cups: All open for 6 hours



P2 was over-ballasted to some degree but appears to have begun adjusting itself up. However at some point (possibly around 1200h on 14/6) the APEX float suffered a major electrical fault and ceased to function - see figures 19 &20. Consequently no position data were transmitted on surfacing and it was by chance that P2 was spotted from the bridge and recovered.

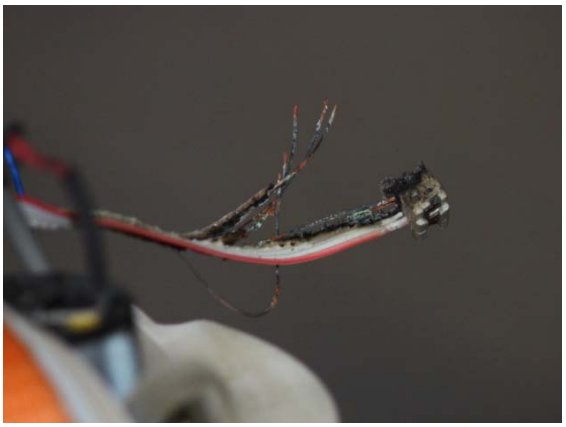


Fig. 20

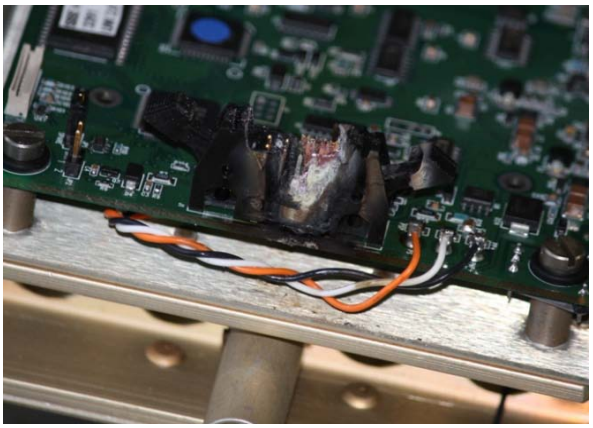
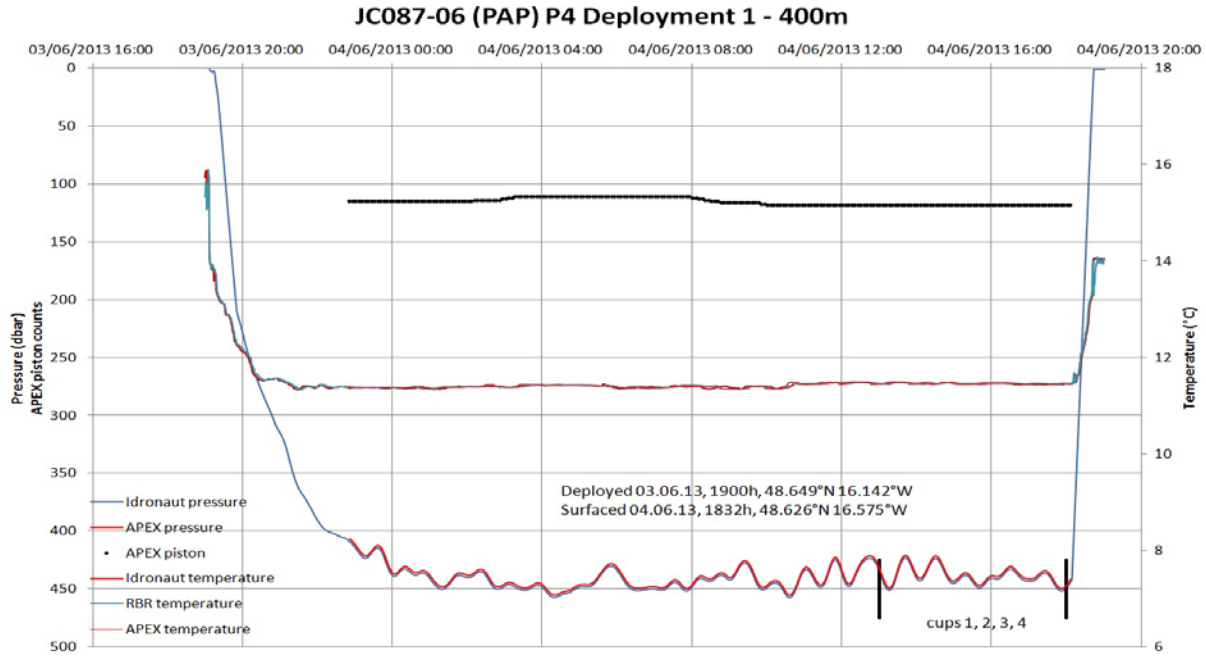


Fig. 21

3.11.2.2 P4, Station JC87-06

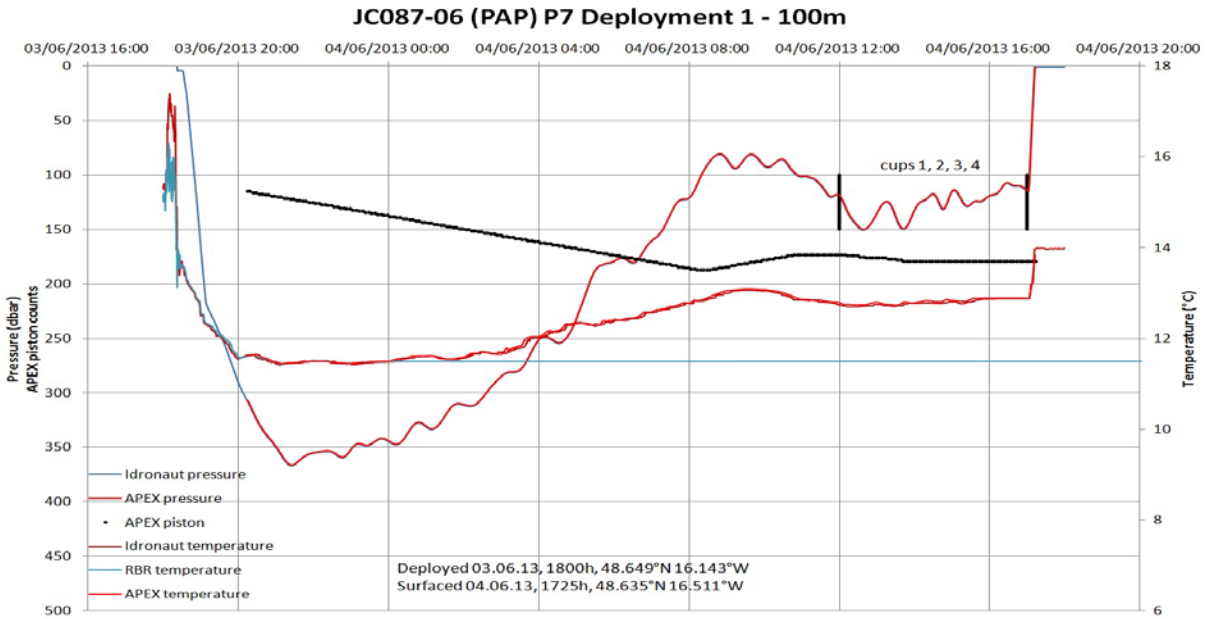
Target depth: 400m
Duration: 24 hours
Added ballast: 4655g (as predicted by ballast spreadsheet)
Sample cups: All open for 6 hours



P4 was correctly ballasted. Camera system functioned as expected.

3.11.2.3 P7, Station JC87-06

Target depth: 100m
Duration: 24 hours
Added ballast: 4622g (as predicted by ballast spreadsheet)
Sample cups: All open for 6 hours



P7 was a little over-ballasted but successfully recovered to close to 100m. Camera system functioned as expected.

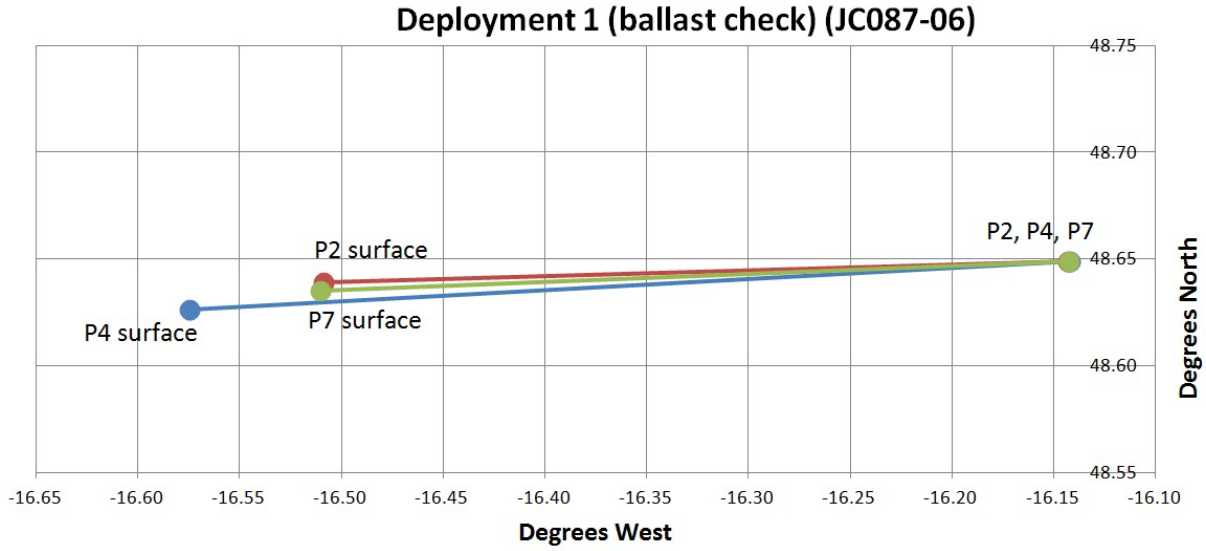
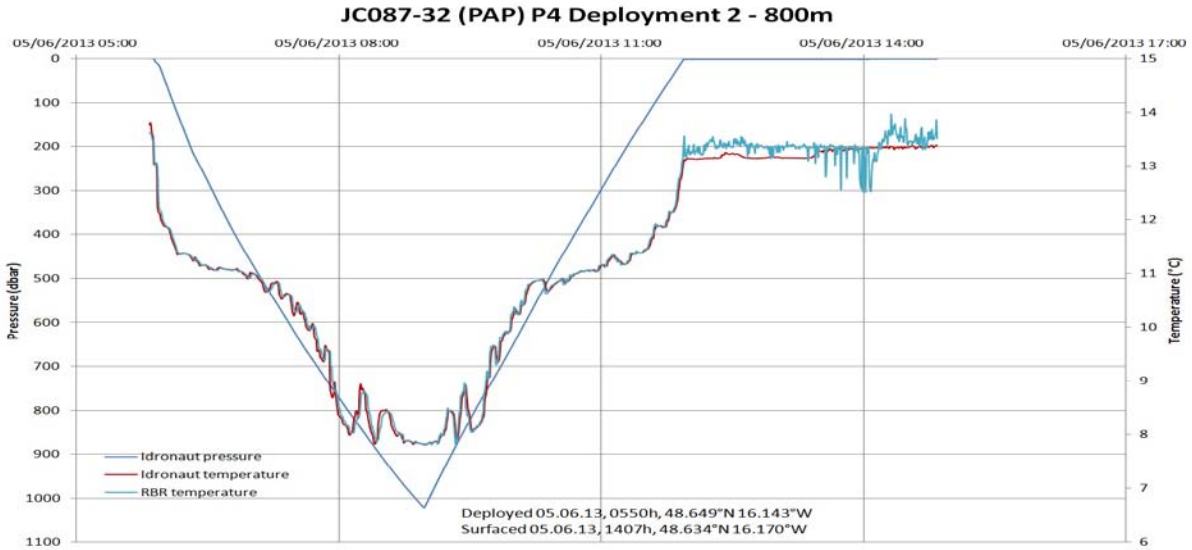


Fig. 22 Deployment 1 Drift Tracks

3.11.3 Deployment 2

3.11.3.1 P4, station JC87-32

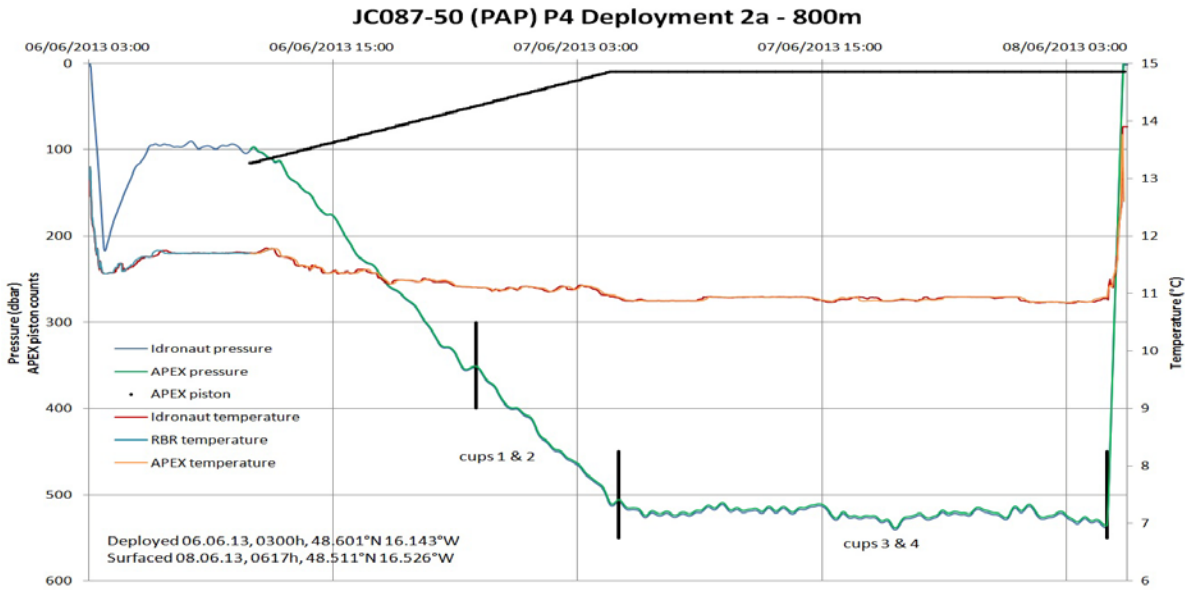
Target depth: 800m
Duration: 72 hours
Added ballast: 4855g (as predicted by ballast spreadsheet)
Sample cups: 1 & 2 then 3 & 4, 24 hours each pair



P4 was over-ballasted, dropped its emergency abort weight at a little over 1000m and surfaced.

3.11.3.2 P4a Redeployment, Station JC87-50

Target depth: 800m
Duration: 51 hours
Added ballast: 4312g (recalculated with adjustments for backplane weight estimate errors)
Sample cups: 1 & 2 for 7 hours (night) then 3 & 4 for 24 hours



P4 was under-ballasted, adjusted to minimum buoyancy but only achieved 520m depth and was still descending when cups 1 and 2 opened. Camera system functioned as expected.

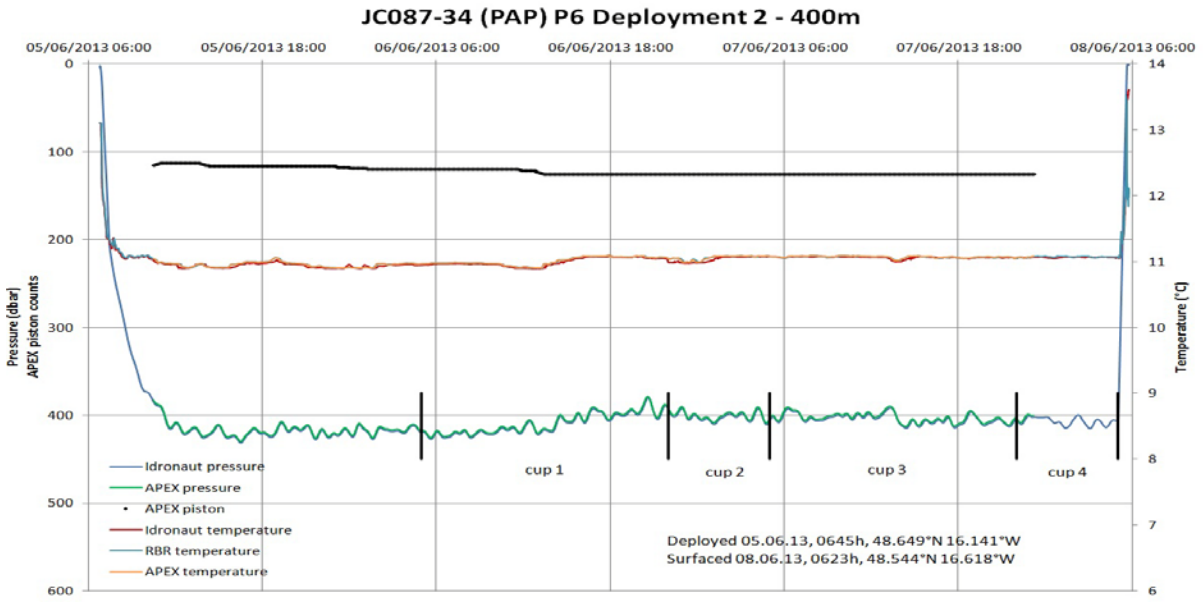
3.11.3.3 P5, Station JC87-33

Target depth: 100m
Duration: 72 hours
Added ballast: 3937g (as predicted by ballast spreadsheet)
Sample cups: 1, 17 hours (day); 2, 7 hours (night); 3, 17 hours (day); 4, 7 hours (night)

There has been no sign from P5 since this deployment. It is likely that it was over-ballasted and that its emergency abort release did not function, thereby causing it to sink below its rated depth and implode. P5 is considered lost.

3.11.3.4 P6, Station JC87-34

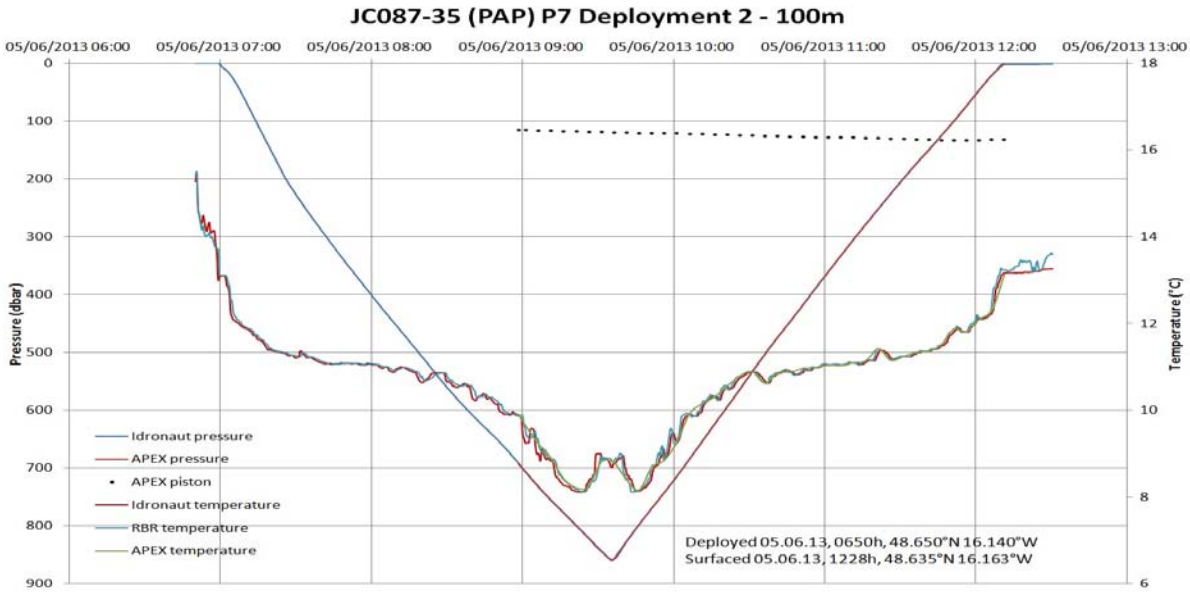
Target depth: 400m
Duration: 72 hours
Added ballast: 3900g (as predicted by ballast spreadsheet)
Sample cups: 1, 17 hours (day); 2, 7 hours (night); 3, 17 hours (day); 4, 7 hours (night)



P6 was ballasted correctly. Cup 3 was open on recovery, apparently having jammed; therefore cup 4 didn't open at all. Opening mechanism tested on deck and all seemed well.

3.11.3.5 P7, Station JC87-35

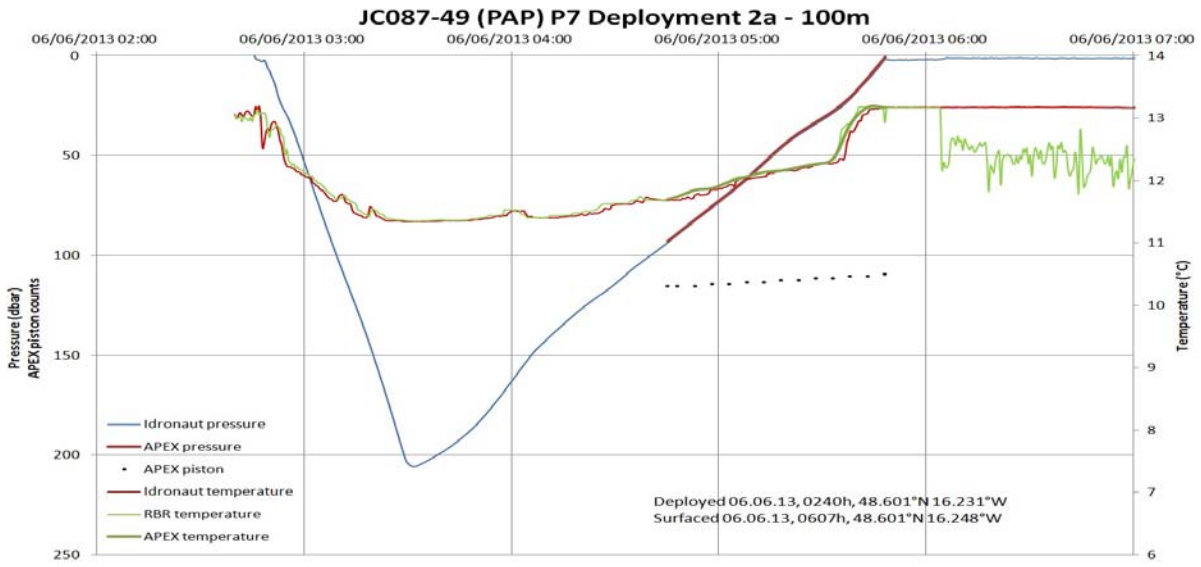
Target depth: 100m
Duration: 72 hours
Added ballast: 4793g (as predicted by ballast spreadsheet)
Sample cups: 1 & 2 for 17 hours (day) then 3 & 4 for 7 hours (night)



P7 was over-ballasted, dropped its emergency abort weight at 850m and surfaced.

3.11.3.6 P7a Redeployment, Station JC87-49

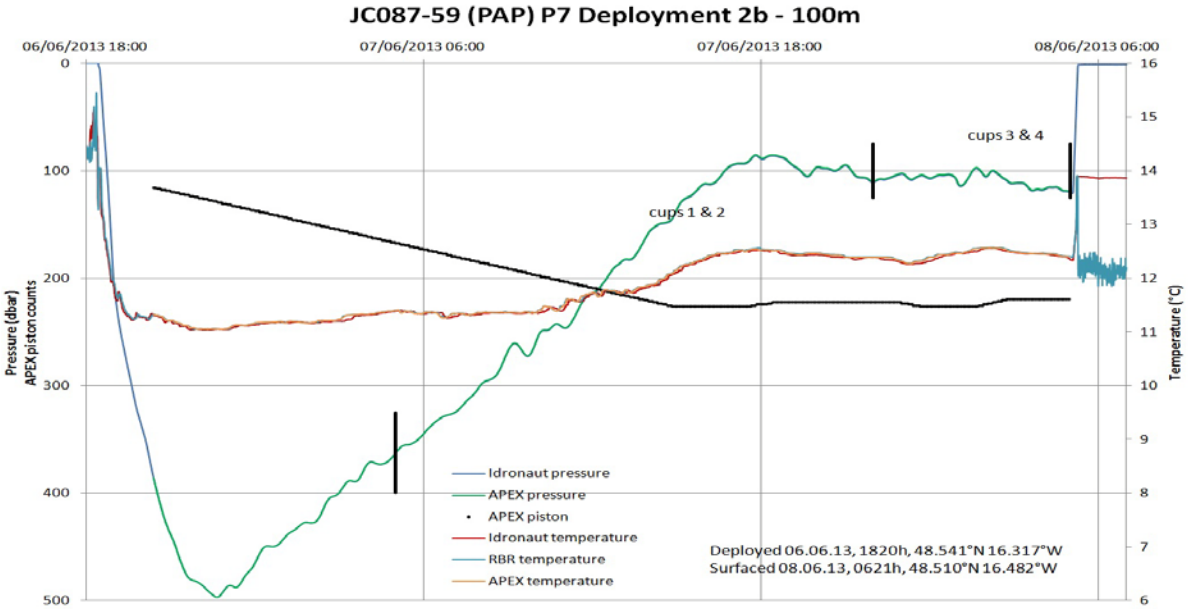
Target depth: 100m
Duration: 50 hours
Added ballast: 4312g (recalculated with adjustments for backplane weight estimate errors)
Sample cups: 1 & 2 for 17 hours (day) then 3 & 4 for 7 hours (night)



P7 was under-ballasted. APEX attempted to adjust but couldn't do so quickly enough.

3.11.3.7 P7b Redeployment, Station JC87-59

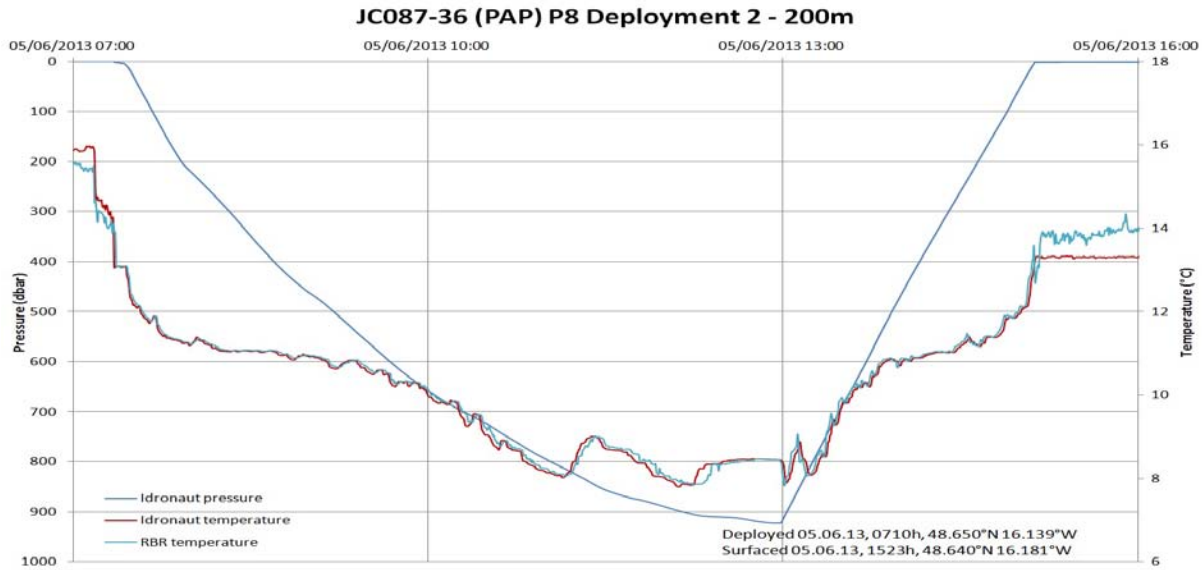
Target depth: 100m
Duration: 50 hours
Added ballast: 4250g
Sample cups: 1 & 2 for 17 hours (day) then 3 & 4 for 7 hours (night)



P7 was a little over-ballasted and recovered to 100m but not before cups 1 and 2 opened. Cups 1 and 4 were half open on recovery (jammed?). Camera system functioned as expected.

3.11.3.8 P8, Station JC87-36

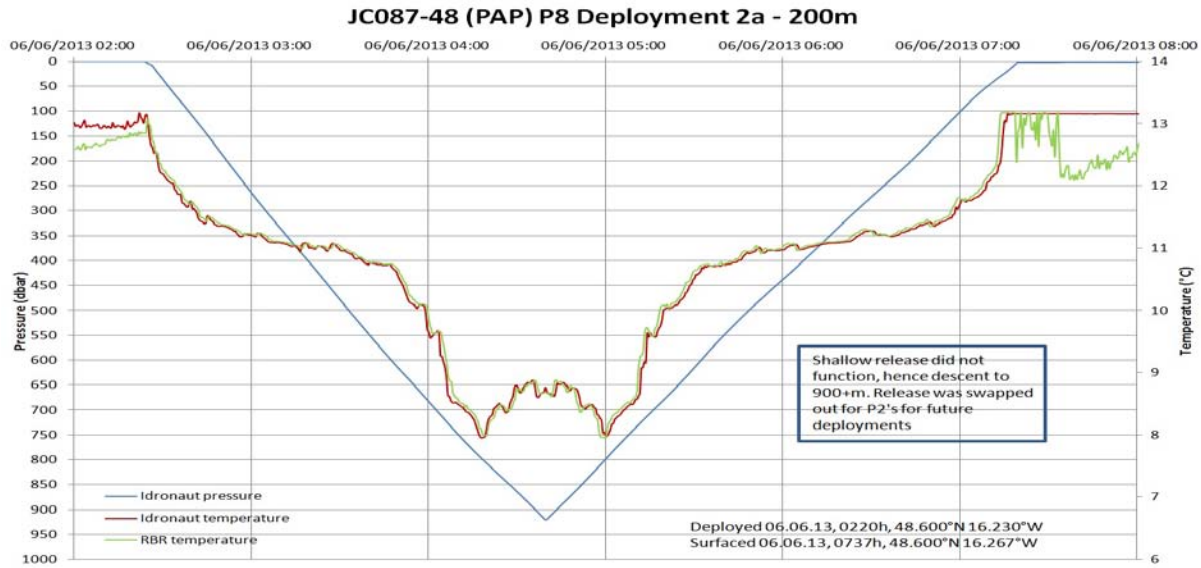
Target depth: 200m
Duration: 70 hours
Added ballast: 3844g (as predicted by ballast spreadsheet but incorrect CTD data was used)
Sample cups: 1 for 17 hours (day); 2 for 7 hours (night); 3 for 17 hours (day); 4 for 7 hours (night)



P8 was over-ballasted, dropped its emergency abort weight at 920m and surfaced.

3.11.3.9 P8a Redeployment, Station JC87-36

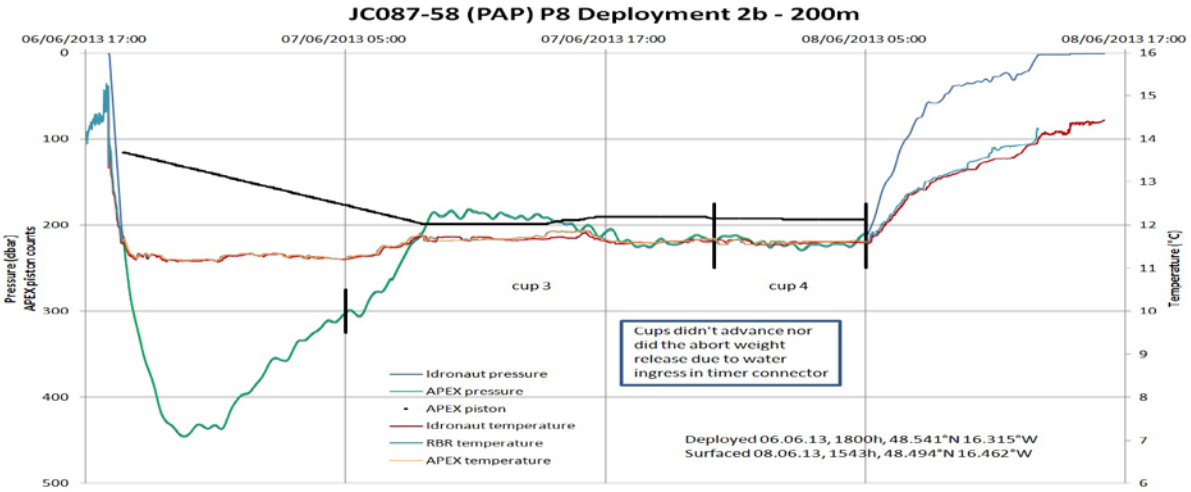
Target depth: 200m
Duration: 50 hours
Added ballast: 3700g (as predicted by ballast spreadsheet with corrected CTD data)
Sample cups: 1 for 17 hours (day); 2 for 7 hours (night); 3 for 17 hours (day); 4 for 7 hours (night)



P8 recovered with depressor weight still attached. Shallow release was swapped with P2 which had previously functioned OK.

3.11.3.10 P8b Redeployment, Station JC87-58

Target depth: 200m
Duration: 35 hours
Added ballast: 3700g (as predicted by ballast spreadsheet with corrected CTD data)
Sample cups: 3 for 17 hours (day); 4 for 7 hours (night)



Ballasting was satisfactory. Recovered with cup 1 open and slow ascent indicating that abort weight did not release. On inspection the timer connector was found to be loose and flooded which prevented any control beyond cup 1 opening. The timer connector was replaced ready for next deployment.

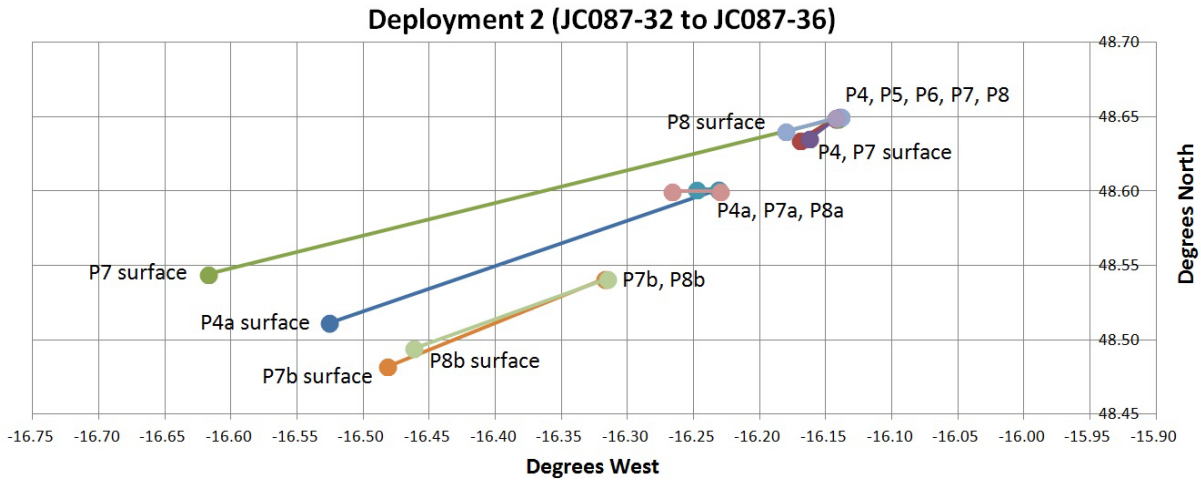
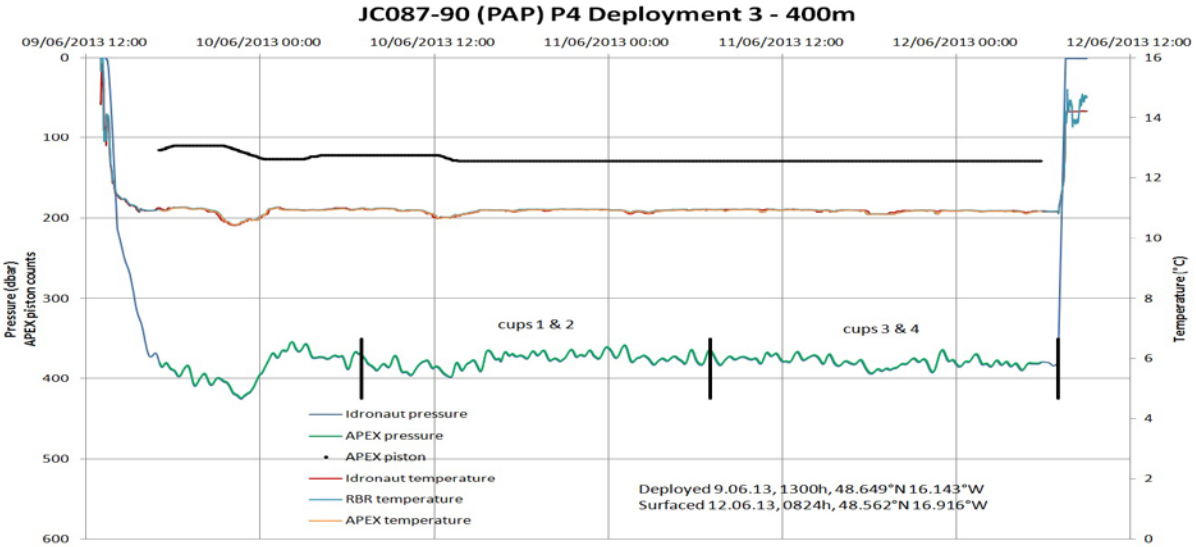


Fig. 23 Deployment 2 Drift Tracks

3.11.4 Deployment 3

3.11.4.1 P4, Station JC87-90

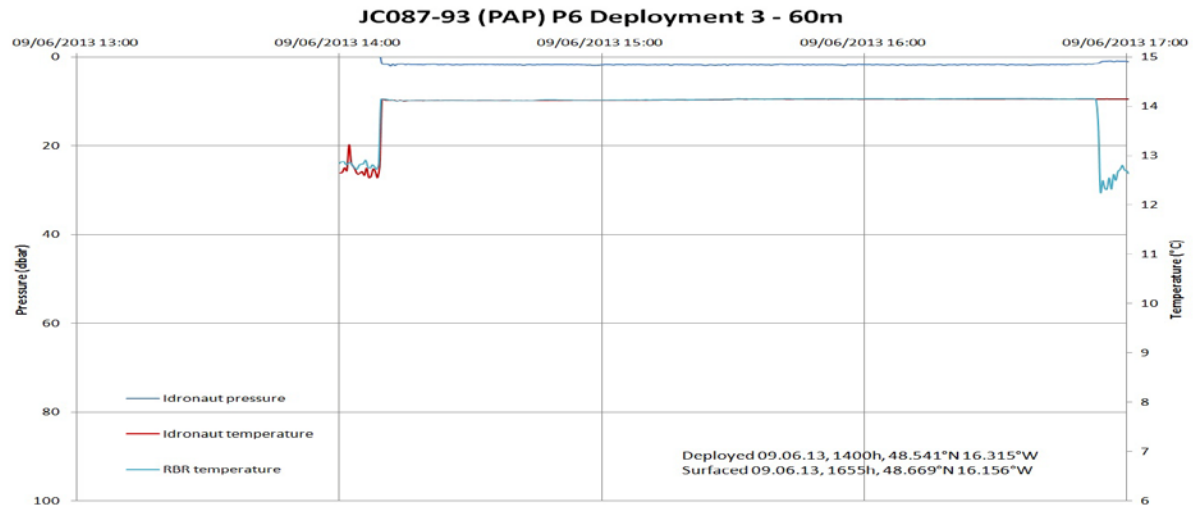
Target depth: 400m
Duration: 66 hours
Added ballast: 4402g (as predicted by ballast spreadsheet + 90g based on previous deployment being under-ballasted)
Sample cups: 1 & 2 then 3 & 4, 24 hours each pair



P4 was ballasted correctly. Collision with ship's side on recovery caused damage to camera end clamp and flash power connector. Camera system functioned as expected.

3.11.4.2 P6, Station JC87-93

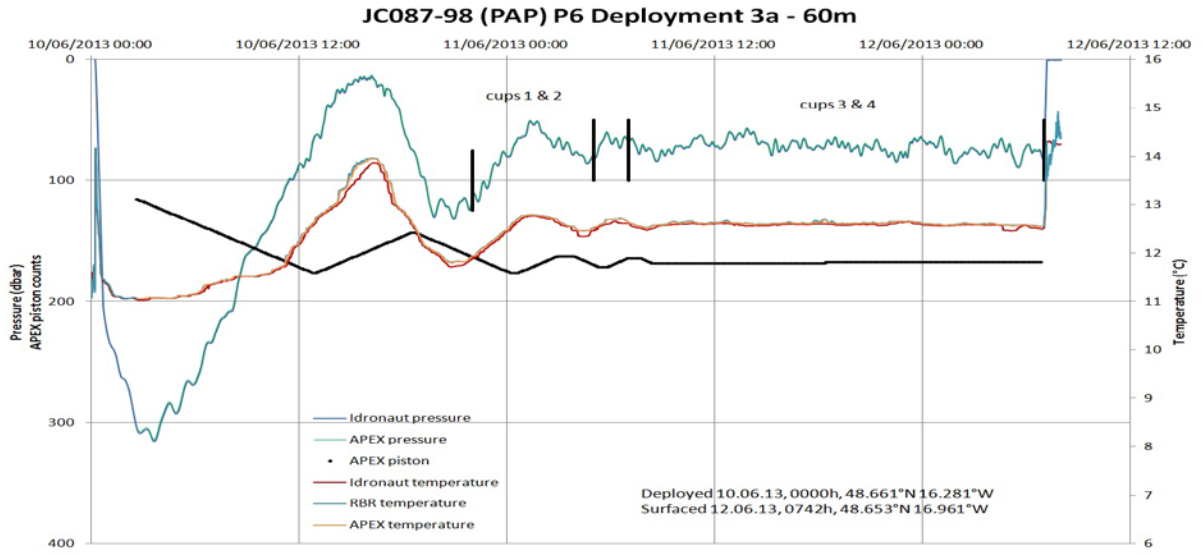
Target depth: 60m
Duration: 65 hours
Added ballast: 3930g (as predicted by ballast spreadsheet + 30g based on previous deployment being under-ballasted)
Sample cups: 1 & 2 then 3 & 4, 24 hours each pair



P6 did not sink. It is not entirely clear why but probably because abort weight fell off on deployment.

3.11.4.3 P6a Redeployment, Station JC87-98

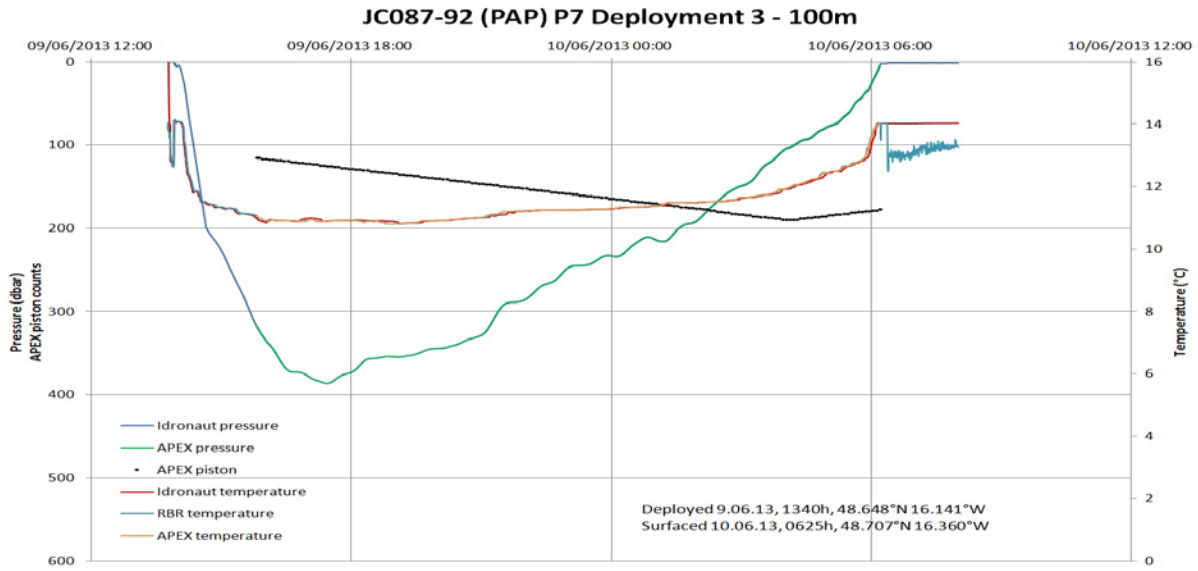
Target depth: 60m
Duration: 55 hours
Added ballast: 3864g (as predicted by ballast spreadsheet + 12g as for 200m to prevent premature surfacing).
Sample cups: 1 & 2, 7 hours (night); 3 & 4, 24 hours



P6 was a little over-ballasted but managed to recover to 60m. Sufficient stability during cups 1 and 2 opening is questionable. Cups 4 and 1 were not quite fully closed; on inspection the motor was sticking – swapped with P2.

3.11.4.4 P7, Station JC87-92

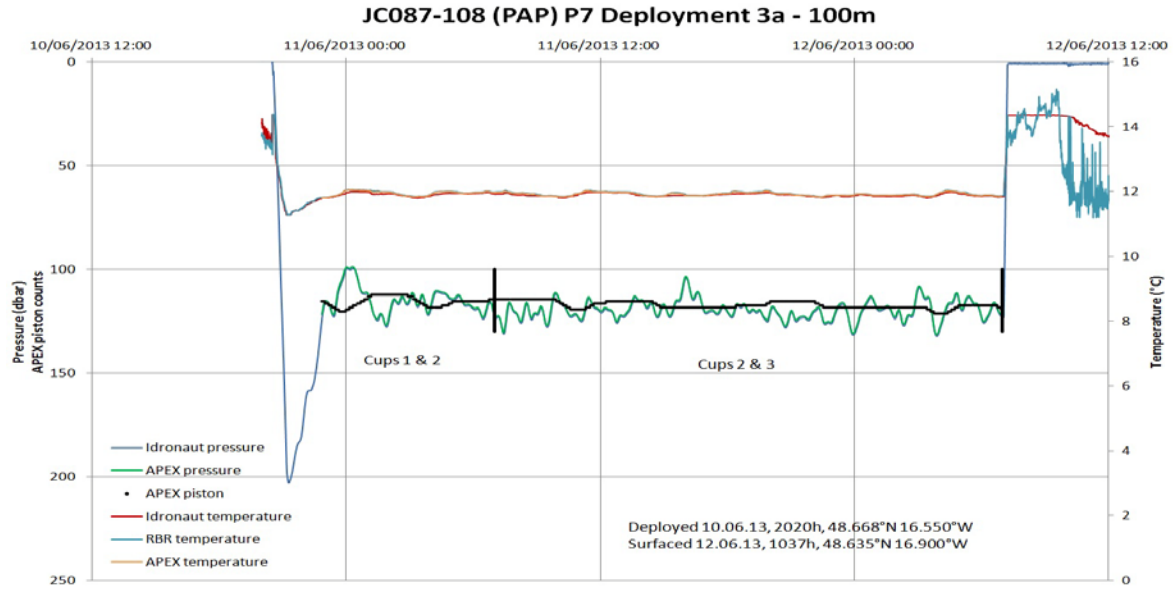
Target depth: 100m
Duration: 65 hours
Added ballast: 4343g (as predicted by ballast spreadsheet -100g based on previous deployment).
Sample cups: 1 & 2 then 3 & 4, 24 hours each pair



P7 was over-ballasted and then over-compensated resulting in premature surfacing.

3.11.4.5 P7a Redeployment, Station JC87-108

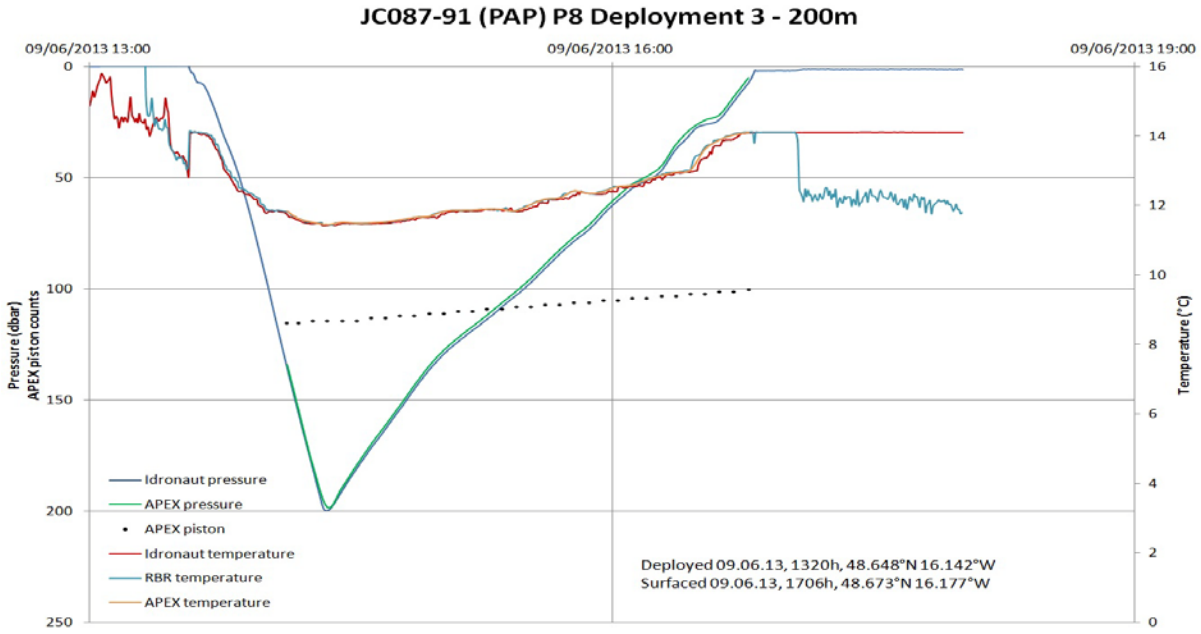
Target depth: 100m
Duration: 35 hours
Added ballast: 4290g (previous ballast -53g based on previous deployment).
Sample cups: 1 & 2 then 3 & 4, 24 hours each pair



Ballasted correctly. Camera system functioned as expected.

3.11.4.6 P8, Station JC87-91

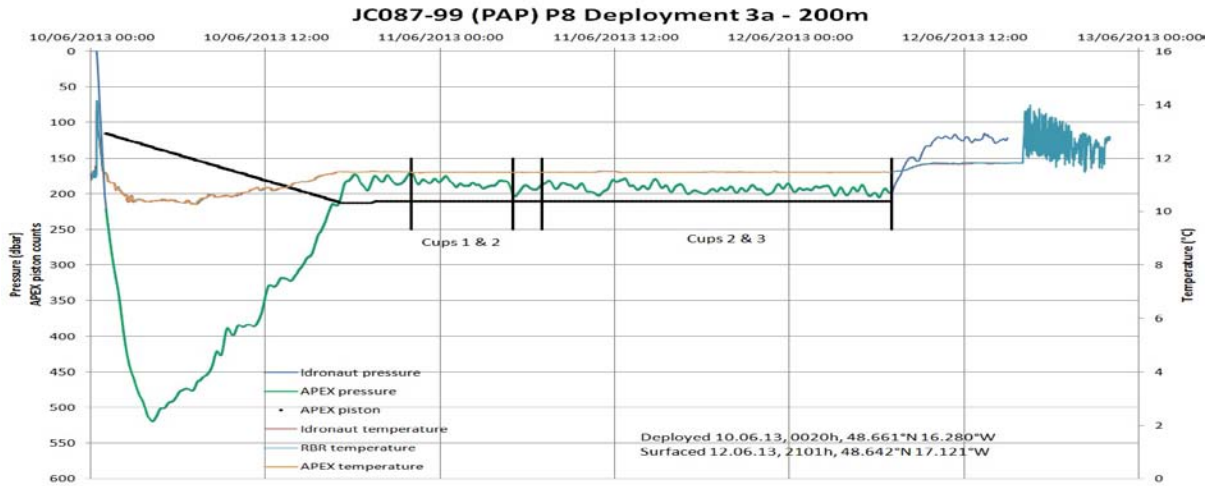
Target depth: 100m
Duration: 65 hours
Added ballast: 3610g (previous ballast -90g based on previous deployment).
Sample cups: 1 & 2 then 3 & 4, 24 hours each pair



P8 under-ballasted; could not recover in time.

3.11.4.7 P8a redeployment, station JC87-99

Target depth: 100m
Duration: 55 hours
Added ballast: 3699g (adjusted based on previous deployment)
Sample cups: 1 & 2, 7 hours (night); 3 & 4, 24 hours



P8 slightly over-ballasted but recovered satisfactorily. It is suspected that the abort weight did not release when expected as the ascent was very slow.

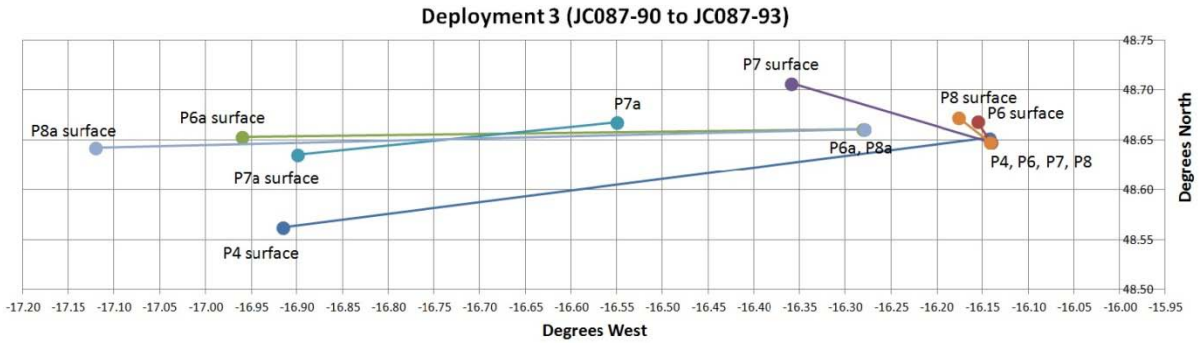


Fig. 24 Deployment 3 Drift Tracks

3.12 Camera Profiles

Stations JC087-134 and JC87-140

One camera system (P7) was fitted to a temporary support structure and deployed twice to 890m in order to obtain particle abundance profiles. These deployments were successful but towards the end of the upcast, the flash was only firing every four or five shots. It is assumed this was because the AA batteries were too drained to allow a fast enough flash recharge.

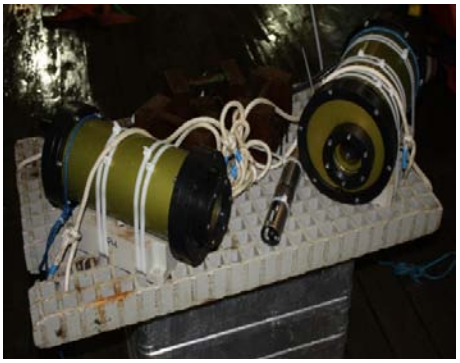


Fig. 25 Camera System (P7)

3.13 Mesozooplankton Studies

Stephanie Wilson, Christina Thiele and Rebekah Newstead

Zooplankton Community Structure and Biomass

There is growing interest in understanding how community structure and trophic linkages can affect the efficiency of the biological pump. Zooplankton characteristics such as species, size, and shape can influence the quality and quantity of the downward flux of carbon to the deep sea. Salps, for instance filter feed on suspended particles and small plankton then produce very large faecal pellets which can sink fast, nearly 1000m

per day. The calanoid copepod, *Pleuromamma* is a diel vertical migrator and can actively transport carbon from faecal material below the euphotic zone. The amphipod *Themisto* is a common large zooplankton in the PAP area and it also produces large, quickly sinking faecal pellets. Quantification of zooplankton community structure, abundance, biomass, feeding ecology, and fecal pellet production rates will help shed further light on marine snow dynamics and pelagic-benthic coupling in the study area.

Collection and Processing Methods

Zooplankton were collected using a Hydrobios Midi Multinet. Mesh size 335 µm and frame size 0.25m^2. The nets were sent to 1000m and opened at 1000-500m, 500-300m, 300-100m, 100-50m, and 50-0m. These depths were used throughout the sampling period. Samples were collected from two stations, Twilight Station (3 day/night pairs) and Pelagra Station (2 day/ night pairs). These two stations were selected in order to obtain a representative zooplankton community structure in the waters above where the Pelagra sediment traps were deployed (Twilight) and predicted to recover (Pelagra).

Zooplankton were processed for biomass, abundance and community structure, grazing impact, and to determine gut contents using DNA-based molecular techniques. Upon Multinet retrieval the nets were rinsed into the cod-end containers and the samples poured into 5L buckets. These were mixed with 10% soda water to anesthetize the zooplankton to avoid bucket feeding and egestion. Until splitting, the samples were kept in the dark in a cold room set to the temperature of the mixed layer depth (13^{o}C). One at a time, starting from the shallowest depth, the samples were split into 4-8 parts. 1/2 of the sample was processed for biomass (see below), 1/4 of the sample was preserved in 4% buffered formalin for abundance and community structure estimates, and 1/4 to 1/8 of the sample was set aside and frozen at -80^{o}C for analyses of grazing impact and DNA extraction back at Bangor University.

The biomass split was poured directly into a set of 5 nested sieves. 200, 500, 1000, 2000, and 5000µm to size fractionate the sample. Once separated the fractions were placed onto preweighed 200 µm nitex circles and into petri dishes. These were stored at -80^{o}C until further laboratory processing for wet and dry weights. Chlorophyll a was measured from the deep CTD cast to 4700m at several depths coinciding with multinet depths (0-1000m). This was completed as it is required in the calculations to measure grazing impact.

Faecal Pellet Production Rate, Egestion and Excretion Rate Methods

There were three experiments throughout the cruise to determine faecal pellet production, egestion, and excretion rates (FP1-3). A marine snow catcher device was used to collect seawater for faecal pellet production rate incubations 1-2 hrs before the zooplankton net tows for live animals. These devices were sent to the depth of the chlorophyll maximum (45-55m). When on the surface, water was gently filtered through a silicon tube with a 200µm mesh attached to exclude microzooplankton but include small plankton for grazing. 0.2µm filtered seawater was used for the egestion and excretion experiments.

Live zooplankton were collected using a 0.25m diameter WP2 ring net with 50µm mesh. A series of WP2 tows were conducted at night to collect vertical migrators which will be likely contributing the most to active and passive carbon flux out of the euphotic zone. Zooplankton selected for incubation included *Salpa* sp. Salps, *Pleuromamma* sp. calanoid copepods, and *Themisto* sp. amphipods. These were the most common of the larger species of zooplankton collected in the nets.

Salps were immediately removed from the bucket and gently rinsed several times in 200µm filtered seawater was used for the egestion and excretion experiments. Filtered seawater. Salps in excellent condition were selected for incubations. One salp was placed in each of 5 1L straight sided plastic jars and incubated for 6 hrs in the cold room set to near MLD temperature. *Pleuromamma* copepods were gently picked out of the net haul using wide pipettes and placed in 200µm filtered seawater to rinse before the experiments. Five animals for each incubation chamber were again gently separated and placed in new 200µm filtered seawater in multi-welled plates for a second rinse and then put into faecal pellet collection trap incubation jars which separate the animal from their faecal pellets to avoid coprophagy (poop traps). The copepods were incubated in 200µm filtered seawater for 6-8hrs.
Themisto amphipods were treated in a similar fashion to the *Pleuromamma* copepods (n=3 or 12 per jar) and incubated 6-9 hrs.

Upon completion of the incubations, zooplankton were removed and preserved in 4% buffered formalin and the faecal pellets were collected, counted, and photographed. The faecal pellets were then placed in a 2ml cryovial and frozen at -80^{o}C for later molecular analysis for prey type.

A subset of Pleuromamma copepods were also incubated in 1L 0.2um filtered seawater to measure egestion and excretion rates. N=5, FP1,2,3. Aliquots of the seawater before and after the incubations were processed for nutrients onboard the RRS *James Cook*. These experiments were otherwise similar in procedure to the faecal pellet production rate experiments.

Post-cruise

Frozen biomass samples will be thawed in the lab for 20 minutes, wet-weighed then placed in a drying oven at 50°C overnight and dry-weighed. Zooplankton in the 4% buffered formalin preserved samples will be sorted and classified into major groups with the major calanoid copepods identified to species level if possible. This data will be used in Christina Thiele's master thesis.
Samples set aside for grazing impact will be processed for gut chlorophyll by Rebekah Newstead and an undergraduate volunteer. Samples set aside for DNA analysis will be stored in a -80°C until funding can be secured to use next generation sequencing using an Illumnia sequencer.

Predicted Outputs

There is the potential for at least three manuscripts from this cruise. Christina Thiele will produce a Masters thesis and manuscript using data collected for biomass and community structure. Rebekah Newstead will produce a manuscript on grazing impact and likely use this as a chapter in her PhD dissertation. The data collected for faecal pellet production, egestion, and excretion can be used in a collaborative manuscript with Morten Iverson and Richard Lampitt using data from the Pelagra traps on the contribution of zooplankton to particle export in the region. The data generated from this project can also be used in collaboration with Marja Koski and Frederica Norrbin.

3.14 Underway Sampling

Antony Birchill, Oliver Willmot, Gillian Damerell, Zoe Morrall, Anna Rumyantseva, Anna Belcher, Adrian Martin and Gayatri Dudeja

Objective

To take regular samples of the ships non-toxic underway supply to provide a time series of chlorophyll, salinity and nutrient data. These data will be used to calibrate underway instrument data after our return to NOC.

Methods

Samples from the ships underway (5m depth) for chlorophyll, salinity and nutrient analysis were taken approximately every 4 hours from 0800 (GMT) on 03/06/2013 (J154) to 1200 (GMT) on 15/06/2013 (J166).

All sampling bottles were rinsed 3 times with sample water prior to sample collection.

Chlorophyll

250ml of sample water was collected in a dark bottle and filtered through 25mm GF/F Whatman filters. Filter then stored in a glass vial with 8ml of acetone and kept in a refrigerator for 18-20 hours before on board fluorescence analysis.

Nutrients

Two samples were collected for nutrient analysis in 15ml centrifuge tubes, a 10ml sample frozen for later analysis and a 14ml sample for onboard analysis.

Salinity

250ml samples collected in glass bottles for the analysis of salinity using the on board salinometer. Full crates were transferred to constant temperature room for at least 24 hours before analysis.

Preliminary Results

Nutrient concentrations from on board analysis of bottle samples are displayed in Fig. 26. There are noticeable increases in nutrient concentrations, including silicate, annotated on Figure 1. Chlorophyll concentrations varied from 0.01 mg m^{-3} to 0.87 mg m^{-3} (Fig. 27).

These results may indicate the presence of different water masses during the duration of the cruise both spatially and temporally.

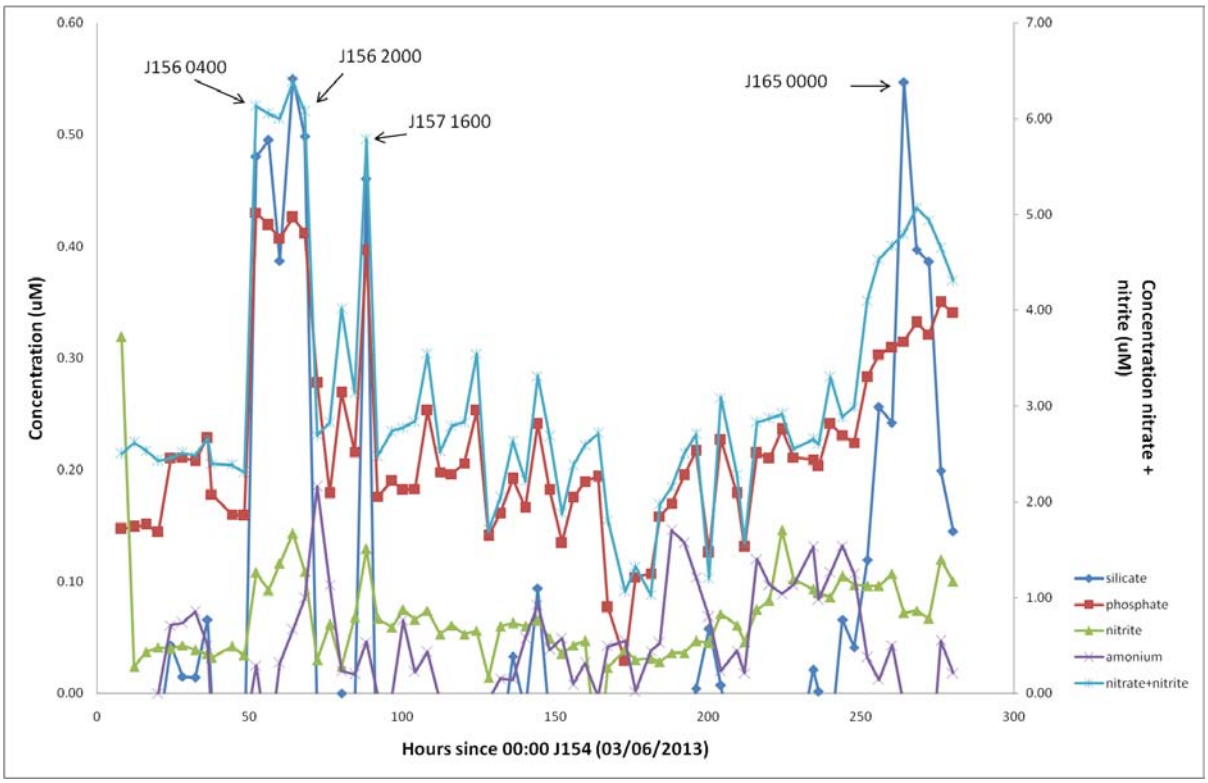


Fig. 26 Underway nutirent data - the time is in decimal minutes and accurate to the nearest hour

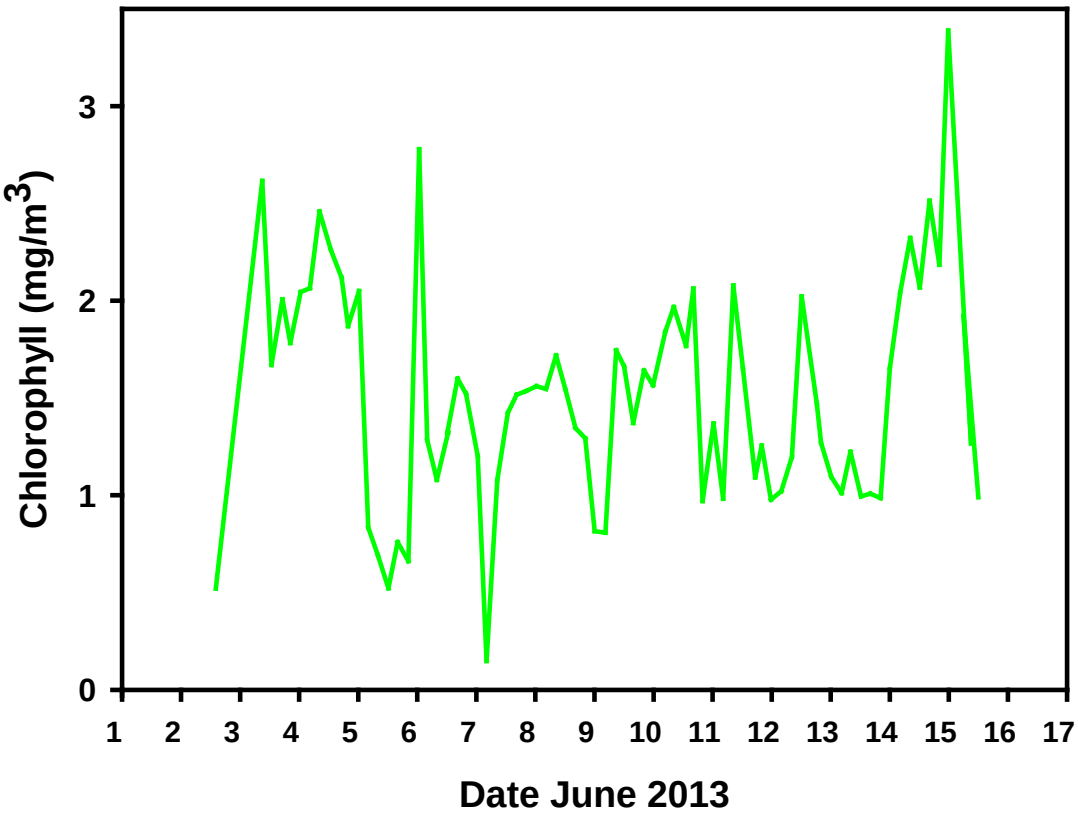


Fig. 27 Underway chlorophyll data - the time is in decimal minutes and accurate to the nearest hour

3.15 13C-based Primary Production and other parameters

Zoe Morrall

Objective

The objective of JC087 was to measure primary productivity at 6 different light depths over the course of the 12 day period at the PAP site. Furthermore, seven additional parameters were to be measured at the same depths as the primary productivity samples.

CTD Deployments

CTD deployments for primary productivity were required to be carried out before sunrise (pre-dawn) in order for accurate incubations and measurements. Deployments were carried out between 0330 and 0500 in time for the samples to be on deck and in the incubator as soon as possible. Please see below for timings of CTD deployments. Originally, 6 depths were required however due to unforeseen circumstances, surface measurements were unable to be taken allowing for only 5 depths to be tested. Also, on the first day of deployments (4/6/2013) the CTD was unavailable for use, so water depths on this date were taken using the Marine Snow Catcher (MSC) and water depths for the 55% (5m) were taken from the Underway (UW). Please see below for specifics.

Date	Julian Day	CTD #	Station #	LD (%)	LD (m)	NB #	Time
04-Jun	155	MSC	#N/A	55	5	#N/A	04:30:00
				20	15	#N/A	04:45:00
				7	25	#N/A	05:00:00
				5	30	#N/A	05:15:00
				1	50	#N/A	05:30:00
06-Jun	157	7	51	55	5	**16**,17,18	04:26:00
				20	15	**13**,14,15	04:24:00
				7	25	**10**,11,12	04:22:00
				5	30	**7**,8,9	04:21:00
				1	50	**4**,5,6	04:19:00
08-Jun	159	11	74	55	5	**22**,23,24	04:09:00
				20	15	**19**,20,21	04:07:00
				7	25	16,**17**,18	04:06:00
				5	30	**13**,14,15	04:04:00
				1	50	**10**,11,12	04:02:00
10-Jun	161	17	101	55	5	**22**,23,24	04:12:00
				20	15	19,**20**,21	04:11:00
				7	25	16,**17**,18	04:10:00
				5	30	13,**14**,15	04:09:00
				1	50	10,**11**,12	04:07:00

13-Jun	163	20	126	55	5	**22**,23,24	05:11:00
				20	15	19,20,**21**	05:09:00
				7	25	16,17,**18**	05:08:00
				5	30	13,14,**15**	05:06:00
				1	50	10,**11**,12	05:02:00
14-Jun	165	22	141	55	5	**UW**	
				20	15	19,20,**21**	
				7	25	16,**17**, 18	
				5	30	13,14,**15**	
				1	50	10,**11**,12	

Primary Productivity

In order for the primary productivity to be measured accurately certain light depths were required to be used for the water sampling. These light depths are considered as a percentage of surface irradiance. For JC087, the light depths required for sampling where 55%, 20%, 7%, 5% and 1% light depths. Their depth in the water column can be calculated using the PAR sensor on the CTD, which was the method used on JC087. Using the 1% light depth, the other depths were calculated using Alex's "Light depth calculator.xls" file.

In order to measure the primary productivity, water samples were taken from these % light depths from the CTD and placed in Nalgene bottles which were covered in a combination of Misty Blue & Neutral Density light film to replicate the light depths (Please see Table 10 for required amount for each light depth). These Nalgene bottles had 200 ul of 13C added to the 1 litre bottles enrich the DIC pool. The Nalgene were then placed in the on-board incubator on the Aft deck for 24 hours making sure that the ships lights weren't shining on the incubator. (See Table 11 for the times of incubations).

Light Depth (%)	Optical Depth	Misty Blue (#)	Neutral Density (#)
55	0.6	1	0
20	1.6	3	0
7	2.7	2	1
5	3	3	1
1	4.6	3	2

Table 10 Number of layers of light film required for each incubation depth.

CTD #	Station #	Date in	Time in	Date Out	Time Out
MSC	#N/A	4/6/2013	0530	5/6/2013	0530
7	51	6/6/2013	0510	7/6/2013	0510
11	74	8/6/2013	0500	9/6/2013	0500
17	101	10/6/2013	0510	11/6/2013	0510
20	126	13/6/2013	0540	14/6/2013	0400
22	141	14/6/2013	0515	15/6/2013	0515

Table 11 CTD deployments, station and times for water samples for primary production in on-deck incubator.

After 24 hours, the bottles were removed from the incubator and all the light depths were filtered through ashed GFF filters. An extra bottle from the 55% light depth was placed in the incubator to replicate surface without any light film covering. This was filtered through an 47mm 10um filter, then with the collected filtrate, filtered through the ashed GGF in order to determine the <10 PP fraction. Once the water samples had been filtered, the filter was acidified with 200ul of 1% HCl solution to remove 13C contamination followed by filtered seawater from a 20L Nalgene waste container, removing residual HCl. These samples were then removed to a petri slide, labelled and placed to air dry* for 24 hours before returning to the box for transportation back to NOC for further analysis.

*all samples, including primary productivity were originally going to be oven dried however on testing, all samples placed in oven melted. Rendered untrustworthy so resorted to air drying method

Other Parameters

Lugols – Species

Lugols samples were generated using 100ml of water samples from the same depths used for primary production samples, to which 2ml of acidic lugols solution was added. These were then labelled and placed in the box to be kept dark and at room temperature before returning to NOC for further analysis.

SEM – Species

Scanning Electron Microscopy (SEM) samples were taken from the same 5 depths used for primary production. 0.5L of water from the CTD was filtered through a 0.8 um polycarbonate filter, then rinsed using pH-adjusted MiliQ. These were then placed in a labelled petri slide and placed

to air dry for 24 hours before being stored in the box for transportation back to NOC for further analysis.

POC & NOC

Water samples were taken in 2L Nalgene bottles from the 5 sampling depths. For each parameter 0.5L were filtered through ashed GFF filters (400C, 12 hours). Once filtered, 200ul of 1% Hcl were added to filter, then rinsed off using pH adjusted MiliQ. These filtered were then placed in labelled cyrovials to be air dried for 24 hours. After drying, the lids were replaced and put in labelled tray.

POP

POP was measured using seawater collected in the 2L Nalgene bottles. Prior to water samples being collected, 3 sandwich boxes were set up containing 10% HC, and two with MiliQ. Ashed GFF filters were placed in the first acid bath for 24 hours, followed by 12 in the first MiliQ bath and 12 in the second before being used. 1 litre was filtered through these washed GFF's. Once filtered, they were put in pre-combusted labelled glass tubes and left to air dry for 24 hours before being sealed with para film and being placed in a zip lock labelled bag.

BSi & PIC

Seawater was collected from the same sampling depths determined by the back calculated depths. For both BSi and PIC 0.5L were filtered through a 0.8um polycarbonate filter, then rinsed with pH-adjusted MiliQ and placed in a labelled Falcon tube to be air dried for 24 hours before being placed in a zip lock bag.

Further Work

On returning to NOC, all samples will be processed in order to compile a full data set of measurements taken on board JC087 for the 6 depths measured over 6 pre-dawn CTD's.

3.16 Turbulence Measurements

Anna Rumyantseva, Adrian Martin and Gillian Damarell

Summary of Turbulence Stations

From experience of analyzing turbulence probe data from the previous cruises to the PAP site it was decided that on every station profiling time would be at least 2 hours (~ 12 profiles per station). This is because the above analysis revealed the turbulent diffusivities to be log-normally distributed (if not worse) with the causative mixing being intermittent. Therefore approximately 10 is viewed as the smallest practical number of

profiles to calculate robust profiles of mean turbulent diffusivity. The turbulence probe was also equipped with a fluorescence sensor. In the beginning of the cruise we did not have proper software to obtain data from the chlorophyll channel. Therefore the first 3 stations do not have fluorescence data. Later we sent an email to Sun & Sea Technology and a new, correct version of the probe file needed by the software was provided.

The turbulence stations were conducted at the "Twilight station" located at 48^{o} 38.9N 16^{o} 08.5W in the south-east of the OSMOSIS array. OSMOSIS Seagliders deployed at the sampling site showed significant increase in chlorophyll concentration at the beginning of the JC087 cruise. We hope that our measurements captured detailed evolution of a water column and chlorophyll distribution during this important event in a phytoplankton annual cycle.

Before or/and after every turbulence station a CTD profile was obtained to collect water samples for phytoplankton species composition and nutrients analysis. The list of CTD stations related to turbulence stations is summarized in the Table 13.

In addition to hopefully providing an excellent dataset, the cruise was also useful in training personnel in use of the new equipment. The laptop end of operations is literally a push one button affair and so of no problem. Spooling out of the cable as the probe descends requires a little more knowledge. Adrian Martin, Anna Rumyantseva, Gillian Damarell, Oliver Willmot (NOC) and Antony Birchill (NOC) all successfully carried out this operation. In addition Gayatri Dudeja (NOC) and Caglar Yumruktepe (METU) all observed deployment and are fully aware of the only two issues: cable should be fed out sufficiently quickly to ensure that at least two loops are always visible in the top few meters of water; the cable has a tendency to catch occasionally, possibly because of salt crystals forming on it, so it is necessary to keep one hand between spooling out cable (but not touching the cable as there is an outside chance this can induce vibrations that would be recorded as turbulence) and the drum, to quickly catch and throw off any loops that catch so that it is not necessary to stop the winch and hence affect the free-fall sinking of the probe. On previous cruises (e.g. D381b) methods to avoid this hands-on approach have been investigated. From blocking pins to foam blocks the cable has proved adept at getting past all, so the manual approach remains the only reliable one to date.

Station number	Date	Jday	Position	Start time (GMT)	Profiles number	Max depth, m	Atm. pressure	Wind speed	Wave height	Comments
JC087-3	03/06/2013	154	48º47.65´ 015º59.67´	10:25	JC0870001	191	1025.3	9.8	1.2	Test of the probe
JC087-8	03/06/2013	154	48º38.69´ 016º08.64´	21:45	JC0870002 - JC0870010	184 - 196	1022.2 - 1022.6	8.2 - 10.6	2.9 - 3.8	Problems with the cable during profile JC0870002
JC087-30	05/06/2013	156	48º38.91´ 016º08.52´	02:16	JC0870011 - JC0870018	172 - 185	1015.9 - 1016.5	3.7 -5.7	3.1 - 3.7	Only temperature was measured on this station
JC087-52	06/06/2013	157	48º38.91´ 016º08.57´	05:08	JC0870019 - JC0870030	162 - 185	1017.4 - 1018.0	5.5 - 10.0	1.6 - 2.1	
JC087-61	06/06/2013 - 07/06/2013	157 - 158	48º38.91´ 016º08.56´	20:25	JC0870031 - JC0870056	195 - 227	1021.4 - 1023	6.7 -11.2	1.2 - 1.4	Fluorescence data obtained
JC087-73	08/06/2013	159	48º38.917´ 016º08.575´	01:12	JC0870057 - JC0870069	175 - 192	1021.8 - 1022.7	8.3 -11.0	0.8 - 0.9	Fluorescence data obtained
JC087-95	09/06/2013	160	48º38.91´ 016º08.48´	16:06	JC0870070 - JC0870084	191 - 220	1006.2 - 1007.4	1.1 -6.3	0.6 - 1.0	Fluorescence data obtained
JC087-131	13/06/2013	164	48º38.92´ 016º08.57´	09:29	JC0870085- JC0870097	203-225	1013.1 – 1013.4	7.6 – 10.6	1.5 – 1.6	Fluorescence data obtained
JC087-142	14/06/2013	165	48º38.91´ 016º08.57´	05:08	JC0870098- JC0870108	200-210	1002.0 – 1003.2	8.5 – 15.7	1.0 – 2.2	Fluorescence data obtained

Table 12 Summary of turbulence measurements

Turbulence station number	CTD station number	Data collected
JC087-3	-	-
JC087-8	CTD-2 JC087-07	Chl-a, Nutrients, Lugols, Oxygen
JC087-30	CTD-3 JC087-31	Chl-a, Nutrients, SEM filters, Lugols, Oxygen
JC087-52	CTD-7 JC087-51	Chl-a, Nutrients, SEM filters, Oxygen
JC087-61	CTD-9 JC087-50	Chl-a, Nutrients, SEM filters, Oxygen
JC087-73	CTD-11 JC087-74	Chl-a, Nutrients, SEM filters, Lugols, Oxygen
JC087-95	CTD-14 JC087-94; CTD-15 JC087-96	Chl-a, Nutrients, SEM filters, Oxygen
JC087-131	CTD-21 JC087-130	Chl-a, Nutrients, Lugols, Oxygen
JC087-142	CTD-22 JC087-142	Chl-a, Nutrients, SEM filters, Lugols, Oxygen

Table 13 Summary of CTD stations related to turbulence measurements

Profiler Description

During JC087 cruise the turbulence probe MSS050 was used for microstructure measurements. The profiler is produced by Sea and Sun Technology GmbH in co-operation with ISW Wassermesstechnik.

The MSS profiler is an instrument for simultaneous microstructure and precision measurements of physical parameters in marine and limnic waters. The current profiler was also equipped with a fluorescence sensor (TURNER designs Cyclops 7 Model # 2100-000 Serial # 2101848). It is designed for vertical profiling within the upper 300m. The data are transferred via electrical cable to an on-board unit which pipes the data to a laptop PC.

The main housing of the MSS050 profiler comprises a cylindrical titanium tube of length 1250mm and diameter 90mm. The housing is pressure tight to 5MPa (500m). Weights and buoyancy rings can be added to the top and bottom of the robe respectively. This allows the user to tune the sinking velocity by altering the buoyancy.

The MSS profiler was equipped with 2 velocity microstructure shear sensors (for turbulence measurements: SHE1 and SHE2), a microstructure temperature sensor (NTC), standard CTD sensors for precision measurements (PRESS, TEMP, COND) , a vibration control sensor (ACC), a two component tilt sensor (TILTX, TILTY), a fluorescence sensor (Chl_A) and surface detection sensor (SD) to indicate the water surface hit at rising measurements. The sampling rate for all sensors is 1024 samples per second, the resolution 16 bit. All sensors are mounted at the measuring head of the profiler (sensor end). Names of the sensors in capitals are the ones used by the probe software. The microstructure sensors are placed at the tip of a slim shaft, about 150mm in front of the CTD sensors to ensure that they are not affected by passage of others through water.

The general behaviour of the MSS profiler is described in detail by Prandke, Holtsch and Stips (2000).

Background to Microstructure Shear Measurement

For measurements of velocity microstructure (turbulence), the MSS profiler is equipped with two shear probes PNS01 (serial # 98 and # 99). This type of shear probe comprises an axially symmetric airfoil separated by a cantilever from a piezoelectric beam. The piezoelectric bending element is isolated by a Teflon tube from water. This gives the sensor excellent long-term stability. The length and diameter of the airfoil are 4mm and 3mm respectively. The spatial resolution of the PNS shear probe is approx 8mm. The general behavior of an airfoil sensor has been described in detail by Osborn and Crawford (1980). The mean velocity due to the profiling speed of the probe is aligned with the axis of revolution. While the probe is not sensitive to axial forces, the cross-stream

(transverse) components of turbulent velocity produce a lifting force at the airfoil. The piezoelectric beam senses the lift force. The output of the piezoelectric element is a voltage proportional to the instantaneous cross-stream component of the velocity field.

Deployment and Operation of the Microstructure Measuring System

The MSS was operated via a winch ISW SWM1000, mounted on the port stern quarter of the vessel. During the MSS measurements, two methods were used for positioning the ship to avoid the cable catching in a propeller. The method previously used is to have the ship was moving with speed approx. 0.5-1.0 knots with respect to the water against the wind. An alternative, devised by the Chief Officer and more commonly used on JC87 was to hold the ship geographically stationary with port propeller off such that cable streamed with current to aft/port. Amore generally it is also important to note that azimuth pod thruster must be off to avoid generating turbulence below the ship's depth.

Disturbing effects caused by cable tension (vibrations) and the ship's movement were minimized by maintaining slack in the cable at descent – as a rule of thumb two "loops" should always be visible just below the sea surface.

In order to take into account the intermittent nature of marine turbulence, repeated MSS measurements were carried out in bursts of typically 10 profiles per station. The measurement interval was approx. 10/9 min for a profile to 170/150dbar. The profiler fell to a depth of typically 170-200dbar even though the winch was stopped when the pressure reached 160/140dbar. The excess 30-40dbar in depth was due to the amount of slack in the cable. As the profiler is rated to 300m it was felt that the extra depth was preferable to the possibility of having insufficient slack in the cable and thereby affecting the measurements through vibrations on the cable.

Data Collection and Archiving

The raw data from the MSS profiler are transmitted via RS485 data link to the on board interface unit of the measuring system. Details relating to each station were noted in an XL log sheet. For data acquisition, on-line display and storage of data the software package SDA_MSS50 2011 version (Sea & Sun Technology GmbH) was used. The icon on the laptop desktop has label SDA_JC87_MSS50. The Rawdata_JC087 directory, in which the raw data from each profile are stored, can be found in C:\sst_sda_50\. The raw data are stored in the MRD (microstructure raw data) binary format.

Calibration and Sensor Tests

Calibration of the shear sensors was performed by ISW Wassermesstechnik using a special shear probe calibration system. The probe rotates about its axis of symmetry at 1Hz under an angle of attack in a water jet of constant velocity. At different angles of attack the rms voltage output of the probe is measured. The probe sensitivity is the slope of the regression (best fit of a cubic approximation) of the sensor output versus the angle of attack.

The calibration of the CTD sensors has been carried out by Sea & Sun Technology GmbH using standard calibration equipment and procedures for CTD probes.
The vibration control sensor and the tilt sensors were calibrated by ISW Wassermesstechnik using special calibration equipment for both sensors.

Protocol for Turbulence Dips

Preparation:

- Check all securing bolts and nuts on the winch and mounting plate.
- Take turbulence probe stand out to deck and position by winch
- Take turbulence probe out on deck and place on stand
- Connect power to winch
- Ensure winch brake is set to "off" – it's not like it sounds (see above notes)
- Let out a little slack in cable from drum
- Connect probe to cable: data cable and bracket
- Turn on interface. **DO NOT DO THIS BEFORE CONNECTING THE PROBE TO THE CABLE.**
- Wait a few seconds for current reading to stabilize (should be 25-60mA)
- Boot up laptop
- Connect laptop to interface
- Start SDA_JC87_MSS50 software by double clicking icon. A header should appear.
- Decide maximum depth with second operative
- Get 2 walkie-talkies: one for winch operator, one for laptop operator

Deployment:

1. Remove securing rope from winch
2. Ask bridge to get ship speed to 0.5-1 knot with respect to the water (and to raise any deployed fish to near surface to avoid turbulent "contamination")
3. Click red cross in top right hand corner of header
4. Click 'no' to request for this to be template header when prompted
5. Check that stream of data appears on screen
6. Remove covers from sensors
7. Ask bridge for permission to deploy probe
8. Gently lower probe so that just below water surface
9. For laptop operator: click "Start Recording" in the "Recording" tab
10. For laptop operator: Tell winch operator to start descent
11. For laptop operator: Note date, time, station number, profile number, atmospheric pressure, wind speed, wind direction, wave height, wave period in the log sheet.

12. For winch operator: begin descent (typically at half of dial for a sinking velocity of 0.6m/s) such that always two coils visible in water near surface. **Cable must be allowed to drop straight down from drum rather than go over 'arm'.**
13. For laptop operator: when pressure reading reaches maximum agreed depth, stop data acquisition by clicking "Stop Recording" in the "Recording" tab
14. For laptop operator: note max pressure in the log sheet
15. For laptop operator: save file with required filename to Rawdata folder
16. For winch operator: put cable over 'arm'
17. For winch operator: begin ascending probe, stop when near surface
18. Back to 12 and repeat as necessary

Recovery:

- Ask bridge for permission to recover probe
- Gently raise probe back on deck and place on to stand
- Tell bridge probe on board
- **TURN OFF INTERFACE**
- Disconnect probe: bracket and cable
- Put cover socket on termination and secure in safe location
- Cover handset with plastic bag and place in safe location still attached
- Disconnect power to winch
- Secure winch with rope
- Wash probe, sensors and their covers. **SEE THE MANUAL FOR THE CORRECT AND SAFE WAY TO WASH THE VELOCITY MICROSTRUCTURE SENSORS.**
- Put probe on stand in hangar or lab to dry
- Back up data by copying the *.MRD files

Basic Guide to Processing Necessary to Obtain Turbulent Characteristics

It is important to set up different directories for the different stages of processing as there is the potential to overwrite files. For JC087 the following directories were used:
Desktop\JC87_turbulence\Raw – for storage of raw files as they are generated
Desktop\JC87_turbulence\Converted – for files now converted to ascii with shear calculated
Desktop\JC87_turbulence\Cut – for files now cut for depth trimming
Desktop\JC87_turbulence\Epsilon – for files once dissipation rate and Thorpe scale calculated

Processing Steps:

1) Start MssPro (detailed description of the MssPro software can be found in previous cruise reports) by clicking an icon on the desktop of "Latitude E6400" laptop
2) Load a file from Desktop\JC87_turbulence\Raw
3) Go Run => batch job => convert+_shearD369Msso50v2
4) Check output file name (JC08700xx.tob is the right format)
5) Save the file in Desktop\JC87_turbulence\Converted
6) Open "cutgraf" utility

7) Cut upcast if it is needed
8) Save output file in Desktop\JC87_turbulence\Cut. Again check format
9) Open the file from Desktop\JC87_turbulence\Cut folder using "datagraf" utility
10) Check: velocity range (0.5 -1 m/s), fluorescence, temperature and consistency between shear1 and shear2
11) Go Run => batch job => epsilon+thropeMSS050v1

3.17 Dissolved Oxygen Analysis

Mark Stinchcombe and Emily Davey

Cruise Objective

The objective of the dissolved oxygen analysis was to provide a calibration data set for the oxygen sensor mounted on the frame of the CTD for cruise JC087 to the PAP site, as well as providing a calibration data set for the sea gliders that were deployed and recovered during JC087. To do this a Winkler titration with amperometric end point detection was performed on water samples drawn from the Niskin bottles mounted on the CTD frame.

Methods

Samples for the determination of dissolved oxygen concentration were taken from the stainless steel CTD casts. They were the first samples to be drawn from the Niskin bottles. Each depth below 10m was sampled in duplicate if there were less than twelve depths on that CTD cast. On the few occasions there were more than twelve depths then the sampling depths were chosen based on the oxygen profile provided by the CTD package. Any steep gradients in oxygen concentration were avoided. Any Niskins within the top 10m were generally not sampled as wave action can produce tiny bubbles in the samples and the oxygen trace can be highly irregular in this area.

The water was drawn through short pieces of silicon tubing into clear, pre-calibrated, narrow-necked glass flasks. The temperature of the water at the time of sampling was measured using an electronic thermometer probe. The temperature would be used to calculate any temperature dependant changes in the bottle volumes. Each of the samples was fixed immediately using 1ml of manganese chloride and 1ml of alkaline iodide, shaken thoroughly and left to settle for approximately an hour. After this time they were shaken again and then left for another hour before analysis but all were analysed within a day.

The samples were analysed in the main laboratory following the procedure outlined in Holley and Hydes (1995) and Langdon (2010). The samples were acidified using 1ml of sulphuric acid immediately before titration and

stirred using a magnetic stirrer. The Winkler whole bottle titration method with amperometric endpoint detection with equipment supplied by Metrohm UK Ltd was used to determine the oxygen concentration.
During the first days on the ship the thiosulphate solution was made up using 50g/L sodium thiosulphate. The normality of the sodium thiosulphate titrant was checked using a potassium iodate standard. This was repeated every other day throughout the cruise, with the exception of when we had a day of bad weather. Sodium thiosulphate standardisation was carried out by adding the reagents in reverse order with, stirring in between, and then 10ml of a 0.01N potassium iodate solution using an automated burette. The sample was titrated and the volume of sodium thiosulphate required was recorded. This was repeated until at least three measurements agreed to within 0.0015ml of each other. The average of these titrations was used to calculate the volume of sodium thiosulphate which was then used in the calculation of the final dissolved oxygen calculation. The volumes of sodium thiosulphate required in this standardisation process can be seen in Table 14.

Date	**1**	**2**	**3**	**4**	**Average**
04/06/2013	0.5275	0.5270	0.5265		**0.5270**
06/06/2013	0.5265	0.5265	0.5275	0.5270	**0.5269**
08/06/2013	0.5265	0.5265	0.5265		**0.5265**
10/06/2013	0.5285	0.5285	0.5285		**0.5285**
13/06/13	0.5265	0.5265	0.5270		**0.5267**

Table 14 Standardisation of the sodium thiosulphate was performed five times on the cruise. This table shows the final volumes with the averages that were used during the calculation of dissolved oxygen. All values are millilitres.

A blank measurement was also carried out to account for the oxygen in the reagents. The reagents were added in reverse order, as for the sodium thiosulphate standardisation, and then 1ml of the potassium iodate

standard was added using an automated burette. This was titrated and the volume of sodium thiosulphate required was recorded. 1ml of potassium iodate was again added to the same sample and it was titrated again. This was repeated a third time. The average of the second and third volumes of sodium thiosulphate was subtracted from the first. The volumes of sodium thiosulphate required in this blanking process can be seen in Table 15.

Date	1st Titration	2nd Titration	3rd Titration	1st - Avg(2nd & 3rd)
04/06/2013	0.0545	0.0520	0.0520	0.0025
06/06/2013	0.0545	0.0520	0.0520	0.0025
08/06/2013	0.0540	0.0520	0.0525	0.0018
08/06/2013	0.0535	0.0525	0.0520	0.0013
08/06/2013	0.0540	0.0520	0.0520	0.0020
10/06/2013	0.0540	0.0525	0.0530	0.0018
13/06/2013	0.0540	0.0525	0.0520	0.0018

Table 15 A blank measurement was performed seven times on the cruise. This table shows the final volumes with the averages that were used during the calculation of dissolved oxygen. All values are millilitres. The blank values on 08/06/2013 were averaged. These were repeated to check reproducibility.

3.18 Nutrient Analysis

Mark Stinchcombe and Emily Davey

Cruise Objectives

Our objective on cruise JC087 to the PAP site was to measure the concentrations of the nutrients: nitrate, nitrite, silicate, phosphate and ammonia, using segmented flow analysis. Analysis was completed on board but one set of samples was frozen to analyse back at the NOC to test the performance of the analyser as this was its first use at sea.

Methods

Analysis for micro-molar concentrations of nitrate and nitrite, nitrite, phosphate, silicate and ammonia was undertaken on a SEAL Analytical UK Ltd, AA3 segmented flow autoanalyser following methods described by Kirkwood (1996). Samples were drawn from Niskin bottles on the CTD into 15ml polycarbonate centrifuge tubes and kept refrigerated at approximately 4^{o}C until analysis, which generally commenced within 30 minutes. Overall 23 runs with 597 samples were analysed. This is a total of 502 CTD samples, 69 underway samples and 26 from other sources.

An artificial seawater matrix (ASW) of 40g/litre sodium chloride was used as the inter-sample wash and standard matrix. The nutrient free status of this solution was checked by running Ocean Scientific International (OSI) low nutrient seawater (LNS) on every run. A single set of mixed standards were made up by diluting 5mM solutions made from weighed dried salts in 1litre of ASW into plastic 250ml volumetric flasks that had been cleaned by washing in MilliQ water (MQ). Data processing was undertaken using SEAL Analytical UK Ltd proprietary software (AACE 6.07) and was performed within a few hours of the run being finished. The sample time was 60 seconds and the wash time was 30 seconds. The lines were washed daily with wash solutions specific for each chemistry, but comprised of MQ, MQ and SDS, MQ and Triton-X, or MQ and Brij-35. Three times during the cruise the phosphate and silicate channels were washed with a weak sodium hypochlorite solution.

Performance of the Analyser

This the first time we have used the AA3 system at sea, it has replaced the old Skalar San+ analysers we had as it is faster and it has a more stable light source in the form of a LED. The baselines during this cruise were very stable as a result of the LED. When we had some rougher weather there was no obvious noise on the baseline or on the peaks. Peak shape was generally good, with the exception of the ammonia channel, which is due to the long and narrow flowcell in the fluorometer. The peak picking software was also a great improved and it cut the data processing time from 30-60 minutes per run to only 10-15 minutes per run.

There had been some concern how the rather delicate looking XY2 sampler would cope with the movement of the ship, but again this concern was proved unnecessary. The speed with which the whole system operated, and the ease of using the centrifuge tubes for sampling as they will fit straight into the sampler meant that we were able to finish analysing

stations and have the data processed much more quickly than we could before.

Data

All the samples were analysed on board, however, as this was the first test for the AA3 we also took a duplicate for each sample and froze them to analyse back at the NOC just to double check its performance. Samples were placed into the sample 15ml centrifuge tubes and placed into the -20oC freezer straight after sampling. They will stay on the ship for transporting back to the NOC in Southampton where they will be analysed on the other SEAL Analytical UK Ltd autoanalyser that we have, the QuAAtro.

The data will also need to be quality controlled before it is finalised. One aspect that needs to be looked at is the correction for any contamination in the sodium chloride used for the artificial seawater. It was noted that the nitrate, nitrite and silicate data had a number of negative peaks, as did the low nutrient seawater used to check the baseline. This contamination can be constrained and the data corrected. This was tried twice during JC087 but both times there were problems with the analyser so it shall now be completed back at the NOC.

Figures 28 to 32 show some of the profiles we were getting with the AA3 for the five channels we were running. The two profiles shown were very close to each other in terms of time and distance so they highlight the spatial variability that is characteristic of this region.

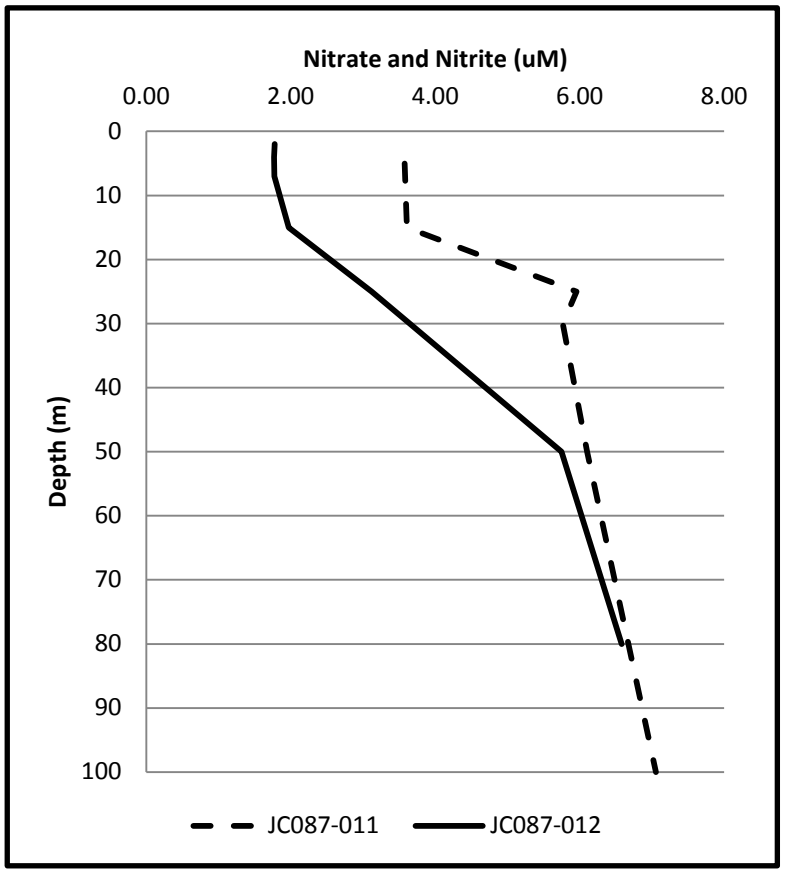


Fig. 28 The nitrate and nitrite profile for two of the stations. These two stations were only an hour or so a part and were also very close to each other in terms of position. There is a difference of approximately 2uM between them at the surface. Everywhere that we sampled had at least 1.0uM nitrate and nitrite. The lowest values were all from stations towards the end of the cruise, JC087-17, -18 and -19.

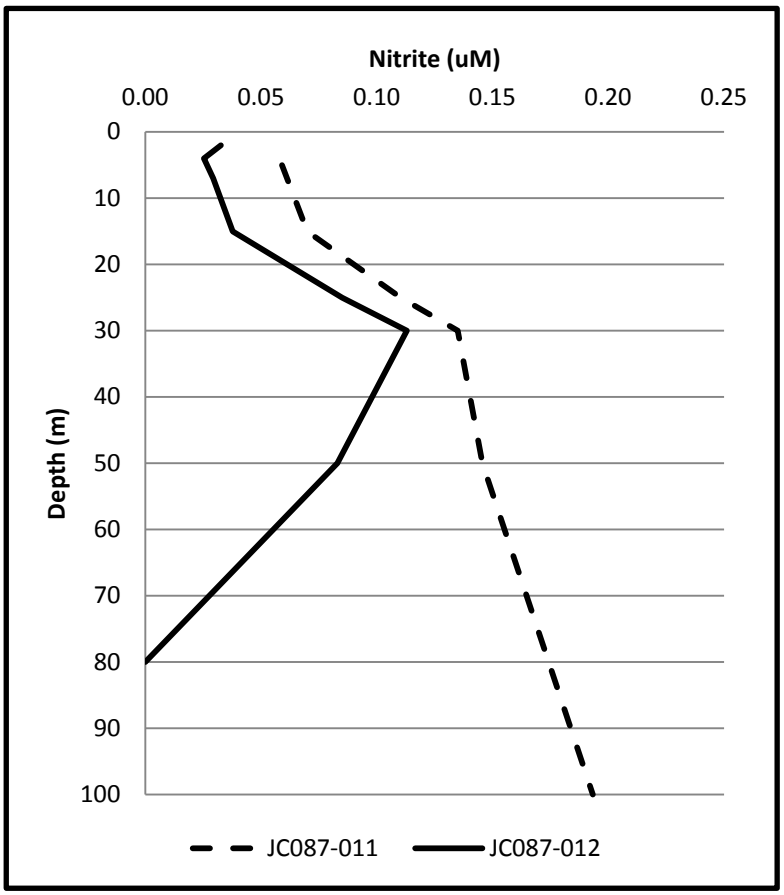


Fig. 29 The nitrite profile for the same two profiles as for Fig 28. These types of profiles were typical for nitrite, with a peak at approximately the DCM which was generally between 20 and 40m. The largest value seen was 0.36uM but this was just from one sample. All other samples were ≤0.21uM.

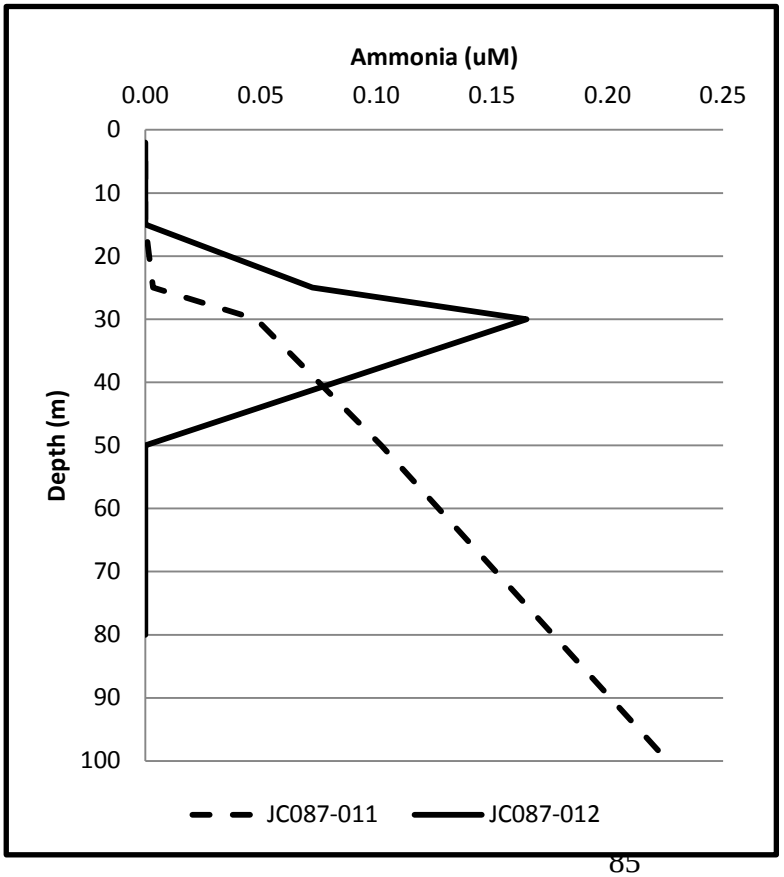


Fig. 30 The ammonia profile for the same two stations as the previous figures. These were again fairly characteristic of the profiles for JC087. There was generally a well defined peak at around the DCM but lower values nearer the surface and at depth. This is the first time we have run the ammonia channel so we will need to have a close look at the data when doing the quality control. Water samples for ammonia are easily contaminated so it's possible we will have to remove some data but we can check this by looking at the replicates and checking the precision where there are more than one bottle fired at a depth.

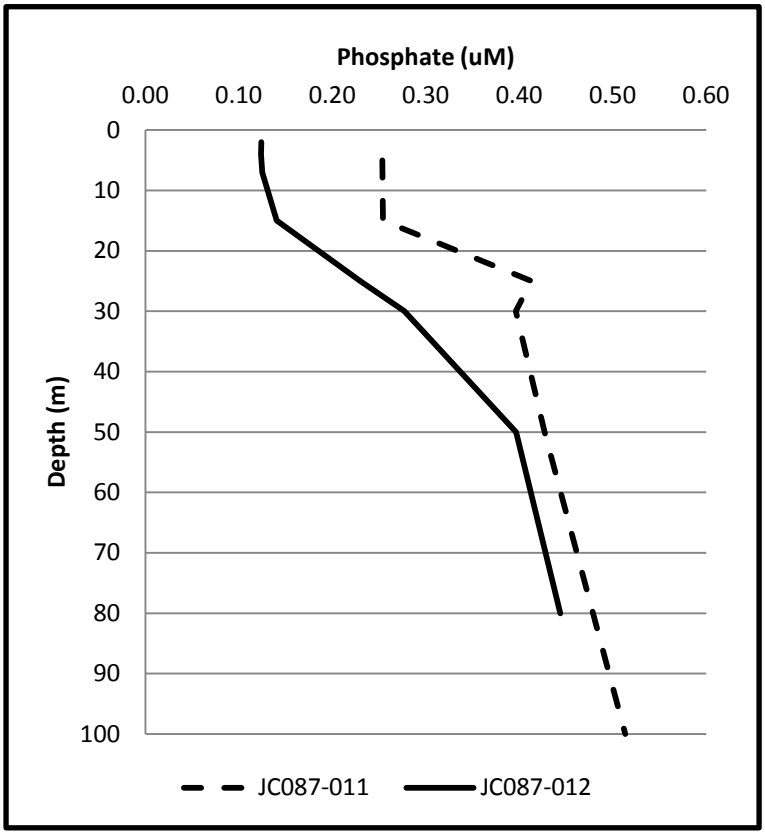


Fig. 31 The phosphate profiles for the same two stations. This profile also shows the spatial variability as JC087-012 is showing a surface phosphate concentration approximately half that of JC087-011. Although there were some very low phosphate concentrations, i.e. on the limit of detection for the AA3, during CTD JC087-017, all other stations had surface phosphate concentrations ≥0f1uM. Generally the later station had the lower concentrations.

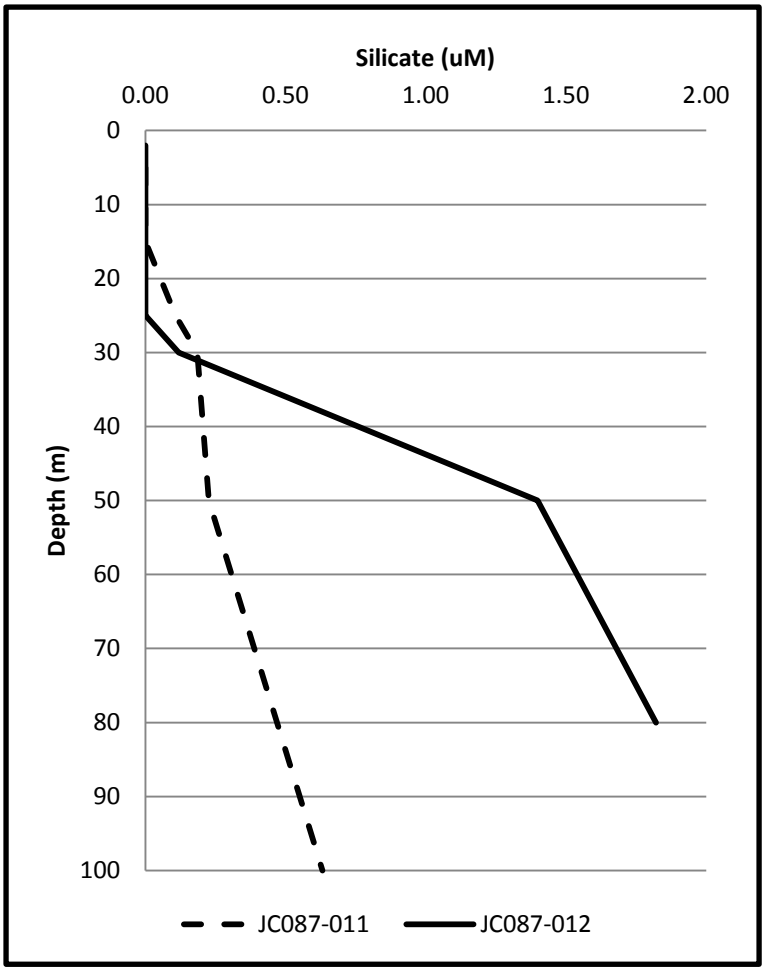


Fig. 32 The silicate profile for the same two stations. Surface silicate concentrations were very low from the moment we arrived at the PAP site. The UW data showed this nicely, as apart from a brief period (6 underway samples) when we were in a water mass with relatively higher surface silicate concentrations (0.4 to 0.5uM), all the other underway samples were below 0.1uM.

3.19 Chlorophyll-a Measurement

Gayatri Dudeja

Water Sampling

CTD rosette was used for collecting water samples from various depths of the water column for chlorophyll analysis. The rosette had 24 number of 20 litre Niskin bottles. The rosette was also mounted with a PAR sensor. Chlorophyll-a samples were taken from Niskin bottles which were fired at depths between 200m and surface. The water sample depth was decided in accordance to the Photosynthetic Active Radiation (PAR) profile in the water column. Five depths were selected between 100% and 1% PAR in the water column and one depth was selected below 1% PAR. Water samples collected were always analyzed for estimation of total chlorophyll concentration but sometimes they were also analyzed for determination of size fraction of phytoplankton.

Water samples for chlorophyll-a analysis were collected for various purposes-

Pre-Dawn: As the name signifies, these samples were taken just before dawn i.e. at 4:00 am.

This was to estimate chlorophyll concentration in the water before the water samples are incubated for primary production analysis. Water samples were taken from 6 Pre-Dawn CTD casts. The samples were analyzed for total chlorophyll concentration and also for determining the size fraction of phytoplankton in the water.

Deep CTD: Two CTD casts were conducted with maximum depth of the cast more than 4500m. These casts were mainly done to match the glider.

3.20 Sea Mammal Sound Records

Adrian Martin and Kevin Saw, with remote assistance from Douglas Gillespie and Mark Johnson of SMRU

Following a discussion with Douglas Gillespie of SMRU, a SMRU self-logging sound recorder was borrowed from SMRU and taken on JC87 for deployment on one of the Pelagra neutrally buoyant sediment traps. The idea behind this is that having no engine and, for the most part, residing at depth, the Pelagra potentially offers a very quiet environment to listen for cetacean calls and noises.

Prior to the cruise the sensor was weighed in fresh water (89.5g) and one of the Pelagras (P8) was ballasted to accommodate it.

Prior to deployment the sensor was connected to a laptop to charge. For the first deployment the time may not have been sufficient for it to charge fully. It was fully charged for the second. The computer was also used to 'arm' the sensor and synchronise its clock to that of the laptop which had itself already been synchronised with the ship clock. Both of these were accomplished using the d3host software provided by SMRU.

At deployment the sensor was fastened with cable ties to one of the vertical plastic struts at the base of the Pelagra. This location was chosen as it is away from the top frame (where it may be damaged on recovery) and also distant from the central flotation rings (as hollow chambers potentially offer a source of noise). The loose nuts used as ballast were also cable-tied together where possible to minimise any noise arising from their banging together.

Deployment details are given in the table below. As a little background, the Pelagra float is ballasted to float at a particular depth by trimming it to the density at that depth, calculated from a preceding CTD cast. Starting at the surface the float inevitably overshoots, eventually rising back to its equilibrium depth. At a programmed time the float jettisons a ballast and rises back to the surface. A GPS transmitter gives its location to the ship allowing it to be picked up. As the float may have been deployed some time previously, the ship may be quite some distance from it by this time meaning that the float spends several hours at the surface before recovery. In some cases on deployment the float overshoots too far. There is safety threshold at ~1000m at which the float will jettison a much larger ballast and rise immediately to the surface for recovery. Further details on Pelagra deployments can be found in that section of the cruise report.

Date	Time	Latitude (^{o}N)	Longitude (^{o}W)	Notes
Deployment A	The float triggered the safety ascent twice, necessitating recovery, re-trimming and redeployment. On third attempt, after an overshoot to~440m, an equilibrium depth of ~200m was achieved and at which it remained for ~20 hours. Changes in depth were generally linear with time.			
5/6/13	0722	48°39.00	16°08.34	At surface
	1257			Max depth of 923m
	1507			At surface
	2022	48°37.29	016°11.76	On deck
6/6/13	0225	48°36.022	016°13.813	At surface
	0439			Max depth of 920m
	0719			At surface
	1508	48°33.88	016°17.11	On deck
	1803	48°32.44	016°18.92	At surface
	2132			Max depth 446m
7/06/13	0904			Equilibrium depth ~200m

8/06/13	0515			Start ascent
	1256			At surface
	1820	48°29.55	16°27.74	On deck
Deployment B	On first deployment the float descended to 200m but then rose straight back up to the surface. After recovery and re-deployment the float sank to 400m before rising to the target depth of 200m where it remained for ~38 hours. Changes in depth were generally linear with time.			
9/6/13	1334	48°38.90	16°08.52	At surface
	1421			Max depth 199m
	1649			At surface
	2116	48°41.48	016°14.29	On deck
10/6/13	0023	48°39.66	016°16.81	At surface
	0414			Max depth 520m
	1715			Equilibrium depth ~200m
12/6/13	0657			Start ascent
	2357	48°38.385	017°08.746	On deck

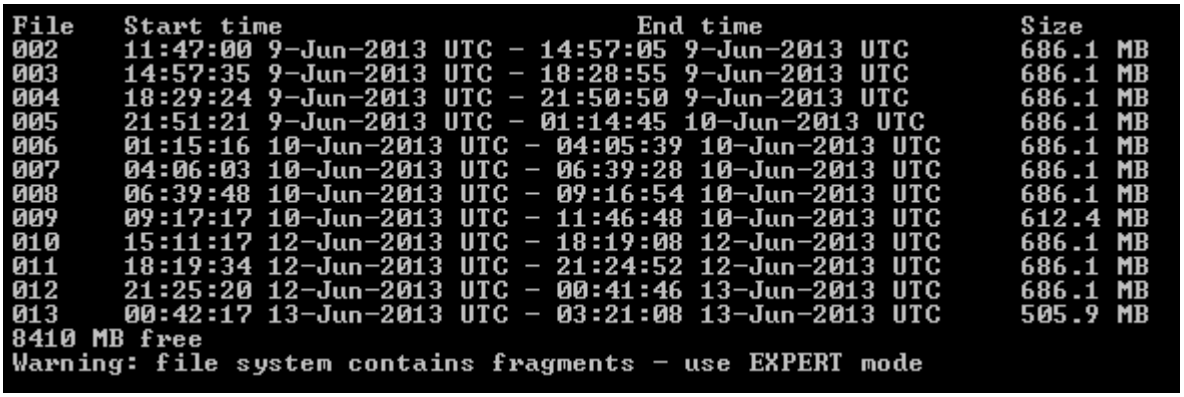
After deployment, the sensor was reconnected to the laptop and files downloaded using the d3host software once again.

The directory listings for the two deployments are shown below.

```
Select an action... 1

File    Start time                          End time                Size
001     03:27:22 5-Jun-2013 UTC - 06:45:33 5-Jun-2013 UTC       686.1 MB
002     06:45:52 5-Jun-2013 UTC - 09:25:41 5-Jun-2013 UTC       686.1 MB
003     09:25:58 5-Jun-2013 UTC - 11:42:37 5-Jun-2013 UTC       686.1 MB
004     11:43:02 5-Jun-2013 UTC - 14:32:44 5-Jun-2013 UTC       686.1 MB
005     14:33:13 5-Jun-2013 UTC - 17:53:37 5-Jun-2013 UTC       686.1 MB
006     17:54:04 5-Jun-2013 UTC - 20:51:00 5-Jun-2013 UTC       686.1 MB
007     20:51:24 5-Jun-2013 UTC - 23:42:29 5-Jun-2013 UTC       686.1 MB
008     23:42:54 5-Jun-2013 UTC - 02:35:52 6-Jun-2013 UTC       686.1 MB
009     02:36:16 6-Jun-2013 UTC - 03:27:16 6-Jun-2013 UTC       262.1 MB
010     03:27:47 6-Jun-2013 UTC - 06:02:23 6-Jun-2013 UTC       686.1 MB
011     06:02:53 6-Jun-2013 UTC - 09:22:11 6-Jun-2013 UTC       686.1 MB
012     09:22:40 6-Jun-2013 UTC - 12:42:04 6-Jun-2013 UTC       686.1 MB
013     12:42:32 6-Jun-2013 UTC - 15:27:54 6-Jun-2013 UTC       686.1 MB
014     15:28:15 6-Jun-2013 UTC - 18:23:35 6-Jun-2013 UTC       686.1 MB
015     18:24:05 6-Jun-2013 UTC - 21:25:52 6-Jun-2013 UTC       686.1 MB
016     21:26:16 6-Jun-2013 UTC - 00:14:09 7-Jun-2013 UTC       686.1 MB
017     00:14:33 7-Jun-2013 UTC - 03:12:48 7-Jun-2013 UTC       686.1 MB
018     03:13:15 7-Jun-2013 UTC - 03:27:23 7-Jun-2013 UTC       55.3 MB
019     03:28:11 7-Jun-2013 UTC - 06:41:46 7-Jun-2013 UTC       686.1 MB
020     06:42:16 7-Jun-2013 UTC - 10:11:32 7-Jun-2013 UTC       686.1 MB
021     10:12:01 7-Jun-2013 UTC - 13:39:39 7-Jun-2013 UTC       686.1 MB
022     13:40:10 7-Jun-2013 UTC - 17:13:38 7-Jun-2013 UTC       686.1 MB
023     17:14:09 7-Jun-2013 UTC - 20:49:32 7-Jun-2013 UTC       686.1 MB
024     20:50:03 7-Jun-2013 UTC - 00:21:41 8-Jun-2013 UTC       686.1 MB
025     00:22:10 8-Jun-2013 UTC - 03:27:58 8-Jun-2013 UTC       604.2 MB
026     03:28:35 8-Jun-2013 UTC - 06:59:10 8-Jun-2013 UTC       686.1 MB
027     06:59:41 8-Jun-2013 UTC - 07:19:36 8-Jun-2013 UTC       65.5 MB
16392 MB free
Warning: file system contains fragments - use EXPERT mode
```

Directory listing for the first deployment



Directory listing for the second deployment

In both cases d3host diagnosed the presence of fragments and recommended use of EXPERT mode. In practice this did not seem necessary for downloading the files but was necessary to delete them prior to the next deployment. It should be noted, though, that the option to select a range of files to 'offload' did not work e.g. selecting 2-5 resulted in files that were unrealistically small. 'Offloading' individually or using the syntax '1,2,3,4,5' worked fine though. Also, another test on the first deployment files revealed that a different number of 'blocks with unrecoverable errors' could be reported for the same file if the 'offload' was attempted twice (carried out as a check).

Because of the unrecoverable bad blocks, deleting the files was carried out in EXPERT mode of d3host. Even in this manner it proved a little tricky. Using option 'g' to clear the recording, followed by a selection of 'a' for 'all' reported that 100% were erased. However, the directory was not empty, with 32 files remaining all with bad blocks. Various things were tried, including rewriting bad blocks and clearing flash chips but the approach that finally worked was to individually delete just the first of these remnant files after which the message given was 'No files on device' and the directory was empty. Though it may not be related, on offloading files from the second deployment there was no file 001 present.

As a quick test and first look at the data, the file was identified corresponding to the time that Pelagra P8 came prematurely back to the surface on the second deployment ~2100, when a large whale (consensus being fin or sei) was seen surfacing just a few hundred metres from the Pelagra. This file was converted into .wav format using the d3read software provided by SMRU and then loaded into the audio software Audacity for some very basic processing. Initially the strongest signal was focussed on, which turned out to be the sound of water sloshing over P8 as it sat on the

surface. However, a quieter sequence of clicks was also present. Refining the search to a quieter adjacent period allowed us to amplify this signal and to find clear evidence of whale vocalisation; specifically a sequence of clicks, like a finger running along a comb, with occasional low moan-like noises. This snippet is attached to the electronic version of this report. Though very limited, this preliminary analysis revealed that the interesting signal may lurk in the regions that, at face value, are 'flat' and uninteresting compared to the louder noises recorded. The only other bit of tentative data that listening revealed was that the sensor may also pick up the noise of the float pumping to make it-self positively buoyant at the start of its ascent.

Short sound file of cetacean vocalisation from second deployment 

cetacean.mp3

Station #	Cast #	Date	Jday	Start Time	Latitude (deg and decimal mins N)	Longitude (deg and decimals mins W)	Max. Depth (m)
5	1	3/6/13	154	12:31	48 41.969	16 2.015	4787
7	2	3/6/13	154	20:35	48 38.898	16 8.573	200
31	3	5/6/13	156	04:10	48 38.916	16 8.577	200
37	4	5/6/13	156	07:56	48 39.012	16 8.325	200
40	5	5/6/13	156	10:24	48 38.919	16 8.576	200
42	6	5/6/13	156	13:22	48 38.915	16 8.578	4800
51	7	6/6/13	157	03:50	48 38.929	16 8.597	200
55	8	6/6/13	157	08:23	48 38.917	16 8.569	200
60	9	6/6/13	157	19:47	48 38.907	16 8.569	200
67	10	7/6/13	158	08:36	48 38.915	16 8.568	200
74	11	8/6/13	159	03:43	48 38.914	16 8.574	200
75	12	8/6/13	159	10:27	48 29.984	16 29.315	200
88	13	9/6/13	160	07:18	48 38.919	16 8.572	500
94	14	9/6/13	160	15:08	48 38.907	16 8.468	200
96	15	9/6/13	160	19:08	48 38.401	16 8.586	200
97	16	9/6/13	160	22:20	48 39.620	16 16.863	250
101	17	10/6/13	161	03:47	48 38.919	16 8.574	200
104	18	10/6/13	161	08:31	48 38.916	16 8.574	200
117	19	11/6/13	162	08:55	48 38.953	16 8.597	200
126	20	13/6/13	164	04:42	48 38.918	16 8.574	200
130	21	13/6/13	164	08:32	48 38.899	16 8.559	200
141	22	14/6/13	165	04:11	48 38.917	16 8.573	200
149	23	14/6/13	165	08:42	48 38.912	16 8.579	200
	24	14/6/13	165	11:42	48 38.912	16 8.579	4800

3.21 OSMOSIS Seaglider Turnaround

Gillian Damerell, Anna Rumyantseva and Adrian Martin

Seagliders

The plan for OSMOSIS is to deploy ocean gliders in pairs for a period of a full year. Each glider deployment will last for approximately four months. The Seagliders are measuring conductivity, temperature, depth (CTD), dissolved oxygen, chlorophyll *a* concentrations, optical backscatter, and Photosynthetically Active Radiation (PAR). Careful monitoring and planning will be required to maintain sufficient battery power throughout the four months. Initial estimates seem to show that the 10V science battery will most likely be the limiting factor. Cruise JC087 was on board the RRS *James Cook*, and was primarily a biological cruise, to which an Osmosis glider turnaround was attached. The plan was to depart from Glasgow, UK on 31st May 2013 and steam to the Porcupine Abyssal Plain (PAP) monitoring station. The glider plan was to recover Seaglider SG510 and deploy SG533. Ship-borne measurements for conductivity, temperature, dissolved oxygen, chlorophyll *a* and PAR from the ship deployed CTD rosette will be used to calibrate the sensors on the Seagliders.

Timeline of glider-related activities

30th May 2013	Came on board ship, ran self-test 23 and sim dives 6 and 7 on SG533. Checked Argos tag.
31st May 2013	Sailed from Govan, Glasgow, assembled SG533, opened hatches, checked cables all tight, closed hatches
1st June 2013	Recovered Fastnet Slocum glider with a leak, checked SG533 self-test and sim dives for errors
2nd June 2013	Updated cmdfile for deployment, including calibration constants for new CT sail – which later proved to be wildly wrong. Piloting team at UEA corrected after deployment. Ran and checked self-test 24 and sim dive 8.
3rd June 2013	Station 001, **deployment of SG533** Station 005, CTD cast 001: ship deployed CTD to 4787m for Seaglider calibration and lipid sampling
9th June 2013	**Recovery of SG510** Station 088, CTD cast 013: ship deployed CTD to 500m for Seaglider calibration
14th June 2013	Begin transit to Govan, Glasgow for the end of cruise demobilisation
18th June 2013	Dock in Govan, Glasgow

Preparation

The team arrived at the ship on the 30th of May. SG533 (Canopus), and the crate for SG510, were already loaded on the RRS *James Cook* when we boarded, both on the back deck.

Communications

We began by switching on SG533 and running a self-test and two sim dives, using NOCS PSTN as the primary phone number and UEA PSTN as the alternative. On the 2nd June, we changed this to be NOCS RUDICS as the primary phone number and NOCS PSTN as the alternative number. Communications were good with both NOCS RUDICS and NOCS PSTN, with the glider lying flat on the back deck with the antenna propped up vertically, or with the glider propped up against the rail of the ship with the antenna fastened in place in the glider. We did not test communications using the UEA PSTN line, noting that it had already displayed problems for SG566's communications. The appropriate numbers are:

- NOCS RUDICS: 881600005139
- NOCS PSTN: 442380634452
- UEA PSTN: 441603597331

Self-tests and Simulated Dives

Multiple self-tests and sim dives were carried out on SG533. The only errors that were encountered involved bathymetry maps and the ability to pick up a GPS signal. The former is not relevant for this project as the water depth is more than 4000m in this area, and the latter is an expected error due to the short period of time that is allowed to obtain a GPS fix during the self test (see Seaglider manual).

Upon going through the iRobot provided checklist of the self tests and sim dives, we noticed, in the tests carried out on 30th May that the pitch was much lower than recommended. This is because we had the glider positioned flat on the back deck rather than propped up against the rail of the ship. Self-test 24 and sim dive 8 showed pitch angles appropriate for a glider propped up against the rail. We also noticed that SG533's VBD was pumping at a rate of 4 to 5 AD/sec, whereas rates greater than or equal to 7 AD/sec are expected. This also occurred for SG566 during the September 2012 deployment, and on that occasion we were advised by iRobot to set both $D_BOOST and $T_BOOST to 0, which allows both the main pump and the boost pump to work in tandem. This was altered for sim dive 8, whereupon the pumping rate increased to 11 AD/sec. All self tests were screen logged on Gillian's laptop.

Assembly

The glider was brought into the main lab where we attached the wings, rudder and antenna. With memories of the loose cables found in the September 2012 deployment, we opened the front and back hatches and checked that all the cables which pass into the pressure hull were tightly attached.

Acoustic Deck Box

We interrogated the glider with the acoustic deck box and received a good reading. The interrogation and return frequencies for SG533 are:

- SG533: Interrogate, 13.0; Respond, 11.5

Argos Tag

The Argos tag had previously been set up by Gareth Lee et al. on JC085. We merely attached the tag to a laptop to check it was still functional.

Deployment

Deploying and recovering Seagliders is always best achieved with the use of a small boat, but this is not always possible. Sea conditions may not be suitable, or the use of a small boat on a large research vessel may be strictly limited to rescue operations (i.e., such a boat is not a *work* boat). When Seagliders are deployed from ships, a winch is required to lower them into the water. On the RRS *James Cook*, the Rexroth winch (located on the Starboard A frame) was used to lower them into the water.

The Rigid Rope Technique

The Rigid Rope technique involves passing a length of rope through two 2m lengths of 25mm flexi-pipe, as used in household plumbing. The 2m lengths of flexi-pipe act as a sheath to keep the rope rigid and eliminate tangling around the antenna. Loops are tied at either to act as a means of fixing the rope to the winch/Sea-Catch release mechanism. The Seaglider then sits between the two lengths of pipe, creating a sling through which the Seaglider can be supported during winch operations. A sea-catch release hook is attached to the end of the winch and one loop of the sling is permanently fixed to the wire with a shackle and cannot be released. The other loop is attached to the release eye of the sea-catch. When the deployment team is satisfied that the Seaglider is ready to deploy, the sea-catch releases the Seaglider. This technique was developed by Gareth Lee for JC085.

We had intended to carry out a separate buoyancy test by using a cable tie to bind the two ropes together and prevent release of the Seaglider, then bring the glider back on deck. If the buoyancy test was satisfactory, we would then remove the cable tie and deploy straight away. However, the

cable tie used was not sufficiently heavy duty and snapped when we started the raise the glider out of the water. The buoyancy had appeared satisfactory so we simply released the Seaglider from the sling without bringing it back on deck.

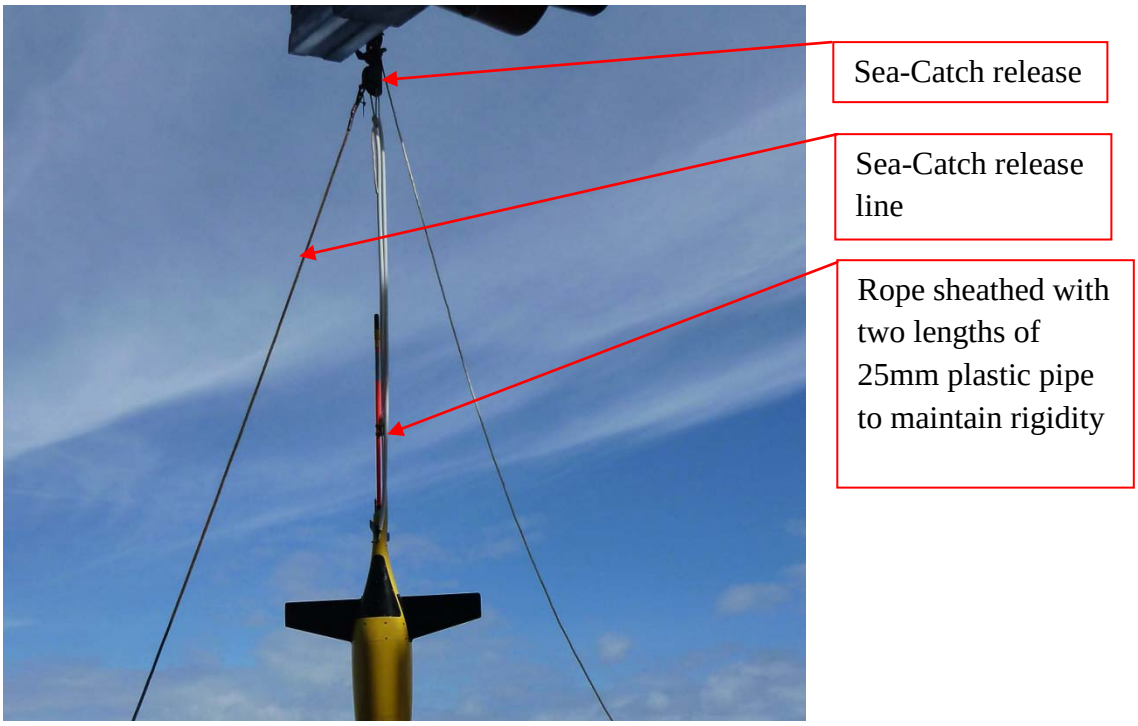


Fig. 33 Deployment using Rigid Rope and Rexroth winch

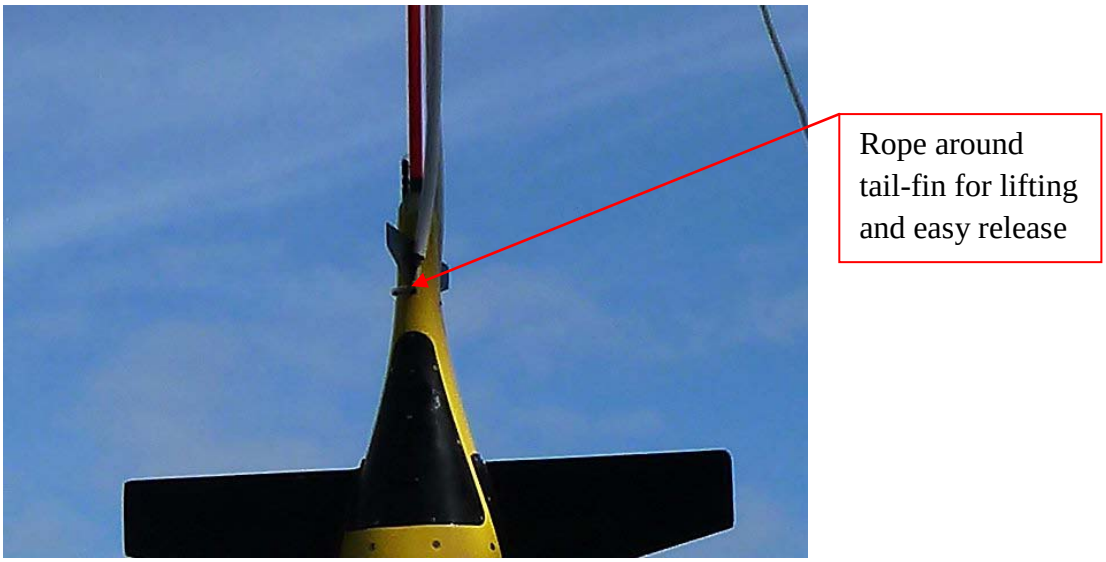


Fig. 34 Close up of deployment sling showing attachment around tail-fin for ease of release

Recovery

The original plan had called for the recovery of SG510 as late as possible in the cruise. However, by Saturday 8th, weather forecasts for the later part of the cruise appeared rather unsettled, so the recovery was brought forward to the morning of Sunday 9th. The piloting team at UEA piloted SG510 to be close to the ship's location then put her in recovery mode. Visibility was good and the glider was spotted rapidly as we approached her GPS location.

The Recovery Loop

A 10 m carbon fibre pole was modified to enable attachment of a plastic loop. The plastic loop was made from 15mm flexi pipe and had spring clips screwed inside the loop to hold the rope in place. The pole was extended to reach the water level and, once SG510 was alongside, the loop was placed over the glider's antenna, making sure to go below the rudder. The rope was then pulled to release it from the spring clips and tighten around the rudder of the glider. A loop was tied in the rope as a lifting point, and the glider was lifted on board using the Rexroth winch. Meanwhile, we fended the glider off to avoid it crashing into the side of the ship.

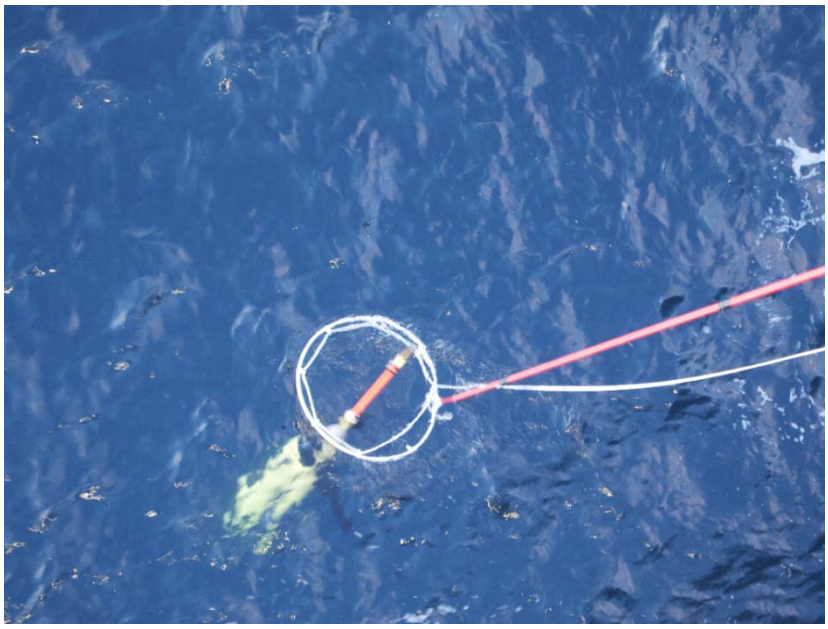


Fig. 35 The Recovery Loop

Post-recovery

SG510 was put in travel mode and switched off. We then washed SG510 as described in the manual – a full freshwater rinse, plus rinsing of all sensors with de-ionised water, and a further cleaning of the conductivity cell with a mild bleach solution to reduce the risk of the growth of micro-organisms. SG510 was then returned to its crate.

4 Station List

Deployment	Rec overy	Station	Cast	Time (GMT)			Start Position		End Position		Activity	Contact Person
Date	Date (if different)		(if CTD)	OB/Start	Bottom	IB/End	Lat (N)	Lon (W)	Lat (N)	Lon (W)		
03/06/2013		JC087-01		0742		N/A	48°41.64	015°59.67	N/A	N/A	Glider Deployment	Gillian Damerell
03/06/2013		JC087-02		0930		1022	48°47.65	015°59.67	48°47.65	015°59.67	Pelagra Test	Kev Saw
03/06/2013		JC087-03		1025		1036	48°47.65	015°59.67	48°47.65	015°59.67	Turbulence Probe test 200m	Anna Rumantseva
03/06/2013		JC087-04		1111		1131	48°41.6	015°59.6	48°41.6	015°59.6	Multinet Test	Marja Koski
03/06/2013		JC087-05	1	1231	1412	1648	48°41.99	016°02.02	48°41.98	016°08.60	CTD 4787m depth	
03/06/2013	04/06/2013	JC087-06		1822		2124	48°38.91	016°08.57	48°39.09	016°32.64	Pelagra (P7)	Kev Saw
03/06/2013	04/06/2013	JC087-06		1840		2354	48°38.92	016°08.55	48°38.32	016°30.53	Pelagra (P2)	Kev Saw
03/06/2013	04/06/2013	JC087-06		1908		2037	48°38.93	016°08.50	48°39.09	016°32.64	Pelagra (P4)	Kev Saw
03/06/2013		JC087-07	2	2038		2119	48°38.92	016°08.56	48°38.92	016°08.56	CTD 200m	Richard Lampitt
03/06/2013		JC087-08		2145		2305	48°38.69	016°08.64	48°38.68	016°08.41	Turbulence probe 200m	Anna Rumantseva
03/06/2013		JC087-09		2316		2344	48°38.70	016°08.43	48°38.70	016°08.43	VPR *(failed)*	Fredrika Norrbin
04/06/2013		JC087-10		0002		0033	48°38.69	016°08.42	48°38.69	016°08.42	Snowcatcher 30-50m 130-150m (2xdeployment)	Anna Belcher
04/06/2013		JC087-11		0112	0206	0249	48°38.917	016°08.573	48°38.917	016°08.576	Multinet 998m	Steph Wilson
04/06/2013		JC087-12		0440		0444	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 15m	Zoe Morrall
04/06/2013		JC087-13		0507		0512	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 25m	Zoe Morrall
04/06/2013		JC087-14		0522		0527	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 30m	Zoe Morrall

04/06/2013		JC087-15		0540		0544	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 50m	Zoe Morrall
04/06/2013		JC087-16		0555		0616	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 150m	Christian Lindemann
04/06/2013		JC087-17		0623		0636	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher	
04/06/2013		JC087-18		0819		0923	48°38.91	016°08.57	48°38.90	016°08.57	VPR 200m	Fredrika Norrbin
04/06/2013		JC087-19		0923		0944	48°38.90	016°08.57	48°38.90	016°08.57	WP2 Plankton net	Bellineth
04/06/2013		JC087-20		1100		1106	48°38.90	016°08.57	48°38.90	016°08.57	Snowcatcher 65m	Valeria Ibello
04/06/2013		JC087-21		1115		1120	48°38.90	016°08.57	48°38.90	016°08.57	Snowcatcher 35m	Valeria Ibello
04/06/2013		JC087-22		1129		1134	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 25m	Valeria Ibello
04/06/2013		JC087-23		1139		1143	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 15m	Valeria Ibello
04/06/2013		JC087-24		1152		1153	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 10m	Valeria Ibello
04/06/2013		JC087-25		1202		1205	48°38.909	016°08.573	48°38.909	016°08.573	Snowcatcher 5m	Valeria Ibello
04/06/2013		JC087-26		1214		1214	48°38.909	016°08.573	48°38.909	016°08.573	Snowcatcher 1m	Valeria Ibello
04/06/2013		JC087-27		1245	1329	1416	48°38.917	016°08.575	48°39.957	016°08.912	Multinet 1013m	Steph Wilson
04/06/2013		JC087-28		2200		2239	48°38.13	016°35.73	48°38.13	016°35.73	WP2 Plankton net 100m	Bellineth Valencia
04/06/2013		JC087-29		2239		2254	48°38.13	016°35.73	48°38.13	016°35.73	WP2 Plankton net 100m	Bellineth Valencia
05/06/2013		JC087-30		0216		0331	48°38.91	016°08.52	48°38.746	016°07.709	Turbulence probe 200m	Anna Rumantseva
05/06/2013		JC087-31	3	0410		0446	48°38.92	016°08.58	48°38.91	016°08.57	CTD 200m	
05/06/2013		JC087-32		0555		2113	48°38.92	016°08.55	48°35.68	016°11.26	Pelagra (P4)	Kev Saw
05/06/2013		JC087-33		0615			48°38.95	016°08.51			Pelagra (P5)	Kev Saw
05/06/2013	08/06/2013	JC087-34		0645		0827	48°38.96	016°08.44	48°52.33	016°37.72	Pelagra (P6)	Kev Saw

05/06/2013		JC087-35		0700		2050	48°38.98	016°08.40	48°35.98	016°10.85	Pelagra (P7)	Kev Saw
05/06/2013		JC087-36		0722		2022	48°39.00	016°08.34	48°37.29	016°11.76	Pelagra (P8)	Kev Saw
05/06/2013		JC087-36a		0730		Not known	48°39.01	016°08.33	Not known	Not known	WP2 Plankton net 100m	Bellineth Valencia
05/06/2013		JC087-37	4	0758	0810	0840	48°39.01	016°08.33	48°39.01	016°08.33	CTD 200m	Valeria Ibello
05/06/2013		JC087-38		0905		0922	48°38.92	016°08.58	48°38.92	016°08.58	Snowcatcher 30-50m	Anna Belcher
05/06/2013		JC087-39		0923		0937	48°38.92	016°08.58	48°38.92	016°08.58	Snowcatcher 130-150m	Anna Belcher
05/06/2013		JC087-40	5	1023	1037	1103	48°38.92	016°08.58	48°38.92	016°08.58	CTD 200m	
05/06/2013		JC087-41		1124		1249	48°38.92	016°08.57	48°38.917	016°08.574	VPR 1000m	Fredrika Norrbin
05/06/2013		JC087-42	6	1324	1501	1704	48°38.917	016°08.575	48°38.91	016°08.57	CTD 4800m	
05/06/2013		JC087-43		1723		1853	48°38.91	016°08.57	48°38.91	016°08.57	Multinet 1008m	Marja Koski
05/06/2013		JC087-44		1910		1915	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 55m	Steph Wilson
05/06/2013		JC087-45		2154		2315	48°38.91	016°08.57	48°38.92	016°08.57	VPR 1000m	Fredrika Norrbin
05/06/2013		JC087-46		2326		0016	48°38.92	016°08.57	48°39.02	016°08.63	WP2 Plankton net 100m	Steph Wilson
06/06/2013		JC087-47		0128		0138	48°36.016	016°13.795	48°36.05	016°13.81	WP2 Plankton net 100m	Bellineth Valencia
06/06/2013		JC087-48		0225		1508	48°36.022	016°13.813	48°33.88	016°17.11	Pelagra (P8)	Kev Saw
06/06/2013		JC087-49		0245		1547	48°36.062	016°13.833	48°33.60	016°15.99	Pelagra(P7)	Kev Saw
06/06/2013	08/06/2013	JC087-50		0302			48°36.0895	016°13.85	48°30.52	016°31.74	Pelagra(P4)	Kev Saw
06/06/2013		JC087-51	7	0358		0430	48°38.917	016°08.574	48°38.91	016°08.57	CTD 200m	Zoe Morrall
06/06/2013		JC087-52		0508		0654	48°38.91	016°08.57	48°38.91	016°08.57	Turbulence probe 200m	Anna Rumantseva
06/06/2013		JC087-53		0724		0730	48°38.91	016°08.57	48°38.90	016°08.74	WP2 Plankton net 100m	Bellineth Valencia
06/06/2013		JC087-54		0730		0742	48°38.90	016°08.74	48°38.89	016°08.83	WP2Plankton net 100m	Bellineth Valencia

06/06/2013		JC087-55	8	0823	0835	0904	48°38.92	016°08.56	48°38.92	016°08.56	CTD 200m	Valeria Ibello
06/06/2013		JC087-56		0935		1053	48°38.92	016°08.56	48°38.92	016°08.56	Multinet 1010m	Marja Koski
06/06/2013		JC087-57		1216		1335	48°38.917	016°08.568	48°38.92	016°08.63	VPR 1000m	Fredrika Norrbin
06/06/2013	08/06/2013	JC087-58		1803		1820	48°32.44	016°18.92	48°29.55	016°27.74	Pelagra (P8)	Kev Saw
06/06/2013	08/06/2013	JC087-59		1825		0934	48°32.46	016°19.02	48°39.04	016°29.30	Pelagra (P7)	Kev Saw
06/06/2013		JC087-60	9	1945		2019	48°38.91	016°08.56	48°38.91	016°08.56	CTD 200m	
06/06/2013		JC087-61		2025		0045	48°38.91	016°08.56	48°38.91	016°08.570	Turbulence probe 200m	Anna Rumantseva
07/06/2013		JC087-62		0105		0258	48°38.915	016°06.611	48°38.870	016°08.653	Multinet 1008m	Steph Wilson
07/06/2013		JC087-63		0441		0443	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 30-50m	Anna Belcher
07/06/2013		JC087-64		0457		0513	48°38.91	016°08.57	48°38.90	016°08.70	Snowcatcher 145m	Anna Belcher
07/06/2013		JC087-65		0710		0725	48°38.91	016°08.89	48°38.91	016°08.74	WP2 Plankton net	Bellineth Valencia
07/06/2013		JC087-66		0725		0735	48°38.91	016°08.74	48°38.89	016°08.86	WP2 Plankton net	Bellineth Valencia
07/06/2013		JC087-67	10	0836	0850	0914	48°38.91	016°08.57	48°38.91	016°08.57	CTD 200m	Valeria Ibello
07/06/2013		JC087-68		1135	1212	1250	48°38.86	016°08.62	48°38.75	016°08.70	Multinet 1012m	Steph Wilson
07/06/2013		JC087-69		1335	1411	1452	48°38.91	016°08.58	48°38.659	016°08.775	Multinet 1011m	Marja Koski
07/06/2013		JC087-70		2055		2105	48°38.92	016°08.75	48°38.92	016°08.75	Snowcatcher 30-50m	Anna Belcher
07/06/2013		JC087-71		2115		2135	48°38.92	016°08.75	48°38.92	016°08.75	Snowcatcher 130-150m	Anna Belcher
07/06/2013		JC087-72		2323		0041	48°38.92	016°08.57	48°38.92	016°08.58	VPR 1000m	Fredrika Norrbin
08/06/2013		JC087-73		0112		0312	48°38.917	016°08.575	48°38.917	016°08.575	Turbulence probe 200m	Anna Rumantseva
08/06/2013		JC087-74	11	0342	0354	0414	48°38.919	016°08.604	48°38.975	016°08.958	CTD 200m	Zoe Morrall
08/06/2013		JC087-75	12	1026	1037	1059	48°39.04	016°29.30	48°39.04	016°29.30	CTD 200m	Valeria Ibello

08/06/2013		JC087-76		1131		1146	48°29.98	016°29.31	48°29.98	016°29.31	WP2 Plankton net 100m	Bellineth Valencia
08/06/2013		JC087-77		1149		1200	48°29.98	016°29.31	48°29.99	016°29.32	WP2 Plankton net 100m	Bellineth Valencia
08/06/2013		JC087-78		2015		2024	48°29.45	016°41.94	48°29.45	016°41.94	Snowcatcher 40m	Steph Wilson
08/06/2013		JC087-79		2142		2158	48°29.45	016°41.94	48°29.45	016°41.94	WP2 Plankton net 100m	Steph Wilson
08/06/2013		JC087-80		2201		2217	48°29.45	016°41.94	48°29.45	016°41.94	WP2 Plankton net 100m	Steph Wilson
08/06/2013		JC087-81		2227		2257	48°29.45	016°41.94	48°29.45	016°41.94	WP2 Plankton net 100m	Steph Wilson
09/06/2013		JC087-82		0535		0540	48°38.94	016°08.58	48°38.94	016°08.58	Snowcatcher 30-50m	Anna Belcher
09/06/2013		JC087-83		0550		0605	48°38.94	016°08.58	48°38.94	016°08.58	Snowcatcher 130-150m	Anna Belcher
09/06/2013		JC087-84		0620		0625	48°38.91	016°08.57	48°38.91	016°08.57	WP2 Plankton net 100m	
09/06/2013		JC087-85		0627		0635	48°38.91	016°08.57	48°38.91	016°08.57	WP2 Plankton net 100m	Bellineth Valencia
09/06/2013		JC087-86		0640		0645	48°38.91	016°08.57	48°38.91	016°08.57	WP2 Plankton net 100m	Bellineth Valencia
09/06/2013		JC087-87		0647		0655	48°38.91	016°08.57	48°38.91	016°08.57	WP2 Plankton net 100m	Bellineth Valencia
09/06/2013		JC087-88	13	0718		0818	48°38.91	016°08.57	48°38.91	016°08.57	CTD 500m	Valeria Ibello
09/06/2013		N/A				0926			48°38.17	016°06.04	Glider recovered	Gillian Damerell
09/06/2013		JC087-89		1021	1100	1135	48°38.92	016°08.56	48°38.92	016°08.56	Multinet 1000m	Marja Koski
09/06/2013	12/06/2013	JC087-90		1324		2119	48°39.125	016°08.5541	48°31.21	016°53.91	Pelagra (P4)	Kev Saw
09/06/2013		JC087-91		1334		2116	48°38.9036	016°08.5193	48°41.48	016°14.29	Pelagra (P8)	Kev Saw
09/06/2013	10/06/2013	JC087-92		1354		1639	48°38.8965	016°08.4865	48°40.48	016°32.68	Pelagra (P7)	Kev Saw
09/06/2013		JC087-93		1409		2049	48°38.8965	016°08.4850	48°41.13	016°11.70	Pelagra (P6)	Kev Saw
09/06/2013		JC087-94	14	1507	1520	1546	48°38.908	016°08.479	48°38.908	016°08.478	CTD 200m	

09/06/2013		JC087-95		1606			48°38.91	016°08.48	48°38.49	016°08.58	Turbulence probe 200m	Anna Rumantseva
09/06/2013		JC087-96	15	1908		1941	48°38.40	016°08.58	48°38.40	016°08.58	CTD 200m	
09/06/2013		JC087-97	16	2224	2235	2246	48°39.62	016°16.86	48°39.62	016°16.86	CTD 250m	
10/06/2013	12/06/2013	JC087-98		0013		0935	48°39.63	016°16.84	48°38.87	016°58.361	Pelagra (P6)	Kev Saw
10/06/2013	12/06/2013	JC087-99		0023		2357	48°39.66	016°16.81	48°38.385	017°08.746	Pelagra (P8)	Kev Saw
10/06/2013		JC087-100		0153	0230	0312	48°38.94	016°08.66	48°38.94	016°08.66	Multinet 1015m	Steph Wilson
10/06/2013		JC087-101	17	0346	0358	0416	48°38.92	016°08.57	48°38.91	016°08.57	CTD 200m	Zoe Morrall
10/06/2013		JC087-102		0715		0720	48°38.91	016°08.57	48°38.91	016°08.57	WP2 Plankton net 100m	Bellineth Valencia
10/06/2013		JC087-103		0723		0730	48°38.91	016°08.57	48°38.91	016°08.57	WP2 Plankton net 100m	Bellineth Valencia
10/06/2013		JC087-104	18	0835	0847	0908	48°38.91	016°08.57	48°38.91	016°08.57	CTD 200m	Valeria Ibello
10/06/2013		JC087-105		1040		1145	48°38.91	016°08.57	48°38.91	016°08.57	Multinet 1016m	Steph Wilson
10/06/2013		JC087-106		1234	1316	1358	48°38.92	016°08.57	48°38.92	016°08.572 7	Multinet 1016m	Marja Koski
10/06/2013		JC087-107		1655	1755	1915	48°40.47	016°32.68	48°40.21	016°32.89	Multinet 1009m	Marja Koski
10/06/2013		JC087-107a		1916		2052	48°40.209	016°32.888	48°40.034	016°33.186	Multinet 1007m	Steph Wilson
10/06/2013	12/06/2013	JC087-108		2037		2300	48°40.05	016°.33.15	48°37.81	017°00.91	Pelagra (P7)	Kev Saw
10/06/2013		JC087-109		2109		2300	48°40.03	016°33.20	48°40.03	016°33.20	VPR 500m	Fredrika Norrbin
10/06/2013		JC087-110		2329	0006	0055	48°40.03	016°33.20	48°40.196	016°33.368	Multinet 1002m	Steph Wilson
11/06/2013		JC087-111		0330		0518	48°40.196	016°33.367	48°40.19	016°33.37	VPR 500m	Fredrika Norrbin
11/06/2013		JC087-112		0724		0730	48°38.91	016°08.58	48°38.91	016°08.58	Snowcatcher 30-50m	Anna Belcher
11/06/2013		JC087-113		0735		0740	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher *(Did not fire)*	Anna Belcher
11/06/2013		JC087-114		0750		0804	48°38.91	016°08.57	48°38.91	016°08.57	Snowcatcher 130-150m	Anna Belcher

11/06/2013		JC087-115		0813		0824	48°38.92	016°08.58	48°38.93	016°08.60	WP2 Plankton net 100m	Bellineth Valencia
11/06/2013		JC087-116		0827		0839	48°38.93	016°08.60	48°38.95	016°08.60	WP2 Plankton net 100m	Bellineth Valencia
11/06/2013		JC087-117	19	0853		0931	48°38.95	016°08.59	48°38.95	016°08.59	CTD 200m	Valeria Ibello
11/06/2013		JC087-118		1252	1342	1427	48°46.38	016°39.92	48°46.496	016°41.108	Multinet 1007m	Steph Wilson
11/06/2013		JC087-119		1451		1505	48°46.49	016°41.12	48°46.408	016°41.215	WP2 Plankton net 100m	
11/06/2013		JC087-120		1520	1556	1636	48°46.408	016°41.302	48°46.67	016°42.43	Multinet 1010m	Marja Koski
11/06/2013		JC087-121		1700		1850	48°46.47	016°42.56	48°46.47	016°42.56	VPR 500m	Fredrika Norrbin
11/06/2013		JC087-122		2244		0005	48°47.40	016°66.21	48°47.111	016°57.094	Mulitnet 997m	Steph Wilson
12/06/2013		JC087-123		0047		0204	48°48.47.113	016°57.097	48°47.129	016°57.083	VPR 500m	Fredrika Norrbin
12/06/2013		JC087-124		0700		0710	48°47.41	017°02.14	48°47.41	017°02.15	WP2 Plankton net 100m	Bellineth Valencia
12/06/2013		JC087-125		0712		0720	48°47.41	017°02.18	48°47.41	017°02.24	WP2 Plankton net 100m	Bellineth Valencia
13/06/2013		JC087-126	20	0443		0514	48°38.91	016°08.57	48°38.91	016°08.57	CTD 200m	Zoe Morrall
13/06/2013		JC087-127		0710		0717	48°38.91	016°08.57	48°38.85	016°08.52	WP2 Plankton net 100m	Bellineth Valencia
13/06/2013		JC087-128		0720		0727	48°38.80	016°08.50	48°38.75	016°08.47	WP2 Plankton net 100m	Bellineth Valencia
13/06/2013		JC087-129		0730		0735	48°38.70	016°08.42	48°38.67	016°08.38	WP2 Plankton net 100m	Bellineth Valencia
13/06/2013		JC087-130	21	0838	0848	0913	48°38.92	016°08.57	48°38.92	016°08.57	CTD 200m	Valeria Ibello
13/06/2013		JC087-131		0928		1133	48°38.92	016°08.57	48°38.79	016°09.67	Turbulence probe 200m	Anna Rumantseva
13/06/2013		JC087-132		1233	1310	1355	48°38.917	016°08.574	48°38.917	016°08.574	Multinet 1011m	Marja Koski
13/06/2013		JC087-133		1417		1452	48°38.917	016°08.575	48°38.918	016°08.574	Snowcatcher 30-50m 130-150m	Anna Belcher
13/06/2013		JC087-134		1835		2035	48°38.917	016°08.575	48°38.917	016°08.575	Pelagra camera	Morten Iversen

13/06/2013		JC087-135		2043		2201	48°38.917	016°08.575	48°38.917	016°08.575	VPR 500m	Fredrika Norrbin
13/06/2013		JC087-136		2213		2218	48°38.917	016°08.575	48°38.917	016°08.575	Snowcatcher 45m	Steph Wilson
13/06/2013		JC087-137		2227		2238	48°38.91	016°08.57	48°38.86	016°08.54	WP2 Plankton net 100m	Steph Wilson
13/06/2013		JC087-138		2242		2252	48°38.83	016°08.57	48°38.76	016°08.47	WP2 Plankton net 100m	Steph Wilson
13/06/2013		JC087-139		2255		2306	48°38.76	016°08.47	48°38.66	016°08.41	WP2 Plankton net 100m	Steph Wilson
14/06/2013		JC087-140		0122		0308	48°38.898	016°08.534	48°38.889	016°08.512	Pelagra camera 1000m	Morten Iversen
14/06/2013		JC087-141	22	0416		0450	48°38.91	016°08.57	48°38.91	016°08.57	CTD 200m	Zoe Morrall
14/06/2013		JC087-142		0508		0653	48°38.91	016°08.57	48°38.91	016°08.57	Turbulence probe 200m	Anna Rumantseva
14/06/2013		JC087-143		0701		0708	48°38.90	016°08.60	48°38.86	016°08.65	WP2 Plankton net 100m	Bellineth Valencia
14/06/2013		JC087-144		0710		0716	48°38.83	016°08.69	48°38.82	016°08.71	WP2 Plankton net 100m	Bellineth Valencia
14/06/2013		JC087-145		0720		0725	48°38.79	016°08.74	48°38.75	016°08.79	WP2 Plankton net 100m	Bellineth Valencia
14/06/2013		JC087-146		0730		0735	48°38.68	016°08.84	48°38.66	016°08.85	WP2 Plankton net 100m	Bellineth Valencia
14/06/2013		JC087-147		0740		0745	48°38.65	016°08.87	48°38.60	016°08.91	WP2 Plankton net 100m	Bellineth Valencia
14/06/2013		JC087-148		0750		0800	48°38.57	016°08.94	48°38.51	016°09.01	WP2 Plankton net 100m	Bellineth Valencia
14/06/2013		JC087-149	23	0841	0852	0913	48°38.91	016°08.58	48°38.91	016°08.58	CTD 200m	Valeria Ibello
14/06/2013		JC087-150		0940		1059	48°38.91	016°08.58	48°38.91	016°08.58	Multinet 1011m	Marja Koski
14/06/2013		JC087-151		1143	1336	1517	48°38.91	016°08.58	48°38.242	016°09.191	CTD 4800m	

NB - stations 36a and 107a initially not recorded so added at a later date, hence different station notation