PROcesses of Vertical Exchange in Shelf Seas (PROVESS)

MAST III contract # MAS3-CT97-0159

Cruise Report

Northern North Sea experiment cruise S-1
R.V. Pelagia 29 March - 09 April, 1999
(Pelagia cruise 64PE136)

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(with contributions from participants)

09 April 1999

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0. Contents

1. Summary of R.V. Pelagia cruise PROVESS S-1

The R.V. Pelagia (NIOZ, the Netherlands) cruise PROVESS S-1 started on Monday 29 March 1999 and ended on Friday 09 April 1999. The cruise consisted of two legs, with a port call at Texel on Wednesday 31 March 1999. The working area was located in the Southern North Sea, about 10 nautical miles off the Ducth coast (Noordwijk). Shipborne sampling was very near the central position 52° 18' N, 04° 18' E, where the majority of instrumentation was moored during leg 1 of this cruise. During the entire cruise the weather conditions were highly favourable, with wind speeds never exceeding 13 m s^{-1}, and generally much lower (Bf 2-6). The only disadvantage was that we spent most of Easter in a tiny world, surrounded by dense fog lasting days.

The purpose of cruise S-1 was to deploy all moored equipment including fast and relatively slow sampling acoustic Doppler current profilers (ADCP's), current meters, temperature and conductivity sensors, pressure recorders, tide-wave recorders, in-situ nutrient (NOx and Si) auto-analyzers, fluorometers and transmissometers. The deployment of the moorings proceeded swiftly, except for the first two moorings, as the NIOZ thermistor string initially could not be programmed and the benthic lander STABLE tipped over upon deployment. The latter was recovered undamaged and redeployed again. The former was repaired at Texel during the port call for leg 2, and moored as the first activity of that leg.

The measurements during leg 2 concentrated near the main mooring site to obtain an extensive set of simultaneous turbulence, CTD, pelagic biological, sedimentological and optical measurements, in order to monitor the vertical exchange in the water column over a tidal cycle and, given the location, its relationship with the variations in haline stratification (the coastal influence). The emphasis of the study is the nutrient recycling in the benthic boundary layer in this tidally dominated shallow sea.

We managed to complete nearly all of the intentional programme, although two misheaps occurred. Firstly, the in-situ AVHRR camera flooded upon its first deployment. Fortunately, an additional, albeit different, optical instrument was on board. Secondly, the CTD did not operate well due to severe fouling. Although it was found out out relatively soon that 'problems' occurred on-and-off during CTD casts, the cause was not found and properly solved before about half of the CTD stations eventually obtained were sampled.

In total 133 CTD casts were done, of which from 78 of them water samples were taken for biological and sedimentological sampling. Two short CTD hydrographic surveys were made in the vicinity of the moorings. Some 900 profiles were obtained of turbulence dissipation rate by the generally flawlessly working microstructure profiler. Particle settling tubes were closed 25 times near the surface and the bottom, resulting in an enormous number of filters awaiting further processing in the lab now. Finally, optical profiling was completed 32 times, with, unfortunately, very few profiles in bright sunshine.

Little can be said about the first results of this cruise, other than that most instruments worked fine, including the first mooring recovered, and that the site is as expected, enormously variable over tidal period, and alternating between well-mixed and strongly stratified conditions, in addition to high turbidity loads at times.

2. PROVESS' general research summary and objectives.

Definition and aim.

PROVESS (PROcesses of Vertical Exchange in Shelf Seas) is an EC-MAST III project. The project is founded on the integration of experimental, theoretical and modelling studies of vertical exchanges in shelf seas, including the joint analysis and interpretation of measurements and model calculations. Innovative measurements of turbulence properties in continental shelf seas (dissipation rate throughout the water column and intensity over a wide frequency range) are the heart of the proposal.These, together with biological measurements concentrating on fluxes near the sea bed, will be made at two contrasting sites in the North Sea - one shallow, high energy, the other deeper, low energy.

This cruise plan is on the experiment at the deeper site, to study the vertical exchanges during the autumnal breakdown of the stabilizing density stratification.

Research summary and objectives.

Since turbulence directly affects the environment perceived by particles, including living biota, detritus and suspended sediment, studies will be made of aggregation, flocculation and sedimentation, and of trophic interactions. New hypotheses about turbulence effects on zooplankton grazing rates, diet selectivity, vertical distribution and patchiness will be tested against process oriented field and laboratory measurements.

Water column numerical models describing turbulent physics and integrated biology/physics will incorporate the understanding gained from the process studies and be rigorously tested against the turbulence and biological measurements, to establish the robustness of parameterisation and the domain of validity of the models.

The improved understanding will be applied to the exchange of nutrients across the stratification and to nutrient recycling in the benthic boundary layer. This fundamental research will contribute towards the long term goal of developing robust water column plankton models applicable in the full range of turbulence environments encountered in shelf seas.

Objectives.

* Improve understanding and quantification of vertical exchange processes in the water column, in the surface and benthic boundary layers and across the pycnocline.
* Explore mechanisms of physical-biological coupling in which vertical exchanges and turbulence significantly affect the environmental conditions experienced by biota.
* Apply innovative technologies to the measurement of physical microstructure features and phenomena, in particular turbulence properties in the water column.
* Provide a new, comprehensive and synoptic data set for validation of vertical fluxes of energy and matter calculated by physical and biological models.
* Develop 1-D physical models for the computation of statistical moments of microstructure phenomena and integrated biological-physical models of the water column, including fluxes from the surface and the sediment.
* Test and validate the models against measurements of mean and fluctuating properties in the water column.
* Provide modules for vertical exchanges which can be implemented in state-of-the-art 3-D water quality and ecological models.

a. Southern North Sea experiment and site.

The observational study on turbulence and on nutrient recycling in the benthic boundary layer in the tidally dominated and shallow Southern North Sea takes place between 29 March – 21 May, 1999. Three ships participate, each cruise lasting between one and two weeks.

The R.V. Pelagia sailed between 29 March – 09 April 1999. During leg 1 of the R.V. Pelagia cruise all of the mooring equipment has been deployed, which will remain on site for about two months. The remainder of the cruise has been dedicated to turbulence, CTD, sedimentological (also settling velocity), optical and biological sampling. The R.V. Mitra sails between 19-30 April, 1999 and focuses on turbulence measurements, suspended sediment sampling, CTD/nutrients and benthic chamber work. The R.V. Belgica sails between 17-21 May 1999 and will recover all the moorings, in addition to some further CTD and turbulence measurements.

The central site is at 52°18' N, 04°18' E, where the water depth is about 16 m. Moored equipment will be deployed within 50 km from this position (see map). The bearings for the two lines along which moorings are located have the following bearings. For A, V, Y 13 degrees and for A, T, U, X 282 degrees. All other measurements are and will be carried out within a range of about 20 km from the above central site, with the exception of a CTD survey along two lines parallel to the A-X line performed by the R.V. Pelagia.

3. Cruise PROVESS S-1.

a. Participants.

Leg 1 29 March – 01 April 1999

Institute	*Name*
NIOZ	Hans van Haren (PI)
NIOZ	Margriet Hiehle
NIOZ	Jan Derksen
POL	John Humphery
POL	Graham Ballard
POL	Anthony Banaszek
POL	Andrew Vile
DML	Ivan Ezzi
SOC	Joyce Boyd

Leg 2 01-09 April 1999

Institute	*Name*
NIOZ	Hans van Haren (PI)
NIOZ	Margriet Hiehle
NIOZ	Jan Derksen
NUE	Karin Wild-Allen
UWB	Tom Rippeth
UWB	Raymond Wilton
UWB	David Boon
UWB	Neil Fischer
UWB	Malcolm Hearn
UWB	Robin McCandliss
UWB	Rebecca Latter
POL	Andrew Lane
BODC	Gwenaelle Moncoiffe

NIOZ Netherlands Institute for Sea Research, P.O. Box 59, 1790 AB Den Burg, the Netherlands
POL Proudman Oceanographic Lab., Bidston Observatory,Birkenhead,Merseyside,L43 7RA, UK
DML Dunstaffnage Marine Lab., P.O. Box 3, Oban, Argyll, PA34 4AD, UK
SOC Southampton Oceanographic Centre, Empress Dock, Southampton SO14 3ZH, UK
NUE Dept. of Biological Science, Napier University, 10 Collinton Rd, Edinburgh EH10 5DT, UK
UWB School of Ocean Sciences, Menai Bridge, Gwynedd LL59 5EY, UK
BODC British Oceanogr. Data Centre, Bidston Observatory,Birkenhead,Merseyside,L43 7RA, UK

b. Instrumentation.

Shipborne equipment

On board the R.V. Pelagia the **NIOZ** CTD/Rosette system contains a Seabird 911 CTD, with additional electronic sensors on fluorescence (Chelsea Instruments Aquatracka MKIII), K-meter (PAR light attenuation) and a transmissometer (Seatech). **UWB** has mounted a LISST-100 transmissometer and scatterometer for particle size detrmination on the CTD frame. The CTD samples at a 24 Hz rate, the LISST-100 at 2 Hz. The Rosette holds 22 12 l water bottles.

UWB brought a FLY-II microstructure profilers with winch and line pulling system. This system has been operated frequently to measure the turbulence dissipation in the water column and its temporal variations in relation to the tide.

NUE and **POL** operated the optical sampling, several times a day around mid-day, by water sampling, profiling irradiance meters, and by installing (permanently) a solar radiometer on an unobscured deck.

POL lowered an AVHRR-camera for sea-truth data for sattelite measurements. Unfortunately, this instrument flooded during its very first deployment.

NUE was responsible for the biological sampling (using the CTD-Rosette sampler) for analysis of pigment concentration, SPM spectral signature, C-N content and microplankton community composition.

UWB lowered and sampled sediment settling tubes during several sessions of 25 hours.

NIOZ took care of the sampling (using the CTD-Rosette sampler) for nutrients and salinity analysis, basically for calibration purposes.

Mooring equipment

The 11 rigs contain the following **POL/UWB/DML/NIOZ/SOC** equipment

Main site. Rigs A, B, D, G, H and NIOZ.

- STABLE, bottom frame. U shaped mooring with spar buoy. **Rig A**.
- 1.2 MHZ ADCP in bottom frame plus conductivity / temperature chain 3 - 13 m below the surface. U shaped mooring with toroid. **Rig B**.
- Near surface current meter S4 4 m below surface.Single string mooring with toroid. **Rig D**.
- Surface nitrate,fluorimeter,transmissometer.Single string chain mooring with toroid. **Rig G**.
- Nearbed nitrate,silicate, fluorimeter, transmissometer at 5 m above the bed. Pop-up. **Rig H**.
- 0.6 MHZ ADCP in bottom frame, wave-tide recorder and temperature chain 3 - 13 m below the surface. U shaped mooring. **Rig NIOZ**.

Rigs T-Y.

- 1.2 MHZ ADCP in bottom frame plus conductivity / temperature chain 3 - 13 m below the surface. U shaped mooring with toroid. **Rig T**.

- Current meter rig, S4 at 13 m and Aanderaa at 3 m above the bed. U shaped mooring with spar buoy. **Rig U**.

- Pressure recorder in bottom frame. Pop-up. **Rig X**.

- Current meter rig, S4 at 9 m and Aanderaa at 3 m above the bed. U shaped mooring with spar buoy. **Rig V**.

- Pressure recorder in bottom frame. Pop-up. **Rig Y**.

4. Daily summary.

Friday 26 March – Sunday 28 March

Loading of the R.V. Pelagia starts at about 8.30 local time in the NIOZ harbour, Texel NL. The next two days prior to the cruise the participants from POL, DML and SOC stay on board to prepare the moorings and the mooring equipment.

Monday 29 March

Departure for the PROVESS Southern North Sea site at 09.00 METZ (07.00 UTC), SSW winds Bf4-5, clear. At 09.45 UTC a test-CTD is taken, for calibration of the transmissometers to be moored later this day. Around 12.30 UTC, arrival at the main PROVESS SNS site. Start deployment of the NIOZ rig, without thermistor string, which happens not to respond. The following deployment, of STABLE, is difficult because of the strong (tidal) current. Serious thoughts rise, that STABLE may have tipped over. In the evening, it is considered to recover STABLE the next day, to be sure. Before that, two more moorings are deployed, before finishing the operations at 18.30 UTC.

Tuesday 30 March

Winds decreasing, S 2-4. A total of seven deployments are successfully performed between 06 and 18 UTC, including the redeployment upon recovery of STABLE. Indeed, this mooring had been on its side, but, fortunately, all instrumentation is undamaged. The bottom-hopping camera is deployed at the main site for about half an hour, for pictures of the bottom structure. Considering the fast and successful deployments and given the one remaining problem of the non-functioning of the NIOZ thermistor string, it is decided to return to Texel, to have more time for repair of the thermistor string.

Wednesday 31 March

Arrival in Texel NL, NIOZ harbour at 08.30 METZ. By 13.30 UTC the NIOZ thermistor string has been repaired and programmed for deployment.

Thursday 01 April

Winds SE 4, warm. Departure of the leg 1 POL, DML and SOC participants, arrival of the NUE, POL, BODC and UWB participants for leg 2. Loading. Departure from the NIOZ harbour at 08.45 UTC. Arrival at the PROVESS SNS main site at 13.15 UTC. 14 UTC recovery of the NIOZ ADCP mooring. By 16 UTC the redeployment is completed of the NIOZ ADCP and thermistor string. At 20 UTC a small CTD+sampling survey is started, with stations separated by 2 miles, along two 20 miles long lines perpendicular to the coast and running about 2 miles north and south of the mooring line A-X.

Friday 02 April

Winds SW 4. Continuation of the CTD survey until 05.15 UTC, return to the main mooring site. All further sampling at this site. Between 06 – 21 UTC a 15 h CTD, water sampling and FLY hourly sampling scheme is followed. Around mid-day optical instruments are lowered immediately after the FLY measurements (at the half hour). Unfortunately, upon the first deployment the POL AVHRR-camera gets flooded and cannot be used further. From 22 UTC onward a 2 hourly CTD sampling starts, which is alternated with a 3 hourly lowering of sedimentation tubes, for a period of 25 hours.

Saturday 03 April

Winds SW 2, dense fog. Continuation of the 25 hour CTD and sedimentological sampling. During day-time optical measurements are made. At 22 UTC the sampling scheme flips to the combination of hourly CTD and FLY measurements. Some CTD testing occasionally.

Sunday 04 April

Winds SW 2, dense fog. Continuation of the 15 hour CTD-FLY sampling session II, which lasts until 13 UTC. During day-time optical measurements are made. From 14 UTC until 22 UTC a second CTD survey is carried out, along the same track as before. Overnight the ship is anchored. More CTD testing.

Monday 05 April

Winds SW 5, finally the fog disappears slowly. The problems with the CTD (too large differences between up- and downcast, too large density inversions, fouled sampling bottles) urge a cleaning and overhaul break. From 11 UTC onwards FLY sampling session III is carried out, initially with CTD sampling, but because of further trouble, the CTD is out-of-order for another four hours to install an entire spare unit. This CTD is noisy, and the data probably need a lot of post-processing. Unfortunately, the cause of all the troubles is not found yet.

Tuesday 06 April

Winds SW 6. End of CTD-FLY programme at 02 UTC. Start with a 15 hour of CTD-sedimentological sampling programme at 04 UTC. During the afternoon and after several additional tests, the problems with the CTD become clearer and solvable. All is attributable to fouling of all the tubing and electronic leads. The 15 hour sampling programme ends at 18 UTC.

Wednesday 07 April

Winds SW-NW 5. At 06 UTC we had a tender to take Tom Rippeth to Scheveningen to catch a flight home later that day. From 07.30 UTC we resumed sampling, this time with all equipment operational within the same 15 hour sampling scheme. Every hour, a CTD cast was taken, followed by 15 profiles of FLY. This was followed every two hours by sediment tubes' settling velocity determination. Additionally, during 6 hours around midday the optical measurements were squeezed into this sampling scheme every hour. The final CTD-cast was made at 22.30 UTC.

Thursday 08 April

Winds NW 4-5. The day started with some CTD check-ups, the CTD indeed working fine now. At 08.30 UTC the final hourly CTD and optical sampling around midday started, and lasting 5 hours. Around 17 UTC the last and final activity of the PROVESS SNS Pelagia S-1 cruise consisted of the recovery of the NIOZ ADCP-thermistor string mooring.

Friday 09 April

Arrival at Texel NL, NIOZ harbour at 08.15 MET DST.

5. Summary and first results of activities *(cf. Appendix A)*.

a. Mooring deployments.

- The U-shaped moorings have two lines below, with two positions and surface markers indicated. The first line indicates the position of the bottom instrumentation, the second the surface marker buoy. Although time is given for both, it is for the last (surface marker) release.
- STABLE was moored on 290399, but pulled over upon deployment. Recovered and redeployed on 300399.
- The NIOZ rig is finally recovered by the Pelagia on 080499.
- At the ***main site*** moorings **A**, **NIOZ**, **B**, **D**, **G** and **H** have been deployed.

Details of the mooring deployments are, with reference to the map on p. 5,

mooring	*name*	*latitude*	*longitude*	*depth*	*date*	*time(UTC)*	*surface marker*
A	STABLE	52 18.38' N	4 18.01'E	20 m	300399	11.44	buff
		52 18.34' N	4 18.05'E	20 m	300399	11.44	SPAR-buff-pellets
--	NIOZ	52 18.13' N	4 18.02'E	19 m	290399	13.30	buff-pellets
		52 18.14' N	4 17.98'E	19 m	290399	13.30	pellets
B	ADCP-TC	52 18.14' N	4 18.40'E	20 m	300399	13.05	buff-pellets
		52 18.19' N	4 18.33'E	20 m	300399	13.05	oroid-pellets
D	Surfcur	52 18.12' N	4 17.67'E	19 m	300399	13.39	toroid-pellets
G	Surfenv	52 17.88' N	4 17.98'E	19 m	290399	16.48	toroid-buff-pell.
H	Bottenv	52 18.01' N	4 18.01'E	18 m	300399	10.08	none (pellets)
T	ADCP-TC	52 19.19' N	4 11.72'E	22 m	300399	08.14	buff-pellets
		52 19.15' N	4 11.74'E	22 m	300399	08.14	toroid-pellets
U	Current	52 20.10' N	4 05.12'E	23 m	300399	06.37	none (pellets)
		52 20.08' N	4 05.00'E	23 m	300399	06.37	spar-buff-pellets
V	Current	52 26.31' N	4 21.02'E	19 m	300399	16.46	none (pellets)
		52 26.34' N	4 20.96'E	19 m	300399	16.46	spar-buff-pellets
X	pressure	52 21.79' N	3 52.02'E	24 m	290399	18.39	none (pellets)
Y	pressure	52 34.09' N	4 24.01'E	19 m	300399	18.03	none (pellets)

b. CTD.

A total of 133 CTD casts has been obtained. Apart from the study on the variations in the hydrographic parameters in association with fluorescence, light transmission and PAR radiation, the CTD casts served two purposes. First of all, 78 times 1-8 bottles were closed near the surface and just above the bottom (called '+sampling' in Appendix A) for biological (**NUE**), sedimentological (**UWB**) and nutrient (**NIOZ**) sampling. Secondly, most of the 61 FLY microstructure deployment sessions were preceded by a CTD cast.

Twice a short hydrographic survey has been carried out in the vicinity of the moorings. The survey consisted of sampling stations two miles apart along two lines, each 20 miles long, roughly perpendicular to the coast and parallel to the mooring line A-X (*see map on p. 5)*. The two lines were situated two miles north and south of the A-X mooring line, respectively. The survey clearly showed the coastal front, and also its high temporal (and spatial) variability. Although the second survey was carried out only three days after the first, the coastal front had moved considerably (towards the coast) during that period. In general, the highly (spatial and temporal) variability of the coastal (tidally strained,) salinity dominated stratification was observed, alternated with well-mixed waters.

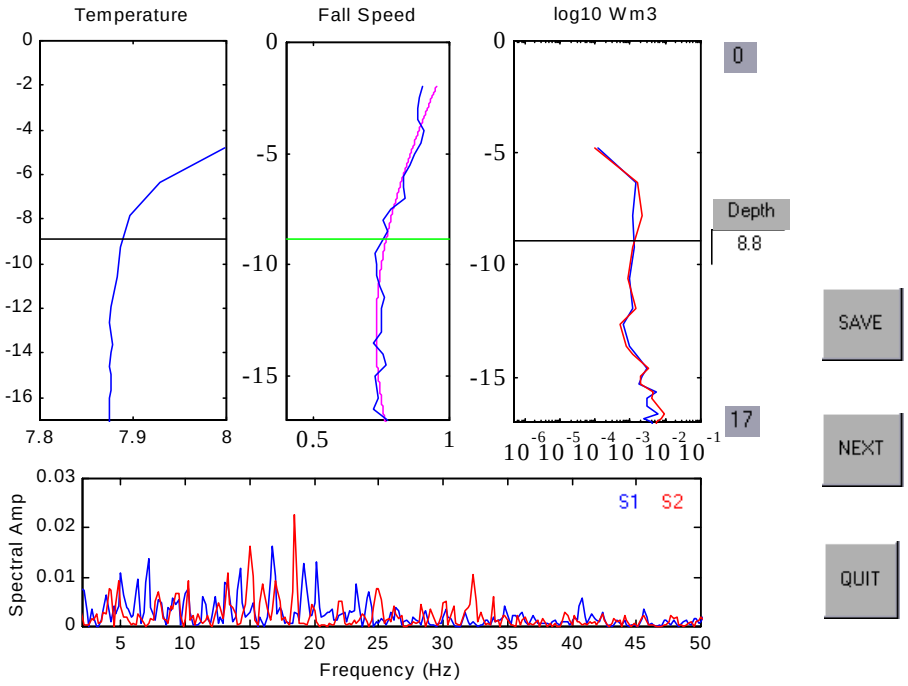
Despite the extensive CTD-sampling great concerns rose about its prformance. Firstly, the sampling bottles were contaminated by sand, and did get cleaned properly about halfway leg 2. Secondly, the electronic performance of the CTD proper showed regularly large density inversions, with a notorious strong one just below the surface, at the start of several 'down-casts'. Several attempts of improving the system, by mounting several spare parts, did not provide the expected results. Only after a major cleaning overhaul and after installing a complete spare under-water unit on 05 April the observations were satisfactorily, albeit slightly too noisy still. As a result, the CTD stations 97+ are good, the CTD stations 62 – 95 moderately good, and the CTD-stations 1-61 at times bad.

*c. FLY microstructure profiling (Tom Rippeth and Neil Fischer, **UWB**).*

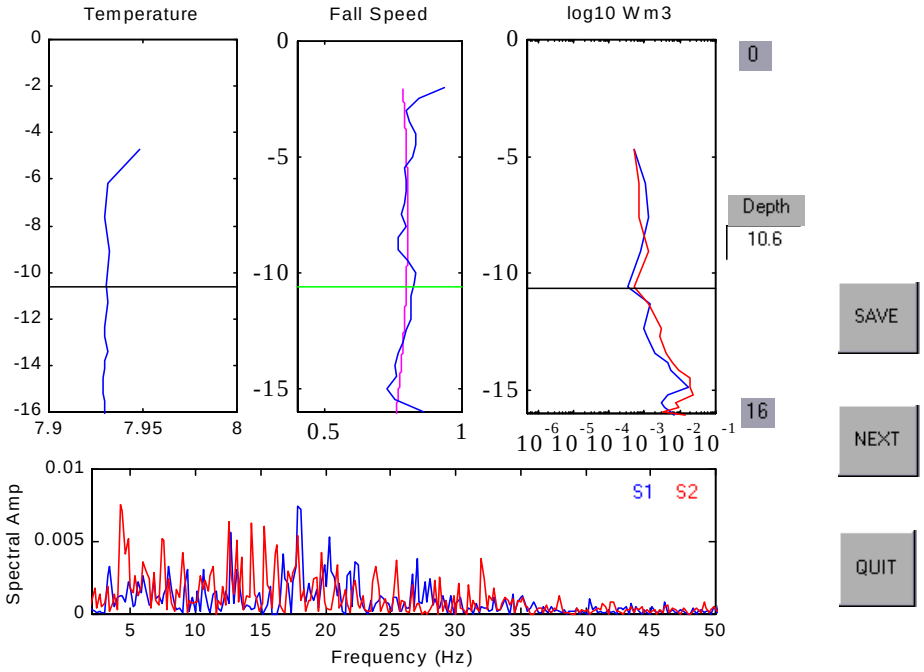
Our aim was to make time series measurements of the evolution of turbulent kinetic energy at the PROVESS southern North Sea site. Previous investigations in the area have revealed so-called periodic stratification, with a well mixed water column around maximum flood and ebb, and a relaxation of the off-shore salinity gradients resulting from the Rhine Outflow, producing periods of stratification around slack-water. With the rapidly evolving water column structure highlighted by these observations in mind, a sampling strategy was devised given the availability of working time and manpower. In this scheme intensive measurements were made over a period of 15 hours, during which time approximately 15 profiles per hour were made, interspersed with an hourly CTD profile. This cycle was repeated 4 times during the 8 days at sea with a total of more than 900 profiles measured.

Examples of the data:

06:40GMT 04/04/99 Drop 390 – Stratified water column.



11:22GMT 04/04/99 Drop 455 - Mixed Water Column.



Prior to the cruise we had two concerns with regard to this data set. The first was the water depth as data collected over the first 5-8 m is generally contaminated (because of ships wake and the need for the profiler to reach terminal velocity). This appears to be the case, although more rigorous checks are required. The second related to the levels of dissipation we expected to measure, initial checks show that levels of dissipation observed are within the range of the instrument.

Two problems arose with the FLY during the second deployment, one was a result of wear in the line-puller wheel rubber and the second a result of a loose battery housing within the FLY. Both were repaired. During the last 15-hour cycle we were able to test modifications to the FLY logging software. These improvements include a bottom detection routine that automatically detects when FLY has reached the seabed and signals to the winch man to wind in.

*d. Biological & optical observations (Karen Wild-Allen, **NUE**).*

Water samples were taken for the analysis of phytoplankton pigments, SPM carbon and nitrogen content and plankton community description. Samples were obtained from the continuous flow-through CTD and fluorometer system and from water bottles attached to the profiling CTD. The profiling CTD was equipped with additional transmissometer, fluorometer, laser particle size analyser and PAR light meter. Water samples analysed for chlorophyll-a concentration will be used to calibrate the fluorometers.

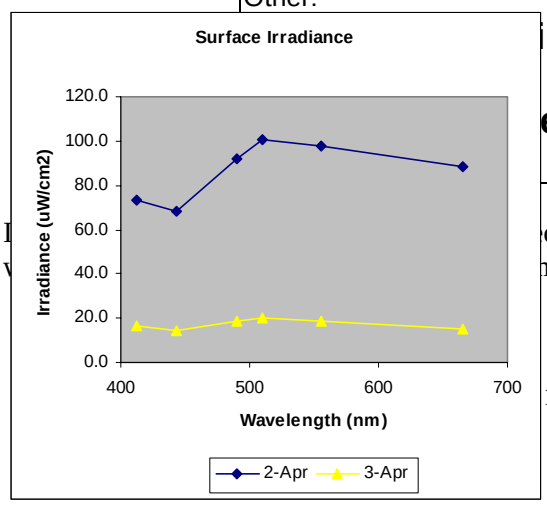
Analysis	**No. Samples**
Pigments (including chlorophyll-a)	145
SPM carbon-nitrogen	20
Microscope (preserved samples)	8

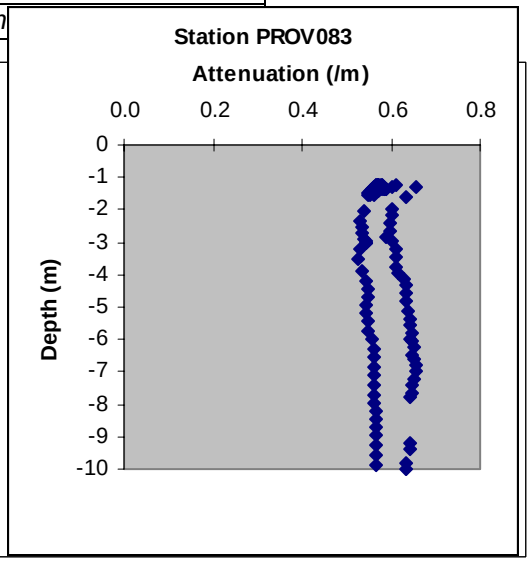
For pigment and SPM carbon-nitrogen analysis samples were filtered through GF/F glass fibre filters and the filters were stored over dessicant in the freezer. Water

samples for microscope analysis were fixed with Lugols iodine and stored in dark bottles. All samples will be transported to Napier University, Edinburgh for analysis.

Throughout the cruise period water samples were viewed with a portable field microscope (x80 and x200 magnification) and many phytoplankton groups were clearly identified. The microscope was very easy to operate and provided an excellent view of live plankton. The plankton community appeared to be very diverse with many different types of diatom and dinoflagellate seen. Diatoms were most abundant and chain forming varieties were common, particularly *Chaetoceros sp.*, *Guinardia sp.* and *Rhizosolenia sp.* . The most frequently seen dinoflagellates were armoured *Peridinium sp.* and these were often mobile, propelled in a tumbling fashion by their flagella. The cilliate *Strombidium sp.* was also seen moving in a remarkable fashion propelled by cillia surrounding the end of its cone like structure. Larger copepods were frequently seen during filtration and occasionally under the microscope.

Group	Items Seen
Diatoms:	**Biddulphia sinensis** *Ceratium sp.* *Chaetoceros sp.* *Fragilaria sp.* *Guinardia flaccida* *Guinardia sp.* *Guinardia sp.* (dead shells) *Leptocylindricus danicus* *Leptocylindricus sp.* *Nitzschia clostarium* *Pennate* diatom - *naviculoid* type *Rhizosolenia alata* *Rhizosolenia setigera* *Rhizosolenia shrubsolei* *Rhizosolenia sp.* *Rhizosolenia stolterfothi* *Skeletonema costatum* *Thalassionema nitzschiodies* *Thalassiosira sp.*
Dinoflagellates:	*Gymnodinium sp.* *Gyrodinium sp.* *Peridinium sp.* *Phaeocystis* *Scripsiella sp.*
Cilliate:	*Strombidium*
Other:	





radiance were recorded at 6 wavelengths (which correspond with channels on the SeaWIFS ocean colour satellite). Weather conditions on the first and final days of the cruise were sunny with the central period dominated by fog, low cloud and occasional drizzle. Significant differences were noted in the light levels available between days; on the 3 April, a cloudy day, light levels were reduced by 70% *cf.* 2 April, a sunny day.

Profiles of downwelling photosynthetically active irradiance (integrated between 400-700 nm) indicate that the euphotic layer was less than 10m and the attenuation coefficient 0.5-0.6 m^{-1}.

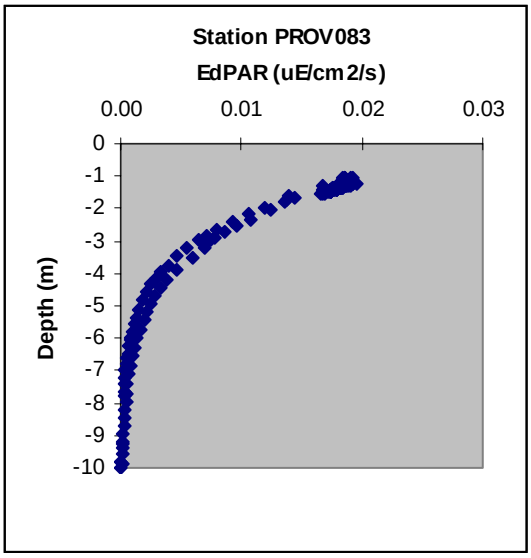
*e. Optical measurements (Andrew Lane, **POL**).*

Objectives sea surface reflectance

Measurements of sea surface upwelling and downwelling irradiances will be made with an in-situ AVHRR camera. Reflectances can then be calculated and compared with sea surface sediment concentrations of CTD water bottle samples. The resulting calibration can then be applied to aid interpretation of AVHRR satellite images of sea surface reflectance as suspended sediment concentrations.

Initial deployment

A test of the AVHRR camera was made (10:35 GMT, 2nd April) in bright, sunny



conditions with small waves present. After recovery, there was no response from the instrument when downloading data. The camera was dismantled and found to be flooded - sea water had seeped in through the seal surrounding the external connector and the electronic components ceased to work.

Sea surface reflectances can still be obtained from the PRR600 irradiance instrument, also being deployed. Unfortunately, reflectances will not be at AVHRR band-1 wavelengths. This instrument measures surface downwelling irradiance (sensor on roof of the bridge), vertical profiles of downwelling irradiance and upwelling radiance simultaneously at six wavelengths and PAR.

Measurements

The PRR instrument was deployed (between 10:00 and 14:00 GMT) as soon as possible before or after hourly CTD casts. Ideally, the wire angle needs to be as near to vertical as possible, with deployment from the side of the ship in direct sunlight. Secchi depths were also taken. Weather and tidal conditions sometimes made these procedures difficult.

Reflectances for each of the PRR channels (ratio of upwelling radiance to downwelling irradiance) and attenuation coefficients (from the surface downwelling irradiance and surface irradiance) can be calculated.

Water at the sea surface, taken from the CTD water bottles (or from the flow-through system), were filtered onto pre-weighed GFF discs. The concentrations of total, organic and inorganic sediment concentrations will be determined later. Filters were taken from water sampled at the surface, except during the first two days (2nd and 3rd April) and the last day (7th April) when samples were taken at the sea bed, 6m depth and surface. These surface data will be used to provide a calibration curve for the measurements of reflectance and suspended sediment concentrations.

Over 30 PRR profiles and 50 filter samples were taken over six days. An example of the parameters recorded are given in the figure enclosed, showing highest reflectance (and lowest attenuation) for light of wavelength 555nm (green/yellow), and lowest reflectance (highest attenuation) for wavelength 412nm (blue). The surface PAR (photosynthetically active radiation) shows variations in light level due to the pitch and roll of the ship during measurements.

*f. Sedimentological observations (SPM group, **UWB**).*

CTD profiles indicate that the concentration of suspended material is greater at the bed than at the surface. Most of the material appears to be biological in origin when viewed on the laser particle sizer video-microscope. The particle size distribution is bimodal at the surface and the bed, with peaks in the 10-20 μm and 100-200 μm size classes.

Particle concentration

A total of 79 surface and near-bed water samples were taken from the CTD and filtered for gravimetric determination of SPM concentration. Regression analysis of SPM concentration against beam attenuation will yield an equation that will be used to convert beam attenuation measured by the CTD and moored transmissometers into SPM concentration.

Particle size and shape

Two instruments were used to measure particle size during the cruise. A LISST (Laser In Situ Scattering and Transmissometery) particle sizer was mounted on the CTD frame to obtain *in situ* profiles of particle size. The second instrument was laboratory-based and required water samples from the CTD to be passed through it. A video-microscope allows the particles to be viewed on a monitor and can be recorded onto video tape for shape analysis at a later date. A total of 133 profiles were obtained from the LISST and 40 surface and near-bed particle size distributions were obtained from the Galai.

Particle settling velocity

A total of 49 QUISSET (Quasi *In-Situ* Settling Tubes) tubes were deployed for determination of particle settling velocity distributions at the surface and bed. The tubes are lowered horizontally into the water and when triggered closed take a horizontal slice of water. When back on deck the tubes are stood vertical and water samples removed from the bottom at specified intervals over a seven hour period. Surface and near-bed deployments were carried out every 3 hours over a 25 hour period on 03/04/99. Two further deployment cycles were carried out 2 hourly over a 15 hour period on 06/04/99 and 07/04/99, the latter period coinciding with a 15 hour cycle of turbulence measurements.

g. NIOZ ADCP-thermistor string mooring.

The NIOZ ADCP-thermistor string was deployed for a period of 7 days and recovered successfully at the end of leg 2. This instrumentation package sampled at a rate of once per 20 s, while the 32 thermistors were resolving 10 m of the water column at more or less regular intervals varying between 20 and 40 cm. The instruments worked fine.

h. Continuous recording.

During the entire cruise the following information has been continuously sampled and stored through the ship's RVS-ABC system: time, ship's position lat/lon, depth, meteorological data, aquaflow (T,S,flc from 4 m below surface). Water samples have been taken for salinity calibration purposes (**NIOZ**), nutrients (**NIOZ**) and chlorophyll (phytoplankton) determinations (**NUE**). **NUE** has installed a solar irradiance meter on the upper deck for continuous radiation measurements.

From the continuous record, one is outstanding, *i.e.* that of the wind speeds…

6. Concluding remarks.

This cruise has been successful, and we have managed to do virtually all the measurements we planned. This is remarkable, even though the weather conditions were rather favourable. This success could only be achieved by the good cooperation between the different scientific groups on board, and, not in the least, by the very pleasant and cooperative attitude of captain Hans Groot and his crew of the R.V. Pelagia.

thank you all
hvh

Appendix A Summary of stations (activities).

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
1	CTD	990329,09.45	52° 40' N	04° 25' E	17	1+ samples
2 NIOZ	MOR	990329,13.30	52° 18.13' N	04° 18.02' E	19	NIOZ (buff+pellets)
			52° 18.14' N	04° 17.98' E		Anchor+pellets
3 A*	MOR	990329,13.30	52° 18.38' N	04° 18.02' E	19	STABLE(on its side)
			52° 18.49' N	04° 18.12' E		Anchor+Spar
4 G	MOR	990329,16.48	52° 17.88' N	04° 17.98' E	19	Surf.Env. toroid
5 X	MOR	990329,18.39	52° 21.79' N	03° 52.02' E	24	Pressure (no marker)
6 U	MOR	990330,06.37	52° 20.10' N	04° 05.12' E	23	Current (no marker)
			52° 20.08' N	04° 05.00' E		Anchor+Spar
7 T	MOR	990330,08.14	52° 19.19' N	04° 11.72' E	22	ADCP/TC(buff+pell.
			52° 19.15' N	04° 11.74' E		Anchor+Toroid
8 H	MOR	990330,10.08	52° 18.01' N	04° 18.01' E	18	Bott.Env. (no marker
9 A	MOR	990330,11.44	52° 18.38' N	04° 18.01' E	20	STABLE(buff+pellets
			52° 18.34' N	04° 18.05' E		Anchor+Spar
10 B	MOR	990330,13.05	52° 18.14' N	04° 18.40' E	20	ADCP/TC(buff+pell.
			52° 18.19' N	04° 18.33' E		Anchor+Toroid
11 D	MOR	990330,13.39	52° 18.12' N	04° 17.67' E	19	Surf.Cur. toroid
12 V	MOR	990330,16.46	52° 26.31' N	04° 21.02' E	19	Current (no marker)
			52° 26.34' N	04° 20.96' E		Anchor+Spar
13 Y	MOR	990330,18.03	52° 34.09' N	04° 24.01' E	19	Pressure (no marker)
Camera		990330,15.00	52° 18' N	04° 18' E	19	Bottom photos
14 NIOZ	MOR	990401,16.02	52° 18.13' N	04° 18.01' E	19	NIOZ (buffs)
15	CTD*	990401,18.03	52° 14.60' N	04° 23.58' E	12	2+ samples SurveyI
16	CTD	990401,18.29	52° 15.15' N	04° 20.36' E	17	3
17	CTD	990401,18.51	52° 15.71' N	04° 17.17' E	18	4

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
18	CTD*	990401,19.12	52° 16.27' N	04° 14.01' E	19	5+ samples
19	CTD	990401,19.38	52° 16.82' N	04° 10.82' E	21	6
20	CTD	990401,20.02	52° 17.33' N	04° 07.59' E	22	7
21	CTD*	990401,20.24	52° 17.91' N	04° 04.53' E	22	8+ samples
22	CTD	990401,20.50	52° 18.47' N	04° 01.11' E	24	9
23	CTD	990401,21.10	52° 18.98' N	03° 57.88' E	24	10
24	CTD*	990401,21.33	52° 19.59' N	03° 54.57' E	27	11+ samples
25	CTD*	990401,21.57	52° 20.16' N	03° 51.23' E	25	12+ samples
26	CTD	990401,23.08	52° 24.31' N	03° 53.79' E	25	13
27	CTD*	990401,23.43	52° 23.80' N	03° 56.80' E	22	14+ samples
28	CTD	990402,00.17	52° 23.34' N	03° 59.63' E	25	15
29	CTD	990402,00.50	52° 22.78' N	04° 02.60' E	23	16
30	CTD	990402,02.18	52° 22.24' N	04° 05.78' E	22	17
31	CTD*	990402,02.48	52° 22.64' N	04° 09.44' E	23	18+ samples
32	CTD	990402,03.20	52° 21.12' N	04° 12.16' E	21	19
33	CTD	990402,03.45	52° 20.51' N	04° 15.54' E	22	20
34	CTD	990402,04.07	52° 20.01' N	04° 18.61' E	20	21
35	CTD*	990402,04.29	52° 19.41' N	04° 21.97' E	18	22+ samples
36	CTD	990402,04.55	52° 18.85' N	04° 25.53' E	19	23
37	CTD	990402,05.15	52° 18.37' N	04° 27.16' E	9	24 SurveyI end
38	CTD	990402,06.06	52° 18.35' N	04° 18.40' E	19	25
39	FLY	990402,06.22	52° 18.30' N	04° 18.72' E	19	1 in
		990402,06.35	52° 18.35' N	04° 18.93' E	19	Out (plug fouled)
		990402,06.44	52° 18.40' N	04° 18.85' E	19	In
		990402,06.55	52° 18.57' N	04° 18.80' E	19	Out
40	CTD	990402,06.59	52° 18.61' N	04° 18.73' E	19	26
41	FLY	990402,07.09	52° 18.62' N	04° 18.48' E	19	2 in
		990402,07.30	52° 18.55' N	04° 18.18' E	19	Out

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
42	CTD	990402,08.06	52° 18.29' N	04° 18.57' E	18	27
43	FLY	990402,08.14	52° 18.32' N	04° 18.58' E	18	3 in
		990402,08.31	52° 18.47' N	04° 18.54' E	18	Out
44	OPT	990402,08.37	52° 18.53' N	04° 18.63' E	18	1 in
45	CTD*	990402,09.00	52° 18.23' N	04° 18.53' E	19	28+ samples
46	FLY	990402,09.14	52° 18.24' N	04° 18.51' E	19	4 in
		990402,09.31	52° 18.13' N	04° 18.73' E	19	Out
47	OPT	990402,09.37	52° 18.03' N	04° 18.68' E	19	2 in
48	CTD*	990402,10.00	52° 18.06' N	04° 18.50' E	18	29+ samples
49	FLY	990402,10.10	52° 18.00' N	04° 18.95’ E	17	5 in
		990402,10.30	52° 17.98' N	04° 18.39' E	17	Out
50	OPT	990402,10.32	52° 17.96' N	04° 18.38' E	17	3 in
51	CTD	990402,11.00	52° 17.95' N	04° 18.37' E	17	30
52	FLY	990402,11.07	52° 17.88' N	04° 18.33’ E	18	6 in
		990402,11.28	52° 17.81' N	04° 18.23' E	18	Out
53	OPT	990402,11.36	52° 17.85' N	04° 18.27' E	18	4 in
54	CTD*	990402,12.00	52° 18.03' N	04° 18.41' E	17	31+ samples
55	FLY	990402,12.06	52° 18.01' N	04° 18.30’ E	17	7 in
		990402,12.27	52° 18.04' N	04° 18.13' E	17	Out
56	OPT	990402,12.30	52° 18.04' N	04° 18.19' E	17	5 in
57	CTD*	990402,13.00	52° 17.95' N	04° 18.26' E	18	32+ samples
58	FLY	990402,13.06	52° 17.94' N	04° 18.28’ E	18	8 in
		990402,13.32	52° 17.82' N	04° 18.45' E	18	Out
59	CTD	990402,14.00	52° 18.19' N	04° 18.66' E	19	33
60	FLY	990402,14.08	52° 18.23' N	04° 18.74’ E	20	9 in
		990402,14.27	52° 17.99' N	04° 18.57' E	19	Out
61	CTD	990402,14.57	52° 18.55' N	04° 18.42' E	19	34

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
62	FLY	990402,15.11	52° 18.58' N	04° 18.46' E	19	10 in
		990402,15.35	52° 18.55' N	04° 18.46' E	19	Out
63	CTD	990402,16.00	52° 18.44' N	04° 18.26' E	20	35
64	FLY	990402,16.33	52° 18.35' N	04° 18.25' E	20	11 in
		990402,16.52	52° 18.33' N	04° 18.23' E	20	Out
65	CTD	990402,17.00	52° 18.29' N	04° 18.14' E	20	36
66	FLY	990402,17.20	52° 18.28' N	04° 18.17' E	20	12 in
		990402,17.42	52° 18.26' N	04° 18.14' E	20	Out
67	CTD	990402,18.00	52° 18.25' N	04° 18.18' E	20	37
68	FLY	990402,18.13	52° 18.25' N	04° 18.74' E	19	13 in
		990402,18.36	52° 18.12' N	04° 19.27' E	19	Out
69	CTD*	990402,19.00	52° 18.22' N	04° 18.81' E	19	38
69a	FLY	990402,19.18	52° 18.06' N	04° 18.79' E	19	14 in
		990402,19.30	52° 18.00' N	04° 18.64' E	19	Out
		990402,19.43	52° 17.96' N	04° 18.82' E	18	In
		990402,19.57	52° 17.69' N	04° 18.74' E	18	Out
70	CTD	990402,20.01	52° 17.71' N	04° 18.78' E	19	39
71	FLY	990402,20.34	52° 18.20' N	04° 18.72' E	19	15 in
		990402,20.50	52° 18.35' N	04° 18.52' E	19	Out
72	CTD*	990402,20.59	52° 18.39' N	04° 18.55' E	19	40+ samples
73	SED	990402,21.10	52° 18.34' N	04° 18.54' E	19	1 bottom
		990402,21.17	52° 18.32' N	04° 18.55' E	19	Surface
74	CTD	990402,23.00	52° 18.35' N	04° 18.76' E	18	41
75	SED	990402,23.58	52° 18.31' N	04° 18.65' E	18	2 bottom
		990403,00.06	52° 18.30' N	04° 18.68' E	18	Surface
76	CTD*	990403,01.00	52° 18.25' N	04° 18.70' E	18	42+ samples
77	CTD	990403,02.59	52° 18.23' N	04° 18.76' E	20	43

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
78	SED	990403,03.06	52° 18.34' N	04° 18.73' E	19	3 bottom
		990403,03.13	52° 18.38' N	04° 18.79' E	19	Surface
79	CTD	990403,05.01	52° 18.31' N	04° 18.59' E	20	44
80	SED	990403,05.56	52° 18.26' N	04° 18.58' E	20	4 surface
81	SED	990403,06.04	52° 18.30' N	04° 18.52' E	19	Bottom
82	CTD*	990403,07.00	52° 18.34' N	04° 18.47' E	19	45+ samples
83	OPT	990403,08.47	52° 18.04' N	04° 18.58' E	18	6
84	CTD*	990403,09.00	52° 17.99' N	04° 18.57' E	18	46+ samples
85	SED	990403,09.14	52° 18.01' N	04° 18.51' E	18	5 bottom
		990403,09.21	52° 18.01' N	04° 18.51' E	18	Surface
86	OPT	990403,10.14	52° 17.93' N	04° 18.42' E	18	7
87	CTD*	990403,11.00	52° 17.99' N	04° 18.71' E	18	47+ samples
88	OPT	990403,11.43	52° 18.16' N	04° 18.60' E	18	8
89	SED	990403,12.00	52° 18.17' N	04° 18.68' E	18	6 bottom
		990403,12.07	52° 18.17' N	04° 18.62' E	18	Surface
90	OPT	990403,12.46	52° 17.99' N	04° 18.49' E	17	9
91	CTD*	990403,13.00	52° 18.04' N	04° 18.54' E	18	48+ samples
92	CTD	990403,15.00	52° 18.23' N	04° 18.54' E	20	49
93	SED	990403,15.05	52° 18.25' N	04° 18.68' E	20	7 bottom
		990403,15.08	52° 18.30' N	04° 18.71' E	20	Surface
94	CTD	990403,17.00	52° 18.24' N	04° 18.53' E	20	50
95	SED	990403,18.00	52° 18.20' N	04° 18.48' E	19	8 surface
		990403,18.06	52° 18.21' N	04° 18.49' E	19	Bottom
96	CTD*	990403,19.00	52° 18.21' N	04° 18.69' E	19	51+ samples
97	SED	990403,20.11	52° 17.88' N	04° 18.75' E	18	9 bottom
		990403,20.18	52° 17.88' N	04° 18.89' E	18	Surface
98	CTD*	990403,21.10	52° 17.79' N	04° 18.56' E	19	52+ samples

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
99	SED	990403,22.00	52° 18.18' N	04° 18.61' E	19	10 bottom
		990403,22.08	52° 18.17' N	04° 18.59' E	19	Surface
100	CTD	990403,22.13	52° 18.11' N	04° 18.57' E	19	53
101	FLY	990403,22.28	52° 18.11' N	04° 18.60' E	19	16 in
		990403,22.52	52° 18.16' N	04° 18.62' E	19	Out
102	CTD*	990403,23.04	52° 18.19' N	04° 18.83' E	18	54+ samples
103	FLY	990403,23.12	52° 18.15' N	04° 18.83' E	19	17 in
		990403,23.25	52° 18.13' N	04° 18.85' E	19	Out
104	CTD	990404,00.00	52° 18.09' N	04° 18.86' E	18	55
105	FLY	990404,00.06	52° 18.14' N	04° 18.89' E	18	18 in
		990404,00.22	52° 18.07' N	04° 18.89' E	18	Out
106	CTD*	990404,01.00	52° 18.12' N	04° 18.82' E	19	56+ samples
107	FLY	990404,01.06	52° 18.11' N	04° 18.82' E	19	19 in
		990404,01.22	52° 18.20' N	04° 18.97' E	18	Out
108	CTD	990404,02.00	52° 18.20' N	04° 18.85' E	19	57
109	FLY	990404,02.09	52° 18.10' N	04° 18.79' E	19	20 in
		990404,02.26	52° 18.48' N	04° 19.01' E	19	Out
110	CTD	990404,03.00	52° 18.10' N	04° 18.78' E	19	58
111	FLY	990404,03.04	52° 18.06' N	04° 18.76' E	19	21 in
		990404,03.33	52° 18.15' N	04° 18.94' E	20	Out
112	CTD	990404,04.00	52° 18.15' N	04° 18.81' E	20	59
113	FLY	990404,04.11	52° 18.16' N	04° 18.91' E	20	22 in
		990404,04.33	52° 18.22' N	04° 19.05' E	20	Out
114	CTD	990404,05.01	52° 18.22' N	04° 18.77' E	20	60
115	FLY	990404,05.09	52° 18.28' N	04° 18.76' E	20	23 in
		990404,05.30	52° 18.20' N	04° 18.73' E	20	Out
116	FLY	990404,05.37	52° 18.29' N	04° 18.72' E	20	24 in
		990404,05.49	52° 18.27' N	04° 18.74' E	20	Out

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
117	CTD	990404,06.02	52° 18.22' N	04° 18.72' E	20	61
118	FLY	990404,06.25	52° 18.21' N	04° 18.61' E	20	25 in
		990404,06.43	52° 17.95' N	04° 18.77' E	20	Out
119	CTD	990404,07.02	52° 18.07' N	04° 18.75' E	19	62
120	FLY	990404,07.18	52° 18.17' N	04° 18.99' E	19	26 in
		990404,07.35	52° 17.84' N	04° 19.22' E	19	Out
121	CTD*	990404,08.01	52° 18.04' N	04° 18.64' E	18	63+ samples
122	FLY	990404,08.10	52° 18.01' N	04° 18.81' E	19	27 in
		990404,08.28	52° 18.46' N	04° 19.00' E	19	Out
123	OPT	990404,08.57	52° 17.94' N	04° 18.83' E	18	10
124	CTD*	990404,09.18	52° 17.93' N	04° 18.76' E	18	64+ samples
125	FLY	990404,09.28	52° 17.85' N	04° 18.62' E	18	28 in
		990404,09.40	52° 18.08' N	04° 18.48' E	18	Out
		990404,09.43	52° 18.14' N	04° 18.52' E	19	In
		990404,09.52	52° 18.29' N	04° 18.67' E	19	Out
126	OPT	990404,09.55	52° 18.30' N	04° 18.69' E	18	11
127	CTD*	990404,10.02	52° 18.26' N	04° 18.71' E	18	65+ samples
128	FLY	990404,10.08	52° 18.22' N	04° 18.77' E	18	29 in
		990404,10.25	52° 18.19' N	04° 18.86' E	18	Out
129	OPT	990404,10.30	52° 18.17' N	04° 18.18' E	18	12
130	CTD*	990404,11.00	52° 18.07' N	04° 18.84' E	19	66+ samples
131	FLY	990404,11.20	52° 18.04' N	04° 18.77' E	18	30 in
		990404,11.55	52° 18.08' N	04° 18.78' E	18	Out
132	OPT	990404,11.56	52° 18.09' N	04° 18.82' E	18	13
133	CTD*	990404,12.22	52° 18.01' N	04° 18.81' E	18	67+ samples
134	FLY	990404,12.35	52° 18.04' N	04° 18.85' E	18	31 in
		990404,13.00	52° 18.18' N	04° 19.08' E	18	Out
135	OPT	990404,13.03	52° 18.18' N	04° 19.08' E	18	14
136	CTD*	990404,13.19	52° 18.10' N	04° 19.08' E	18	68+ samples

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
137	CTD	990404,14.05	52° 14.57' N	04° 23.60' E	12	Test cast
138	CTD	990404,14.14	52° 14.64' N	04° 23.66' E	12	69 Survey II
139	CTD	990404,14.35	52° 15.14' N	04° 20.48' E	17	70
140	CTD	990404,14.57	52° 15.77' N	04° 17.29' E	18	71
141	CTD	990404,15.19	52° 16.27' N	04° 14.27' E	20	72
142	CTD	990404,15.41	52° 16.79' N	04° 11.06' E	22	73
143	CTD	990404,16.02	52° 17.32' N	04° 07.93' E	23	74
144	CTD	990404,16.26	52° 17.89' N	04° 04.88' E	24	75
145	CTD	990404,16.47	52° 18.41' N	04° 01.70' E	24	76
146	CTD	990404,17.11	52° 19.00' N	03° 58.01' E	27	77
147	CTD	990404,17.40	52° 19.65' N	03° 54.74' E	26	78
148	CTD*	990404,18.02	52° 20.08' N	03° 51.39' E	24	79+ samples
149	CTD*	990404,18.28	52° 24.42' N	03° 53.96' E	28	80+ samples
150	CTD	990404,18.58	52° 23.82' N	03° 56.97' E	26	81
151	CTD	990404,19.17	52° 23.25' N	04° 00.11' E	25	82
152	CTD	990404,19.39	52° 22.59' N	04° 03.28' E	23	83
153	CTD	990404,19.56	52° 22.06' N	04° 06.43' E	23	84
154	CTD*	990404,20.17	52° 21.97' N	04° 09.82' E	20	85+ samples
155	CTD	990404,20.39	52° 21.02' N	04° 12.91' E	21	86
156	CTD	990404,20.56	52° 20.24' N	04° 16.10' E	17	87
157	CTD	990404,21.15	52° 19.63' N	04° 19.32' E	18	88
158	CTD	990404,21.36	52° 18.98' N	04° 22.90' E	18	89
159	CTD	990404,21.59	52° 18.30' N	04° 26.65' E	12	90 Survey II end
160	CTD	990405,10.16	52° 18.11' N	04° 18.53' E	19	91
161	OPT	990405,10.26	52° 18.12' N	04° 18.52' E	19	15
162	CTD*	990405,11.00	52° 18.17' N	04° 18.48' E	19	92+ samples
163	FLY	990405,11.06	52° 18.17' N	04° 18.48' E	19	32 in
		990405,11.30	52° 17.74' N	04° 18.82' E	18	Out

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
164	OPT	990405,11.44	52° 18.16' N	04° 18.71' E	18	16
165	CTD	990405,11.54	52° 18.21' N	04° 18.68' E	18	93
166	FLY	990405,12.01	52° 18.21' N	04° 18.77' E	17	33 in
		990405,12.25	52° 18.56' N	04° 19.13' E	18	Out
167	OPT	990405,12.50	52° 18.26' N	04° 18.71' E	18	17
168	CTD*	990405,13.10	52° 18.28' N	04° 18.74' E	18	94,95+ samples
169	FLY	990405,13.20	52° 18.24' N	04° 18.76' E	18	34 in
		990405,13.39	52° 17.80' N	04° 18.53' E	18	Out
170	OPT	990405,13.52	52° 18.32' N	04° 18.68' E	18	18
171	FLY	990405,14.01	52° 18.32' N	04° 18.75' E	18	35 in
		990405,14.17	52° 17.97' N	04° 19.26' E	18	Out
172	FLY	990405,15.05	52° 18.41' N	04° 18.82' E	18	36 in
		990405,15.22	52° 18.28' N	04° 19.66' E	20	Out
173	FLY	990405,16.17	52° 18.39' N	04° 18.80' E	19	37 in
		990405,16.37	52° 18.40' N	04° 19.87' E	19	Out
174	FLY	990405,17.16	52° 18.35' N	04° 18.70' E	20	38 in
		990405,17.41	52° 19.65' N	04° 19.41' E	20	Out
175	FLY	990405,18.05	52° 18.28' N	04° 18.67' E	20	39 in
		990405,18.25	52° 18.14' N	04° 18.85' E	20	Out
176	FLY	990405,19.03	52° 18.07' N	04° 18.56' E	19	40 in
		990405,19.19	52° 17.99' N	04° 18.80' E	19	Out
177	CTD	990405,20.12	52° 18.23' N	04° 18.65' E	19	97 (96 non-exist)
178	FLY	990405,20.14	52° 18.23' N	04° 18.72' E	19	41 in
		990405,20.31	52° 18.14' N	04° 18.64' E	19	Out
179	CTD	990405,21.02	52° 18.29' N	04° 18.77' E	19	98
180	FLY	990405,21.08	52° 18.22' N	04° 18.75' E	19	42 in
		990405,21.23	52° 18.01' N	04° 18.98' E	19	Out
181	CTD	990405,22.04	52° 18.29' N	04° 18.82' E	18	99

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
182	FLY	990405,22.12	52° 18.28' N	04° 18.84' E	18	43 in
		990405,22.29	52° 17.92' N	04° 18.18' E	18	Out
183	CTD	990405,23.00	52° 18.34' N	04° 18.70' E	18	100
184	FLY	990405,23.09	52° 18.29' N	04° 18.70' E	18	44 in
		990405,23.27	52° 17.88' N	04° 18.82' E	18	Out
185	CTD	990406,00.00	52° 18.27' N	04° 18.58' E	19	101
186	FLY	990406,00.05	52° 18.23' N	04° 18.61' E	18	45 in
		990406,00.21	52° 17.91' N	04° 18.87' E	17	Out
187	CTD	990406,01.00	52° 18.33' N	04° 18.60' E	18	102 failure
188	FLY	990406,01.06	52° 18.28' N	04° 18.69' E	18	46 in
		990406,01.25	52° 18.16' N	04° 19.03' E	18	Out
189	SED	990406,04.00	52° 18.34' N	04° 18.73' E	19	11 bottom
190	SED	990406,04.08	52° 18.35' N	04° 18.70' E	19	Surface
191	CTD*	990406,05.00	52° 18.39' N	04° 18.57' E	20	103 failure
192	CTD*	990406,05.58	52° 18.28' N	04° 18.65' E	20	104+ samples
193	SED	990406,06.07	52° 18.26' N	04° 18.59' E	19	12 bottom
		990406,06.11	52° 18.25' N	04° 18.60' E	19	Surface
194	CTD*	990406,06.59	52° 18.30' N	04° 18.46' E	20	105+ samples
195	SED	990406,08.00	52° 18.30' N	04° 18.57' E	19	13 bottom
		990406,08.07	52° 18.36' N	04° 18.53' E	19	Surface
196	OPT	990406,08.41	52° 18.31' N	04° 18.53' E	19	19
197	CTD*	990406,08.59	52° 18.37' N	04° 18.67' E	19	106+ samples
198	SED	990406,10.08	52° 18.18' N	04° 18.63' E	19	14 bottom
		990406,10.13	52° 18.19' N	04° 18.65' E	19	Surface
199	OPT	990406,10.17	52° 18.20' N	04° 18.68' E	19	20
200	CTD*	990406,11.04	52° 18.30' N	04° 18.89' E	18	107+ samples
201	OPT	990406,11.12	52° 18.26' N	04° 18.86' E	18	21

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
202	SED	990406,12.02	52° 18.34' N	04° 18.49' E	18	15 surface
203	SED	990406,12.10	52° 18.34' N	04° 18.51' E	19	Bottom
204	OPT	990406,12.16	52° 18.34' N	04° 18.52' E	18	21
205	CTD*	990406,12.58	52° 18.29' N	04° 18.71' E	18	108+ samples
206	OPT	990406,13.11	52° 18.81' N	04° 18.78' E	17	22
207	SED	990406,13.57	52° 18.43' N	04° 18.55' E	17	16 bottom
208	SED	990406,14.04	52° 18.37' N	04° 18.59' E	18	Surface
209	CTD*	990406,15.00	52° 18.30' N	04° 18.48' E	19	109+ samples
210	SED	990406,16.00	52° 18.42' N	04° 18.66' E	18	17 bottom
211	SED	990406,16.03	52° 18.40' N	04° 18.64' E	18	Surface
212	CTD*	990406,17.00	52° 18.42' N	04° 18.56' E	20	110+ samples
213	SED	990406,18.00	52° 18.41' N	04° 18.55' E	20	18 bottom
		990406,18.08	52° 18.43' N	04° 18.62' E	20	Surface
214	CTD*	990407,07.29	52° 18.09' N	04° 18.71' E	20	111+ samples
215	FLY	990407,07.35	52° 18.18' N	04° 18.00' E	20	47 in
		990407,08.00	52° 17.76' N	04° 19.04' E	20	Out
216	SED	990407,08.09	52° 17.89' N	04° 19.16' E	19	19 bottom
		990407,08.15	52° 17.97' N	04° 19.17' E	19	Surface
217	OPT	990407,08.20	52° 18.11' N	04° 19.42' E	19	22
218	CTD*	990407,08.30	52° 18.17' N	04° 19.37' E	19	112+ samples
219	CTD	990407,08.58	52° 18.18' N	04° 18.81' E	20	113
220	FLY	990407,09.05	52° 18.14' N	04° 18.71' E	19	48 in
		990407,09.20	52° 17.76' N	04° 18.72' E	19	Out
221	OPT	990407,09.50	52° 18.02' N	04° 18.87' E	19	23
222	CTD*	990407,10.01	52° 18.04' N	04° 18.85' E	19	114+ samples
223	FLY	990407,10.11	52° 18.02' N	04° 18.76' E	19	49 in
		990407,10.26	52° 17.74' N	04° 18.38' E	19	Out

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
224	SED	990407,10.28	52° 17.72' N	04° 18.36' E	19	20 bottom
225	SED	990407,10.32	52° 17.63' N	04° 18.45' E	19	Surface
226	OPT	990407,10.45	52° 17.46' N	04° 18.95' E	18	24
227	CTD*	990407,11.04	52° 17.46' N	04° 18.91' E	18	115+ samples
228	FLY	990407,11.14	52° 17.50' N	04° 18.70' E	18	50 in
		990407,11.28	52° 17.71' N	04° 18.69' E	18	Out
229	OPT	990407,11.44	52° 17.77' N	04° 18.69' E	19	25
230	CTD	990407,12.00	52° 17.79' N	04° 18.74' E	19	116
231	FLY	990407,12.05	52° 17.74' N	04° 18.67' E	18	51 in
		990407,12.21	52° 17.84' N	04° 18.46' E	18	Out
232	SED	990407,12.23	52° 17.85' N	04° 18.47' E	18	21 bottom
233	SED	990407,12.27	52° 17.74' N	04° 18.51' E	19	Surface
234	OPT	990407,12.42	52° 17.49' N	04° 18.46' E	18	26
235	CTD*	990407,12.56	52° 17.60' N	04° 18.41' E	18	117+ samples
236	FLY	990407,13.04	52° 17.57' N	04° 18.43' E	18	52 in
		990407,13.18	52° 17.78' N	04° 18.52' E	19	Out
237	OPT	990407,13.45	52° 17.98' N	04° 18.89' E	18	27
238	CTD*	990407,13.57	52° 17.75' N	04° 18.70' E	18	118+ samples
239	FLY	990407,14.09	52° 17.52' N	04° 18.76' E	17	53 in
		990407,14.24	52° 17.09' N	04° 18.25' E	19	Out
240	SED	990407,14.29	52° 17.03' N	04° 18.19' E	18	22 bottom
241	SED	990407,14.33	52° 17.02' N	04° 18.15' E	18	Surface
242	CTD*	990407,15.00	52° 18.18' N	04° 18.83' E	19	119+ samples
243	FLY	990407,15.08	52° 18.12' N	04° 18.70' E	19	54 in
		990407,15.17	52° 17.93' N	04° 18.31' E	19	Out
244	CTD*	990407,16.00	52° 18.15' N	04° 18.97' E	19	120+ samples
245	FLY	990407,16.09	52° 18.15' N	04° 18.76' E	20	55 in
		990407,16.25	52° 17.72' N	04° 18.20' E	20	Out

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
246	SED	990407,16.40	52° 18.24' N	04° 18.59' E	20	23 bottom
247	SED	990407,16.45	52° 18.26' N	04° 18.60' E	20	Surface
248	CTD*	990407,17.00	52° 18.30' N	04° 18.97' E	19	121+ samples
249	FLY	990407,17.07	52° 18.41' N	04° 18.76' E	19	56 in
		990407,17.28	52° 17.86' N	04° 18.20' E	20	Out
250	CTD	990407,18.00	52° 18.35' N	04° 18.63' E	20	122
251	FLY	990407,18.08	52° 18.41' N	04° 18.82' E	19	57 in
		990407,18.26	52° 17.88' N	04° 18.74' E	19	Out
252	SED	990407,18.30	52° 17.92' N	04° 18.82' E	19	24 bottom
		990407,18.35	52° 17.97' N	04° 18.96' E	19	Surface
253	CTD*	990407,18.58	52° 18.28' N	04° 19.00' E	20	123+ samples
254	FLY	990407,19.06	52° 18.31' N	04° 19.02' E	19	58 in
		990407,19.23	52° 18.06' N	04° 19.03' E	20	Out
255	CTD	990407,19.58	52° 18.18' N	04° 18.80' E	20	124
256	FLY	990407,20.08	52° 18.16' N	04° 18.81' E	20	59 in
		990407,20.23	52° 18.02' N	04° 18.85' E	20	Out
257	SED	990407,20.28	52° 17.99' N	04° 18.87' E	20	25 bottom
		990407,20.33	52° 17.99' N	04° 18.92' E	20	Surface
258	CTD*	990407,21.00	52° 18.20' N	04° 18.79' E	20	125+ samples
259	FLY	990407,21.09	52° 18.04' N	04° 18.69' E	20	60 in
		990407,21.23	52° 17.89' N	04° 18.52' E	19	Out
260	CTD	990407,21.59	52° 18.07' N	04° 18.81' E	19	126
261	FLY	990407,22.03	52° 17.99' N	04° 18.84' E	18	61 in
		990407,22.20	52° 17.82' N	04° 18.38' E	19	Out
262	CTD	990407,22.26	52° 17.78' N	04° 18.35' E	19	127
263	CTD	990408,08.19	52° 18.06' N	04° 18.70' E	19	128 test 15/60
264	OPT	990408,08.45	52° 17.95' N	04° 19.27' E	19	28
265	CTD*	990408,08.59	52° 18.19' N	04° 18.80' E	19	129+ samples

CTD=CTD,**CTD*=**CTD+samples,**FLY=**FLY,**MOR=**mooring,**SED**=sediment trap,**OPT**=optics

Station	Activ	Date time (UTC)	Latitude	Longitude	Depth (m)	Remarks (# indiv. Activity)
266	OPT	990408,09.44	52° 17.94' N	04° 18.74' E	18	29
267	CTD*	990408,10.00	52° 17.93' N	04° 18.86' E	18	130+ samples
268	CTD*	990408,11.00	52° 17.83' N	04° 18.58' E	18	131+ samples
269	OPT	990408,11.10	52° 17.76' N	04° 18.71' E	18	30
270	OPT	990408,11.52	52° 17.87' N	04° 18.54' E	18	31
271	CTD*	990408,12.00	52° 17.71' N	04° 18.30' E	18	132+ samples
272	OPT	990408,12.50	52° 17.92' N	04° 18.58' E	18	32
273	CTD*	990408,12.57	52° 17.66' N	04° 18.41' E	18	133+ samples
274	MOR	990408,17.02	52° 18.13' N	04° 18.01' E	19	NIOZ (recovery)

Appendix B Mooring diagrams (*John Humphery, POL*)