CRUISE REPORT: CD146

CONTENTS PAGE

1. SCIENTIFIC PERSONNEL

Henrik Andersson	National Institute of Ecology (NIOO, the Netherlands)
Anastasios Anestis	Newcastle University (Edinburgh)
Eric Breuer	Scottish Association for Marine Science
Greg Cowie (PSO)	University of Edinburgh
Muhammad Danish	National Institute of Oceanography (Pakistan)
Andy Gooday	SOC – George Deacon Division
Kate Larkin	SOC – George Deacon Division
Lisa Levin	Scripps Institute of Oceanography
Sue McKinlay	Scottish Association for Marine Science
Oli Peppe	Scottish Association for Marine Science
Matthew Schwartz	University of Edinburgh
Clare Woulds	University of Edinburgh
William Thompson	Scottish Association for Marine Science
Rhys Roberts	SOC - Ocean Engineering Division
Dave Tear	SOC - Ocean Engineering Division
Darren Young	SOC - Ocean Engineering Division
Rob Lloyd	SOC - Ocean Engineering Division

2. SHIP'S PERSONNEL

P. Sarjeant	Master
P. Newton	Chief Officer
A. Cope	2nd Officer
T. Owoso	Extra 2nd Officer
I. McGill	Chief Engineer
A. Greenhorn	2nd Engineer
G. Collard	3rd Engineer
K. Conner	3rd Engineer
D. Jakobaufderstroht	Electrical-Technical Officer
M. Drayton	Bosun
K. Luckhurst	Bosun's mate
P. Allison	Seaman 1A
J. Dale	Seaman 1A
G. Crabb	Seaman 1A
P. Dollery	Seaman 1A
I. Thomson	Seaman 1A
K. Pringle	Motorman
C. Perry	Ship's Catering Manager
P. Lynch	Chef
W. Isby	Assistant Chef
J. Osborn	Steward

3. ITINERARY

Sailed Port Victoria, Mahe, Seychelles	12 April
Arrive Pakistan Margin work area	20 April
Departed Pakistan Margin work area	28 May
Docked in Port Sultan Qaboos, Muscat	30 May

4. OBJECTIVES

RRS Charles Darwin cruise 146 forms part of a larger programme of research (*Benthic processes in the Arabian Sea: mechanistic relationships between benthos, sediment biogeochemistry and organic matter cycling*), focusing on the benthic biogeochemistry of the Pakistan Margin, that includes four cruises in total (CD145,

CD146, CD150 and CD151). The research conducted over the four cruises is closely linked and is designed to provide a comprehensive assessment of benthic communities, sediment biogeochemistry and benthic system function at sites with contrasting redox conditions across the mid-slope oxygen minimum zone (OMZ) in monsoon vs. intermonsoon conditions of contrasting productivity. The primary objectives of the present cruise (intermonsoon conditions) are:

a) To complete characterisation of benthic communities under intermonsoon conditions at five sites spanning the mid-slope OMZ on the Pakistan margin, as commenced on CD145 (to provide cross-cruise replication). This will entail use of a combination of coring devices (multi- and megacorers) and an Agassiz trawl.

b) Using the same coring techniques at the same stations to complete a parallel investigation of sediment geochemistry (solids and porewaters; organic, inorganic, nutrients, radiochemistry).

c) To complete characterisation of sediment microstructure, bioturbation and sediment mixing and accumulation rates via x-radiography, radiochemical analyses and particle tracer studies.

d) To further assess water-column and benthic boundary layer chemistry as commenced on CD145, using sensors and/or water samples collected by CTD and Benthic Boundary Layer Sampler (BBLS), respectively.

e) To complete seabed characterisation in the work area using acoustic remote sensing (EM12 and 3.5kHz).

f) To assess the importance of chemosynthetic C sources in the OMZ via molecular and isotopic analyses and opportunistic sampling of bacterial mats.

g) To assess oxygen penetration depths and benthic consumption rates via shipboard and *in situ* microelectrode profiling and sediment incubation studies.

h) To determine benthic fluxes of nutrients, trace metals and dissolved organic matter using shipboard and *in situ* incubation studies maintained at ambient O_2 levels.

i) To complete assessment of benthic microbial process rates (commenced on CD145 with sulfate reduction) by aforementioned 0_2 consumption studies combined with rate determinations of denitrification and Fe/Mn cycling via direct analysis, or modeling of porewater profiles and benthic fluxes.

j) To quantify benthic C cycling using added ^{13}C-enriched organic matter in shipboard and *in situ* incubation experiments, tracking the ^{13}C into overlying waters, sediments and fauna, and to assess meio- and macrofaunal tracer uptake and transformation via molecular-level ^{13}C tracking.

k) To assess short-term sediment mixing rates and size-selective particle mixing using shipboard incubation studies with added flourescently-labeled particles in different size ranges.

Greg Cowie

5. NARRATIVE

5.1. Diary (all times are local; GMT+4)

Thursday, April 10.
PSO joins the vessel after it arrived in Port Victoria on April 9. Most CD145 scientific personnel are still present, including Dr. Brian Bett, with whom handover was completed, including swath bathymetry chart, CD145 draft cruise report and discussion of events and preliminary results from CD145 pertinent to site selection and methods for CD146. Several CD145 and CD146 scientific parties (Anestis, Brand, Breuer, McKinlay and Woulds) remain on vessel for instrument training handover (nutrient analysis etc).

Friday, April 11.
Remainder of scientific party arrives, including Mr. M. Danish, observer/scientist from the National Institute of Oceanography of Pakistan (Karachi). Diplomatic clearance from Pakistan in hand. All parties sign on with Master and attend vessel familiarisation and safey briefing. Unpacking and laboratory set-up commenced.
Sailing planned for 13.00 on April 12 (local – all narrative times will be given in ship's local time; GMT+4) after planned delivery and customs-clearance of last airfreight.

Saturday, April 12
Airfreight arrived and ship sailed ca. 13.00. Continued unpacking and laboratory and equipment set-up. Meeting between PSO and M. Schwartz at 15.00 to discuss redrafting of lander and shipboard incubation plans for ca. 8 fewer days on station. Safety drill at 16.15. Lander meeting at 18.30 attended by TLO and Captain: OP - Stated preference to moor landers at 150 and 300 m stations to reduce risk of loss, to work at these stations first, and to lower landers on the wire to 5-10m off the seabed before release. Also suggested retention of 8h turnaround on all landers, although it may be possible to reduce this at some sites. A minimum of 0.5 nm distance from the lander deployment co-ordinates (at 2000m) is suggested for all other equipment deployments. Captain - prefers day or night deployment but daylight recovery. 22:00 – News from S. Mowbray (Edinburgh) that ^{13}C algal slurry is far less C-rich than originally thought. Will need to scale down planned ^{13}C enrichment studies (fewer sites and fewer timepoints).

Sunday, April 13.
Continued lab' and gear set-up, including correction of freeze-drier gas ballast problem. 13.30 General science meeting in the main laboratory (with Master). PSO stressed safety issues and both personal and collective responsibilities. Outlined draft revised plans for station locations: i.e. ca. 150 m (subject to scouting for site at Sonne 90 station 124 at ca. 136m), 300m, 1200m and 1850m as visited during CD145. NAST site visited on CD145 will be dropped, as will the 500m site in favour of an 800-1000m site in an area slightly east of the main transect (as discussed with Brian Bett). The latter will be selected on the basis of swath bathymetry and exploratory megacoring. We are restricted to a total of 5 stations for lander deployments; the NAST site is too much of a contrast to the other mid-slope sites, and the 500 m site was dropped because it roughly replicates the 300m site at the core of the OMZ, but has sediments that are exceedingly difficult to recover. Moreover, it leaves the 500m-1200m depth range unsampled, and, based on previous studies on both Oman and Pakistan margins, this transition zone is likely to be distinctive and important. ^{13}C enrichment studies (lander and shipboard) will be restricted to 3 sites, most likely 150, 1200 and 1850m sites (due to lack of algae and to address the shortened cruise duration), with only 2 timepoints for the shipboard incubations. LL suggests possible inclusion of the 800-1000m site for ^{13}C enrichment studies in place of the 1200m site, dependent on the sediment and faunal characteristics found there. MS outlined draft workplan at each site; 2-3 CTD casts, 2 multicorer drops, 3+ megacorer drops, 2 PROFILUR deployments, 2-3 ELINOR deployments (in different modes), 1 BBLS deployment, and swath bathymetry and Agassiz trawl at selected sites. 20.40 – crossed the equator without great fanfare.

Monday, April 14
Continued preparation of lab's and equipment. 13.00 PSO met with Captain to discuss site codes and procedures for watch keepers. 13.30 Meeting with Biology team in the Plot. Detailed discussions of core requirements (drops and barrels) for all types of sampling (survey, biochemistry, ^{13}C enrichment, plus opportunistic sampling of large fauna and bacteria). AG agrees to need for additional trawls at selected sites. LL stressed need for Time Zero controls on 13C incubations. PSO acknowledged but suggested CD151 because of limited enriched algal slurry supply. LL also stressed need for sample fate logs as well as equipment logs and to assign leaders for each major equipment type. PSO agreed and asked Biology group to reconvene to assign tasks and arrange training for assistants (AA, MD and HA). PSO stressed need for separation of all ^{13}C enrichment work from natural abundance studies. Stopped for ca. 2.5 h to test acoustic releases around mid day. 19.00: Geochemical core processing and shipboard analyses group meeting in PSO's cabin. Similarly detailed discussion of drop and core requirements, plus glove bag requirements, locations of core processing etc. CW designated to draft workplan for core processing and assign tasks/shifts. PSO again stressed need for separation of kit used in ^{13}C enrichment work from that used in natural abundance studies.

Tuesday, April 15
Continued preparation of lab's and equipment. 10.00 – Core processing team meeting in Main Lab' led by MS/CW (streamlining of work plan and agreed task assignments). 13.30 – Lander and shipboard incubation group meeting in PSO's cabin. MS/OP agreed to design programmes for 150m and 300m sites as models. Dry runs planned for lander and shipboard incubations.

Wednesday, April 16
Continued preparation of lab's and equipment. Temporary brownout. 19.00: PSO met with MS and CW to finalise draft deployment schedule for discussion with Captain, TLO, chief engineer and bosun. Meeting postponed until 10.30 April 18. TLO constructing x-ray trays for use with split megacorer (to be trialed at first site).

Thursday, April 17
Continued preparation of lab's and equipment. Meeting with science personnel (PSO, MS, CW, AG, OP, TLO, chief engineer and bosun) at 10.30 in the bar. Chief engineer asked for all T changes to cold store and CT lab' to go through bridge to duty engineer. Also recommended tests with full electrical demand. MS informed that autoclave had been tested successfully on new circuit. Captain informed PSO that no freezer storage would be possible on board > CD146. Estimated ETA now ca. noon on Sunday, April 19. Captain advised all new science personnel to be fully briefed on risk assessments for all methods, and MS to check that RA folder is complete. Also informed that 2 ABs would be available on day watches, and Rhys plus assistant at night. Aft deployment/recovery is preferred for the landers. OP agreed, although noted that midships often used because of less movement or likelihood of collision. Bosun reminded science personnel to keep access to fire door clear in CT lab'. Also, harnesses to be warn in all red-zone activity.

Friday April 18
Continued preparation of lab's and equipment. 10.30: Lander demonstration by OP on deck. 13.00: X-radiography demonstration by LL. 16.15: Emergency muster- fire drill. 17.00: General meeting in main lab' to discuss Equipment and Sample-Fate logging methods. Draft logs prepared by PSO and left for review.

Saturday, April 19
Continued preparation of lab's and equipment. Acoustic release test in the afternoon (WT). Final rigging of incubation rigs and sterilisation of components.

Sunday, April 20
Approaching work area and proposed alternative shallow work site (Sonne 90 station 124KG, 23 16.76N, 66 42.77E, ~ 136m). Echosounder profiling (20.12 to 21.15) along 3 2-nm tracks (~ 335° and 115°) parallel to depth contours and crossing station (8 knots). Also logged 3.5KHz. Referred to as station A140. Arrived at station 21.32. 55901#1 – CTD cast (12 bottles collected 3mab for filtering and shipboard incubations; 12 bottles at 45m Chl max for suspended solids). 55901#2 – Megacorer deployment. Long cores showing fine homogeneous sediment and few if any shells – paydirt! (same features as Sonne 90 core at this site, but unlike coarse sediments at CD145 – A150). Incubations and core processing started.

Monday, April 21
ELINOR lander (chamber mode without oxystat, EO) deployed at 05.30 (55901#3). PROFILUR lander deployed (electrode profiling) at 07.11 (55901#4). Three multicorer deployments (55902#5, #6 and #7 – 12/12, 0/12 and 12/12 good cores, respectively) followed by a megacorer deployment (55901#8, 8/8 good cores). Core processing (biological and geochemical) and recovery of cores for shipboard incubations.

Tuesday, April 22
Elinor (EO, 55901#3) recovered at 08.15-08.30. Appeared to have been dragged - no sediment recovered or water samples/data. Appears to have been on side. Megacorer drops 55901#9 and #10, 8/8 good cores each, at 06.50 and 10.32 respectively. Multicorer (55901#11) at 13.40 (12/12). ELINOR deployment (EF) at 14.52 (55901#12). Evening: swath bathymetry and 3.5KHz carried out along ca. four ca. 2nm tracks spanning the lander deployment site. Logged but not processed.

Wednesday, April 23
PROFILUR (55901#4) recovered at 05.32 (successful). Multicorer deployment 55901#13 at 09.15 (12/12 good cores). Megacorer deployment 55901#14 at 11.24 (11/12). PROFILUR redeployed at 13.30 (55901#15). Megacorer deployment 55901#16 at 14.27 (9/12). This included Edinburgh split cores. These were successful in retaining water and mud, but proved impossible to seal for bead incubations. Will be used for x-radiography instead, using sampling tray built by Darren Young. Bead incubations commenced in normal megacorer barrels. Non-oxystat shipboard incubations also commenced.

Thursday, April 24
CTD cast (55901# 17) for a full column water profile (nutrients, DOC, pigments etc, plus multiple bottles at 45 m chlorophyll max. Benthic boundary layer sampler (BBLS) deployed successfully at 16.06 (55901#18). A general science meeting was held at 19.00 in the main laboratory to assess status at A140 and to discuss plans/modifications and task assignments for the next station (A300). All incubations and core processing completed.

Friday, April 25
ELINOR (EF) recovered at 05.30 – successful. Sediment somewhat disturbed, but sampled. Moved to station A300 at same co-ordinates for CD145. CTD cast (55902#1) at 10.00 for bottom waters (shipboard incubations). Megacorer deployment (55902#2) at 11.00 for shipboard incubation cores (12/12); laminated soupy sediments with fluff and redox banding close to interface. ELINOR (EO) deployed successfully at 14.40 (55902#3). Multicorer deployments at 15.56 (55902#4; 11/12) and 17.11 (55902#5; 11/12). CTD cast at 19.20 (55902#6; 24 bottles, bottom water, 295m). Megacorer deployment at 20.02 (55902#7; 6/12 good cores). Two more shipboard incubations started.

Saturday, April 26
Megacorer deployments at 10.20 and 11.20 (55902 #8 & #9; 11/12 and 9/12) followed by PROFILUR deployment (moored) at 15.21 (55902#10). Recovered ELINOR (EO) at 16.28 but hit side of ship due to swell (sediments messed up but water samples OK). Considerable swell developed, creating problems for lander deployments/recoveries. Incubation sampling and core processing. Oxystat system on shipboard incubation rigs appears to be functioning well at low O_2 levels apart from tubing collapse on selected lines.

Sunday, April 27
ELINOR deployment (moored, oxystat EF) at 07.25 (55902#11) but this was aborted at 14.04 due to swell and to fit longer tether. Multicorer deployment (55902#12, 08.57, 10/12) and a PROFILUR recovery (10.05; dud deployment due to swell, short rope caused 'bounce') followed. Megacorer deployment (55902#13, 8/12) at

13.09, and redeployments of ELINOR (55902#14, moored EF, 16.50) and PROFILUR (55902#15, moored, 17.46) both with longer mooring ropes. Shipboard incubations (SO, SF, SF13 and beads) started or ongoing.

Monday, April 28
Started with a 24-bottle CTD cast for water-column profiling (55902#16) at 09.35, followed by a multicorer drop (55902#17, 10/12) at 11.03, a PROFILUR recovery at 13.27 (successful), a megacorer drop (55902#18, 10/12) at 14.51 and a moored PROFILUR deployment at 16.24 (55902#19).

Tuesday, April 29
Moored PROFILUR recovery (successful) at 09.05. Megacorer (55902#20, 6/8) at 13.34. Benthic Boundary Layer Sampler (BBLS) deployed successfully at 14.32 (55902#21) and CTD cast for bottom waters (297m) at 18.46 (55902#22).

Wednesday, April 30
Successful ELINOR recovery at 10.05 (EF, 55902#3) followed by a megacorer drop (55902#23, 8/8) and an ELINOR deployment (moored, EF13, 55902#24) at 15.31. Emergency drill at 16.15. Continued biological and geochemical core processing and sampling from shipboard incubations.

Thursday, May 1
Megacorer deployment 55902#25(7/8) at 13.23 followed by multicorer deployment 55902#26 (10/12) at 15.29. Continued shipboard incubations and core processing.

Friday, May 2
Multicorer drop 55902#26 at 09.16 (10/10) followed by ELINOR recovery (EF13, 55902#24, successful for mud and water) at 14.45. Left station at ca. 15.40 for CD145-18850m site, stopping at ca. 400m depth contour for exploratory megacoring for bacterial mats (close to A400 WASP track from CD145). Four megacorer drops (55903#1-4) were performed at ca. 19.00 – 20.00, all unsuccessful. Transit to A1850 site.

Saturday, May 3.
CTD cast (55904#1) at 01.44 for bottom waters for shipboard incubations. Megacorer (55904#2) at 05.46 (8/8) followed by ELINOR deployment (EO, 55904#3, autonomous) at 07.19 and PROFILUR deployment at 14.54 (55904#4, autonomous). Shipboard incubations commenced.

Sunday, May 4
Megacorer deployments 55904#5 and #6 (both 8/8) at 6.48 and 11.07, respectively. ELINOR (EO, 55904#3) recovered at 08.44; no mud – lowered feet for next deployment. Megacorer drop 55904#7 at 12.56 (8/8) followed by multicorer drop 55904#8 at 15.57 (11/12). ELINOR deployment (EF, autonomous, 55904#9) at 17.40.

Monday, May 5
PROFILUR (55904#4) recovered at 05.05 (autonomous, successful) followed by a multicorer drop (55904#10; 12/12) at 07.22, a megacorer drop (55904#11; 7/8) at 09.25 and a BBLS deployment (55904#12, successful) at 14.17. These were followed by a PROFILUR deployment (autonomous, 55904#13) at 16.50 and a further multicorer drop (55904#14, 6/6) at 19.41.

Tuesday. May 6
Megacorer drop (55904#15, 8/8) at 08.08 followed by a transit up-slope to an 1100m depth site on a transect to the E of the main station transect. A preliminary CTD cast (55905#1) was conducted at 13.51 for sound velocity profiling, which was followed by a series of megacorer drops at stations A1100, A1050, A1000, A950 and A900 (55905#2, and 55906-9#1, respectively) between 16.07 and 22.25 (8-core drops, selected cores retained for biological and geochemical sampling).

Wednesday, May 7
Swath bathymetry on 5 tracks over the same sampling area and up to ca. 400m depth contour was conducted between 00.24 and 06.06, followed by return to site A1850. CTD cast (55910#1) for full 24-bottle water column profile at 11.26, followed by ELINOR recovery (EF, 55904#9) at 16.40.

Thursday, May 8
Megacorer drop 55910#2 (7/8) at 09.57 followed by an Agassiz Trawl deployment at ca. 1800-1900m from 13.20 to 15.20. This was followed by transit to the CD145-A1200 site where work commenced at 20.04 with a CTD cast (55911#1) and a megacorer drop (55911#2; 8/8) at 22.03 for bottom waters and sediments for shipboard incubations and both biological and geochemical sediment characterisation. Shipboard incubations commenced.

Friday, May 9
An ELINOR (EO) deployment (55911#3, autonomous) was carried out at 06.35, followed by a megacorer drop (55911#4; 12/12) at 09.37. A multicorer drop (55911#5; 12/12) took place at 13.15. Continued core processing and sampling from shipboard incubations.

Saturday, May 10
PROFILUR deployment (autonomous, 55911#6) at 07.09 followed by an ELINOR (EO, 55911#3; no mud) recovery at 08.33 and a megacorer drop (55911#7; 12/12) at 10.35. ELINOR (EO) was redeployed at 16.55 (55911#8, autonomous) followed by a multicorer drop (55911#8; 12/12) at 19.42.

Sunday, May 11
Megacorer drop 55911#10 at 09.57 (12/12) followed by a CTD cast (55911#11; 24 bottle profile) at 12.16, a PROFILUR deployment (55911# 12, autonomous) at 16.20 and an ELINOR recovery at 16.55 (EO, 55911#8; no mud again).

Monday, May 12
PROFILUR recovery (55911#12, autonomous) at 06.40 followed by a BBLS deployment (55911#13) at 10.16, a multicorer drop (55911#14; 12/12) at 11.14 and a megacorer drop (55911#15; 8/8) at 14.57. A CTD cast was performed at 19.37 (55911#16; 14 bottles at 40m Chl max.).

Tuesday, May 13
ELINOR (EF, autonomous, 55911#17) was deployed at 07.11 followed by transit to A950m site. An Agassiz trawl was deployed (55912#1) between 12.44 and 13.30 centred on a depth of approximately 900m. This was followed by 5 exploratory megacorer drops at depths of 950, 850, 800, and 600m (x2) (55913-5#1 and 55916#1&2, respectively) between 15.53 and 21.49. Selected cores were retained for x-radiography and both biological and geochemical processing.

Wednesday, May 14.
Transit back to site A1200 followed by test megacorer drop at 10.50 and megacorer drop 55917#1 (7/8) at 14.40 and CTD tests between 17.15 and 19.00. Continued biological and geochemical processing of cores and shipboard incubation samples. Decided not to conduct EF13 ELINOR deployment at this site due to shovel failures, lack of ^{13}C-labeled algae and better likelihood of sediment recovery at shallower sites with higher-porosity sediments.

Thursday, May 15
ELINOR (EF, autonomous, 55911#17) recovered at 06.40 (successful water sampling but no sediments) followed by transit to A940 (~A950) and deployment of the CTD (55918#1; bottom waters for shipboard incubation, 10 bottles fired) at 10.00. This was in turn followed by a megacorer deployment (55918#2; 9/12) at 13.41, and an ELINOR deployment (EO, autonomous, 55918#3) at 18.38. Shipboard incubations and core procession commenced.

Friday, May 16
Two megacorer deployments (55918#4,5; both 12/12) for biological and geochemical sampling processing at 09.05 and 10.25, respectively. These were followed by a PROFILUR deployment (55918#6, autonomous) at 11.22 and a multicorer drop (55918#7; 11/12) at 13.20.

Saturday, May 17
ELINOR was recovered at 06.00 (EO, autonomous, 55918#3) followed by a multicorer drop 55918#8 at 06.39 (12/12) and by two megacorer drops (55918#9,10; 12/12 and 8/8) at 9.23 and 11.23. An ELINOR deployment (EF, autonomous, 55918#11) then took place at 16.46.

Sunday, May 18
Megacorer drop 55918#12 (4/8) took place at 8.24 and this was followed by PROFILUR recovery at 10.19, a multicorer drop (55918#13; 10/12) at 12.16, an Agassiz trawl between 14.00 and 15.43 (55918#14, ca. 950m), and a redeployment of PROFILUR at 17.43 (55918#15).

Monday, May 19
Megacorer deployment at 09.09 (55918#16; 8/8). Transit to 700m depth contour (A700) and then 1000m depth contours (on same eastern margin transect) to further expand our sediment characterisation across the lower OMZ boundary (megacorer drops 55919-20#1 (4/8, 6/8 respectively) at 14.50 and 20.18. Continued core processing and returned to A940 site.

Tuesday, May 20
PROFILUR recovery (55918#15) at 08.20 at A940 site, followed by transit to the 850m depth contour (A850) where there was a megacorer drop (55921#1; 7/10) at 10.25 followed by an Agassiz trawl at ca. 750-770m depth (55922#1) between 13.10 and 14.10 (torn net and broken weak link, but successful sample recovery). This was followed by a further megacorer drop at A750 (55922#2; 8/8) at 16.00 and return transit to A940 where PROFILUR was deployed (55923#1) at 18.18. A BBLS deployment (55923#2) was made at 19.47 but hit the interface at an angle causing cloudy water samples. Confirmation arrives that we shall return to Muscat rather than the Seychelles.

Wednesday, May 21
Recovery of PROFILUR (55923#1) at A940 at 06.48 followed by transit to ca. 450m depth contour where a series of 6 megacorer drops were undertaken between ca. 450 and 360m in search of the elusive bacterial mats (55924-27#1, 55928#1-2); all unsuccessful and all cores discarded. Returned to A940 and conducted a megacorer drop (55929#11) followed by a CTD cast (55929#2; 4 bottles) at 18.32 and 20.10, respectively.

Thursday, May 22
A further BBLS cast (55929#3; successful) was conducted at A940 at 09.17 followed by transit to the A400 site where a further attempt to find bacterial mats was made (55930#1; unsuccessful) at 12.57. Transit to A140 site where a CTD cast was made to collect bottom waters for shipboard incubations (55931#1; 16.30) followed by an ELINOR deployment (EF13; 55931#2) at 21.08.

Friday, May 23
Two megacorer drops 55921#3-4 (failed and 8/8) followed by core processing and commencement of last shipboard incubation experiments. Lost GPS on two occasions.

Saturday, May 24
No deployments. Continued final sample processing and shipboard incubation experiments.

Sunday, May 25
Recovered ELINOR (EF, 55931#2) at 05.46 (failure due to no lid closure) and redeployed (EF) at 15.57 (55931#5). Continued core and sample processing and shipboard incubations and analyses. Megacorer test deployments.

Monday, May 26
No deployments. Continued core and sample processing.

Tuesday, May 27
Recovery of ELINOR (EF, 55931#5) at 17.50 (successful sediment and water recovery) followed by start of transit towards Muscat.

Wednesday, May 28
Transit towards Muscat (Port Sultan Qaboos). Comparatively heavy seas. Commenced lab', deck and hold clean-up.

Thursday, May 29
Continued transit and clean-up. Arrived offshore PSQ at ca. 23.00.

Friday, May 30
Docked at PSQ ca. 08.30. Commenced clearing the hold and lab's.

Saturday, May 31
Problems encountered at port immigration authorities due to incorrect visas. Resolved only by all scientific party planning to return to vessel on June 1 being forced to stay on the ship rather than in the hotel. Continued offloading. Airfreight offloaded and refrigerated container delivered and loaded.

Sunday, June 1
PSO leaves in the a.m. with remaining party due to complete packing and offloading of frozen samples after delivery of dry ice, and finalisation of plans for gas cylinders for CD150 and CD151.

Greg Cowie

5.2 Conclusions
As outlined above, the objectives of this cruise were mixed; both to complete biological and geochemical survey work that commenced during CD145 but also, and primarily, to conduct an ambitious programme of shipboard and in situ experimental studies in order to assess the nature and rates of benthic biogeochemical processes. A further objective was to attempt to collect surficial sediments with bacterial mats in order to characterise these mats and to assess the importance of chemosynthetic C inputs within the OMZ. At the same time, further sampling and profiling of the water column was also planned.

Although a variety of technical problems were encountered with the benthic landers that made some of the *in situ* studies impossible, the large majority of deployments were successful, and there is reason to believe that the remaining problems will be resolved before CD151. Also, the back-up shipboard incubation rigs proved to be successful on essentially all fronts, and it was possible to conduct a variety of additional, unforeseen shipboard incubation studies.

A problem encountered on CD145 was that was inadequate time to seek out 5 primary study sites that best covered the range of redox conditions, sediment types and faunal communities encountered across the OMZ. At site A150, above the OMZ. coarse shelly sediments were recovered that were wholly unlike any others that were recovered across the margin, and from which porewaters could not be extruded. Further, there was no sampling

conducted between the depths of 500 and 1200m, which represents a critical transition across the lower OMZ boundary. These problems were rectified on CD146 firstly by returning to a 140m depth site previously visited on FS Sonne 90 (1993; station SO90 124KG), where fine sediments were recovered, with a texture similar to those recovered from greater depths. Secondly, the complex bottom topography that prevented sampling in the 500 to 1200m depth range on CD145 was overcome by working on a transect to the S and E of the transect previously occupied on CD145. This involved an extensive survey of megacorer deployments at every ca. 50m between 1100 and 600m depths, which provided a uniquely detailed set of cores for biological and geochemical characterisation of the dramatic changes that occur across the lower OMZ boundary. This survey was also complimented by additional swath bathymetry and Agassiz trawls and, together, these led to the selection of a ca. 950m depth site for a final primary study location (replacing A500 from CD145). Full, replicate sampling was conducted at both the A140 and A950.

Addressing our specific objectives in turn:

a) Sampling for the characterisation of benthic communities under intermonsoon conditions at five sites spanning the mid-slope OMZ on the Pakistan margin (A140, A300, A950, A1200 and A1850) was completed, including replicate sampling at sites not previously visited on CD145 (A140 and A950).

b) Sampling for the characterisation of sediment porewater and solid-phase geochemistry was similarly completed, including replication for all parameters at those sites not previously visited on CD145.

c) Photography, x-radiography and shipboard gamma counting were conducted at all 5 sites, plus x-radiography for sediments recovered every ca. 50m from sites between 600 and 1100m depths. These, plus additional radiochemical analyses to be conducted post-cruise, will provide unprecedented information on sediment microstructure and bioturbation, and on sediment mixing and accumulation rates.

d) CTD profiling and water-column sampling, along with BBLS deployments were successfully conducted at all 5 primary sites..

e) Seabed characterisation in the work area was completed using acoustic remote sensing (EM12 and 3.5kHz).

f) Attempts were made to collect bacterial mats from sites at ca. 400m depth where seabed video footage suggested the highest density of occurrence. None were found in 10 megacorer deployments, but we are hopeful that this can be rectified on CD150 and CD151.

g) Oxygen penetration depths and benthic consumption rates were successfully determined at all primary sites via shipboard and *in situ* microelectrode profiling and sediment incubation studies.

h) Sampling for determination of benthic fluxes of nutrients, trace metals and dissolved organic matter was successfully conducted at all 5 sites (using shipboard and *in situ* incubation studies maintained at ambient O_2 levels).

i) Sampling for the determination of benthic microbial process rates (commenced on CD145 with sulfate reduction) were assessed at all sites by aforementioned 0_2 consumption studies combined with rate determinations of denitrification and Fe/Mn cycling via direct analysis, or modeling of porewater profiles and benthic fluxes.

j) Sampling for the quantification of benthic C cycling was successfully conducted at all primary sites using added ^{13}C-enriched organic matter in shipboard incubation experiments, and at one site via *in situ* incubation (tracking the ^{13}C into overlying waters, sediments and fauna).

k) Short-term sediment mixing rates and size-selective particle mixing were successfully assessed using shipboard incubation studies with added flourescently-labeled particles.

In summary, the cruise was highly successful on most fronts and we believe that it has laid an excellent foundation for the linked, post-monsoon sampling and experimental work to be conducted during CD150 and CD151.

Greg Cowie

5.3 Acknowledgements

This entire research project and the series of cruises it is based around have been beset by a long series of obstacles that started with submittals and resubmittals of proposals and cruise plans and went on to include budget cuts and postponements, changes of ships and ports and finally, details like a major war, the threat of terrorist attacks, endless risk assessment exercises, failure to get diplomatic clearance and a further last-minute change of ports.

The project has only survived thanks to the perseverance of all the scientists involved in the project, but I am also especially indebted to Mike Webb at NERC, and to Andy Louch and Colin Day (and colleagues) at RSU and UKORS who have been consistently supportive and helpful throughout a challenging process.

CD146 was always going to be a long cruise but, at a total of 48 days that resulted from days added due to the last-minute change of ports from Muscat to the Seychelles, it became quite extreme (possibly a record for the Darwin?). This, combined with a challenging work plan, could easily have made for a particularly difficult cruise and I feared a rude introduction to the job of being a PSO. Instead, I have been quite amazed at the professionalism and persistently positive attitude of everyone on board – crew, engineers, officers, technicians and scientists alike - and I am grateful to all for making my job remarkably easy.

I am also indebted:

Back on shore, to Tracy Shimmield, without whose enormous effort from the start this project would not have got off the ground and onto the water.

To all participants of CD145 and especially to Brian Bett as PSO, for doing a phenomenal job despite all of the setbacks, and who thus in turn got this cruise and the whole project off to a good start. Thanks also to Brian for so efficiently passing on all the key information for CD146 at the poolside bar in the Seychelles.

To Darren, Dave, Rob and Rhys for their excellent and varied technical help throughout the cruise.

To the crew, engineers and officers, who were professional and helpful throughout and managed to keep us afloat, operational and on track, and almost always with lights.

To Clive, Peter, Geoff and Tulip, who not only kept us all entertained but provided an exceptional variety and quality of food during the entire cruise. The food I ate during the last few of my 48 days on *RRS Charles Darwin* was far better than what I have had on the first days of cruises on many other research vessels.

To the Captain for his patience with a novice PSO and for his enormous help on all fronts in making this a successful cruise.

To Sue and Eric, for being everywhere doing everything at all hours, and for providing competition on the darts board.

To Lisa, Andy and Kate for the remarkable hours and phenomenal fortitude they put into bug picking, on which so much depends, and to Danish for being willing to convert from geology to biology.

To Matt and Clare, who never seemed to tire of playing in the Wendy Hut(t) in silly outfits at all different temperatures, and managed somehow to hold up Edinburgh's part of the bargain.

To Tasos and Henrik for between them handling all the water-column samples and nutrient analyses, and for being willing multitaskers. Also to Tasos for deeply meaningful phrases such as "water is everything" and for singing "For He's a Jolly Good Fellow" at the dinner table for no discernible reason (although I have my suspicions).

To Willie and Oli for managing to complete a phenomenally demanding lander deployment schedule. I am especially grateful to Oli for his incredible endurance in the face of endless setbacks, and for resisting the temptation to "forget" the buoyancy.

And finally to Kate, who must take the biscuit for managing to remain positive and energetic despite spending ridiculous hours staring down a microscope on two long, consecutive cruises.

Thank you all. Enjoy your time on land. **Greg**

6. SITE SURVEY AND SELECTION AND EXPERIMENTAL DESIGNS

6.1 SITE SURVEY AND SELECTION

Site selection for the present cruise was largely determined by 10KHz echo-sounder, 3.5KHz and swath surveys conducted during CD145 (see CD145 cruise report). Primary criteria were contrasting depths, redox conditions and sediment types across the OMZ, but also suitability for trawling and benthic lander operations (hence a need to be removed from canyons, steep slopes or other major topographic features).

On this basis, 5 main mid-slope sites were selected for detailed investigation during CD145, in addition to an abyssal site (NAST) visited while waiting for diplomatic clearance from Pakistan. Three of these sites, at 300m, 1200m and 1850m, at the core, lower boundary and below the OMZ, respectively, have been returned to on CD146 for continued coring and experimental work. However, two sites, at 150m (above OMZ) and 500m (OMZ core) have been dropped for CD146, due to coarse, shelly (largely relict) sediments at the 150m site and because sediments at the 500m site were exceedingly difficult to recover but were otherwise very similar in nature to those from the 300m site.

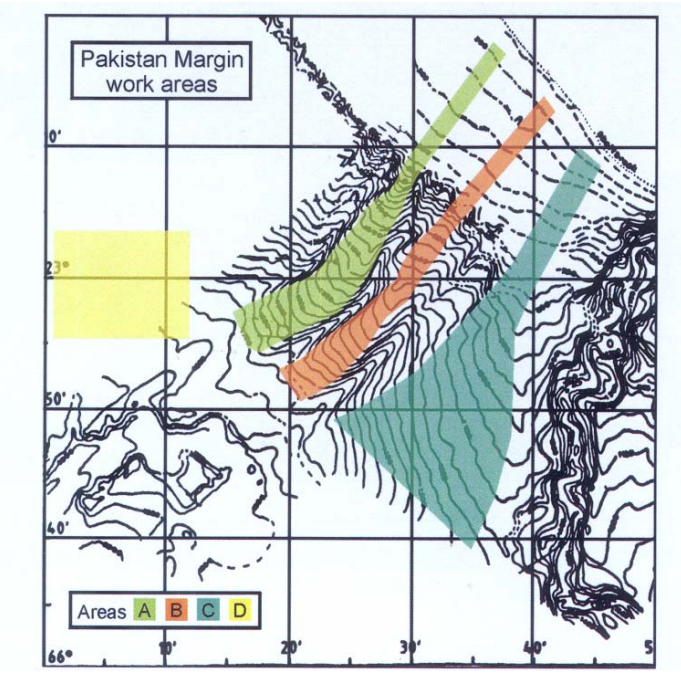


Figure 1. Pakistan margin work area, with sub-areas as defined during CD145. Primary coring sites on CD145 were in Area A. Additional coring and lander deployments were conducted at ca. 950m depth at a site in Area C during CD146.

Therefore, it was decided with Dr. Brian Bett, PSO on CD145 (during mob/demob) and in consultation with other CD146 participants, to investigate a ca. 140m site previously visited on an *FS Sonne* cruise in 1993, from which fine, homogeneous sediments were recovered, with grain size distributions similar to those found within the OMZ. Also, a decision was reached to investigate a slope area (CD145 Area C) to the east of the main coring transect visited in CD145 (Area A) in order to identify a site in the 800-1100m depth range that would be representative of the critical lower transition zone of the OMZ (see Fig. 1). This depth range (500-1200m) was unsampled during CD145 due to topographic complexities.

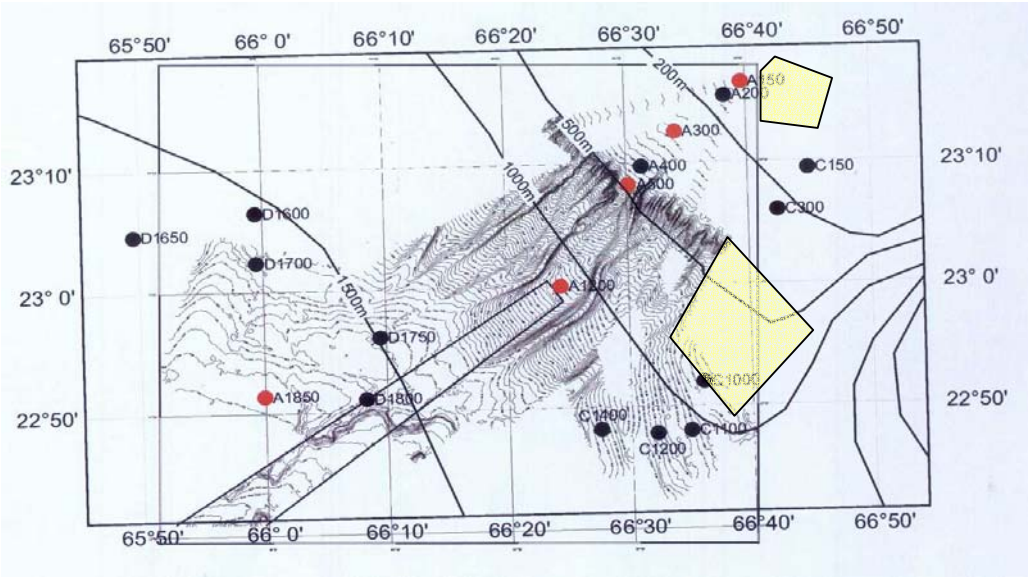


Figure 2. Swath bathymetry and station locations from CD145, plus approximate areas of swath bathymetry conducted during CD146.

To help select locations for coring, trawling and lander operations, combinations of 10KHz echosounder and swath bathymetry were conducted as shown approximately in Figure 2. Only preliminary, unprocessed results were available on board. Logged data (including 3.5KHz) have been stored for processing at SOC post-cruise.

Greg Cowie

6.2 EXPERIMENTAL DESIGN

A central focus of the present cruise was to conduct shipboard and *in situ* experiments to compliment the characterisation of benthic communities and sediment geochemistry that commenced during CD145 (and was completed during CD146). These experiments are described in detail below, but consisted in essence of chamber incubation studies in which sediments and overlying waters were enclosed and changes in the composition of the stirred overlying waters over time used to determine oxygen consumption and sedimentary denitrification rates,

and benthic fluxes of nutrients, trace metals and dissolved organic material and inorganic carbon. Due to the wide-ranging, and often vanishingly small dissolved oxygen content of bottom waters, and the need to avoid stresses to local fauna and to permit representative flux determinations for redox-sensitive solutes, an essential feature of both shipboard and *in situ* experiments was a capability to prevent anoxia from developing in the enclosed chambers and to maintain differing near-ambient oxygen levels. This was achieved by circulating the enclosed chamber waters through a "gill" or "oxystat" system of gas-permeable, silicone tubing outside the chamber, in contact with surrounding bottom waters in the case of the benthic lander, or in a seawater reservoir with a fixed but manipulable oxygen concentration in the case of the shipboard incubations. In the latter case, ambient temperature conditions were also maintained by using a controlled temperature laboratory set at the local bottom-water temperature. In both cases, water samples of known volume were collected over time, using pre-programmed spring-loaded syringes in the case of the benthic lander chamber, or simply by extracting overlying water at desired times in the case of the shipboard experiments. These waters were either replaced by local bottom waters (of known composition) or not replaced at all in the case of some shipboard incubations; in both instances, corrections could thus be made, which, in combination with known initial volumes (from injection and subsequent analysis of KBr as a conservative tracer) permit accurate benthic flux determinations

In all cases, *in situ* experiments were replicated by shipboard studies. Experiments fell into 3 categories:

a) *No oxygen control*; sealed *in situ* and shipboard chambers are left to go progressively more anoxic, and overlying waters are monitored for dissolved oxygen concentration and for N_2/Ar ratios (for sedimentary denitrification rate determinations, Section x).

b) *Controlled oxygen studies*; as above but with maintained ambient oxygen concentrations and periodic sampling for trace metals, nutrients and dissolved inorganic and organic C, and total dissolved organic N in order to determine benthic fluxes.

c) *^{13}C enrichment studies;* Controlled oxygen levels as for b) but with initial addition of ^{13}C-labeled diatom detritus and subsequent monitoring of overlying waters for DIC, δ^{13}DIC, and DOC, and post-incubation sampling of sediments, fauna, and porewaters for elemental, isotopic and molecular analyses. The purpose of these experiments is to quantify benthic C cycling and burial rates and to assess the roles of benthic fauna in these processes.

The durations of both *in situ* and shipboard incubation studies were set by a combination of guesswork, the results of previous studies in other settings and by information accumulated over the course of the cruise. Typically, these ranged from 1 day for the in situ "no oxygen control" studies, to up to 5 or 6 days for shipboard ^{13}C enrichment studies.

Despite potential pressure artifacts that might arise from bringing deep-sea sediments to the surface, the shipboard incubations offered multiple potentially valuable features, including comparatively undisturbed sediments, manipulable oxygen levels and ratios of overlying water to sediment surface area, as well as the option to conduct replicate incubations (up to 14 megacore chambers could conceivably be operated at once) and/or for multiple durations. Above all, they provide a back-up in the event of lander failure.

A final variety of shipboard experiment (with the oxystat system) involved incubations with the addition of fluorescently labeled particles. Three size ranges of particle (clay-fine silt, medium-coarse silts and fine sands), covering the grain-size distributions of sediments at the study sites, were used, each with a distinct fluorescent colour. The purpose of these experiments was to provide an extra measure of sediment mixing rates as well as the extent of size-selective particle ingestion and mixing by benthic fauna. The fluorescent particles were recovered from different vertical sections of cores recovered post-incubation, and will be counted by fluorescence microscopy and/or flow-through cytometry.

Greg Cowie

7. SURVEY EQUIPMENT

7.1 Computing and Data logging

No particular problems were experienced with the ship's computer suite or data logging systems. Navigation data, surface sample data, meteorology data and winch data were all logged to the onboard computing system. Processed navigation, salinity, corrected bathymetry and processed wind speed data were also produced. These data were backed-up to a data CD.

The 3.5kHz record was also logged and the data backed-up to CDs. This will be returned to Dr. Brian Bett at SOC for post-cruise processing.

Data from the EM12 swath bathymetry system were logged to *.all files. These files contain backscatter, bathymetry and navigation data. Raw data were backed up to CD and will be returned to Dr. Brian Bett at SOC.

Rob Lloyd

7.2 Acoustic systems

10 kHz echo sounder

This was used throughout the cruise without problem.

3.5 kHz sub-bottom profiler.

This was used during the short swath survey, no problems were encountered.

Simrad EM12 swath bathymetry

This was run for 3 short periods, mainly to collect data for a small area not surveyed on CD 145. The data was not processed on board.

Surfmet

The surface\meteorology system was run throughout the cruise. There were no instrument failures but bio-fouling was a problem on the surface monitoring sensors. This was a particular problem on the transmissometer, which required cleaning on a daily basis.

Waterfall display

Initially the system appeared not to be working. After about an hour the system suddenly started to work. No problem was identified and the unit continued to operate for the rest of the cruise

Dave Teare

7.3 Mechanical handling

CTD deployments

A total of 21 deployments to a maximum depth of 2000m (wire out, during release test) were carried out using the starboard gantry and CTD winch. During one of the CTD deployments the wire jumped off the scroll sheave due to a loose turn left on the winch drum prior to the deployment. The CTD was just below the surface, so we did not have a large inboard tension. The cable/CTD were stoppered off and the wire was replaced on the sheave and the loose wire sorted out. The CTD was recovered back onboard and the wire examined for damage. There was no need to re-terminate the cable and the CTD deployment continued.

BBLS, Multicorer, Megacorer and test deployments

A total of 93 deployments were carried out using the trawl warp over the starboard gantry with a maximum wire out of 2000m (during sphere tests). No problems were encountered.

Agassiz Trawl Deployments

Trawl deployments were carried out over the aft gantry. No problems were encountered during deployments. A total of 4 deployments were carried out with a maximum wire out of 2500 metres. The weak link activated on one trawl just before recovery was about to begin. The trawl frame was undamaged on its return onboard.

Moored Lander Deployments

Moored Landers were deployed over the stern of the ship using the ship fitted cranes and a 3 tonne general purpose Dauntless deck winch. No problems were encountered with the winch.

Rhys Roberts, Darren Young

7.4 Laboratory facilities

Liquid Nitrogen Generator

Although problems were encountered with the LN_2 generator during the CD145 cruise, the system maintained a supply of LN_2 throughout the cruise. The locating of the system in the Airgun annex is not ideal and problems with cutting out on high temperature at times were experienced. The level indicator gauge on the liquid dewar stopped working on CD145 cruise. The only way to cure this is to empty the dewar and let it thaw out for a couple of days. The continuous requirement for LN_2 during the cruise did not allow for the dewar to be thawed out therefore the gauge was left disconnected. The level was physically checked every few days and the system was started / shutdown manually as required.

Clean Chemistry Container Laboratory

The air conditioning unit iced up on several occasions. On one occasion, power was lost to some of the electrical sockets in the lab. On investigation one of the lab MCCB's (circuit breaker) had tripped off. The trip was reset and no further power problems were encountered

Radio Nuclide Container Laboratory

Used infrequently during the cruise, when the lab temperatures could be set to required level for calibration and other work. In the early days of the cruise when the Air conditioning unit was running full time, it was constantly tripping out on high temperature. During the investigation of this fault it was found that the seawater flow rate was being excessively restricted through the unit. When the pressure maintaining valve was removed from the inlet line of the unit no further problems were encountered.

Millipore Water Purifiers

Two RO12 systems were used during the cruise. One in the chemistry container lab, and one in the Ship's wet lab. During the duration of the cruise the pre filters were changed twice on both units. The Milli Q pack on the lab container system had to changed due to the product water not being of an acceptable quality. There was also a water leak on the same Milli `Q` unit, which was traced to a damaged sealing `O` ring.

Flake Ice Maker Machine

The Ice Maker was installed in the wet lab and worked without problems during the cruise.

Rhys Roberts, Darren Young

7.5 CTD

The CTD system was the same as used on CD 145. And comprised of the following.

Seabird 911+ CTD and deck unit.
Seabird type 43 oxygen sensor
Chelsea Inst. Fluorometer Aquatracka mk3
Chelsea Inst. Transmissometer Alphatracka 25cm path
Seatech light backscatter type LSS6000
Datasonics altimeter
24 way G.O. 1016 rosette
24 10-litre water bottles

A total of 15 casts were performed at the sites listed below:

A140	55901#1, 55931#1
A150	55901#17
A300	55902#1, 55902#6, 55902#16, 55902#22
A1850	55910#1, 55904#1
A1200	55911#1, 55911#2, 55911#16
A950	55918#1
A940	55929#2, 55905#1

In addition to the above, 2 casts were performed for Lander release test and 2 for CTD tests.

In general the CTD performed satisfactorily. Initial noise and loss of signal on the transmissometer were traced to a damaged cable, which was replaced. The oxygen sensor was compared to titrated samples and found to be performing well. The conductivity offset problem experienced on CD 145 persisted during CD 146. The suspect secondary unit was replaced, at the beginning of the cruise, which improved data for several casts. The error then re-appeared over several casts. Wet sample tests and electronic tests suggested the problem may lie with the primary sensor. This was changed and the data improved for several casts. On the last cast of the cruise the offset problem started to manifest itself again, wet samples indicated that the secondary sensor may well be the cause. No satisfactory answer to the problem has been established, as different sensors, cabling and data channels were affected in a similar way. Data files are being sent back to Seabird for analysis. At this point bio-fouling cannot be ruled out, as each sensor affected, was the one that had been on the CTD for the longest period of time.

Dave Teare

7.6 Benthic Boundary Layer Sampler (BBLS)

A benthic boundary layer sampler (BBLS) has been designed at SAMS (Willie Thomson); the frame built at the University of Edinburgh (Jim Smith) and the sampling bottles at SAMS (Drew Connelly). The BBLS frame (Fig. 1a) accommodates 1.5 litre capacity PVC/Perspex sampling bottles (Fig. 1b), aligned horizontally at variable intervals between 0.16 and 2.12 metres (to the centre of each bottle) from the bottom plate of the frame. A mechanical trigger (vertical movement of bottom plate) fires the closing mechanism (spring-taught pistons) of all bottles simultaneously upon impact with the bottom, whilst a magnetic switch changes the frequency of the pinger used to monitor deployments.

Bottles were situated at 0.16, 0.55, 1.01, 1.56 and 2.12 metres (to the centre of each bottle) above the base. The uppermost bottle was a 'prototype', which was produced to ensure that the design was suitable for the purpose and as such it was never intended for practical use. On this bottle the closing mechanism failed to fire on triggering, this was due to a mistake in the machining where the holes for the sear pins were drilled too big and metal inserts were used to reduce the diameters. The coefficient of friction between the two metal components is approximately 3 to 4 times that of the original metal to polymer contact and so the sliding action was reduced to such an extent that the bottle did not close. This was temporarily resolved by a re-engineering of the pins but will need to be properly repaired before subsequent use. There was also no drain vent in this prototype bottle, so the stopper had to be rapidly opened and closed in order to withdraw water. The bottle at 1.01 metres consistently leaked from the rear of the piston and this was due to a machining error that will also need to be fixed before subsequent use.

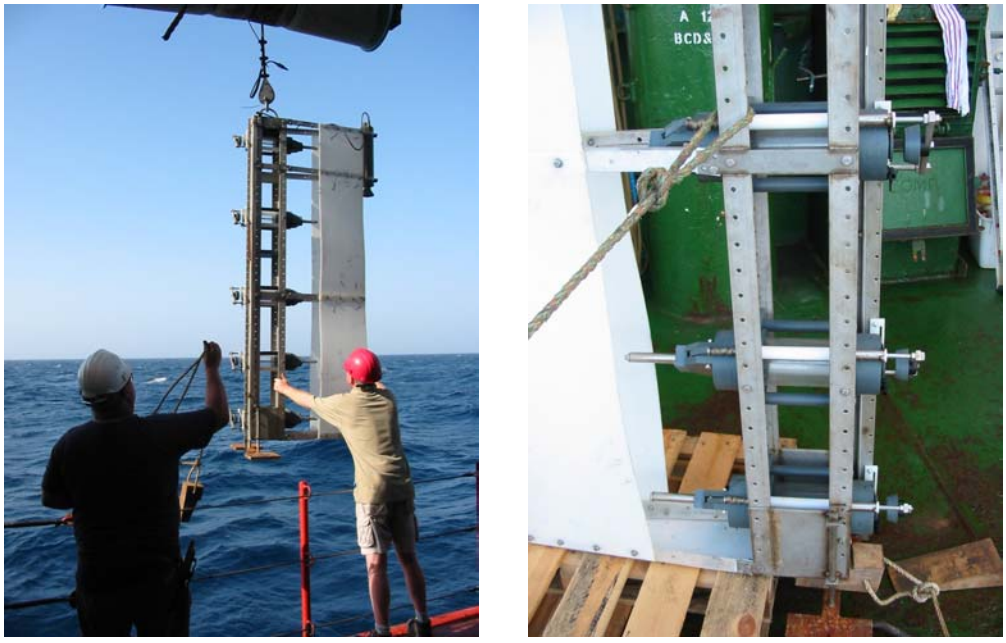


Figure 1: a) BBLS being deployed, showing frame, and b) detail of sample bottles.

The BBLS was deployed from the core warp (19mm wire). This relatively heavy wire, compared to the sampling device, has previously been shown to provide greater control for 'light equipment', reducing "kiting" and increasing the likelihood of the gear landing squarely on the seabed (Bett, *pers. comm.*). During the first deployment there was a good swell and the rig triggered prematurely as it hit the water. Some chain was used to increase the weight of the footplate and this solved the problem. A descent rate of 25-30 m/min was used until the frame was approximately 15 metres off the bottom then at a rate of 5 m/min until the firing mechanism has been triggered as indicated by the change in frequency of the pinger signal from 1 Hz to 2 Hz. Monitoring of BBLS operation was carried out using the SIMRAD EA500, the display of which is a little slow to update.

William Thomson

7.7 Multiple corer (multicorer)

The SOC-GDD supplied SMBA-pattern multiple corer (Fig. 1) was used throughout the cruise and served as the primary coring device for meiofaunal sampling and for collecting sediments for a variety of geochemical analyses. It performed reliably at all of the main coring stations, with no special measures taken at any sites. A record of all deployments is provided in Table 1.

Fig. 1. Multicorer deployment from the starboard gantry at sunset.

Table 1. Multicorer deployment details for CD146

Station	Series #	Site	Date (03)	Time (utc)	Latitude DN	MN	Longitude DE	ME	Depth (m)	Recovery
55901	5	A140	21/04	4.52	23	16.65	66	42.75	134	12/12 good
55901	6	A140	21/04	5.34	23	16.87	66	42.60	135	FAILED
55901	7	A140	21/04	6.31	23	16.87	66	42.55	134	12/12 good
55901	11	A140	22/04	9.33	23	16.61	66	42.30	135.5	12/12 good
55901	13	A140	23/04	5.08	23	16.71	66	42.94	133	12/12 good cores
55902	4	A300	25/04	12.10	23	12.40	66	33.79	304	11/12 good cores
55902	5	A300	25/04	13.34	23	12.32	66	33.98	304	11/12 good cores
55902	12	A300	27/04	4.57	23	12.74	66	33.90	298.5	10/12 good cores
55902	17	A300	28/04	7.03	23	12.37	66	34.26	300	10/12 good cores
55902	26	A300	01/05	11.29	23	12.61	66	34.05	309	10/12 good cores
55902	27	A300	02/05	5.16	23	12.54	66	33.94	301	10/10 good cores
55904	8	A1850	04/05	11.57	22	52.21	66	0.04	1857	11/12 good cores
55904	10	A1850	05/05	3.22	22	52.28	66	0.00	1855	12/12 good cores
55904	14	A1850	05/05	15.41	22	52.62	65	59.93	1851	6/6 good cores
55911	5	A1200	09/05	9.15	23	0.09	66	24.39	1191	12/12 good cores
55911	9	A1200	10/05	15.42	23	0.03	66	24.47	1189	12/12 good cores
55911	14	A1200	12/05	7.14	22	59.97	66	24.49	1189.5	12/12 good cores
55918	7	A940	16/05	9.20	22	53.58	66	36.65	944	11/12 good cores
55918	8	A940	17/05	3.39	22	53.52	66	36.65	943	10/12 good cores
55918	13	A940	18/05	8.16	22	53.45	66	36.49	950.5	10/12 cores

Greg Cowie

7.8 Megacorer

The SOC-GDD megacorer performed very well during the cruise: No modifications other than varying the ballast load and number of tubes deployed were required to recover good quality cores from all sites sampled.

Set-up for RRS *Charles Darwin* cruise 146 operations:

Site A140 – full ballast, 12 or less tubes. Fine, homogeneous mud with surficial flocculent layer and occasional shells.

Site A300 – Full ballast, 8-12 tubes – very soft mud, core "slipping" technique was used for removal to alleviate bubbling problem. Laminated sediments with thick surficial fluff layer and redox banding.

Site A400, A600, A650, A700, A750, A800, A850 – no ballast (all weights removed), 12 tubes ultra soft mud, core "slipping" technique was used for removal to alleviate bubbling problem. Distinctly to indistinctly laminated with increasing water-column depth, and increasing evidence of macrofauna.

Site A900, A940(50), A1000, A1050, A1100, A1200, A1850 full ballast, 8-12 tubes. Indistinctly laminated to fully bioturbated and homogeneous, and progressively lower porosity, with increasing water-column depth.

Figure 1. A night-time megacorer deployment.

Table 1. Summary of CD146 megacorer deployments.

Station	Series #	Site	Date (03)	Time (utc)	Lat. DN	MN	Long. DE	ME	Depth (m)	Recovery
55901	2	A140	20/04	3.01	23	16.87	66	42.56	136	7/8 good cores
55901	8	A140	21/04	7.23	23	16.77	66	44.58	136	8/8 good cores
55901	9	A140	21/04	8.43	23	16.85	66	42.72	135	8/8 good cores
55901	10	A140	22/04	6.23	23	16.78	66	42.89	133	8/8 good cores
55901	14	A140	23/04	7.15	23	16.75	66	42.63	133	11/12 good cores
55901	16	A140	23/04	10.27	23	16.66	66	42.72	135	9/12 good cores
55902	2	A300	25/04	7.17	23	12.50	66	34.02	300	12/12 good cores
55902	7	A300	25/04	17.07	23	12.40	66	33.40	302	6 misfires/12
55902	8	A300	26/04	6.20	23	12.47	66	33.92	301	11/12 good cores
55902	9	A300	26/04	7.25	23	12.50	66	33.66	305	9/12, ship dragged corer
55902	13	A300	27/04	9.09	23	12.34	66	33.96	303	8/12 good cores
55902	18	A300	28/04	10.51	23	12.53	66	33.95	301	10/12 good cores
55902	20	A300	29/04	9.34	23	12.51	66	33.97	301	6/8 good cores
55902	23	A300	30/04	9.26	23	12.49	66	33.96	301.5	8/8 good cores
55902	25	A300	01/05	9.23	23	12.54	66	33.61	305	7/8 good cores
55903	1	A400	02/05	13.09	23	9.53	66	30.90	410	8/8 no mats
55903	2	A400	02/05	14.50	23	9.40	66	30.80	418	6/8 no mats
55903	3	A400	02/05	15.40	23	9.50	66	30.88	414	8/8 no mats
55903	4	A400	02/05	16.22	23	9.61	66	31.09	405	8/8 no mats
55904	2	A1850	03/05	1.36	22	52.38	65	59.85	1854	8/8 cores
55904	5	A1850	04/05	2.48	22	52.38	66	0.12	1853	8/8 cores
55904	6	A1850	04/05	7.07	22	52.45	66	0.04	1854	8/8 cores
55904	7	A1850	04/05	8.56	22	52.51	65	59.70	1856	8/8 cores
55904	11	A1850	05/05	5.25	22	51.97	66	0.02	1858	7/8 cores
55904	15	A1850	06/05	4.08	22	52.37	66	0.13	1855	8/8 cores
55905	2	A1100	06/05	12.07	22	52.75	66	33.01	1099	8/8 cores
55906	1	A1050	06/05	13.35	22	53.60	66	34.00	1048	8/8 cores
55907	1	A1000	06/05	15.06	22	54.73	66	34.93	1000	7/8 cores
55908	1	A950	06/05	16.30	22	55.90	66	36.10	938	6/8 cores
55909	1	A900	06/05	18.25	22	56.80	66	37.01	897.5	6/8 cores
55910	2	A1850	08/05	5.57	22	52.24	66	0.09	1850	7/8 cores
55911	2	A1200	08/05	18.03	23	0.08	66	24.30	1194	8/8 cores
55911	4	A1200	09/05	5.37	23	0.07	66	24.40	1191	12/12 cores
55911	7	A1200	10/05	6.35	23	0.01	66	24.47	1188	12/12 cores
55911	10	A1200	11/05	5.57	23	0.07	66	24.57	1184	12/12 cores
55911	15	A1200	12/05	10.57	22	59.99	66	24.58	1186.5	8/8 cores
55911	18	A1200	13/05	4.57	23	0.64	66	24.40	1191	8/8 cores
55913	1	A950	13/05	11.53	22	55.89	66	36.17	946	6/8 cores
55914	1	A850	13/05	13.26	22	57.47	66	37.69	848	4/8 cores
55915	1	A800	13/05	15.05	22	58.27	66	38.61	798	8/8 cores
55916	1	A600	13/05	16.59	23	1.69	66	42.07	598	4/8 cores
55916	2	A600	13/05	17.49	23	1.65	66	42.97	601	4/8 cores
55917	1	A1200	14/05	10.40	23	0.03	66	24.49	1188	7/8 cores
55918	2	A940	15/05	9.41	22	53.50	66	36.63	941	9/12 cores
55918	4	A940	16/05	5.05	22	53.56	66	36.69	941	12/12 cores
55918	5	A940	16/05	6.25	22	53.50	66	36.71	944	12/12 cores
55918	9	A940	17/05	5.23	22	53.54	66	36.64	944	12/12 cores
55918	10	A940	17/05	7.26	22	53.48	66	36.68	945.5	8/8 good cores
55918	12	A940	18/05	4.24	22	53.62	66	36.44	947.5	4/8 good cores, some bubbled
55918	16	A940	19/05	5.09	22	53.63	66	36.54	940	8/8 cores, 3 bubbled
55919	1	A700	19/05	10.50	22	59.96	66	41.20	711.5	4/8 good cores, overpenetration
55920	1	A1000	19/05	16.18	22	54.67	66	34.90	1002	6/8 good cores, 2 bubbled
55921	1	A850	20/05	6.25	22	57.61	66	37.66	843.5	7/10
55922	2	A750	20/05	12.00	22	57.57	66	41.63	737.5	8/8 good cores
55924	1	A430	21/05	6.28	23	8.78	66	30.99	432	bacterial mat hunting, no finds
55925	1	A440	21/05	7.28	23	8.75	66	30.63	446	ibid
55926	1	A435	21/05	8.12	23	8.85	66	30.82	436.5	ibid
55927	1	A390	21/05	9.17	23	9.60	66	31.69	391.5	ibid
55928	1	A370	21/05	10.14	23	10.24	66	32.39	364	ibid
55928	2	A370	21/05	10.57	23	10.04	66	32.35	369.5	ibid
55929	1	A940	21/05	14.32	22	53.56	66	36.71	940	11/12 good cores
55930	1	A400	22/05	8.57	23	9.50	66	30.94	412	no mats, cores discarded
55931	3	A140	23/05	5.24	23	16.70	66	42.70	135	failed
55931	4	A140	23/05	5.51	23	16.75	66	42.50	133	8/8 good cores

Eric Breuer

7.9 Agassiz Trawl

The Agassiz trawl (Fig. 1) was not used as a central component of the sampling programme on CD146, but was used on 4 occasions for mega- and macrobenthos sampling at depths ranging from 750-2100m.

Fig. 1. The Agassiz trawl in action during CD146.

Table 1. Summary of Agassiz trawl deployments.

Station	Series #	Approx Depth	Start Date (03)	Comment
55910	3	1850-2100	08/05	successful
55912	1	900	13/05	successful
55918	14	950	18/05	successful
55922	1	750	20/05	torn net, weak link went at ~980mwo

8. SAMPLING AND ANALYTICAL PROTOCOLS

8.1 Macrobenthos sampling

Macrobenthos sampling activities on CD146 occurred in 5 categories:

I. Survey sampling at main stations for SAMS (Gage/Lamont)
II. Fine-scale transition zone sampling (700-1100 m) for SIO (Levin)
III. Sampling of background macrobenthos for natural abundance isotope, amino acid and lipid analyses.
IV. Sampling and sorting of macrofauna from ^{13}C shipboard and in situ incubation experiments
V. Sampling and sorting of macrofauna from bead incubation experiments.

Protocols for each are given below:

I. Quantitative Macrobenthos Survey Sampling at Main Stations (CSUR)

The goal of this sampling was to obtain samples from 2 megacore drops per station (3 cores per drop) at those stations sampled previously on CD 145, and from 5 drops per station at newly selected stations (140 m, 940 m). The boxcore was lost, so all macrobenthos samples were taken from megacore tubes (10 cm diameter, 78.5 cm^2). From each megacore drop, one core was sliced at vertical intervals of 0-0.5, 0.5-1, 1-2, 2-3,3-5,5-10, 10-15, and 15-20 cm. Two additional cores from each drop were sectioned at 0-10 and 10-20 cm intervals. Sliced sediments were placed in pots (500 ml to 2 l) unseived, with 10% buffered formalin and seawater. Vertical core sections of 3 or 5 cm thickness were broken up with a spatula to ensure adequate preservation. Pots were labeled on the outside and inside on waterproof paper or tape labels with the date, the series and drop number, the megacore number and the vertical fraction. Samples are logged in Table 1. Agglutinated foraminifera were removed from the surface of some samples by Andrew Gooday and are noted on the log (Table 1). Preserved samples were stored in the cold room in the Darwin's hold until transport to the United Kingdom.

II. Fine Scale Transition Zone Sampling of Macrobenthos (CSIO)

The goal of this sampling effort, carried out in conjunction with Greg Cowie, was twofold. Initially it was to determine a suitable additional study site within the OMZ lower transition where animal biomass was high and biogeochemical processes were in transition between core OMZ conditions (300 m) and more oxygenated conditions (1200 m). Megacore samples were taken every 50 meters water between 700 and 1100 m. Sediments

from at least one core per drop was sieved live on a 300 micron mesh and examined under a dissecting microscope to assess general animal abundance, biomass and composition in a relative sense. In addition, one or two cores from each depth (drop) were sectioned at vertical intervals of 0-1,1-2,2-5,5-10 and 10-20 cm and preserved in 10% formalin for subsequent analysis of community structure. Samples from intervals > 2 cm were sieved on a 300 micron mesh prior to preservation, mainly to reduce sample volume. These will be returned to Scripps Inst. of Oceanography for workup by L. Levin. It is recognised that these samples will not be sufficient for full characterisation of communities at each 50 m depth interval, but they will provide some indication of community changes in composition and diversity across the lower OMZ transition zone, and can be placed in context by comparison to the station data of Gage and Lamont. Additional samples that will compliment interpretation of the changes across the transition zone are sediment samples collected at 50 m intervals by G. Cowie for $\delta^{13}C$ and organic C analyses, and Agassiz Trawl samples collected at 770 m (55922#1), 875 m (55912#1), 970-1070 m (55918#14).

An additional set of cores (1 per station) were profiled for oxygen (1 or more profiles per core) by E. Brewer and then sectioned at 0-1,1-2,2-5,5-10 and 10-20 cm and preserved in 10% formalin for subsequent analysis of distribution and composition at Scripps. It is hoped that they can provide information about burrows and other animal activity that might influence oxygen profiles in the sediment.

III. Processing Bulk Background Macrofauna for Biogeochemical Analyses (CBIO)

From each station megacore and multicore sediments were obtained to provide macrofaunal biomass for analysis of natural (background) isotopic, lipid and amino analyses. Core sediments were sectioned at 0-10, 10-20 cm intervals, or in some cases, a group of cores were sectioned at 0-2, 2-5, 5-20, 10-20 cm interval and combined in groups of 4-6 cores, to provide more material. After sectioning, all sediments were sieved on a 300-micron mesh and the retained sediments and fauna were put in the refrigerator until they could be sorted for animals. Sorting was done on dissecting microscopes at 6x and 12x magnification. Animals were removed, identified to the lowest taxon possible and frozen in numbered vials or tin boats at $-70^{o}C$ for subsequent analyses. Where possible a reference specimen was preserved in 10% formalin for later identification, and in some cases, the individuals were photographed before freezing. Observations were made regarding the colour and contents of guts, reproductive status or portions of the animal that were obtained. Additional macrofaunal material was obtained from the CBIO, natural cores processed by Larkin and Gooday for Foraminifera (see foraminifera protocols). Originally macrofauna were to be extracted only from 2 CBIO cores at each station, but it soon became evident that the two CBIO cores processed for foraminifera would not provide sufficient material for the research needs of Woulds, Jeffreys and Levin.

IV. Macrofauna Protocols for Processing ^{13}C Experiments: Shipboard Incubations and *In Situ* Elinor Sediments

Cores were obtained in 10-cm diameter megacore tubes. These were sectioned at intervals of: 0-0.5, 0.5-1, 1-1.5, 1.5-2, 2-3,3-4,4-5,5-7,7-10, 10-18 and in some cases 10-core bottom. Biological samples consisted of half of a core, with each experiment replicated 2 times. Thus samples included Rep A and Rep B from 2 da, 5 da or Elinor incubations (Table 2). Core sections were sieved on 2 screens to generate size fractions > 300 microns and one 150-300 microns. Material smaller than 150 microns was not retained. Macrofauna were sorted live from the > 300 micron fraction only. All vertical fractions were examined at each site except A300, where only the top cm was processed on the ship (no macrofauna were expected below this). Macrofauna were removed, identified and frozen in boats or vials. Specimens were combined across vertical fractions and across replicates (A and B) where necessary to create a sample large enough for bulk $\delta^{13}C$ analysis. In some cases all members of one taxon were combined (e.g., Polychaeta). In some cases all specimens within a size group (e.g., metazoan meiofauna) were combined.

V. Protocols for Processing Macrofauna from Bead Incubation Cores

Macrofauna were examined for bead incubation experiments conducted with sediments from 140 m, 940 m, 1200 m and 1850 m stations. From one half of one bead incubation core at each station, sediments were obtained to provide information about macrofaunal composition and use of beads. Core sediments were sectioned at 0-1, 1-2, 2-5, 5-10, > 10 cm intervals. After sectioning, all sediments were sieved on a 300-micron mesh and the retained sediments and fauna were put in the refrigerator until they could be sorted for animals. Sorting was done on dissecting microscopes at 6x and 12x magnification. Observations were made of bead incorporation into biological structures and animal guts. Animals were removed, identified to the lowest taxon possible and preserved for later identification.

Lisa Levin

8.2 Meiofauna sampling

As on CD145, multicores were taken, sliced and preserved in 10% formalin for two main purposes: (i) faunal analysis focussed on the development of a proxy for bottom-water palaeo-oxygenation (Frans Jorissen; University of Angers, France) and (ii) a survey of meiofauna across the OMZ (Kate Larkin/Andy Gooday).

Some additional 0-1cm multicores and megacores slices were obtained from at each site and frozen at –70°C to provide material for molecular studies on foraminifera.

Protocol for oxygen proxy study

One replicate was required per site for the oxygen proxy studies and therefore the only additional cores taken on CD146 were at the new site A950m and the exploratory sites at 600m, 700m, 800m, 850m, 900m, 1000m and 1100m (see table below).

Each core was sliced down to 10cm where possible in 0.5cm intervals to 2cm and in 1cm intervals thereafter. Core slices were washed into 500ml bottles using a funnel and seawater. 10% formalin was then added to all samples in order to preserve the fauna.

Table 1. Cores taken for oxygen proxy study

Station number	Site	Gear	Core number	Depth taken
55916#1	580m	MgC subcore	C3	0-7cm
55919#1	711.5m	MgC subcore	C6	0-10cm
55922#2	737m	MC	C12	0-10cm
55915#1	798m	MC	C3	0-7cm
55921#1	850m	MC	C8	0-10cm
55909#1	897.5m	MC	C11	0-5cm
55918#7	944m	MC	C8	0-10cm
55907#1	1000m	MgC subcore	C7	0-10cm
55905#2	1098m	MC	C3	0-10cm

Protocol for Meiofaunal Survey Studies

For Meiofaunal Survey Studies, two additional replicates from separate deployments were taken to complement the three replicates obtained on CD145. One core was sliced down to 10cm in 0.5cm intervals to 1cm and then in 1cm intervals thereafter. The second core was sliced to 5cm using the same interval protocol. Core slices were washed into 500ml bottles using a funnel and seawater. 10% formalin was then added to all samples in order to preserve the fauna.

At the new A950m site, three replicates were taken and at the exploratory sites spanning the lower transition of the Oxygen Minimum zone (600-1100m), a single multicore or megacore subcore was taken. Top surface material (0-1cm or 0-2cm) was taken opportunistically from Multicores or Megacores from all sites. This was to provide additional material to enable replication for investigating faunal patterns at sites across the lower transition zone of the Oxygen Minimum zone (600m-1100m).

Table 2. Cores taken for Meiofaunal Survey Studies

Station number	Site	Gear	Depth taken
55901#13	133m	MC	0-10cm
55901#9	134m	MgC	0-1cm
55901#5	134m	MC	0-10cm
55901#7	134m	MC	0-10cm
55901#5	134m	MC	0-1cm
55901#5	134m	MC	0-1cm
55901#7	134m	MC	0-1cm
55901#11	135.5m	MC	0-10cm
55902#12	298.5m	MC	0-1.5cm
55902#2	300m	MgC	surface
55902#2	300m	MC	surface
55902#13	303m	MC	0-0.25cm
55902#4	304m	MC	0-10cm
55902#4	304m	MC	0-1cm
55902#5	304m	MC	0-5cm
55902#5	304m	MC	0-1cm
55902#26	309m	MC	0-5cm
55903#1	400m	MgC subcore	0-5cm
55903#2	400m	MgC subcore	0-5cm

55903#2	400m	MgC	surface
55903#4	400m	MgC	0-1cm
55916#1	580m	MC	0-5cm
55916#2	600m	MC	0-10cm
55919#1	711.5m	MgC subcore	1-10cm
55922#2	737m	MgC subcore	0-7cm
55915#1	798m	MC	0-5cm
55914#1	848m	MC	0-10cm
55914#1	848m	MC	0-2cm
55921#1	850m	MgC subcore	0-10cm
55909#1	897.5m	MgC subcore	0-5cm
55908#1	938m	MgC	0-2cm
55918#8	943m	MC	0-7cm
55918#7	944m	MC	0-10cm
55918#13	950.5m	MC	0-5cm
55907#1	1000m	MgC subcore	0-5cm
55906#1	1048m	MgC	0-2cm
55906#1	1050m	MC	0-2cm
55905#2	1099m	MgC subcore	0-10cm
55911#9	1189m	MC	0-5cm
55911#5	1191m	MC	0-10cm
55911#14	1208m	MC	0-2cm
55910#2	1850m	MC	0-2cm
55904#10	1855m	MC	0-5cm
55904#8	1857m	MC	0-10cm

Extraction of fauna for biochemical analyses

a) Natural Abundance Studies: CBIO Protocol

Megacores were collected as in CD145 and fauna was subsequently extracted for biochemical analyses (bulk ^{13}C, lipids, amino acids and carbohydrates). A further two megacores were taken from two separate drops at each site to add to the three replicates obtained on CD145. The megacores were sliced down to 10cm as follows: 0.5cm intervals to 1cm, in 1cm intervals to 5cm followed by 5-7cm and 7-10cm intervals. Slices were placed in labeled petri dishes and stored at ambient bottom water temperature in the C/T lab or at 3C in a fridge to keep the organisms fresh for biochemical analysis prior to their extraction.

Each sediment slice was sieved in turn on a 300μm sieve using cold seawater, The <300μm finer fraction was retained in a bucket. The >300μm sieve fraction was then transferred to a sealed container and the finer fraction passed through a 150μm sieve. Finally, the 150-300μm fraction was transferred into another sealed container and the two sieve fractions were retained in the fridge or on a cold plate until sorted.

b) Ludox method

Various trials were undertaken with the Ludox centrifugation method (Burgess, 2002) for the extraction of organisms, according t the following protocol.

Protocol:

1. Wash two spatulas of sieved residue with freshwater and transfer into two centrifuge tubes with a minimal amount of freshwater.
2. Add equal amounts of Ludox solution (colloidal silica) into each centrifuge tube so that the tubes are 2/3 filled.
3. Whirlimix the centrifuge tubes at the same time on a vortex mixer first at high speed setting for 30 seconds and then at a slow speed setting for 4 minutes
4. Centrifuge the tubes for 10 minutes at 2500rpm.
5. Pour the ludox off onto a 45μm sieve using freshwater taking care not to disturb the pellet.
6. Transfer the organisms retained on the sieve extracted by the centrifugation into a petri dish and sort
7. Sort through the pellet to check the efficiency of the Ludox extraction.

This method had been found to be ineffective on CD145, possibly due to the high organic carbon and water content of the sediments at the sampling sites which causes ludox solution (colloidal silica) to solidify into a gel.

Further trials were conducted with the Ludox method on CD146 using the top 0-0.5cm slice of core #1 from A300 (Stn 55902#4).

Table 3. Organisms extracted from components of a sample treated with ludox

Organisms successfully extracted in Ludox supernatant	Organisms retained in Sediment Pellet
Globobulimina sp. (2)	Reophax sp. (many)
Globular agglutinated foraminiferan (5)	Brizalina sp. (many)
Ammodiscus sp. (3)	Ammodiscus sp. (many)
Uvigerina (1)	Uvigerina sp. (many)
	Leptohalysis sp. (many)

Despite various trials involving reducing the quantity of sediment in the centrifuge tubes and increasing the amount of mixing of sediments in the vortex mixer prior to centrifugation, the ludox method remained inefficient at extracting a representative sample of organisms. It was therefore decided to concentrate on sorting the fresh material and to confine the sorting effort to the >300μm fraction.

Kate Larkin, Andy Gooday

8.3 Porewaters and solids for inorganic geochemistry

Objectives were to collect undisturbed sediments for vertical sectioning and isolation of porewaters for nutrient, sulfide and trace metal analysis, and solids for major and minor inorganic elemental analysis and radiochemical analyses (^{210}Pb, ^{234} Th, ^{14}C; for sediment accumulation and mixing rate determinations).

111 mm diameter cores (megacores) were collected with little to no disturbance to the sediment-water interface by using a Bowers and Connelly megacorer. Megacores were obtained from all sites for metal and radionuclide analyses. Once collected, cores were sectioned at 0.5cm intervals to a depth of 10cm, 1cm intervals to 20cm depth then 2cm slices to the bottom of the core. For samples for dissolved- and solid-phase metal analyses, sample slicing and centrifugation was performed under N_2-atmosphere.

Station/sampling	Date	Event	Depth
55901#9 (A140)	20/04/03	1 Megacore (PW) 1 Megacore (RN) 1 Megacore (M) 1 Megacore (EP) 1 Megacore (CTO)	140m
55901#16(A140)	23/04/03	1 Megacore (PW) 1 Megacore (RN) 1 Megacore (M)	140m
076_eli Lander deployment	25/04/03	Collected lander water samples for metal analysis Sub cored chamber for porewater analysis.	140m
55902#13(A300)	27/04/03	1 Megacore (PW) 1 Megacore (RN) 1 Megacore (M) 1 Megacore (EP)	300m
55902#18	28/04/03	1 Megacore (DOC)	300m
086_eli	30/04/03	Collected lander water samples for metal analysis Sub cored chamber for porewater analysis.	300m
55904#11	5/5/03	1 Megacore (PW) 1 Megacore (RN) 1 Megacore (M) 1 Megacore (EP) 1 Megacore (CTO)	1850m
55904#12	6/5/03	1 Megacore (DOC)	1850m
55905#2	6/5/03	1 Megacore (M)	1100m

55906#1	6/5/03	1 Megacore (M)	1050m
55907#1	6/5/03	1 Megacore (M)	1000m
55911#7(A1200)		1 Megacore (PW) 1 Megacore (RN) 1 Megacore (M) 1 Megacore (EP) 1 Megacore (CTO)	1200m
55911#11(A1200)	10/05/03	1 Megacore (DOC)	1200m
55918#5(A940)	16/05/03	1 Megacore (PW) 1 Megacore (RN) 1 Megacore (M) 1 Megacore (EP) 1 Megacore (CTO)	940m
55918#9(A940)	17/05/03	1 Megacore (DOC)	940m
55918#9(A940)	19/05/03	1 Megacore (DOC)	940m

Table 1: SAMS megacore and lander sub-core processing on CD146 (PW = porewaters; RN = radionuclides; M = metals; EP = Electrode profiling; CTO = Core-top O_2 concentration; DOC = organic geochemistry (solids and porewaters) for Edinburgh.

NOTE: Full details of depth intervals and planned geochemical analytes for solid –phase and porewater samples collected by the SAMS group are available as a spreadsheet from Eric Breuer or Greg Cowie.

Standard Operating Procedure - Sediment Pore Water Extraction for metals and nutrients

People required: TWO

Corer – Megacore

Sample resolution: 0-10 = 0.5cm
10-20 = 1cm
20-40 = 2cm = total 40 samples

The most *undisturbed* core should be used for pore water extraction. Mark each core tube with electrical tape and marker e.g. station number and type of analysis (PW, RN etc)

FIRST STEP

1. Check equipment (see attached) is prepared before the cores are collected to speed up core processing e.g. all bags are labeled correctly for station, tubes are numbered 1-40.
2. Set up one large glove bag on to the tabletop, attaching nitrogen gas line. Seal gas line.
3. Position all the large glove bag equipment (see list) neatly and so that it can all be reached using the gloves. Take the centrifuge tops OFF. Fill with nitrogen and purge the bag until all O_2 has gone (use judgement but N.B. nitrogen quantity is limited!)
4. Make sure the core extruder "lego" pieces and jack are ready by the table.
5. For each core, measure the length of sediment, take temperature and pH of overlying water and describe it . Photograph it when possible.
6. Once an undisturbed core has been obtained, carefully siphon off overlying water until ~5 inches remains. Insert the core into the table hole up into the glove bag and replace the top bung. Then remove the bottom bung and replace with the extruder. Add lego pieces and position the jack. Remove the top bung and jack up the extruder until the water level is close to the top.
7. Wearing cloth glove bag gloves directly on your skin put arms into glove bag and put on disposable gloves over the bag material.
8. Using the large syringe, remove the overlying water taking care not to disturb the sediment surface and syringe through the brown (5um) and blue filter (.25um), filling the 30ml bottle (which contains 300 µl of HNO_3). Remove the rest of the water and discard.
9. NOW THE SEDIMENT SLICING. 0.5 cm slices to start with. Place 0.5-cm ring over core. Get 2nd person to carefully jack up the core until the surface is in alignment with the top of the ring.
10. Slice the sediment and *slide* the slice back off the core. Using the spatula, fill the no.1 centrifuge tube (approx. 70%). The remaining sediment, place in the first sample bag and seal.
11. Place all used equipment in plastic bag, wash down gloves and wipe off.
12. Repeat this process down the core at the above resolution. Your final sample will be 40cm if the core is long enough. When the sediment is drier, use a second centrifuge tube to obtain enough porewater for analysis.
13. Make notes of sediment change at different depths and anything else to comment upon e.g. large shell at 17cm etc.

14. Upon completion, remove all equipment, wash off mud and soak in de-ionised water for proceeding core. Throw away glove bag unless in good, clean condition (yeah?).
15. Check all bags are well sealed and place in large plastic bag, label and store in cold store (~4°C).

Tips: when filling the centrifuge tubes, knock tube on table to get sediment to drop down. When you are approximately half way through slicing, remove the full centrifuge tubes and get second person to start centrifuging (see below).

SECOND STEP

Keep samples chilled whenever possible.

1. Centrifuge the samples for c. 20 minutes at 3000 rpm, 15 at 5000rpm etc…. Place tubes of a similar weight opposite each other in the rotor otherwise the centrifuge will lose balance and stop.
2. Clean tubes of lose mud.
3. Label vials if necessary with station number, date and depth.
4. Place all equipment on list into small glove bag including the centrifuged samples. Connect nitrogen, fill and purge as before.
5. Place the pipette tip onto the end of the syringe and syringe up as much water from the centrifuge tube as possible.
6. Remove pipette tip and replace with filters. Only one end should fit – the brown is 5µm so should be first on to the syringe.
7. Syringe the water through the filters with care into the number corresponding 8ml, 3.5ml and 2ml bottles. Fill the nutrient bottle (2ml) first where c. 1.2ml is required. Put ~ 3ml into the 8ml metals bottle and ~2.5 ml in the 3.5 ml sulphide vial.
8. The 8ml bottles should be labeled but check and adjust if necessary.
9. Place the 8ml bottles in a small Tupperware container and refrigerate.
10. The 2ml: Out of glove bag take 1ml from tube and dilute up to 10ml with de-ionised water in designated nutrient analysis tubes. Give to Tim Brand.
11. Place the 3.5-ml vials for sulphide/sulphate in cold store to ship back to Edinburgh.
12. Use small glove bag as many times as is possible.

Tips: it may be easier to write the depth and their corresponding number down on paper to prevent confusion e.g. 0-0.5 = 1, 0.5-1 = 2, 1-1.5 = 3 etc.

Sulphide Preparation

1. Locate zinc acetate powder bags.
2. Pour one bag into a 500ml beaker and add ~300ml de-ionised water. Stir well until dissolved.
3. Transfer solution to a 500ml volumetric flask. Make up to mark and stir.
4. Add 1ml to each 3.5ml vial and label.

Standard Operating Procedure - Sediment Slicing for Solid Phase Analysis

People required: One

Corer – Megacore

Sample resolution: 0-10 = 0.5cm
10-20 = 1cm
20-40 = 2cm = total 40 samples

One core will be sliced for metals and one for radionuclide analysis (RN) using the same slicing method but varying post-slicing treatment.

Slicing.

1. Ideally all cores should be undisturbed. Place cores in the core stand. Label core with electrical tape stating station and type of analysis: RN or Metals (M). Cores should be stored in the cold room but can be sliced on deck.
2. Measure length of sediment, write core description (see sediment description sheet) and photograph if have access to digital camera.
3. Equipment needed: slice, rings (0.5, 1 and 2 cm), sealable and labelled bags, extruder, extension poles and notebook.
4. Remove the top bung and siphon off some water. Replace bung firmly.
5. Remove bottom bung and immediately replace with the extruder. Add extensions when necessary.
6. One person hold the core steady and move up when necessary while other person slices:
7. Place ring over core surface and push up extruder until sediment surface reaches the top of the ring. Slide the slicer between the core tube and ring and slide back off. Place this sediment in the bag and seal well. Clean rings and slices in between each sample using ordinary water. Continue slicing at the above resolution until end of core.
8. Place all sample bags for Metals core in a large plastic bag, label and store in cold room.

9. Place all samples for RN's in a large plastic bag, label and freeze.
10. At the end of each cruise, these samples need to be sent to SAMS in cold container. Clean off equipment and store in geochem box.

Sulphide Preparation

1. Locate zinc acetate powder bags.
2. Pour one bag into a 500ml beaker and add ~300ml de-ionised water. Stir well until dissolved.
3. Transfer solution to a 500ml volumetric flask. Make up to mark and stir.
4. Add 1ml to each 3.5ml vial and label.

Eric Breuer/Sue McKinlay

8.4 Solid-phase radiochemistry

Standard Operating Procedure - Shipboard Radionuclide Analysis

Gamma Spectrometer Preparation.

1. Top up the dewar with liquid nitrogen every other day (see PV30 protocol and risk assessment).
2. Before placing a sample on the detector ensure clingfilm is surrounding detector head, check it is undamaged and protecting the detector. Seawater will destroy detector.
3. Place sample holder very carefully over detector head.
4. When sample is in place, please secure lid with appropriate device.
5. CHECK ENERGY CALIBRATION EVERY DAY WITH EU-152 SOURCE. IF ENERGY OK NO NEED TO RECALIBRATE

Sediment Sampling and analysis

1. Section core as described in solid phase sampling protocol. (0.5cm to 10cm, 1cm to 20cm and 2cm thereafter).
2. Place maximum amount of sample in gamma pot and place on cap. Cover pot with parafilm before placing cap on. Seal round cap with duck tape or insulating tape to ensure seal.
3. Measure depth of sediment in gamma pot to the nearest mm and record.
4. Place gamma pot in sample holder (Check clingfilm is around detector).
5. Start count. Record cruise number station number and depth in Gamma Analysis log sheet for cruise.
6. Stop count when has been counting for 2 hours or in low activity samples when a minimum of a 1000 NET area counts has been achieved. Use common sense here. If the sample is very active and you have a few thousand counts in a relatively short time then stop count and start another sample. If sample has very low activity then stop after 2hrs if other samples need counting. The sediment samples will probably need longer than 2 hrs, which is fine providing there are no gut samples waiting for analysis (count each sediment sample for a maximum of 6hrs).
7. Stop count and store use the following naming system: Cruise number, station number, depth i.e. CD146STNXXX01
8. Record stop time and date, real time and spectra file name in gamma log sheet.
9. Each day back up files on floppy or CD - ensure a different folder for each day.
10. Remove sample and freeze to prevent moisture loss.
11. These samples should be returned to UK after the cruise in the cold container and placed in a freezer or cold store at DML.

Eric Breuer/Sue McKinlay

8.5 Dissolved oxygen determinations and microelectrode profiling

A. Protocols for OXYGEN TITRATIONS on the 702 SM Titrino

The following configurations and parameters are programmed into the unit and shouldn't have to be changed. To scroll through them just press the 'configuration' or 'parameter' key and press 'enter' to scroll down. If anything needs to be changed then press 'select' which gives you the alternatives for the particular feature.

THE PRESENT SET-UP IS:
Configurations

Peripheral units

Send to	Epson
Balance	Sartorius
Record	v
Aux	English
Date	-
Time	-
Run no.	0

Auto start	off
Start delay	0s
Device label	TITR1
Program	702.0012
RS232 settings	
Baud rate	9600
Data bit	8
Stop bit	1
Parity	none
Handshake	HWs
RS control	on
Common variables	
C30	0
Parameters	Met U Oxygen
Titration parameter	
Vstep	0.1ml
Titr. Rate	max ml/min
Signal drift	20mv/min
Equilib. Time	38s
Start v	off
Pause	0s
Meas. Input	1
Temp.	20°C (may want to change)
Stop conditions	
Stop V	abs
Stop v	30ml (may want to change)
Stop u	off mv
Stop EP	1
Filling rate	max ml/min
Statistics	
Status	off
Evaluation	
EPC	30mv
EP recognition	all
Fix EP1 at u	off mv
Pk/HNP	off
Preselections	
Req ident	off
Req smpl size	off
Activate pulse	off

To start a titration press 'start'.

Before running samples the molarity of thiosulphate should be checked. This should be repeated at least 3 times. Once endpoint (EP1) has been reached the titration stops and automatically prints out the titrant volume. The titrant volume is also displayed in the autotitrator display until the next titration is started, which is a backup if the printer fails. This volume is then put into a spreadsheet for oxygen titration calculations. Samples can then be analysed and their titre volume put into the spreadsheet.

FOR SAMPLE AND REAGENT SET-UP FOLLOW EXPLANATIONS BELOW

Reagents:

1. Manganese sulphate ($MnSO_4.4H_2O$) 48g→100ml
2. Alkaline Iodide 40g NaOH
   90g NaI = 100ml
   56ml H_2O
3. Stock sodium thiosulphate ($Na_2S_2O_3^{2-}.5H2O$) ≈ 7.44g + 1 pellet NaOH→100ml
4. Stock potassium iodate (KIO_3) 0.089175g (dried 105^0C for 1 hour) →100ml

5. H_2SO_4 (98% = 18.4M) 34ml conc. → 100ml (=6.25M = 12.5N). or H_3PO_4 (85%)

NB these reagents are already provided made up as above

For 10 ml titrations:
Dilute reagent 3. 1→100 for working solutions (=0.003M =0.0015N)
Dilute reagent 4. 1→10 for working solutions (0.00125N iodate)

Sample preparation:
COLLECTION: Collect sample without introducing any air bubbles, let water gently flow out of collection bottle (e.g., Niskin) through a short length of silicon (or similar) tubing that has been put to the bottom of the sample bottle (supplied). Let the water gently fill and overflow the sample bottle while gently extracting tube. Once the bottle is full insert stopper carefully, then remove and add the reagents to fix the sample. Restopper the bottle (without introducing any air) and shake thoroughly to ensure complete mixing. After fixation store the bottles underwater in the ship's CT room, in a covered container to exclude the light.FIX: 10ml samples fixed with 0.1ml manganese sulphate and 0.1ml alkaline iodide. ADJUST WRT TO SAMPLE VOLUME

Standardisation of thiosulphate:
10ml 0.00125N iodate + 0.1ml alkaline iodide + 0.1ml 12.5N H_2SO_4 (or 0.2ml H_3PO_4), titrated with ≈ 0.0015N thiosulphate.

Titration of samples:
10ml sample (already fixed with 0.1ml manganese sulphate and 0.1ml alkaline iodide) acidified with 0.1ml 12.5N H_2SO_4 or 0.2ml orthophosphoric acid and titrated with ≈ 0.0015N thiosulphate.
NB Prior to and during acidification the precipitate at the bottom of the bottle should not disturbed as little as possible ie the acid should be added gently just below the surface of the contents. The bottle should then be restoppered and shaken vigorously. This will dissolve the precipitate to leave a clear yellow brown solution.

NOTE: The above recipe is the standard ratio. Adjust as necessary wrt sample size, reagent weight etc.....

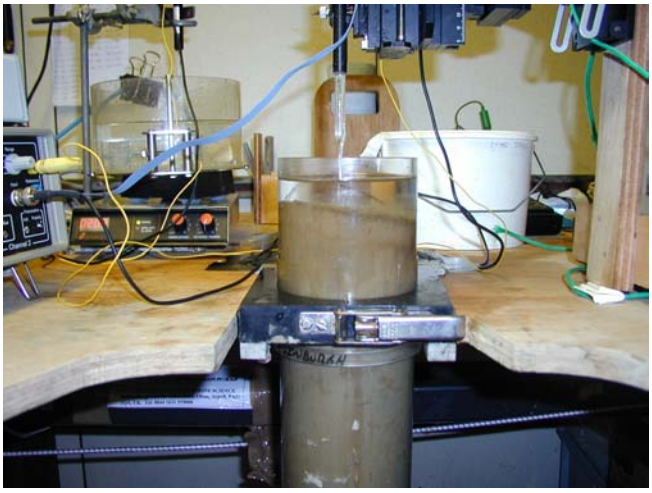


Figure 1: Microelectrode profiling of a megacore in the controlled temperature laboratory.

B. Sediment porewater oxygen profiling
In conjunction with the *in-situ* profiling system (see Oli Peppe's report) a shipboard system for the measurement of O_2 microprofiles was used. Micro-electrodes with a sensing tip diameter of < 10 μm and 90% response time of 1s were used to measure O_2 concentrations in the sediment porewaters at a vertical resolution of 50 - 250 μm in a controlled temperature laboratory using a precision micrometer. Oxygen profiles were measured from 2 retrieved megacores at each site. One profile was obtained as soon as possible after collection while the other profile was done on a core put into an incubator tank with controlled O_2 levels in order to bring the overlying water O_2 concentration and temperature to *in situ* bottom water conditions. Shipboard O_2 profiles were obtained at all stations. Once profiled the megacores were turned over to Lisa Levin of SIO for biological sampling.

Eric Breuer/Sue McKinlay

8.6 DIC, δ^{13}DIC, $\delta^{18}O_2$ and pH

a) δ^{13}DIC, $\delta^{18}O_2$

1. Take headspace vial of appropriate size; 2 ml for porewater, 6ml for lander samples and 10ml for shipboard incubations and CTD cast.
2. Fill slowly, using e.g. a syringe and needle and overfill if possible; otherwise fill so there is a small bulge on the top.
3. Add saturated $HgCl_2$ solution carefully (without destroying the bulge). 10 μL $HgCl_2$ for 2-ml vials, 20 μL $HgCl_2$ for the other vials.
4. Drop cap on top.

5. Use crimp seal capper to close; make sure the cap does not rotate after it has been closed.
6. Store upside-down

b) DIC

1. Take vial of appropriate size, 6 ml for porewater and lander samples, 20ml for shipboard incubations.
2. Fill slowly, using e.g. a syringe and needle and overfill if possible otherwise fill so there is a small bulge on the top.
3. Add saturated $HgCl_2$ solution carefully (without destroying the bulge); 20µL $HgCl_2$ for 6-ml vials and 100µL $HgCl_2$ for the 20-ml vials.
4. Screw cap on top tightly.
5. Store upside-down

c) pH

1. Samples for pH are sensitive to changes in redox conditions; this means that porewater samples must be collected and measured in a glove bag.
2. Dispense 1ml of porewater into 2-ml plastic vials.
3. Calibrate pH meter is by recording output in 7.00 and 10.00 standards, record ambient temperature as well.
4. Measure the output in the samples; make sure that the pH electrode doesn't touch the walls of vial. Wait for a stable signal.

Henrik Andersson

8.7 Solids and porewaters for organic geochemistry

Sampling, processing and storage of samples for biochemical, elemental and stable isotopic analyses at Edinburgh and/or Liverpool was essentially as per protocols carried out on CD145 (as follows).

In general, single cores of each type were collected at primary stations previously visited on CD145 (i.e. A300, A1200, A1850) and duplicate cores collected at new stations (i.e. A140, A940).

	A140	A300	A940 (A950)	A1200	A1850
CORG (CDOC)	2	1	2	1	1
CORGB	1	1	1	1	1
CPIG	2	1	2	1	1
CLIP	2	1	2	1	1
CARCH (CEDIN)	1	1	1	1	1

CORG (CDOC): Megacores collected for solids for CN, stable isotopes and biochemicals (split for Edinburgh and Liverpool after centrifugation and freeze drying) and porewaters (dissolved amino acids, Edinburgh). Glass or, later in cruise, polyethylene centrifuge tubes were used. Solids to foil-lined petri dishes (Liverpool) or plastic bags (Edinburgh). Porewaters to precombusted 4 ml glass vials with teflon cap liners (Edinburgh); frozen.

CORGB: Megacores collected for solids and porewaters (Edinburgh). Polyethylene centrifuge tubes. Solids freeze dried and transferred to plastic bags. Porewaters to 4ml glass vials and frozen.

CPIG: Multicores for pigment analysis. Frozen in 25ml glass scintillation vials.

CLIP: Multicores for lipid analysis. Solids only, frozen in foil-lined petri dishes.

CARCH (CEDIN): Archive multi- or megacores. Solids only. Freeze-dried in plastic zip-lock bags.

Sectioning intervals for all core types were:

- 0.5cm over 0-2cm core depths
- 1cm over 2-10cm core depths
- 2cm over 10cm core depth to core bottom.

Solid- and dissolved phase sampling:

One or two megacores were obtained from each station (depending on sampling during CD145). These were stored in the controlled temperature laboratory for a minimum of time before sectioning in a glove bag.

1) Make a note of the site, station number, date, depth, time, core number and to what depth the core was sliced.
2) Ensure that a yellow cap and not a rubber bung is placed on the top of the core and store in the CT lab until the core can be processed.
3) Label up enough plastic bags (provided by Edinburgh) for the amino acid analysis. For the lipids, label up foil covered Petri dishes.

4) Label ca. 36 centrifuge tubes (glass tubes were used initially but, due to breakages on centrifugation or freezing, were eventually replaced with polyethylene).
5) Label appropriate numbers of 5ml ampoules (DOM) and 4ml glass vials (amino acids; with teflon-lined caps).
6) Place all tubes and necessary core-sectioning materials in the glove bag. Seal glove bag and fill/evacuate with N_2 twice.
7) Slice the core at the following intervals, 0.5 cm down to 2cm, 1cm down to 10cm and 2cm thereafter. Using a spatula, please make sure to trim off the edges of each slice of the core to minimise contamination due to vertical smearing along core edges.
8) During slicing rinse the plastic ring, slicer and spatula in seawater and then the spatula and slicer only in DCM in the separate bucket provided for this purpose.
9) Place the remaining sediment in the centrifuge tube. Below ca. 10cm, fill duplicate tubes. Seal tubes.
10) Once you have finished slicing centrifuge at 3000 rpm for 15 mins (glass tubes) or 5000rpm for 10 mins (polyethylene tubes). Make sure the centrifuge is balanced.
11) Replace centrifuge tubes in the glove bag. Please ensure that you wear powder-free surgical gloves or polyethylene gloves for the whole procedure. Label up the appropriate vials, i.e. 5 ml ampoules for DOM and 4ml vials (Ed) for the DFAA fraction. The filtering is done in the glove bag.
12) Prepare a glass ampoule with a foil-lined cap for each slice and place in the wooden rack. To each ampoule add 15 microlitres of 85% orthophosphoric acid using the auto dispenser ensure that foil caps are replaced onto the vials after adding the acid. Place all vials and ampoules in racks in the glove bag, along with centrifuge tubes, 5ml plastic syringes, precombusted glass Pasteur pipettes and 13mm GFF filter cartridges. Seal and reinflate/flush glove bag twice.
13) Place GFF filter on a disposable plastic syringe and transfer supernatant from centrifuge tubes to the open syringe barrel. Replace the plunger and gently filter supernatant into appropriate ampoule and vial (minimum of 3ml each, as possible) after discarding the first few drops. Draw up sample into syringe, take off the silicone tubing and set aside for reuse, attach a 13mm GFF filter unit, discard 3-4 drops into waste then fill the glass ampoule to 0.5 cm below the neck, replace foil cap. If required (i.e. back-pressure), use additional filters. Discard syringe and GFF filter unit after each slice.
14) Remove any remaining porewater from the centrifuge tubes and freeze at -20˚C. Then freeze dry, split samples to Liverpool (foil-lined Petri dishes) and Edinburgh (zip-lock bags) and store refrigerated. To be returned to the UK in a refrigerated container.

NOTE: Only gentle pressure should be applied when the filter unit is attached. If the filter is blocked (i.e. there is strong resistance against the plunger) or ruptured (i.e. cloudy solution breaking through) then replace the filter unit remembering to drip the first few drops to waste. It may be necessary to use several filter units for particularly turbid pore water. Avoid disturbing the sediment while taking supernatant from the tube.

Cleaning: Please note it is important to wash all slicers, spatulas, rings, tubs, tube lids, centrifuge tubes and Teflon liners and the rubbish bag in seawater and then in Milli-Q. Muffle the centrifuge tubes in the oven at 400˚C for 4 hours. Dry everything else in the drying oven overnight and rinse the Teflon liners in DCM.

Solid phase sampling for lipids and pigments

As above but with multicores, not in a glove bag and without centrifuge tubes. Sediments for lipid analysis (CLIP) are placed directly in foil-lined Petri dishes. Samples for pigment analysis are placed in 25ml glass scintillation vials. Samples for lipids are placed in foil-lined Petri dishes. Both are frozen at –20°C.

1. Make a note of the site, station number, date, depth, time, core number and to what depth the core was sliced.
2. Label up enough scintillation vials and ensure that the Teflon liners and caps for the vials are to hand, along with tweezers, this is for the pigment work (provided by Edinburgh). For the lipid core label up four foil covered Petri dishes (provided by Liverpool).
3. Slice the core at the following intervals, 0.5 cm down to 2cm, 1cm down to 10cm and 2cm thereafter. Using a spatula, please make sure to trim off the edges of each slice.
4. During slicing rinse the plastic ring, slicer and spatula in seawater and then the spatula and slicer only in DCM in the separate bucket provided for this purpose. The DCM need only be used when slicing the lipid/pigment core. Please wear a pair of yellow marigold gloves or something similar when slicing the core for your own protection.
5. Place the remaining sediment in foil covered Petri dishes (CLIP) or glass vials (CPIG). Do not fill glass vials over 2/3 (to allow for expansion on freezing).
6. Once the core has been sliced freeze the samples at -20˚C. Return to the UK under dry ice.

NOTE: Do not freeze glass containers (centrifuge tubes or vials at –70°C – they will fracture!!!!

Cleaning: Please note it is important to wash all slicers, spatulas, rings, tubs, tube lids, centrifuge tubes and Teflon liners and the rubbish bag in seawater and then in Milli-Q. Muffle the centrifuge tubes in the oven at 400˚C for 4 hours. Dry everything else in the drying oven overnight and rinse the Teflon liners in DCM.

Collection of Megafauna from Agassiz Trawls for Lipid and SIA

1. If organisms are small enough take the whole organism, wrap it in foil and place it in a clearly labeled (cruise number, site number, station number, specimen name, individual number) zip-lock bag.
2. If the organism is too large then dissect with the clean dissection kit provided on a foiled lined dissection tray. Once a piece of tissue has been dissected, ensure that this is not the gonad or guts, then once again wrap in foil and place in a zip-lock bag.
3. Please make sure that there are at least 5 of the same species taken to ensure good replication. At the same time also ensure that there is one of each species preserved in formalin for later species identification.
4. If there are any interesting large echinoderms or crustaceans, place in a Teflon bag.
5. All organisms should be frozen immediately at -70˚C.
6. After use the dissection kit should be cleaned in Decon 90 for ~ 4 hours and then wrapped in clean foil and dried for ~ 4 hours in the drying oven at 60˚C.

The organisms are taken for lipid and stable isotope analysis. However, if there is a particularly abundant species take enough whole specimens i.e. around 15, so that pigment analysis can be done on the gut contents as well.

Laboratory Equipment Used

Muffle Furnace: Supplied by Edinburgh. Temperature set at 400˚C.

Points to note: a) Make others aware when it is switched on.
b) Let the oven cool down before removing contents.
c) Use glove and tongs to remove hot items.

Drying Ovens: Supplied by Edinburgh. Temperature variable/adjustable.
Take note of the points for the muffle furnace.

Freeze- Drier: Supplied by Edinburgh.
Straightforward to use. Please make sure that there is sufficient oil in the vacuum pump before running, that the in-line valve is closed before releasing the vacuum to the chamber, that the gas ballast on the vacuum pump is closed (! to avoid excessive use of pump oil!), and that the cold-trap is left to reach –60°C or lower (for at least 20 minutes) before starting freeze-drying..

Eppendorf, 5416 Centrifuge: Supplied by Edinburgh.
This was self-explanatory and worked well during the cruise. It is important to keep the centrifuge clean, in order for it to balance and prevent the breakage of the glass tubes. The optimum setting for the glass tubes in this centrifuge was at 3000 rpm for 15 minutes.

Greg Cowie (Rachel Jeffreys)

8.8 X-radiography

Summary of safety precautions

1) Try to X-ray between 8:00 and 17:00, avoiding the morning smoke break (approx. 10:00-10:30), lunch break (11:30-12:30) and the afternoon smoke break (14:30-15:00). Weekends are also "sensitive" times, especially after lunch.
2) In addition to the X-ray risk assessment form, separate forms for the chemicals involved in development have been produced and copies distributed as required.
3) Access to the darkroom is restricted to everyone without the operator's consent. A note from the Master to the effect has been posted on the darkroom door.
4) Within the darkroom:

- a note cautions that the chemicals kept in the closed tubs covered in plastic bags are irritant to the skin and eyes. This is accompanied by a recommendation that in case of a flood the operator must be notified immediately.
- the X-ray machine, which is securely tied on the bench top, is not plugged in. The power cord and the remote control pedal are stored away in the machine case. This ensures that the machine is not readily usable.

5) Before every exposure or set of exposures, the bridge is notified with an estimate of the duration of the procedure (phone number 01). If permission to proceed is obtained, the engine control room is also notified (phone number 02). In turn, "Caution – X-rays" signs are placed on the door of the darkroom and the door

opening to the alleyway. Finally, the red sign warning of the darkroom being in use is turned on. As soon as the X-raying is completed bridge and control room are notified and the "caution" signs are removed.

Sampling procedure

Megacores were subsampled with 1-3 short, thin slab cores or 1 long thin slab core. Typically 2 or 3 megacores were sampled per site, yielding at least 4 thin slab images. X-raying and development procedures are described below. Preliminary observations on X-radiographs were made using the circular window in the plat as the best transmitted light source. Notes were made throughout these stages and can be found in the Results section of this document. Box cores were not used on this leg so thick slab cores were not taken.

X-ray slab core details

a) Thin slab cores (short)
   Dimensions: 6.9 X 0.9 cm X 14.5 cm long
b) Thin slab cores (long)
   Dimensions: 8 x 1.2 cm X 24 cm long

Also, 7 x 1.0 cm x 20 cm long (constructed by Darren Young on board)

X-raying procedure

1) Prepare and attach lead labels to film, place film behind slab. Include cruise no, drop number, and water depth. Also label film protective envelope with date, water depth, drop number, core number and exposure time
2) Mount slab(s) onto base in front of x ray film. Clean plexiglass walls
3) Prepare machine:

- Plug in machine
- Plug in remote control pedal
- Plug light box into machine and centre the beam on slabs
- Set Ma/KVF at 15/70.

4) Notify bridge (phone number 01) and engineers in control room (phone number 02).
5) Place signs on doors and turn darkroom-in-use light on..
6) Turn lights off and red light on.
7) Set line at 3rd notch or centre on green diamond.
8) X-ray at desired time.

X-ray developing procedure

1) Remove film and place in developer bath.
2) Proceed with development and further exposures. Development is carried out as follows:

- D-19 developer 5 min
- Stopbath 1 min
- Fixer 5 min
- Running water 1 + min
- Water tub 5 min
- Hang to dry

3) Turn machine power off.
4) Notify bridge of termination of X-raying.
5) Remove caution signs.

Solution preparation instructions

Developer D-19: (OK to mix in tub)

1) Place 3.8 l of water at 52° C
2) Stirring, add a packet of the developer
3) Stir continuously until solution is well mixed (very light reddish colour)

Stopbath:

Mix 40 ml stopbath / l of water. Prepare 2 l. Mixture is good while slightly yellowish and not dark (has indicator).

Fixer:

1) 1 whole bag of fixer should be added to 15 l of water below 26.5° C. A quarter of the bag added to 3.5 l should be adequate for a month in the containers we are using.
2) Add 4 l of water to bring total volume up to 19 l (or 1 l in case of a quarter of a bag used).
3) Stir until mixed. If milky, it will clear on standing.

Supplies

Kodak Industrex film AA400	Ref. 523-1899	10 X 24 cm
	Ref. 522-9364	24 X 30 cm (9.4 X 11.8 in)

	Ref. 827-8137	8 X 10 in. (Ready Pack)
Developer Kodak D-19	Ref. 146-4593	
Kodak Stopbath	Ref. 140-8731	
Kodak fixer	Ref. 146-4163	

Lisa Levin

8.9 Dissolved organic carbon and total dissolved nitrogen

In this work precision DOC measurements were to be made shipboard using a *Shimadzu TOC 5000A* analyser that incorporates a *LiCor 6252*, solid-state IRGA, and a PC-based analog-digital conversion and integration system (*hplc Technology*). Addition of a nitrogen-specific chemiluminescence detector (*Sievers 280i*), in series with the IRGA, was to provide a method for simultaneous measurement of TDN. Combustion of nitrogenous compounds under an oxygen atmosphere at 680°C (in the *TOC 5000A* furnace) leads to quantitative production of the nitric oxide (NO) radical. Subsequent reaction with ozone produces excited nitrogen dioxide (NO_2) species, which emit quantifiable light energy upon decay to their ground state. Using total combined inorganic N-based nutrient data, the TDN concentrations can be used to derive DON, complementary to HTCO-DOC measurements.

Unfortunately a number of faults were encountered with various components of the analytical system during CD 145 and shipboard analysis of DOC and TDN samples was not carried out during CD146. Porewater, water-column and both shipboard and *in situ* incubation samples were therefore collected and placed in combusted glass ampoules (5-15ml), acidified with phosphoric acid, sealed with a propane torch and then returned in a refrigerated container for post-cruise analysis at SAMS.

Tasos Anestis (Axel Miller)

8.10 Water column chemistry

Phytoplankton photosynthetic pigments and degradation products.

Samples were collected from the Seabird CTD 24 bottle rosette using the 10l Seabird bottles. The samples were initially collected in 5l polythene bottles and then transferred to polycarbonate bottles for use on the SAMS vacuum water filtration rig. The rig uses the ship's compressed air via a pneumatically operated Seimens venturi pump to provide the vacuum. Samples were filtered through 25mm dia. Whatman GF/F filters and the filters stored frozen in 15ml polypropylene vials.

Water column particulate organic carbon and nitrogen.

Samples were collected from the Seabird CTD rosette using 10l Seabird bottles. The samples were initially collected in 5-litre polythene bottles and then transferred to polycarbonate bottles for use on the SAMS vacuum water filtration rig. Samples were filtered through pre-ignited 25mm dia. Whatman GF/F filters and the filters stored frozen in plastic 10ml vials.

Water column dissolved nutrients (ammonium, phosphate, silicate, nitrate and nitrite)

Samples were collected from the Seabird CTD rosette using 10l Seabird bottles. The samples were initially collected in 5l polythene bottles and then transferred to polycarbonate bottles for use on the SAMS vacuum water filtration rig. Samples were filtered through 25mm dia. Whatman GF/F filters (filters used for pigment analysis described above) and the filtrate initially collected in 250ml polythene bottles. The dissolved nutrients were analysed on a Lachate model flow injection autoanalyser. The instrument uses flow injection modifications of classic colourimetric methods. Ammonium, phosphate, silicate and nitrate were analysed on all samples collected. By removal of the cadmium-copper reduction column in the nitrate line samples (see below for details) were also analysed for nitrite.

Operational considerations

The ammonium concentration in the water column is very low and there is a large negative blank effect due to the refractive properties of the saltwater sample in the deionised water carrier stream. The salinity effect is normally corrected by running nutrient poor seawater or artificial seawater blanks as part of the standard calibration. The artificial seawater was found to be contaminated with ammonium and so blank correction will be carried out at SAMS.

Various operational problems occurred during nutrient analysis. One of the most obvious ones was the introduction of air in the nitrate channel and eventually in the copper cadmium reduction column. Great care was taken to synchronise the switching of the valves and according to the manual this should be sufficient to eliminate any air bubbles entering the manifold. Initially the problem was solved by replacing the broken clamp of the peristaltic pump that was holding the line of the colour reagent.

The autosampler pipette was thought to be sucking air instead of sample (T. Brand pers. comm.) but this didn't seem to be the case. As a result new reduction columns were introduced on the manifold in order to achieve

satisfactory levels of reduction of nitrite to nitrate. This could be due to the movement of the ship, which was a lot more than on the previous cruise (K. Larkin, pers. comm.) or a problem with the autosampler. Generally, the flow injection autoanalyser is a reliable piece of a equipment for nutrient analysis. On this cruise the number of samples and the hours that the machine was operating were substantially more than the last cruise and this might have affected its capability to run as efficiently as it should.

During the last part of the cruise the autosampler pipette started moving a lot slower than it did at the first weeks of the cruise indicating either lack of lubrication or a mechanical problem with the movement of the pipette. This was partially improved by rebooting the computer and switching it on and off for a few times and even so its movement was not as free as it was initially.

Tasos Anestis (Tim Brand)

8.11 Sedimentary denitrification rate determinations

The rate of denitrification in sediments was assessed at each station via two separate methods: 1) nitrogen ingrowth into lander and shipboard incubation chambers and 2) nitrous oxide ingrowth in parallel multicore incubations.

a) Nitrogen ingrowth into lander and shipboard incubation chambers

Denitrification involves the transformation of nitrate through reduced nitrogen species (NO_2, N_2O) to form dinitrogen (N_2). Denitrification rates can be inferred by assessing the ingrowth of nitrogen into a closed incubation chamber, such as the Elinor lander chamber or the multicores employed for oxygen consumption (SO) shipboard incubations. In these chambers, denitrification will result in decreased nitrate concentrations accompanied by increased nitrite and nitrogen concentrations.

During CD146 samples were collected from Elinor incubation deployments (EO) and duplicate oxygen consumption shipboard incubations [SO(7) and SO(8)] at each station, with the exception of station 55908 (1200m), where lander malfunctions precluded the collection of EO samples. Samples were collected for nitrogen analysis as follows:

- A 5-ml gastight syringe fitted with a syringe valve was purged three times with He gas using a low-pressure vent from the GC-TCD main carrier line. For shipboard incubation sampling, the final He volume was left in the syringe and the syringe valve was closed (NOTE: this step was not followed in all instances).
- The He-filled syringe was connected to a three-way luer-lock stopcock.
- The sample was then collected into 5-ml gas-tight syringes
    - For shipboard incubations: the stopcock-fitted syringe was attached to the luer-lock stopcock on the appropriate SO incubation barrel and the both stopcocks were flushed with He by expelling the volume remaining in the syringe. The syringe was then used to draw 3.5-5-ml of water from the shipboard barrel. Any air bubbles were expelled immediately and the syringe valve was closed.
    - For Elinor lander incubations: the stopcock fitted syringe was inserted into the end of the PTFE sampling line to form as tight a seal as possible (Note in future work, a silicone tubing connector may be introduced to provide a better seal between stopcock and PTFE line). The sample (3.5-5-ml) was then drawn into the syringe, which was closed after expelling any air bubbles.
- Sample analysis was performed on an HP5890 Series I gas chromatograph (GC) fitted with a thermal conductivity detector (TCD). The GC-TCD included parallel calcium chabazite columns as defined in An and Joye (1999). A sample sparge and trap rig was also constructed as described in An and Joye (1999), a copy of which is included following this section.

Following a ship's mains power loss on 27 April 2003 and a low He carrier gas condition on 28 April 2003, samples run on the GC-TCD failed to show the expected peaks corresponding to argon, oxygen, and nitrogen. As this problem was assessed, samples were first delayed (by delaying the initiation of related lander and shipboard incubations) and then, after the problem was not quickly resolved, preserved by transferring the samples from 5-ml gas-tight syringes to 12-ml evacuated vials (evacutainers) and then poisoning each sample with 20 μL of saturated mercuric chloride solution. These samples and accompanying equipment blanks and standards will be analyzed on the GC-TCD once it is functional.

b) Nitrous oxide ingrowth into multicore incubations

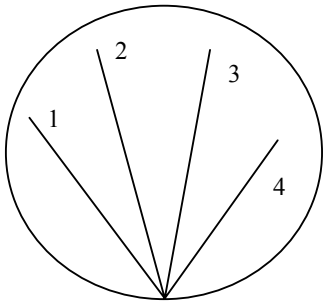
Multicores collected at each station were prepared for incubation using the acetylene block method (Jonathan Barnes, personal communication 2003). Multicore barrels were drilled and countersunk at 1.5 cm intervals and fitted with PTFE/silicone septa (Chromacol 8-ST15 214 from Burke Analytical; see Figure 1). Septa were secured into the countersunk holes using silicone sealant.

A 10% acetylene solution in seawater is known to inhibit both nitrification and denitrification. In the case of denitrification, this inhibition takes the form of halting the transformation of N_2O to dinitrogen. By injecting an acetylene-seawater solution that is equivalent to 10% of the porewater volume, the $N_2O \rightarrow N_2$ step can be halted in a multicore barrel, thus resulting in the accumulation of N_2O. Denitrification rates can be inferred by quantifying the ingrowth and accumulation of N_2O during an incubation.

Figure 1. Acetylene block barrel.

Samples were prepared for the acetylene block incubations as follows:

- Septa in 3 drilled multicores were checked for integrity before being loaded onto multicorer.
- Two 1-litre HDPE bottles of GFF-filtered seawater were sparged with acetylene for ~30 minutes each. Bottles were capped after sparging was completed.
- After core collection, three multicores (in prepared/drilled barrels) were transported to the controlled temperature (CT) lab.
- Sediment and water column heights were measured and recorded for each of the three barrels.
- One-mL disposable syringes were used to inject four 220-µL aliquots through each septum into each sediment depth horizon. The four aliquots were injected along four parallel paths at each depth, as shown in the cross-section below, until all depths in the core were injected. This injection resulted in a porewater solution that is 10% saturated at each depth.
- 10% of the overlying water volume was withdrawn and replaced by acetylene-sparged water.
- When acetylene injections were completed in all three cores, core tops were placed in each barrel and final sediment and water column heights were taken.
- Two cores (A and B) were connected via a silicone tube, so that core B provided replacement overlying water to the water sampled from core A. The third core (C) was a whole-core incubation (Fig. 2).



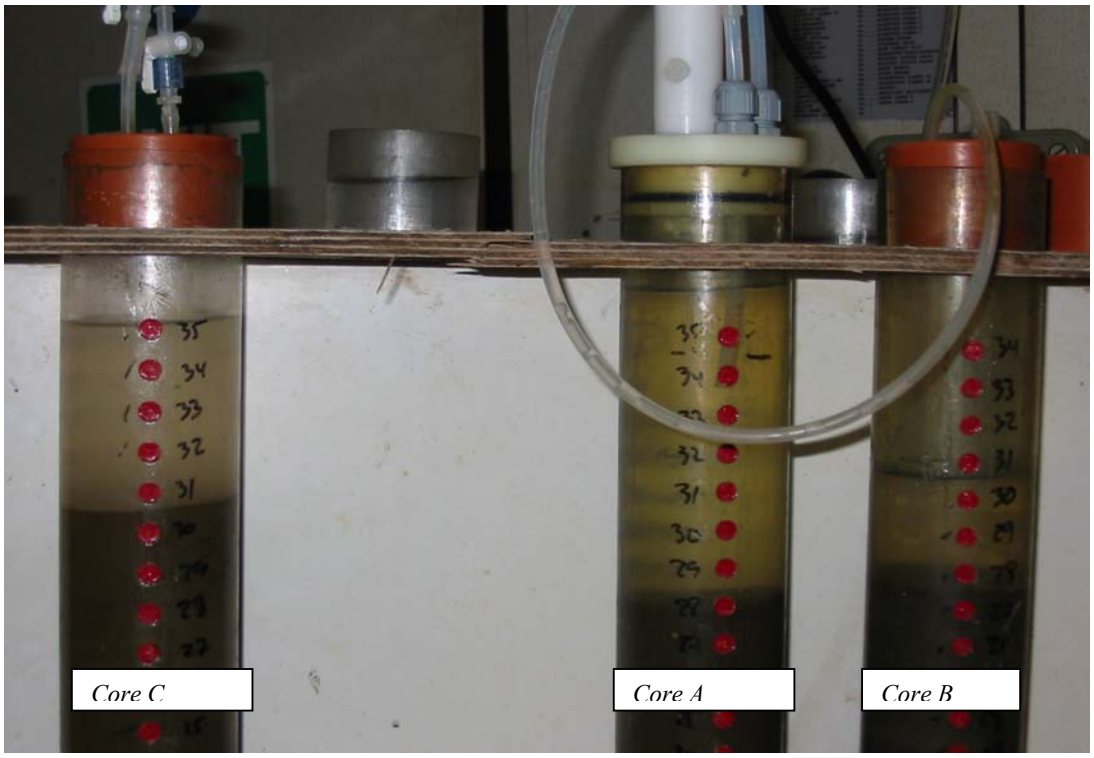


Figure 2. Acetylene block cores

- Core A was sampled every two hours for eight hours (T_0, T_2, T_4, T_6, T_8). At each sampling point, a 100 mL syringe was used to withdraw 50 mL of water from the water column within the incubation barrel (replaced by water from Core B). The 50 mL water sample was then allowed to equilibrate for 20 minutes with 50 mL of atmosphere within the 100 mL syringe. The sample was agitated gently at beginning and end of equilibration period. After equilibration period, a headspace sample was withdrawn from the syringe into a 12 mL evacutainer (evacuated glass vial with butyl rubber septum).
- A headspace of 2-5 cm was left above the water column in Core C. After acetylene-sparged water was injected into the sediment and water column, a sample of this headspace was collected in a 12 mL evacutainer; this sample represented the T_0. After eight hours, the sediment and water column was gently rocked to mix porewaters and sediment with the overlying water. Twenty minutes after the barrel was mixed, a second, T_{final} headspace sample was withdrawn directly into an evacutainer.

All samples collected during CD146 will be analyzed on a GC-ECD at University of Newcastle-Upon-Tyne.

Matthew Schwartz

8.12 Porewater ultrafiltration

Megacores from each station were sliced at 1 cm intervals and the sediment was centrifuged in acid-cleaned centrifuge bottles for 15 minutes at 3000 rpm. The supernatant was transferred with a sterile syringe into ultracentrifugation (UF) tubes (Pall, Macrosep Centrifugal Devices) and centrifuged for 60 min at 5000 rpm. The UF devices provide rapid and convenient concentration and desalting of 5 to 15 ml samples. A starting sample of 15 ml was concentrated to 0.5 ml in 60 min without multiple decanting steps.

Each centrifugal devices is constructed of polypropylene and contains a low-protein binding Omega membrane, two factors which significantly reduce non- specific adsorption and enable the device to yield the highest recoveries. Centrifugation at up to 5,000 x g provides the driving force for filtration, moving the sample towards the encapsulated Omega membrane. Biomolecules larger than the nominal molecular weight cut-off of the membrane are retained in the sample reservoir.

The UF tubes are fitted with a membrane with a nominal cut-off of 10 kDa. Solvent and low molecular weight (LMW) molecules pass through the membrane into the filtrate receiver. The part of the sample passing through the membrane is defined as the LMW fraction of the sample (<10 kDa) and the part of the sample which is retained (>10kDa) is the high molecular weight (HMW). Both fractions were then transferred into pre-ashed and acidified (85% ortho-phosphoric acid) 5ml glass ampoules for later analysis for dissolved organic carbon (DOC) and total dissolved nitrogen (TDN).

The same procedure was followed for another megacore from a different deployment and the porewaters were collected in sterile plastic vials and returned frozen for further ultrafiltration (at 1kDa) back in the UK.

Tasos Anestis

8.13 NIO sampling

The abundances of the clay size fraction of polysilicate minerals in marine sediments contain information on the composition and climate of terrain from which these minerals were derived. The general characteristics of the clay mineral assemblage in Arabian Sea sediments and their lateral and temporal variations provide valuable evidence of their provenance for the interpretation of their dispersal patterns through time. The changes in the depositional process and accompanying compositional changes record the shift from the Himalayan source areas. The source regions their rates of sediments supply and the sediment transport pathways may have changed subtly in response to climate, tectonic, and /or eustatic effects.

Proposed Work

I am currently involved in the studies related to the sedimentology and geochemistry of Indus River sediments in an on–going project. Study of Nutrients, Sediments and Carbon Fluxes to the Indus Delta, and their Relationship to Human Activities, the sediment sampling during Charles Darwin 146 cruise will form an offshore link to sediment and carbon flux to the Arabian Sea.

Sub-samples from the selected multicores and megacores collected during CD146 were taken in order to identify sedimentary environments and sediment distributions in the studied area. These samples will be analysed at NIO, Karachi. Echo sounding and other acoustic data acquired during CD146 will be required, in order to evaluate bed morphology and internal structure as a function of hydrodynamic process.

I have collected five multicores and three megacores from eight selected stations with different depths - 140m, 300m, 400m, 600m, 950m, 1100m, 1200m, and 1850m - in plastic containers for onward transportation to NIO, Pakistan. The top 5cm sediment samples were preserved in formalin for biological studies. Multicores and megacores have been sliced into 10 and 5cm intervals respectively. The sliced sediment samples for geological observations were stored in the cold room.

The sediment samples will be analysed for particle size on a MicroMeritics Sedigraph 5100. The mineralogical and elemental analyses (XRD and XRF) of the selected sediment samples will be carried out with the support of the Geological survey of Pakistan. Organic carbon and calcium carbonate will be analysed at NIO, Pakistan on a LECO Carbon analyser.

M. Danish (NIO, Karachi)

9. IN SITU AND SHIPBOARD EXPERIMENTAL EQUIPMENT AND PROTOCOLS

9.1 Benthic landers: in situ microelectrode profiling and sediment incubation studies

Introduction

The KC-Lander is a modular benthic lander system that can be used either autonomously or moored. SAMS have two systems that can be set up with any of four different instrument configurations. The two configurations used on CD146 were:

Profilur System designed to measure oxygen and pH and sulphide concentrations over the sediment-water interface at very fine resolution (~ 100 μm) using micro-electrodes. On CD146 we were using oxygen and pH micro-electrodes only.

Elinor A chamber incubation system for measuring oxygen and nutrient fluxes over long deployments, using both mini-electrodes and a syringe sampling unit. The system is also designed to retrieving a small box core. Further developments have been made to the *Elinor* chamber at SAMS to enable oxygen levels in the chamber to be maintained close to those of the ambient water – an "oxystat" system.

The objectives of the cruise required the *Profilur* system to be deployed twice at each of the main sites across the OMZ and the *Elinor* system to be deployed three times at each site, one deployment each of three different modes: a standard non-oxystated oxygen incubation; an oxystated incubation for nutrient fluxes; and an oxystated ^{13}C tracer incubation. The landers were deployed using moored mode at the shallowest stations (A140 & A300) and autonomous mode at all others.

A summary of the lander configuration and the deployment and recovery times and positions for each deployment is given in Table 1

Pre-cruise preparation

The cruise objectives required substantial developments and modifications to both the lander platform and the instrumentation. This work is detailed in a separate SAMS Marine Technology report, but a summary is included below:

- An oxystat system was developed for the *Elinor* chamber, enabling oxygen levels to be maintained close to the ambient level using a semi-permeable silicone membrane.
- The ballast arrangement of the lander was re-designed to allow for deployments in the soft muds found in the OMZ region.
- A miniature camera system was developed capable of being fitted in the small spaces of the lander frame to provide diagnostic information.
- Hardware and software developments were made to enable the sediment surface to be detected on the *Profilur* system using a resistivity probe.
- The *Elinor* shovel system and syringe sampler were overhauled, including the strengthening of the shovel closure by inclusion of a spacer to pretension the spring.
- New control software was implemented, in collaboration with Unisense A/S, to remove bugs and improve functionality.
- A new buoyancy frame was made and tested to a modified design allowing twin Oceano acoustic releases to be fitted.
- An entire new lander system was purchased and assembled to replace a system lost on a previous cruise off Svalbard.

Deck operations and mooring configuration

Moored mode

At the shallower sites (A140 and A300) the lander was used in its moored mode with the top buoyancy frame of the lander removed (see Fig. 1), and no ballast fitted to the instrumentation frame. This was both to conserve on ballast but also because it was thought that the mud at these stations would be much softer, and so more risky for autonomous deployments. In fact the mud at A300 was much the same as at A940 where the landers were deployed in autonomous mode with no problems.

Fig. 1 *Profilur* being deployed in moored mode off the aft deck.

Mooring configuration
Mooring was done with 16mm sea-steel rope (Gaelforce UK) and a 30" marker float with flashing light. After a bit of experimentation the original plan to use a mooring rope 1.5 times water depth was found to be best, with a 17" Benthos glass sphere used as a sub-surface float. In calmer weather 1.2 times water depth was OK, but as soon as the seas picked up we had problems with movement of the lander on the bottom. Leaded sea-steel was used on the top part of the mooring line to reduce minimise line on the surface in calm conditions.

Deployment and recovery
The lander was deployed and recovered over the stern using the port after crane with block attached, and the UKORS deck winch. This proved reasonably simple, though care must be taken to ensure good co-ordination of the winch and crane when lowering over the rail, and to ensure good comms with the bridge to regulate ship's speed to avoid dragging of the lander. In rough conditions extra care must be taken due to the pitching of the ship. We successfully deployed the *Elinor* system in a swell of around 2m (steady 20 – 25 knot winds for over a week), but this is probably the limit. Fortunately by the time of the recovery conditions had calmed down significantly.

Autonomous mode

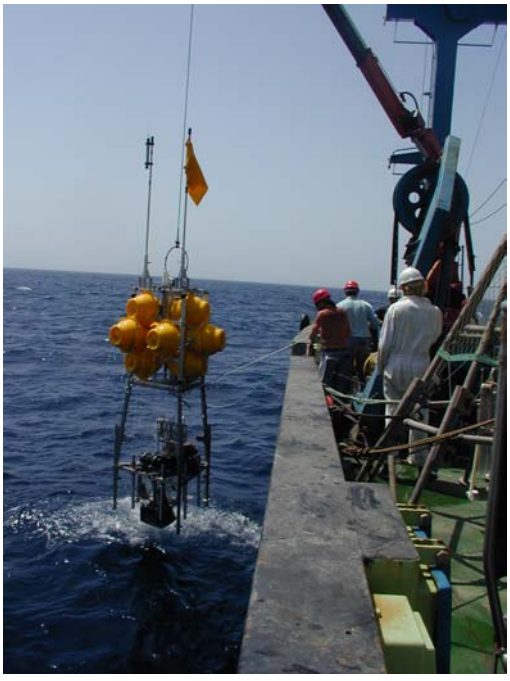


Fig. 2. *Elinor* is deployed in autonomous mode over the starboard rail.

Ballast, buoyancy and releases
Autonomous mode was used at A1850, A1200 and A940m. We started at the deepest station and worked back up the slope because mud type gets more consolidated in deeper water, and so risk of loss was minimised.

The ballast used was a steel plate with a steel bin on top, filled with between 30 – 60kg of steel shot, depending on the instrument configuration and hold down force / descent speed required. This new ballast arrangement, which uses disposable steel foot plates rather than the original fixed aluminium feet, proved reliable, and not too difficult to rig. However altering the height of lander legs is a bit difficult once the ballast is fitted.

Buoyancy used was 17" Benthos glass spheres (see Fig. 2). These were tested to 2000m at the start of the cruise. 8 spheres were fitted to the *Profilur* frame plus one 17" pellet and 11 spheres fitted to the *Elinor* frame (two lashed on) plus one 17" pellet.
Releases used were two Oceano (RT861 and AR661 type) on the *Elinor* system, and one Oceano (AR861 type) and one Interocean (1090ED) on the *Profilur* system. Due to a fault in the Interocean release for part of the cruise we used a burnwire back-up release system on the *Profilur*. The releases were all tested to 2000m at the start of the cruise.

Deployment and recovery (Fig. 2)
In calm conditions the lander was deployed and recovered over the starboard rail using the starboard after crane. This worked reasonably well, though there was a tendency, even with next to no swell, for the lander to get caught under the counter. In rougher conditions we resorted to previously used methods of deploying and recovering with the mid-ships crane, and, during recovery, with the ship coming off the wind to put the lander in its lee. This proved successful, allowing the lander to be cleared away from the ship's side much further for'ard. Despite one or two knocks no significant damage was sustained. The biggest problem encountered with recoveries was with the pellet spheres getting caught up in the masts, which seems to be a fairly random occurrence. However it is essential to use a 17" sphere for the pellet, as the smaller 10" spheres don't rise fast enough and can get caught under the instrumentation frame. This happened on the *Profilur* early on, and resulted in smashed electrodes.

Equipment description and protocols

***Profilur* System**
The *Profilur* system uses micro-electrodes to obtain high resolution oxygen and pH profiles across the sediment-water interface. The instrumentation consists of a precision controlled motor rack on which is mounted a computer housing with the micro-electrodes attached to the bottom, spaced approx. 35mm apart. The system was fitted with 5 oxygen, 1 pH and 1 resistivity electrodes for all deployments. After a period of around 3 hours on the bottom to allow the temperature to equalise and electrode signals to settle, the electrodes were moved to within a few cm of the sediment surface in a single step, and then driven into the sediment in steps of between 50 and 250 μm. The electrodes were left at each step for 10s prior to recording 3 measurements (at 1s sample interval). A temperature logger (Richard Brancker TR1050) is fitted to the frame about 0.5m above bottom to record water temperature at 10s intervals throughout the deployments.

Oxygen electrodes are miniaturised Clark-type micro-electrodes with tip diameters of around 25 μm. The electrodes were calibrated using a two point in-situ calibration. Water bottles on the lander were used to take samples of the overlying water to give the oxygen concentration using Winkler titration. The zero oxygen point was taken from the asymptote of the electrode signal. As a back-up and to assess the stability of the electrodes, lab oxygen calibrations were done at the start and end of each station in the CT lab (set to the bottom water temperature) after the system had been left to stabilise for 2 hours or more. A 100% DO value was obtained from bubbling air through bottom water and then sodium-dithionite was added to remove all oxygen and obtain a zero point. A magnetic stirrer was only used once sodium-dithionite was added (for a minute or so), as the heat given off by the unit warms up the calibration water.

The system also had a pH glass micro-electrode fitted, with tip diameter of 25 μm. The pH is measured as the potential of the electrode tip relative to an external reference electrode. The pH electrodes were calibrated in the CT lab at the same time as the oxygen electrodes using seawater and pH 4 buffer to give a 2 point calibration.

The resistivity probe was fitted mainly for test purposes to obtain data on the correlation of the change in resistivity with the sediment-water interface and corresponding change in oxygen. Ultimately the plan is to use the resistivity probe, positioned 10mm or so below the oxygen electrode tips, to detect the sediment surface and trigger high resolution profiling.

The new camera system was used on the *Profilur* for deployments at A140, A300 and A1850. This proved an invaluable tool in assessing the real position of the electrodes relative to the sediment, and in giving an idea of the overall surface topography and faunal activity. At the other sites the camera was moved onto the *Elinor* system.

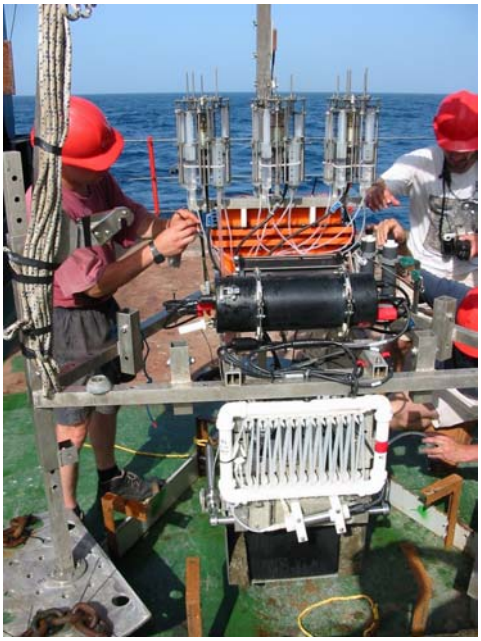


Figure. 3. Elinor system showing (from bottom) the box core and chamber, and the oxystat and syringe sampling systems.

Elinor system (Fig. 3)
The *Elinor* system consists of a PTFE coated titanium chamber that sits partially below the level of the lander feet and so is driven into the sediment as the frame lands on the seabed. The chamber is 30 x 30cm across, and the water column enclosed above the sediment is normally between 10 – 15cm, giving an

overlying water volume of 9 – 13 l and a maximum core depth of around 20cm. The chamber is sealed at the top by a lid which is open during deployment and landing, in order to minimise the bow wave, and then falls closed when released by a computer controlled burnwire. A magnetic cruciform stirrer is used to mix the chamber water during the incubation, at a speed of 15 RPM. Fitted to the lid are two oxygen mini-electrodes and a pH mini-electrode which monitor conditions inside the chamber during the experiment. A third oxygen electrode is fitted to the computer to monitor ambient oxygen levels. A water sampling port is fitted to the lid, and water can be withdrawn from the chamber by a syringe sampling system controlled by the computer. There are 15 plastic syringes, nominally capable of taking 55ml each, three of which can be used to inject rather than withdraw if required. On withdrawing samples, chamber water is replaced by ambient bottom through a valve in the lid. A spring driven hydraulic shovel system is used to recover the sediment in the chamber at the end of the deployment. This is fired using a burnwire at the end of the incubation period which releases a hydraulic valve. The burnwire also triggers the closure of 3 small water bottles to provide bottom water for oxygen electrode calibrations. A temperature logger (Richard Brancker TR1050) is fitted to the frame about 0.5m above bottom to record water temperature at 10s intervals throughout the deployments. A camera can be fitted in various places around the frame, and was used at A1200 and A940 (at previous sites it was fitted to the *Profilur*).

Oxystat system (Fig. 3)
In addition to the above components, for this cruise an oxystat system was used for the first time. This consists of a rack of 20m of silicone tubing (0.125" id, 0.188" od, Cole Parmer 06411-64), which is permeable to oxygen, located on the frame outside the chamber. The chamber water is continuously circulated through this "gill" at 300ml/min using a Seabird SBE5T deep-sea pump. As the water passes through the tubing, oxygen diffuses from the ambient water across the tube wall and into the chamber water. Thus the oxygen level inside the chamber is maintained close to the ambient level.

Elinor experimental modes
The *Elinor* system was used in three different modes:
Mode 1 (EO) Non-oxystated incubation for oxygen demand calculations and de-nitrification measurements.
Mode 2 (EF) Oxystated incubation for nutrient and trace metal fluxes.
Mode 3 (EF13) Oxystated incubation with ^{13}C labeled slurry injection for measurement of bioturbation.

Generic Elinor protocols

Water sampling For DO measurements, 15ml glass vials were used, ensuring vial flushed twice before final sample. These ensure no diffusion of oxygen during course of incubation. For all other analytes greater sample volumes were required, and so coils of PTFE tubing holding 30ml were used. Because the overall id is more constant with the coils, less flushing is required to prevent mixing of the sample. These vials or coils were connected to the chamber port and the syringes with lengths of Versilic silicone tubing (3mm id, 5mm od). All tubing and vials were primed with Milli-Q prior to deployment.
Sterilisation: All water sampling tubing, the syringe sampling port and the entire oxystat system, except the pump, were autoclaved between each deployment. Separate tubing and oxystats were used for the EF13 deployments. New (sterile) syringes were used for each deployment (this was partly to improve on sample volumes, as it was found that the friction of the syringe could increase after each deployment, maybe due to seawater, or to sunlight?).
Electrodes: Oxygen and pH measurements were made at 5 or 10 minute intervals throughout the incubations (depending on overall deployment length). Bottom water was collected and processed for DO using the Winkler method (see Breuer oxygen protocols) for oxygen calibrations, and laboratory calibrations were also performed between most deployments (see *Profilur* description for calibration details). 3 hours was allowed for electrode stabilisation at the start of each deployment given the extreme temperature changes between deck and seabed.
Oxystat: The gill was primed with Milli-Q water prior to deployment, and then ambient water was pumped through it for 5 minutes prior to the lid closing at start of incubation.
Volume The volume of overlying water can be calculated using a dilution method. We injected 1M KBr solution at the end of each deployment (prior to shovel closure). After 10 minutes stirring to ensure complete mixing of injected solution, a water sample was taken for bromide concentration analysis.

Oxygen incubations (EO)
The deployments were roughly one day each, with 20 hours of incubation time. The syringe sampling system was rigged with nine vials (3 x triplicates) for DO measurements, and four tubing coils (2 x singles & 1 duplicate) for N_2/Ar measurements. After the 3 hours settling time on the seabed, t_0 samples were taken, stirrer started and the lid closed. One intermediate set of water samples was taken at roughly t_{10}, and then final samples at t_{20}. Electrode measurements were made every 5 minutes.

On recovery oxygen vials were immediately removed and fixed for later Winkler titration (see Breuer oxygen protocols) and the N_2/Ar coils were sealed off and processed as per shipboard protocols (Schwartz).

Nutrient and Trace metal incubations (EF)
The deployments varied between 2 – 3 days. 7 PTFE coils were fitted for trace metal analysis, and 6 for nutrients (processed for all nutrients, DIC, DIC13 and DOM). t_0 (duplicates) water samples were taken prior to lid closure, and there were then three further sample points during the course of the incubation. The oxystat was turned on roughly 10 minutes after lid closure (to ensure any sediment disturbed during closure had settled out prior to pumping) and left on throughout the incubation. Electrode measurements were made every 10 minutes.
On recovery water sample lines were sealed off and removed. Nutrient lines were processed as per shipboard protocols for NO_3, NO_2, NH_4, SO_2, PO_4, DIC, DIC13, DOM. Trace metal lines were filtered through 0.45 μm filter, acidified to < pH2 and stored chilled for later analysis with ICP-MS. A subcore was taken of the chamber sediment, using a shortened megacore barrel, and processed for trace metals (as per Breuer et al. shipboard protocol). Residue sediment was sieved with 1mm mesh for bulk faunal analysis.

^{13}C tracer experiments (EF13)
Roughly 2 day deployments. 12 PTFE coils were fitted for nutrients etc. (see above). 1284mg of ^{13}C labeled slurry (4% carbon, of which 80% is ^{13}C) was mixed with ~ 30ml of Milli-q and then injected into a 920mm length of PVC tubing (8mm id) fitted to the chamber lid, blocked off at the bottom end and with a u-bend shape forced into the tube when the lid is open. The tube was then topped up with Milli-q and connected to a 60ml catheter tip syringe fitted to an injection slot on the syringe sampler and also filled with Milli-q. The slurry settles in the bottom of the u-bend and so doesn't fall out of the tube when the lid is open, even once the bung is removed from the bottom. When the lid closes, the u-bend is straightened out and the slurry starts to fall out of the tube. After a few minutes the injection port is fired to flush the tube through. During the slurry injection the stirrer is on at full speed (29 rpm), and then is slowed down in steps to zero over the next 5 minutes. There is then a 15 min period with stirrer off to allow all the slurry to settle out, after which the stirrer is turned on again at the standard 15 rpm and the oxystat pump is turned on. t_0 water samples were taken prior to the lid closure, and then further samples were taken 1 hour after slurry injection. After this there were 3 further sample points during the incubation (all samples at least duplicates). Electrode measurements were made every 10 minutes.

On recovery water samples were removed and processed for nutrients as per EF (see above). Two subcores (shortened megacore barrels) were taken for slicing for ^{13}C analysis (as per shipboard protocols) and surface samples were taken across the remaining area to determine slurry distribution. Residue sediment was sieved with 1mm mesh for bulk faunal analysis. The contents of the slurry injection syringe and tube were saved for determining ^{13}C residue.

9.2 Shipboard sediment incubation rig and incubation protocols

Objectives
The shipboard incubation rig aims to maintain megacore sediment samples and an overlying water column in conditions replicating those at the seafloor for the duration of a number of experiments, each designed to study a

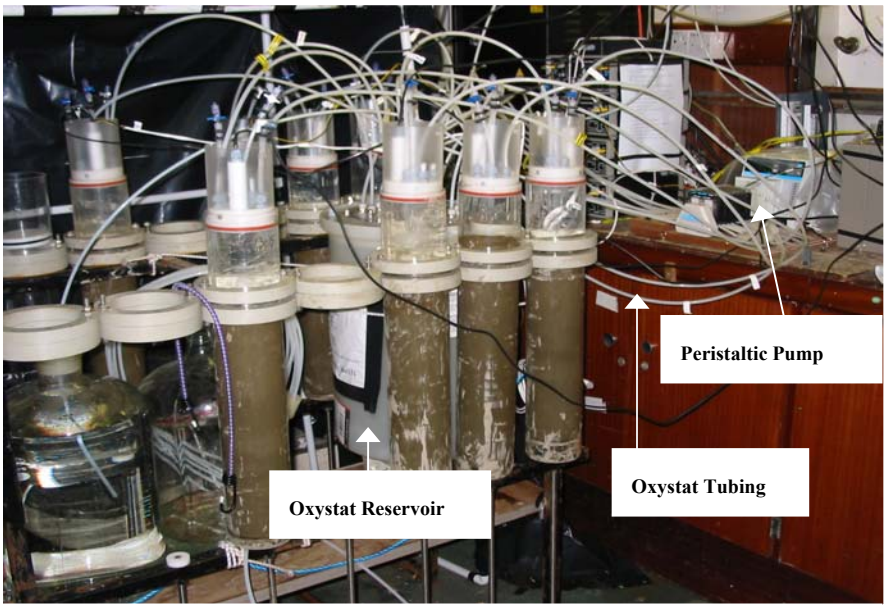


Figure 1. The incubation rig in action**.**

selection of benthic biogeochemical processes. To this end, the rig features mechanisms to control and monitor sediment temperature and the concentration of dissolved oxygen in core top water. These mechanisms and the experiments conducted are described below.

a) Sediment incubation rig design and set-up

Outline of Design

The shipboard incubation rig comprises two steel racks, each supporting up to 7 megacore barrels (Figure 1) and is set up in the controlled temperature laboratory, thus permitting incubation at ambient seafloor temperature.

The racks have facilities for pushing the lower seals up the barrels to adjust the height (and, thus, volume) of overlying water. Each barrel is fitted with a top seal through which ports allow a range of implements to penetrate. As illustrated in figures 2 and 3, these include a temperature probe, an oxygen microsensor, a magnetic stirrer, two sample withdrawal lines, two oxystat lines and a slurry injection line. The core tops thus allow the monitoring of temperature and dissolved oxygen in addition to sampling of the overlying water and the injection of experimental tracers. The oxygen electrodes are connected to picoammeters, and both temperature and oxygen data are continuously logged by computers.

Eight core barrels are fitted with oxystat systems, a mechanism designed to replace any oxygen removed from the overlying water by sediment oxygen demand. Thus, *in situ* bottom water oxygen conditions are maintained and the biota under investigation are kept living. This is achieved by pumping core top water out of the barrel and through a dedicated oxystat gill before returning it to the barrel, leaving each core an entirely closed system. The oxystat gills comprise 25 feet of gas permeable, peroxide-cured silicone tubing submerged in a reservoir of GFF-filtered bottom water (obtained from a CTD deployed to within 10 m of the sea bottom). Each incubation has a dedicated oxystat gill and associated tubing; these gills are maintained between incubations (e.g., the bead incubations at each station utilize the same oxystat tubing and gill). Sparging the bottom water with air and nitrogen maintains reservoir dissolved oxygen concentration slightly above that of ambient bottom water prompting diffusion of oxygen from the reservoir into the core top water being pumped through each gill. Thus oxygen consumed by sediment oxygen demand in each barrel is replaced. Surrounding the incubation rig is a frame of plastic tubing covered in opaque black plastic sheeting. This can be opened up for incubation setup and sampling, but for the rest of the time maintains darkness around the experiments preventing photosynthesis. Figure 1 shows the incubation rig in use with core tops connected to the oxystat system.

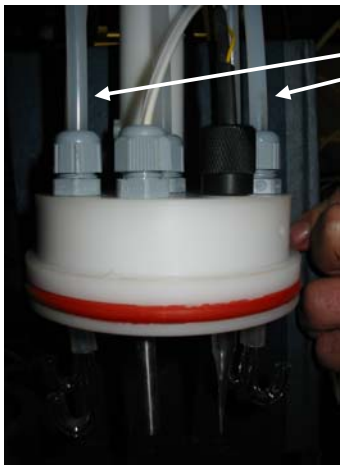


Figure 2. Core top seal, side view.

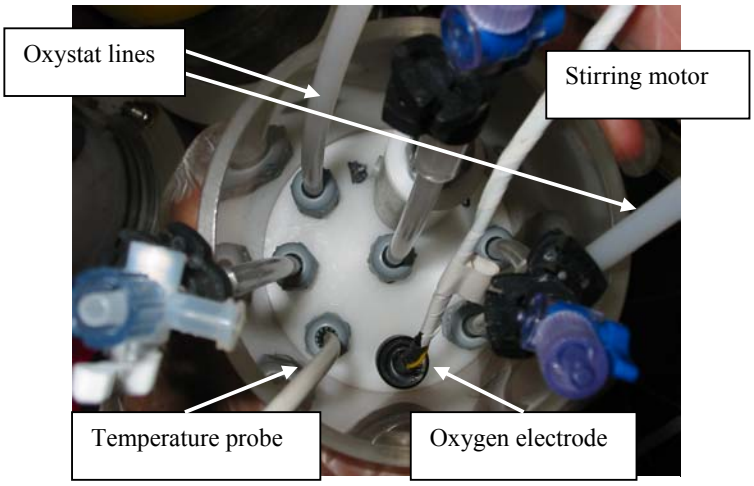


Figure 3. Top seal, view from top.

Experiments

Five separate experiments are conducted using the incubation rig, all of them dependent on the presence of live, normally functioning sediment and benthos, and four of which employ the oxystat system. At each station two megacores are subjected to each experiment, thus replication is provided.

Oxygen Consumption (SO)

The oxygen consumption incubation is designed to observe the decline in dissolved oxygen levels of the overlying water in a megacore barrel due to sediment oxygen demand, and as such is the only incubation experiment which does not utilise the oxystat system. Cores are incubated for 24 hours or more and dissolved

oxygen is monitored using oxygen electrode micro sensors. At intervals during this time water samples are withdrawn for DIC, $\delta^{13}C$ DIC, $\delta^{18}O$, nutrients (NO_3, NO_2, SiO_2, NH_4, PO_4), N_2/Ar, and DOM analyses. Thus, the production of these analytes may be directly related to the consumption of oxygen. The N_2/Ar analysis specifically tracks the rate of microbial denitrification so that this process may be related to oxygen consumption.

Benthic Flux (SF)

This incubation has the objective of directly measuring biogeochemical fluxes to and from sediments under their *in situ* temperature and dissolved oxygen conditions. For these experiments the oxystat system is employed and the five samples withdrawn over a four day period are processed for DIC, $\delta^{13}C$ DIC, trace metals, nutrients and DOM. This experiment gives a direct measure of benthic fluxes, representing an advantage over the traditional method of calculating such fluxes from porewater concentration gradients.

^{13}C Labeling (SF13-2 and SF13-5)

This experiment is conducted on two pairs of cores at each station, each pair being run for a different period of time (roughly two and five days). The aim is to quantitatively trace the fate of fresh organic carbon when it arrives at the sediment surface. The tracer used is detritus from algae cultured on a ^{13}C-only substrate. By comparing experimental ^{13}C distribution with that of natural (i.e., "unspiked") samples, the path of algal carbon through the sediment will be assessed. These experiments begin with the introduction of labeled algal slurry, proceed with the oxystat system in use, and terminate with sediment core sectioning. The fauna, bulk sediment and porewaters are then separated so that the amount of excess (above natural abundance) ^{13}C in each pool may be quantified.

Fluorescent Bead / Bioturbation (SB)

Tracer studies using fluorescent beads are conducted to assess the possible particle size selectivity of the bioturbating community. This three-day experiment begins with the introduction of a mixture of three size fractions of bead (<38μm, 38-63 μm and 63-106 μm in diameter). Each size fraction is a different (fluorescent) colour (violet/pink, yellow and magenta/purple, respectively). Flow cytometry will be used to quantify the downcore penetration of each colour of bead during the experiment. Thus, these experiments terminate with core sectioning. Half slices from one of each replicate pair of cores are examined for any visual evidence of the benthos ingesting or otherwise interacting with tracer beads.

b) Incubation Experiment Protocols

In the following section the general protocols for incubation setup and sampling are given, followed by the specific requirements / timings for each experiment.

Core Installment On Rig

1) With core cap removed from barrel, replace bottom rubber bung with a custom made seal (hard nylon with rubber o-ring).
2) Place core into steel frame, screwing top part of split ring on frame above core tube ring.

Core Top Installment

The following should be carried out wearing gloves.

1) Start with a hard nylon core top with sample extraction line, seawater replacement line and slurry injection line emplaced with top stopcocks open and bottom glass hooks attached (Figure 1 in Incubation Rig Description).
2) Thread sample extraction line, seawater replacement line and slurry injection line through Perspex collar; leave collar unattached to core top.
3) Feed the following through the Perspex collar and core top;
    a) Oxystat pump-to-barrel line. Attach glass hook to bottom of line and tighten fitting.
    b) Temperature probe. Tighten fitting.
    c) Stirring motor. Place into port.
    d) Barrel-to-reservoir oxystat line. Attach glass hook to bottom of line and tighten fitting.
    e) Oxygen microsensor, retaining in protective glass tube until it is threaded through Perspex sleeve. Slide through appropriate port, taking care not to break electrode on hard nylon core top.
4) Slide Perspex collar down into place and secure onto core top with screws.
5) Submerge ends of oxystat lines (now emplaced in core top) in a beaker of GFF-filtered bottom water.
6) Attach pump head to allow peristaltic pump to pump. Prime oxystat system by pumping GFF-filtered bottom water through the system lines.
7) Turn pump off / release pump head.
8) Turn on stirrer.
9) Place core top in barrel and push down to expel air.

10) Close stopcocks as sample withdrawal, seawater replacement and slurry injection lines are filled, then overfilled with water displaced as core top is inserted.
11) Turn on peristaltic pump / attach pump head.

Slurry Injection

Bead slurry is prepared by adding 3-5 drops of DECON antisurfactant to ~250ml of Milli-Q water. This is used to suspend first the finest (violet) pre-weighed beads to which are gradually added the yellow and finally magenta. Prepare the mixture days to weeks in advance of slurry injection, as initial flocculation decreases with pre-injection standing time.

Labeled algal slurry is prepared by adding Milli-Q to pre-weighed algae/silica gel ballast mix. This should be performed as close to injection as possible to avoid desorption of algae from silica gel slurry.

1) Ensure oxystat system is off (pump head not attached / pump off) and stirring motor is on at a moderate level.
2) Unscrew central bulkhead fitting and completely remove slurry injection line from core top. (NOTE: in future, tests should be accomplished to determine if slurry can be injected through injection line).
3) Slowly introduce slurry (^{13}C algae or beads) using a syringe fitted with a length of fine (1/8" OD) tubing through opening in core top. Ensure stirrer speed is sufficient to disperse slurry, but not so strong as to pull slurry up and into the stirrer.
4) Record volume of slurry and water added.
5) Replace central slurry injection line and tighten bulkhead fitting.
6) Turn off stirrer for 30 minutes.
7) After 30 minutes turn on stirrer and oxystat system and take T_0 sample (for ^{13}C incubations).

Sampling Protocol

The height of water column above the sediment in each core is recorded before the first, and after the final, water sampling of each experiment. This facilitates calculation of sample volume relative to total incubation volume.

1) Attach 50ml glass syringe to sampling line with three-way luer lock stopcock.
2) Open stopcock on central (slurry injection/vent) port.
3) Withdraw sample of required volume while core is being pushed up the core barrel by turning the bottom wheel. This prevents the development of a headspace.
4) Repeat with second 50ml glass syringe and any other syringes required (see details of each experiment below).
5) Remove syringes and close stopcocks on all sample / vent lines. Check that no headspace or significant bubbles remain in barrel top
6) Record the total volume withdrawn and process sample as below.

Sample Processing Protocols

Here follows a summary of the treatment of incubation water samples for each analyte.

a) Dissolved Inorganic Carbon

Water is introduced into a 20ml vial through a needle, such that 10ml are allowed to overflow and a convex-up meniscus is produced. Sample is poisoned with 100µl $HgCl_2$ and the cap is fastened. Samples are stored upside down.

b) $\delta^{13}C$ Dissolved Inorganic Carbon and $\delta^{18}O$ Dissolved Oxygen

Water is introduced into a 10ml headspace vial (a separate vial for each analyte) such that 5ml overflows and a convex-up meniscus is produced. Sample is poisoned with 20µl $HgCl_2$ and crimp caps are fastened. Vials are stored upside down.

c) Nutrients

Water is filtered either through a 0.2µm disposable filter (SO experiments) or through a combusted GFF filter into a plastic screw cap tube. Samples are refrigerated or frozen prior to shipboard analysis.

d) Dissolved Organic Carbon

Water is filtered through a GFF filter into a 10ml ampoule. 15µl of orthophosphoric acid are added and the ampoule is sealed.

e) Trace Metals

Gloves must be worn for this procedure. Sample is introduced to a pre-acidified 30ml Nalgene bottle through a 0.2µm disposable filter. Bottle is stored double bagged.

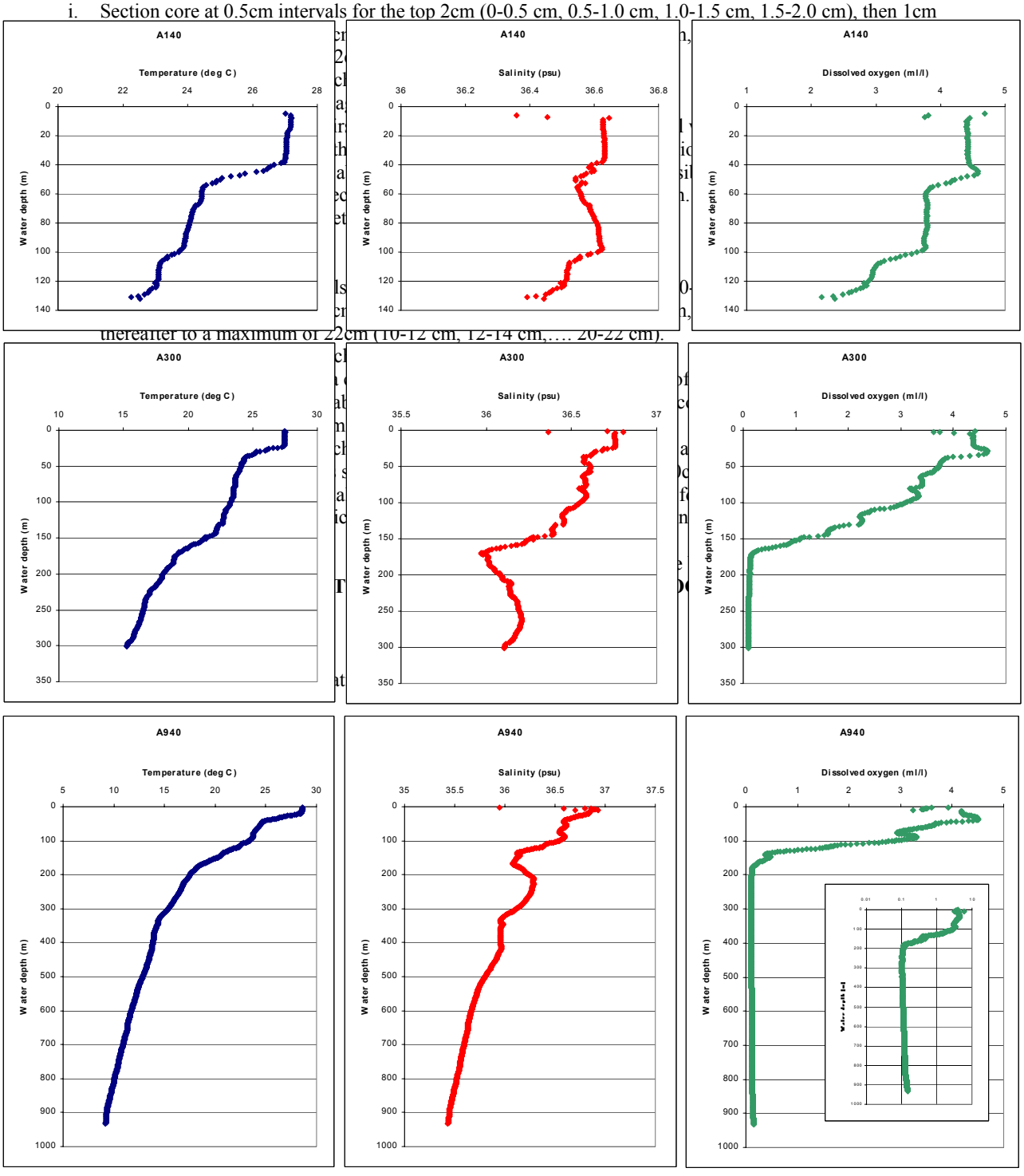
f) N_2/Ar

Sample is collected in a 5 mL gas tight syringe and transferred to an evacutainer. Sample is either analyzed immediately or poisoned with 20µL $HgCl_2$ until analysis by GC-TCD.

Core Processing Protocols

a) Bead Cores

i. Section core at 0.5cm intervals for the top 2cm (0-0.5 cm, 0.5-1.0 cm, 1.0-1.5 cm, 1.5-2.0 cm), then 1cm



thereafter to a maximum of 22cm (10-12 cm, 12-14 cm,…. 20-22 cm).

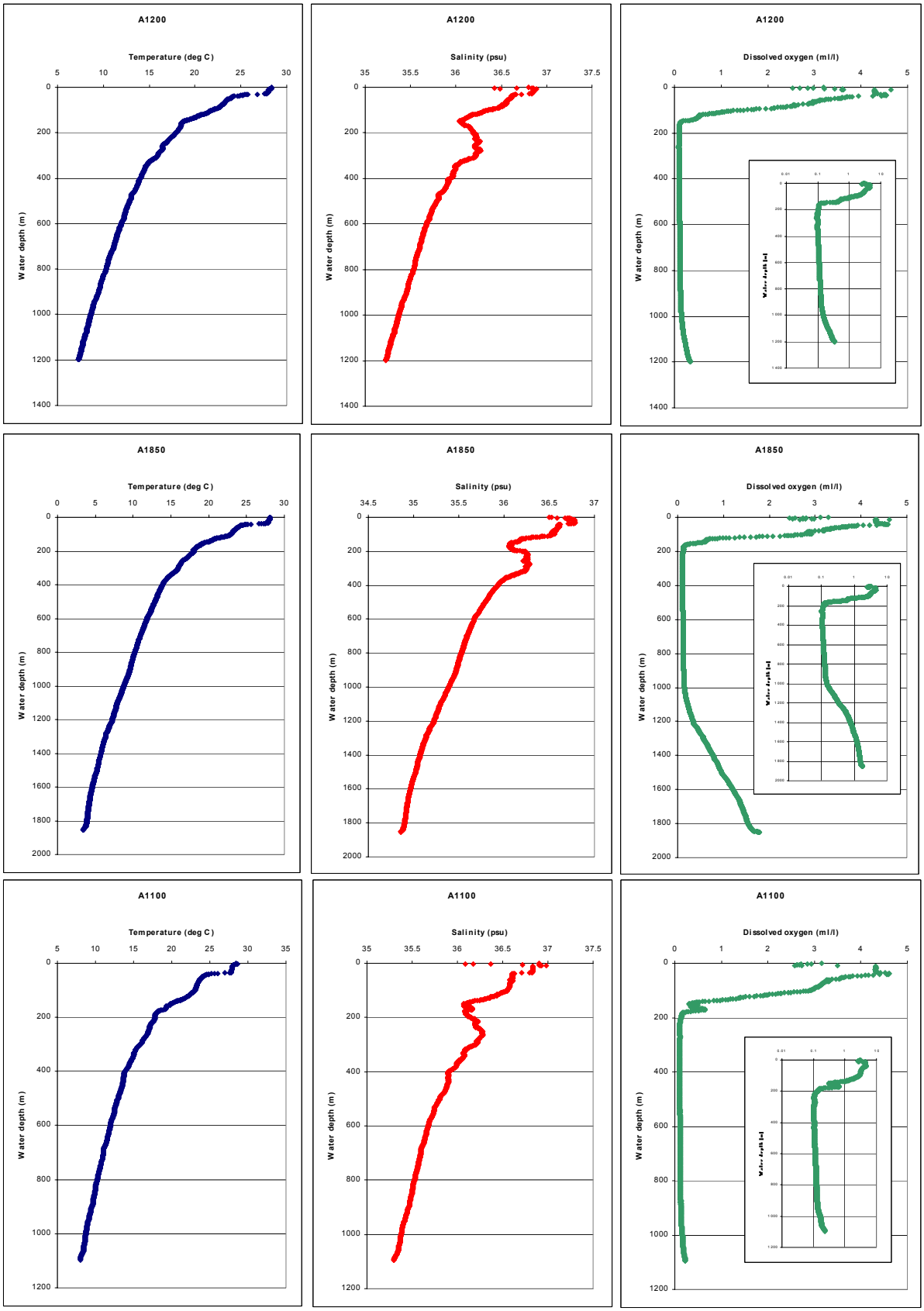


Figure 1b. CTD data for CD146 stations A1100, A1200 and A1850.

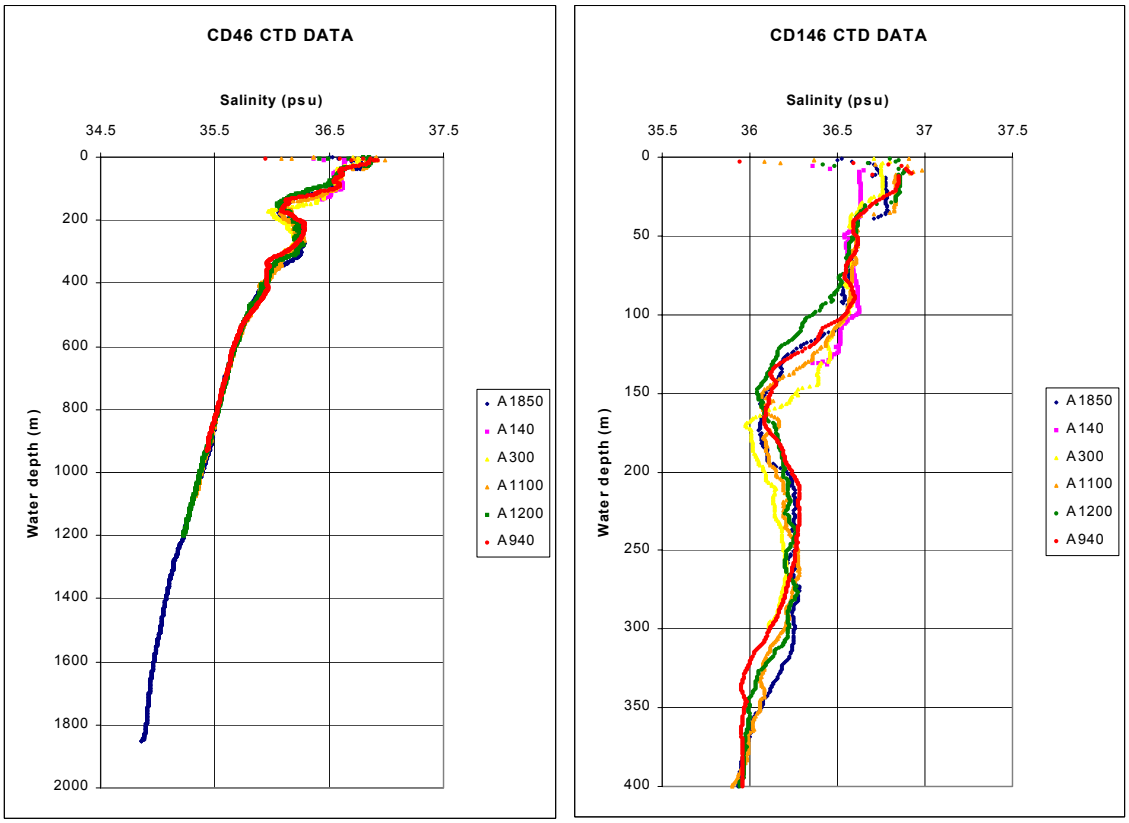


Figure 2. Co-plotted CD146 CTD temperature profiles.

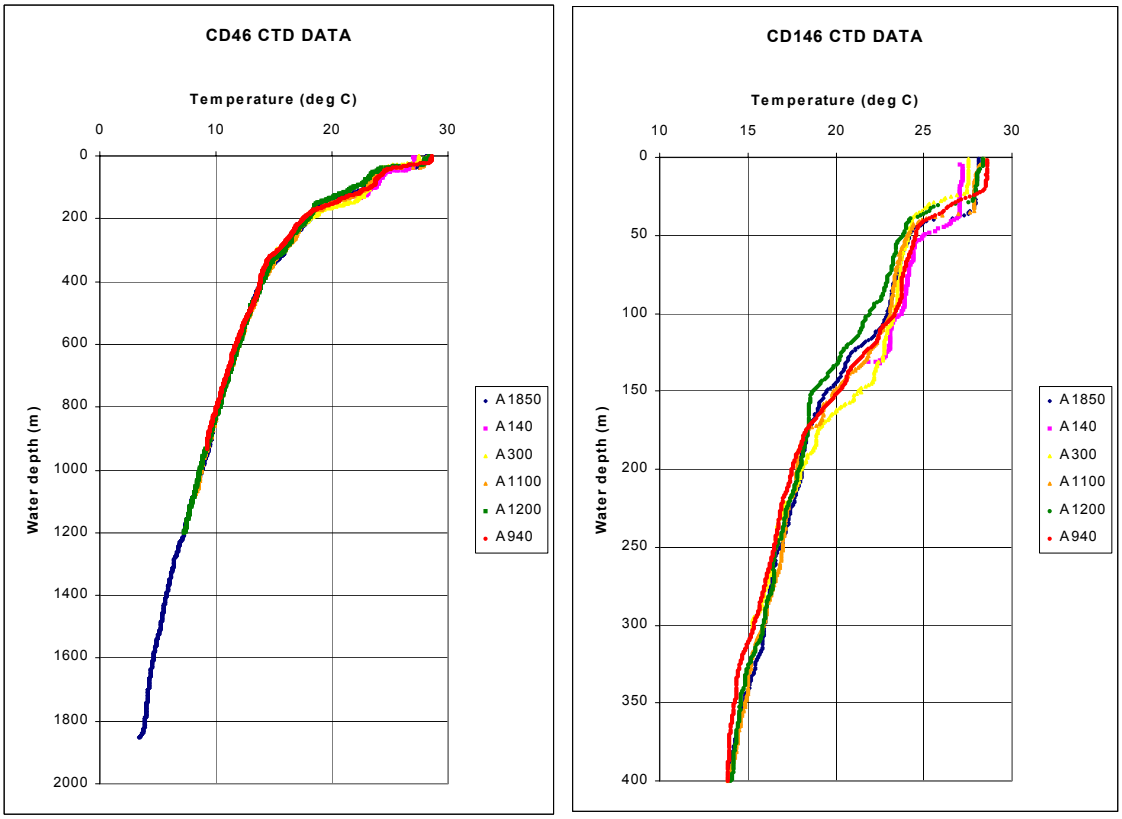


Figure 3: Co-plotted CD146 CTD salinity data.

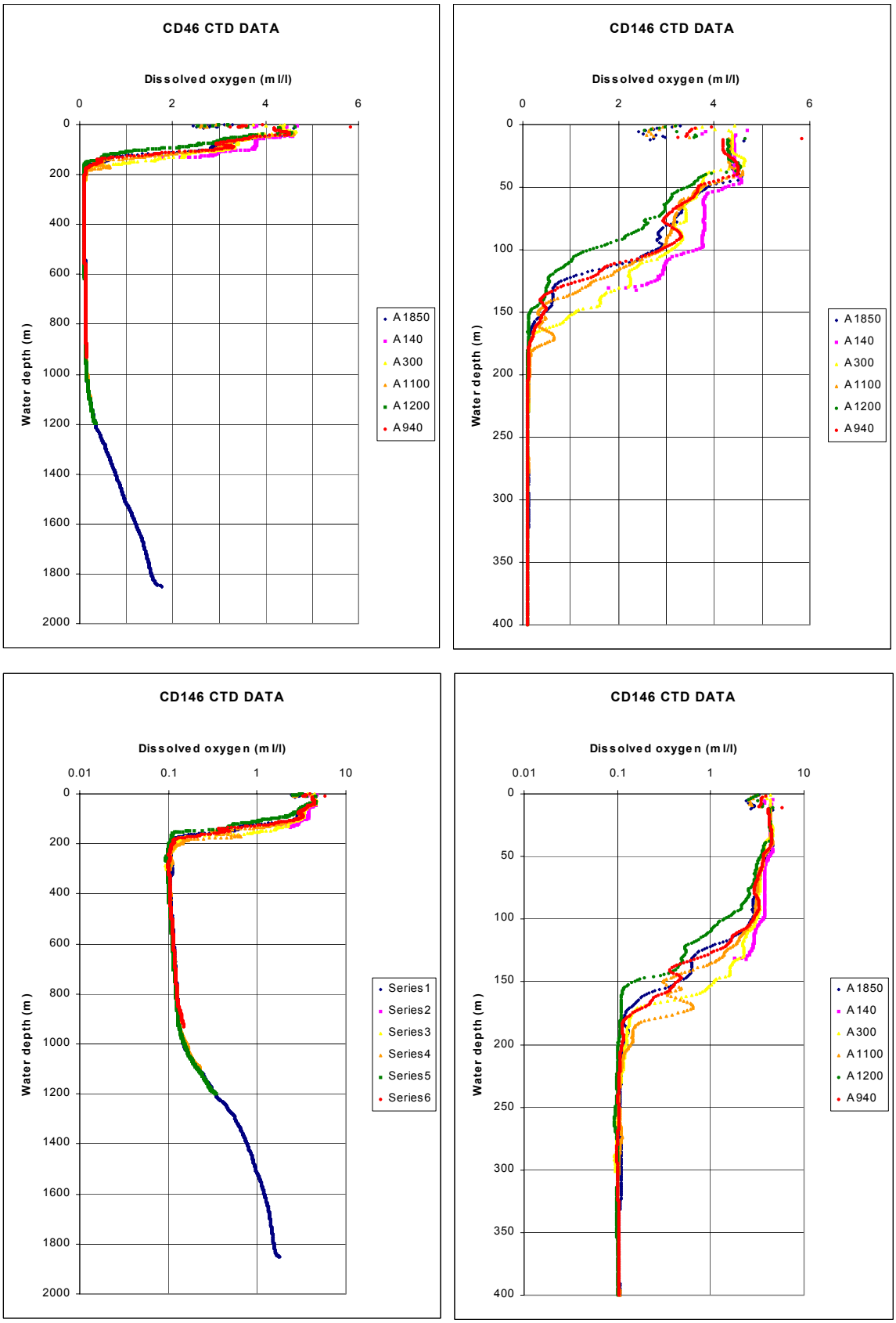
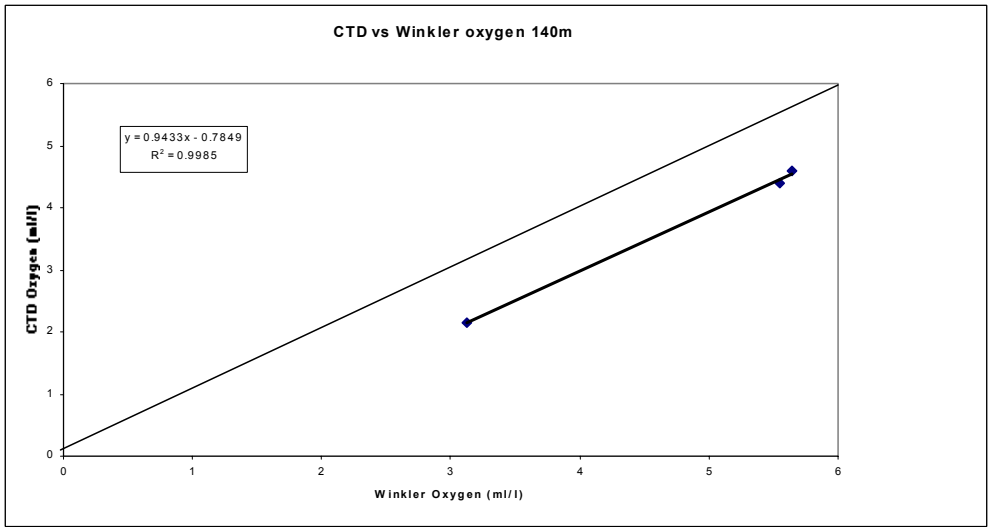
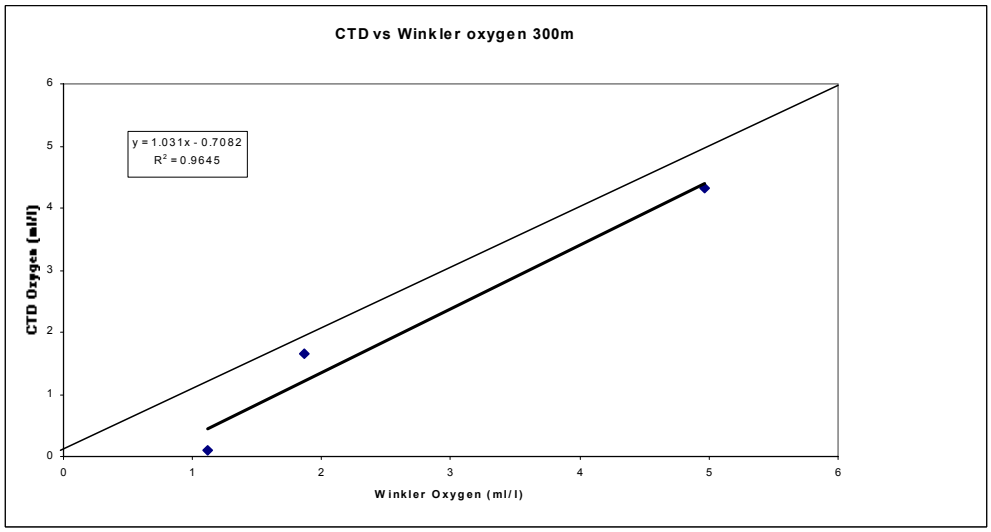


Figure 4. CD146 CTD dissolved oxygen concentration profiles (linear and logarithmic scales).

10.12 Winkler titration results





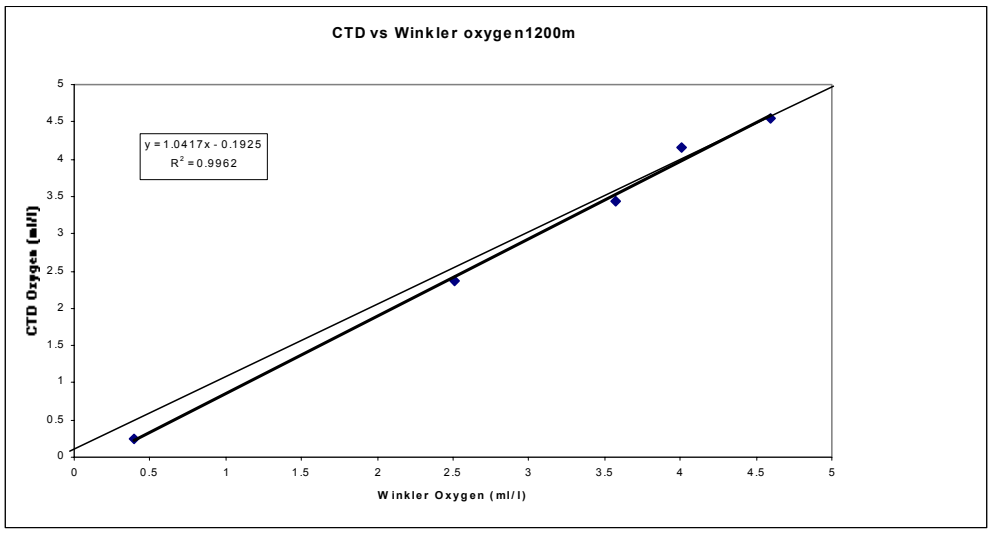


Figure 1: Comparison of CTD probe and Winkler titration oxygen results for CD146 water column profiles.

10.13 Water-column nutrient data

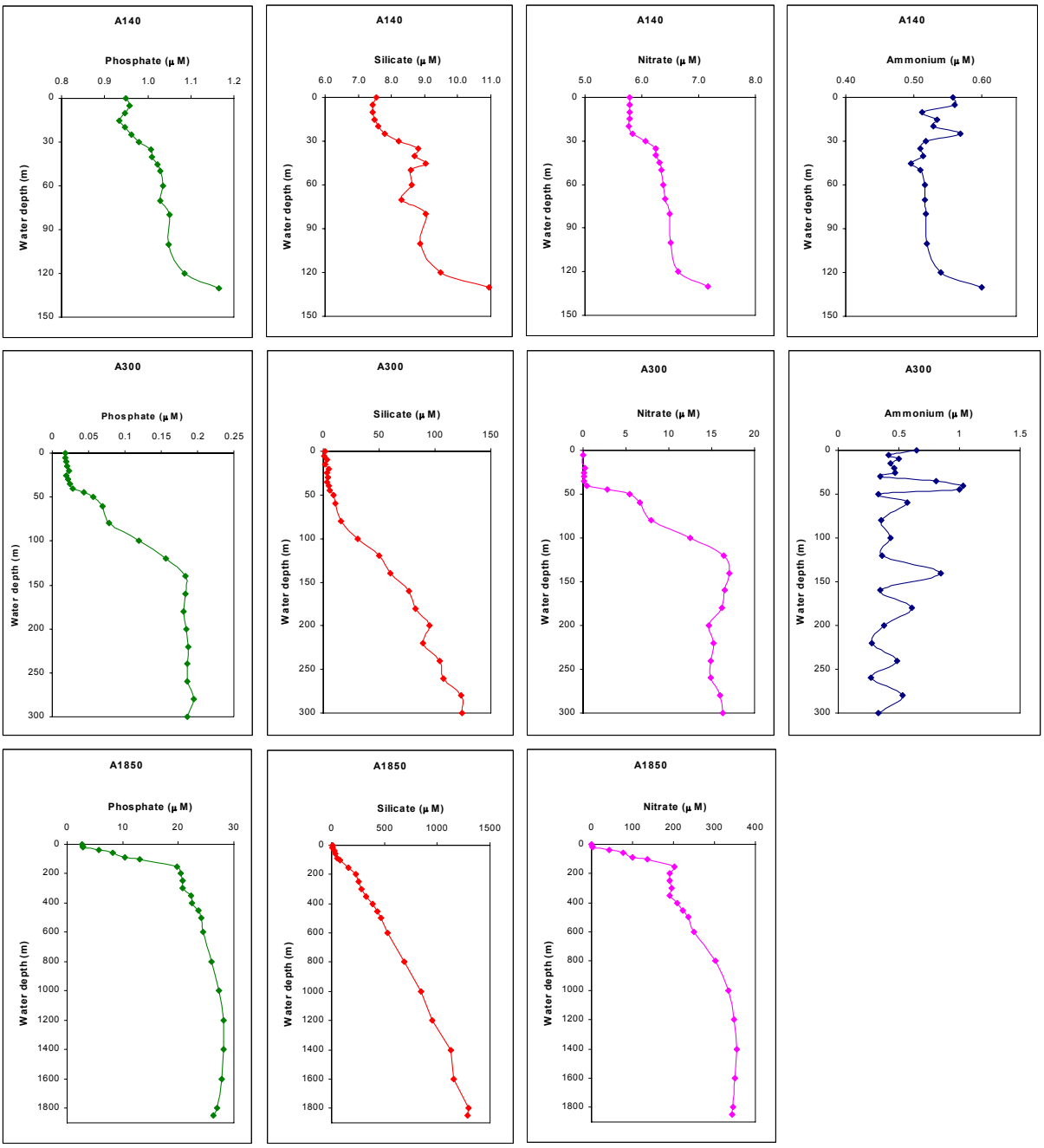


Figure 1: Preliminary CD146 Water-column nutrient data for station A140, A300 and A1850.

Note: Data plotted data are preliminary, and will be subject to post-cruise QA. Data for remaining stations are pending post-cruise analyses and/o processing.

Table 1: CD146 sampling inventory for water-column chemis**try**

Site	**Station Number**	**Gear**	**Depths Sampled**	***Analysis***
A 140	55901#17	CTD	0	Nuts,Chl A POC/PON
			5	Nuts,Chl A POC/PON
			10	Nuts,Chl A POC/PON
			15	Nuts,Chl A POC/PON
			20	Nuts,Chl A POC/PON
			25	Nuts,Chl A POC/PON
			30	Nuts,Chl A POC/PON
			35	Nuts,Chl A POC/PON
			40	Nuts,Chl A POC/PON
			45	Nuts,Chl A POC/PON
			50	Nuts,Chl A POC/PON
			60	Nuts,Chl A POC/PON
			70	Nuts,Chl A POC/PON
			80	Nuts,Chl A POC/PON
			100	Nuts,Chl A POC/PON
			120	Nuts,Chl A POC/PON
			130	Nuts,Chl A POC/PON
A 140	55901#18	BBLS	0.165mab	Nuts,Chl A POC/PON
			0.555mab	Nuts,Chl A POC/PON
			1.01mab	Nuts,Chl A POC/PON
			2.12mab	Nuts,Chl A POC/PON
A 300	55902#16	CTD	0	Nuts,Chl A POC/PON
			5	Nuts,Chl A POC/PON
			10	Nuts,Chl A POC/PON
			15	Nuts,Chl A POC/PON
			20	Nuts,Chl A POC/PON
			25	Nuts,Chl A POC/PON
			30	Nuts,Chl A POC/PON
			35	Nuts,Chl A POC/PON
			40	Nuts,Chl A POC/PON
			45	Nuts,Chl A POC/PON
			50	Nuts,Chl A POC/PON
			60	Nuts,Chl A POC/PON
			70	Nuts,Chl A POC/PON
			80	Nuts,Chl A POC/PON
			100	Nuts,Chl A POC/PON
			120	Nuts,Chl A POC/PON
			140	Nuts,Chl A POC/PON
			160	Nuts,Chl A POC/PON
			180	Nuts,Chl A POC/PON
			200	Nuts,Chl A POC/PON
			220	Nuts,Chl A POC/PON
			240	Nuts,Chl A POC/PON
			260	Nuts,Chl A POC/PON
			280	Nuts,Chl A POC/PON
			299	Nuts,Chl A POC/PON
A300	55901#18	BBLS	0.165mab	Nuts,Chl A POC/PON
			0.555mab	Nuts,Chl A POC/PON
			1.01mab	Nuts,Chl A POC/PON
			2.12mab	Nuts,Chl A POC/PON
A 1850	55910#1	CTD	2	Nuts,Chl A POC/PON
			10	Nuts,Chl A POC/PON
			20	Nuts,Chl A POC/PON
			40	Nuts,Chl A POC/PON
			60	Nuts,Chl A POC/PON

Site	Station Number	Gear	Depths Sampled	*Analysis*
			90	Nuts,Chl A POC/PON
			100	Nuts,Chl A POC/PON
			150	Nuts,Chl A POC/PON
			200	Nuts,Chl A POC/PON
			250	Nuts,Chl A POC/PON
			300	Nuts,Chl A POC/PON
			350	Nuts,Chl A POC/PON
			400	Nuts,Chl A POC/PON
			450	Nuts,Chl A POC/PON
			500	Nuts,Chl A POC/PON
			600	Nuts,Chl A POC/PON
			800	Nuts,Chl A POC/PON
			1000	Nuts,Chl A POC/PON
			1200	Nuts,Chl A POC/PON
			1400	Nuts,Chl A POC/PON
			1600	Nuts,Chl A POC/PON
			1800	Nuts,Chl A POC/PON
			1850	Nuts,Chl A POC/PON
			1857	Nuts,Chl A POC/PON
A 1850	55911#13	BBLS	0.165mab	Nuts,Chl A POC/PON
			0.555mab	Nuts,Chl A POC/PON
			1.01mab	Nuts,Chl A POC/PON
			1.560mab	Nuts,Chl A POC/PON
			2.12mab	Nuts,Chl A POC/PON
A1200	55911#12	CTD	0	Nuts,Chl A POC/PON
			2	Nuts,Chl A POC/PON
			5	Nuts,Chl A POC/PON
			10	Nuts,Chl A POC/PON
			15	Nuts,Chl A POC/PON
			20	Nuts,Chl A POC/PON
			30	Nuts,Chl A POC/PON
			40	Nuts,Chl A POC/PON
			60	Nuts,Chl A POC/PON
			80	Nuts,Chl A POC/PON
			100	Nuts,Chl A POC/PON
			150	Nuts,Chl A POC/PON
			200	Nuts,Chl A POC/PON
			250	Nuts,Chl A POC/PON
			300	Nuts,Chl A POC/PON
			350	Nuts,Chl A POC/PON
			400	Nuts,Chl A POC/PON
			450	Nuts,Chl A POC/PON
			500	Nuts,Chl A POC/PON
			600	Nuts,Chl A POC/PON
			700	Nuts,Chl A POC/PON
			900	Nuts,Chl A POC/PON
			1100	Nuts,Chl A POC/PON
			1150	Nuts,Chl A POC/PON
			1183	Nuts,Chl A POC/PON
A 940	55923#2	BBLS	0.165mab	Nuts,Chl A POC/PON
			0.555mab	Nuts,Chl A POC/PON
			1.01mab	Nuts,Chl A POC/PON
			1.560mab	Nuts,Chl A POC/PON
			2.12mab	Nuts,Chl A POC/PON

KEY: *BBLS* *Benthic boundary layer sampler*
Nuts Nutrients (ammonium, phosphate, silicate, nitrate, nitrate)

Chl A	Chlorophyll, other pigments and degradation products
POC/PON	Particulate organic C and N
mab	*Meters above bottom*

Table 2: A list of all CD146 nutrient data files and corresponding sample descriptions.

File name	Description
081.eli	Elinor incubations, nutrients
010503d	Elinor incubations, Nitrite
030503a	Cu-Cd column efficiency test
040503h	Elinor and Shipboard incubations, Nutrients
050503b	Elinor and Shipboard incubations for Nitrite
050503c	A 1850 Porewaters for Nitrite
050503d	A 1850 BBLS
060503b	A 1850 Porewaters for Nutrients
070503b	A 1850 CTD and shipboard incubations for Nutrients
080503b	A 1850 CTD and shipboard incubations for Nitrite
220403b	A 140 porewaters
220403c	A 140 porewaters
A140pw	A 140 pore waters
250403c	A 140 CTD, Elinor and shipboard incubations for Nutrients
260403c	A 140 CTD, Elinor and shipboard incubations for Nitrite
260403d	A 140 Porewaters for Nitrite
290403a	A300 CTD and Porewaters for Nutrients
290403c	A300 Shipboard incubations for nutrients
300403b	A300 CTD, Shipboard incubations for Nitrite
300403d	A300 porewaters for nitrite
300403e	Elinor incubations for Nitrite

Tasos Anestis

10.2 Sediments.

10.21 Visual observations, photography, X-radiography

Thirty one sediment slabs were examined from 15 different water depths. Depth-related trends are summarized below and in Table 1.

Fully bioturbated sediments with tube and burrow structures present are found above the oxygen minimum zone at 140 m (Fig 1a), and in the lower OMZ, from 1000 – 1200 m [Fig. 1; l,m,n] as well as below the OMZ (1850 m [Fig. 1o]). Irregular, disturbed laminations are present within the upper portion of the oxygen minimum zone (300, 400 m [Fig. 1b,c]), and uniform, unbroken, seasonal laminations (< 1 mm thick) are present at 600-800 m [Fig. 1 d,e,f]. In many cases these laminations are can be observed directly in sediments without x-rays [Fig. 2]. From 700 to 950 m [Fig. 1e-k] there is a dense layer of light colored clay located about 5-6 cm below the surface. This probably represents some sort of relatively local event (e.g., turbidity flow, slump or flood deposition). In the lower portion of the OMZ (850-950 m) vertical burrows overlie laminations (Fig 1 i,j,k). A list of observations from individual x-radiographs is given below.

ABOVE THE OMZ

140 m

55901#8 (short thin cores)

Burrow networks to 6-7 cm
Burrow diameters range from 0.25 to 0.3 mm , oriented both horizontally and vertically
Tubes present (1.5 mm diameter)
Sediments relatively homogenous to 12 cm (depth of core)
Higher and lower density 'patches' (not laminae)

55901#10 (long core – slumped somewhat)

Sediments homogeneous to 18.5 cm
Very fine burrows < 0.25 mm)

55901#10 (thin slab)

Lg burrow in center (possibly a crack), diameter 1.5 cm at widest, narrows to 0.4 cm, burrow visible to 7 cm
Fine burrow network, criss crossing sediment, 0.2 to 0.5 mm diameter
Burrows present to 7. 5 cm
Feather tube visible (cirratulid?)
High and low density patches

OMZ CORE

300 – 400 m

55902#2, 55902#13, 55093#1,2,3
Laminated sediments, to at least 12 cm.
Laminations broken and wavy, with evidence of disturbance
Surface sediments are finely laminated (< mm scale).

600 m

55916#2 Laminated to 12.5 cm.
Wavy laminations, 1mm to 4 mm thick.
No biogenic features

712 m

55919#1 Uniform, unbroken laminations throughout to 19 cm
Laminations very fine: 0.5 to 1mm
Dense layer (appears white) present 8.2 to 8.5 mm below surface
Possible (?) burrows visible at 1.0, 4.5 and 10.5 cm below surface
Soupy, low density layer on surface (few mm)

737 m

55922#2 Sediments laminated to 12.5 cm
Laminae very fine: 0.5 to 1 mm
High density (event?) layer 6.5 to 7 cm and 7.3 to 7.4 cm below surface.
Single burrow (?) 1.5 to 2 cm below surface, 1.5 mm diameter

OMZ TRANSITION ZONE

800 m

555915#1 Laminated to 10.5 cm
Laminae 1 mm thick
High density layer 5.5 to 5.9 cm and 6.3 cm below surface
Faint vertical burrows visible throughout core

850 m

55914#1 Laminated to 12.5 cm
Laminae 1 mm thick
High density layer 5.6 to 5.8 mm and 6.3 to 6.4 mm below surface
VERY faint vertical burrows: 1mm wide and 1 cm long

55921#1 Laminated throughout to 12.5 cm.
Laminae range from 0.5 mm to 1 cm (light/dark zones)
Dense sediment layer 5.5 to 5.8 cm and 6.1 to 6.2 cm below
Burrows overly lamination to core bottom, most dense in to 6 cm
Burrows are vertical: 1-2 mm wide, 0.5 to 1.5 cm long

900 m

55909 #1 Cm-scale laminations to 21 cm, mostly 4-9 mm thick.
Laminations are more evident in upper 10 cm than below.
Faint burrow network and mottling present to 5.5 cm, overlying laminations.
No evidence of mm-scale fine laminations.
Dense sediment layer (appears white) at 6.5-7.1 cm below surface. Some thin laminae evident below this.

940 m

55913#1 Faint laminations to 21.5 cm
Dense sediment layer 5.5 to 6.4 cm
Vertical burrows to 6.5 cm
2 sm (few mm) clam shells at surface (thyasirids)
tube 1 cm long at surface. 1 mm diameter
few biogenic features below 6 cm

55918#4 Faint laminations to 19.5 cm: laminae 4 to 10 mm thick
High density layer 5.3 to 6. 1 cm and 6.4 cm below surface
Dense burrows to 5.8 cm, overlying laminations
Burrows vertical and horizontal, reaching to surface: 1-2 mm diameter, up to 3 cm long
Thyasirid(?) clam at surface

55918#5 Faint laminations to 13.5 cm
Dense sediment layer at 5.4 to 5.9 cm below surface
Dense, small burrows to 5.8 cm

	Clam shells present
	1 tube 2 cm long and 2 mm wide located 3.5 to 5 cm below surface
	Few biogenic features below 6 cm
55918#9	Faint laminations to 21.5 cm (cm scale laminae)
	2 thyasirid shells in upper 1 cm
	Dense sediment layer (white) at 5.5 to 6.1 cm and 6.2 cm below sed surfacer
	Dense burrow network in upper 6 cm
	Mottling of sediments from 13 to 15 cm
55918#10	Very faint laminations on cm scale
	Dense layer 5.3 to 5.67 cm and 6.0 cm below surface
	Dense small burrows in upper layers to 5.8 cm (1 mm diameter)
	One large, vertical burrow: 4.8 cm long extending to surface, 4 mm wide (anemone)?
1000 m	
55920#1	Bioturbated to 23 cm
	Heavily mottled (light/dark patches) in upper 6 cm and 9-11 cm
	Lower density sediment layer at 6.5 to 9 cm
	Uniform sediment below 11 cm
	Void spaces 0.7 to 2.5 cm below surface.
55907#1	Sediments mottled (mixed?) to 6.5 cm.
	High water content in top 6.5 cm
	No laminations to 12-13 cm.
1050 m	
55906#1	High water content in top 5 cm
	Fully bioturbated and no laminations to 12-13 cm.
	Horizontal burrows or mottling in upper 4 cm. No features below.

1100 m

55905#2 High water content to 5 cm, no biogenic features below
Fully bioturbated to 12 cm
Faint burrows in upper 5 cm
No laminations (to 12 cm)

1200 m

55911#10 Bioturbated to 22cm
7 tube pieces present in upper 4 cm. Most 2mm, 4mm, 1.5mm inside diameter. About 1-2 cm long.
Mottling of sediment throughout the core
No density variation evident downcore

55911#7 Mottling of sediment to 13 cm
Fine burrow networks to 4.5 cm. 0.2-0.3 mm diameter
Horizontal tube pieces (1.5-2.5 mm wide)

55911#10 Bioturbated to 22 cm
Tubes in upper 3 cm: 3 mm diameter, 1 –2 cm long
Horizontal tube: 4 mm diameter
Some void areas present

55911#15 Bioturbated to 17.2 cm
Fine burrows present to 15.5 cm: < 1 mm diameter
2 tubes: 0.4 mm diameter 2.5 to 3.5, 12.5-12.8 cm below surface
High and low density sediment patches

BELOW THE OMZ

1850 m

55910#2 Heavily burrowed in upper 5-6 cm (network of vertical & horizontal burrows)
Burrow diameter ranges from 0.5 to 4 mm
Mottling of sediment below 6 cm

55910#2 Bioturbated to 20 cm
Tube present at surface (3.5 mm i.d.) and at 5-6 cm below surface (4 mm i.d.)
Burrows evident to 12 cm
High water content to 6.5 cm (greatest mixing)

55910#2 c. 4 Bioturbated to 12 cm
Heavily burrowed to 5.5 cm
Vertical and horizontal burrows: 0.5 mm to 4 mm diameter

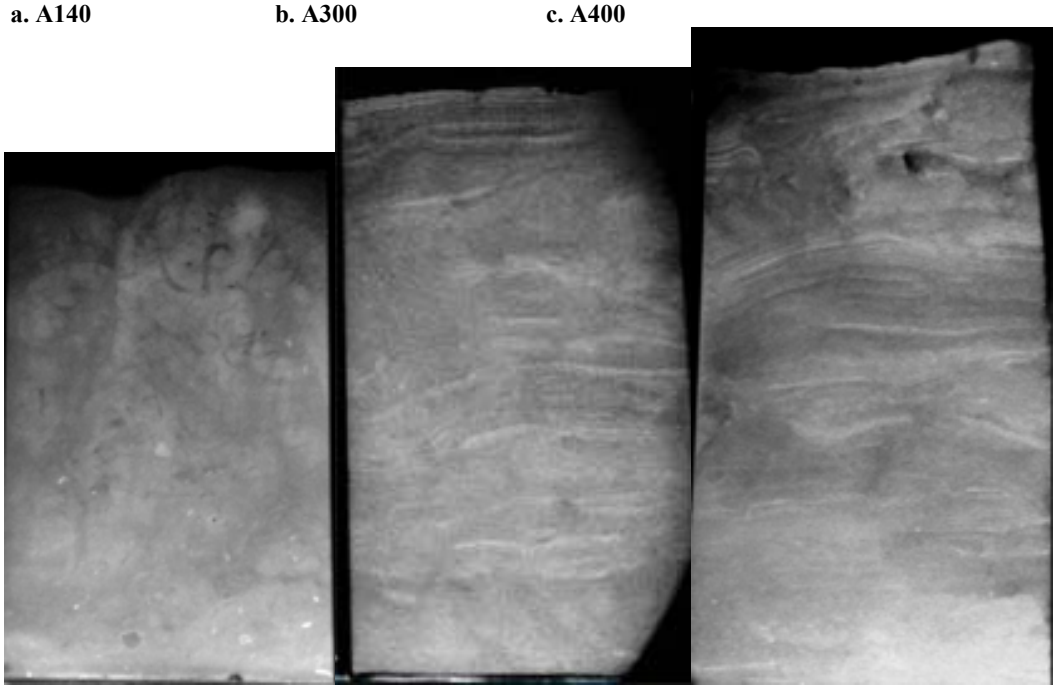
Table 1. Summary of x-radiographs taken on CD 146.

Date	Water	Station no.	Core	Core	Exposure	x ray type	comments
2003	**Depth (m)**		**Type**	**No.**		**all slabs 9-12 mm thick**	
18-Apr-03	150	TEST/DEMO	Mega	2	20 s, 16.3 s		Sat on Deck for 2.5 wk
21-Apr-03	140	55901#8	Mega	IX	14, 16.3	3 short slabs	soupy sed.
22-Apr-03	140	55901#10	Mega	VII	15 S	2 short slabs	slumped (need to clamp 4th plate
22-Apr-03	140	55901#10	Mega	X	15 s	1 long slab	
25-Apr	300	55902#2	Mega	IV	12, 14 s	2 short slabs	top mounded (sides pulled down)
27-Apr	300	55902#13	Mega	V		3 short slabs	photo of Vb
27-Apr	300	55902#13	Mega	IV		1 long slab	photo of Vb
2-May	400	55903#1	Mega		10/12: 13/15	1 short, 1 long	
2-May	400	55903#2	Mega		10 s	1 short	all three A400 short cores combined
2-May	400	55903#3	Mega		10 s	1 short	for a single shot (10 s and 12 s).
4-May	1850	55904#5	Mega	9	20 s	1 long	overexposed
5-May	1850	55904#11	Mega	4	20 s	3 short	overexposed
6-May	1850	55904#15	Mega		20 x		overexposed
6-May	1100	55905#2	Mega	4	8 s		

Date	Water	Station no.	Core	Core	Exposure	x ray type	comments
2003	Depth (m)		Type	No.		all slabs 9-12 mm thick	
6-May	1050	55905#1	Mega		8 s	1 short	
6-May	1000	55907#1	Mega	10	8 s	1 short	
6-May	900	55909#1	Mega		10 s	1 long	
8-May	1850	55910#2	Mega	4	14, 10 s	3 short	
8-May	1850	55910#2	Mega	12	10 s	1 long	
10-May	1200	55911#7	Mega	3		3 short	
11-May	1200	55911#10 (11)	Mega	1	10 s	1 long	good exposure
13-May	940	55913#1	Mega	1	8 s?	1 long	
15-May	940	55918#2	Mega	1	8 s	1 long - new core	
16-May	940	55918#4	Mega	3	6.2 s, 7.3 s	1 long	
16-May	940	55918#5	Mega	4	6.2 s	2 short	
17-May	940	55918#9	Mega	5	6.3 s	1 long	
17-May	940	55918#10	Mega	7	6.3 s	1 short	
18-May	A712	55919#1	Mega	12	6.3 s	1 long	good exposure (photo)
19-May	1000	55920#1	Mega	7	8 s	1 long	good exposure
20-May	850	55921#	Mega	3	6.3 s	1 short	good exposure (photo)
20-May	750	55922#2	Mega	11	6.3 s	1 short	good exposure (photo)

Figure 1. X-Radiographic Images of Pakistan Margin Sediments.

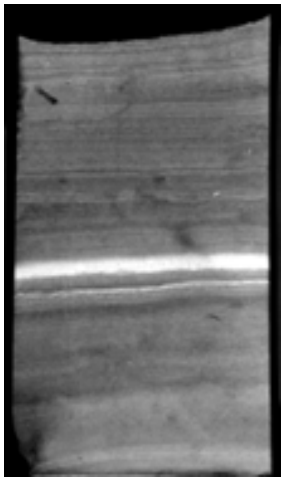
a. A140 **b. A300** **c. A400**



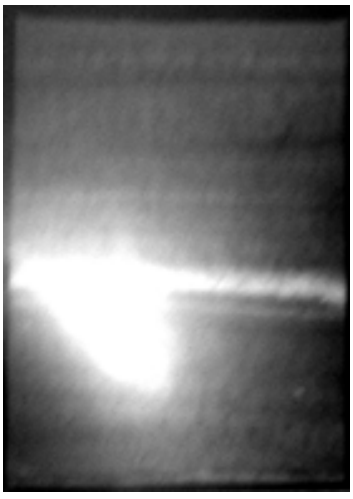
d. A600

e. A700

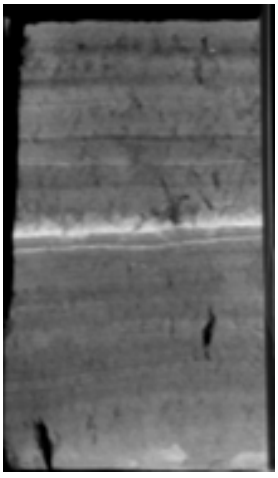
f. A750



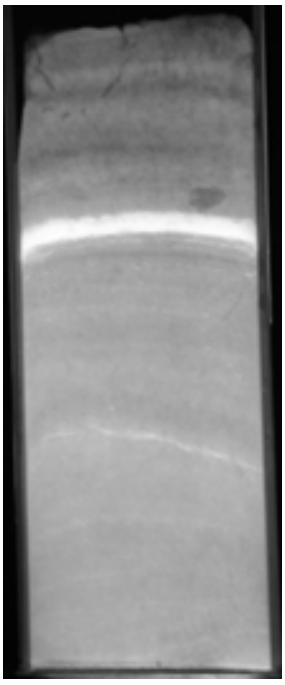
h. A800



i. 850



j. 900



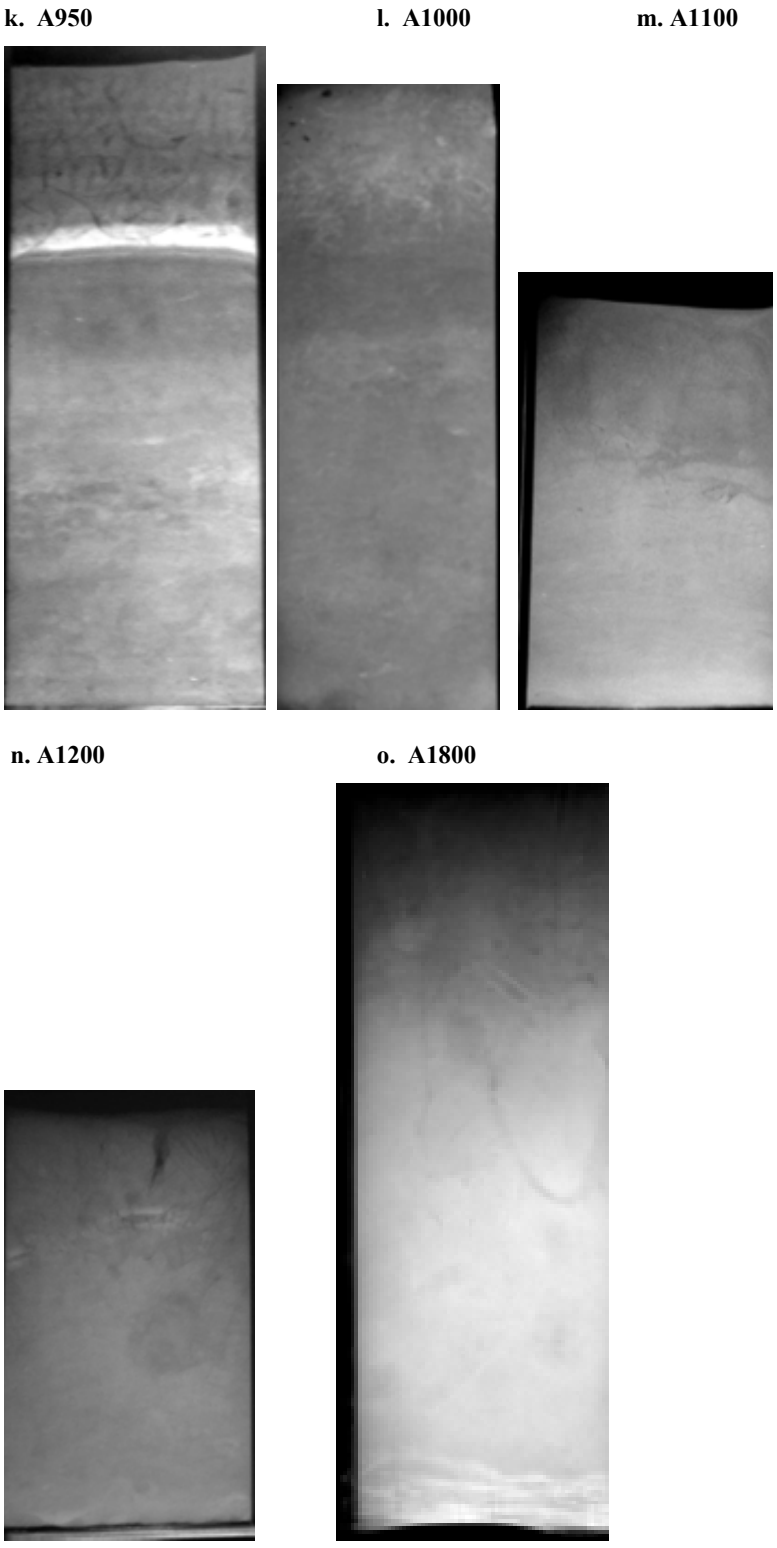


Figure 1. X-radiographs of sediments from the Pakistan margin. Bioturbated sediments are found at 140 m, and from 1000 m and deeper. Irregular, disturbed laminations are present within the upper portion of the oxygen minimum zone (300, 400 m), and undisturbed laminations are present at 600-800 m. In the lower portion of the OMZ (850-950 m), burrows overlay laminations.

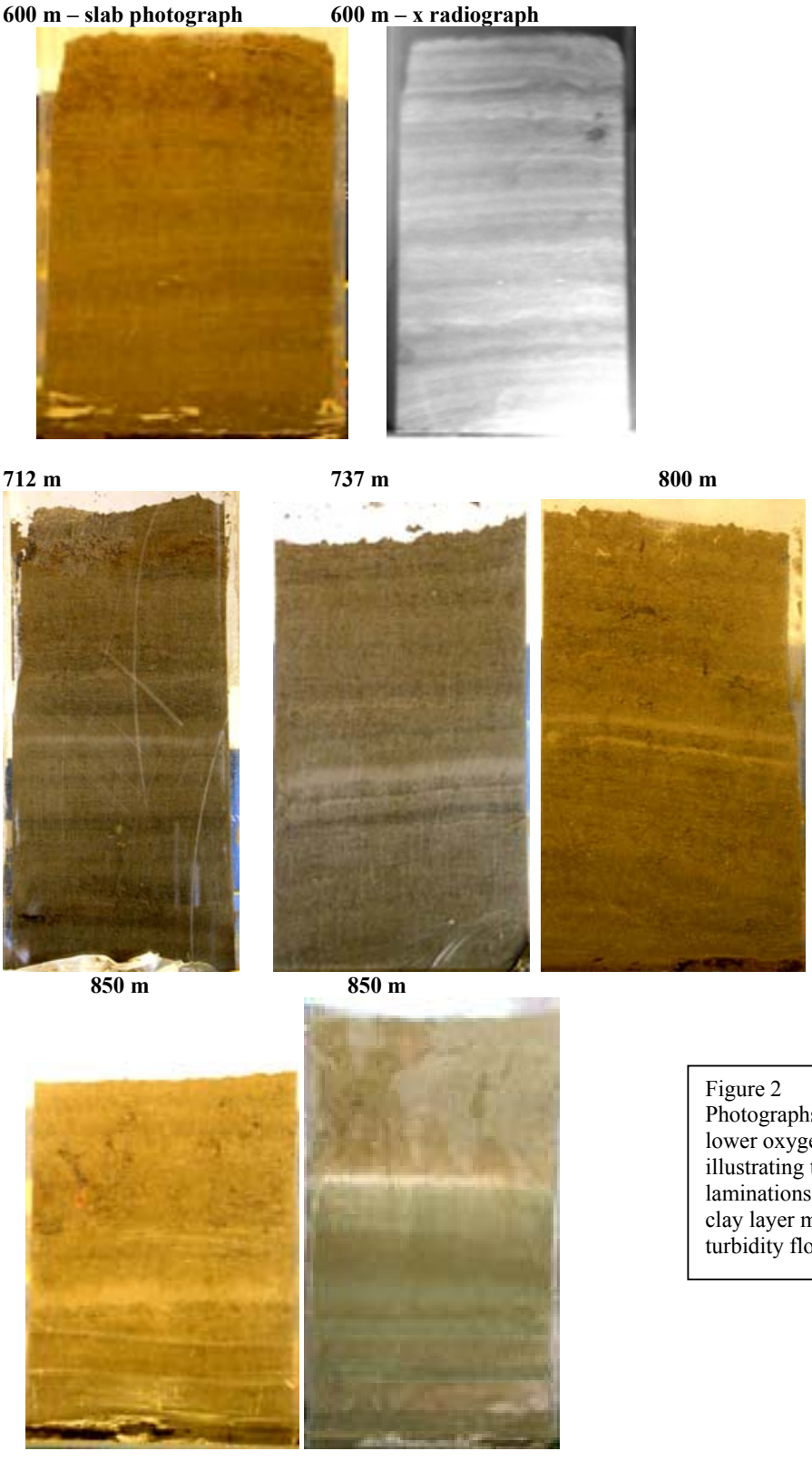


Figure 2
Photographs of sediment slabs in the lower oxygen minimum zone illustrating the presence of laminations. The dense white clay layer may represent a turbidity flow, slump or other event.

Lisa Levin (M. Danish, H. Andersson)

10.22 Faunal sampling

10.22.1 Metazoan macrobenthos:

A. Quantitative Macrobenthos Survey Sampling at Main Stations for Gage/Lamont (CSUR)
A total of 46 cores from 17 megacore drops were sectioned and preserved for SAMS survey work. Samples are logged in Table I. They include the following:

*140 m (16 cores: 7 drops including 7 vertically sectioned cores and 9 cores 0-10/10-20)
*300 m (3 cores: 1 drop including 1 vertically sectioned core and 2 cores 0-10/10-20 cm)
*940 m (15 cores: 5 drops including 5 vertically sectioned cores & 10 cores 0-10/10-20 cm
*1200 m (6 cores: 2 drops including 2 vertically sectioned & 4 cores 0-10/10-20 cm)
*1850 m (6 cores: 2 drops including 2 vertically sectioned & 4 cores 0-10/10-20 cm)

A detailed sample list is provided in Table Levin-1. A description of community composition is given in section 10.32 (Metazoan and protozoan assemblages).

Table I-A
Macrobenthos survey samples collected for J. Gage and P. Lamont (SAMS).

Date	Water depth	Station no.	Core no.	Vertical Fractions standard (0-0.5, 0.5-1, 1-2,2-3,3-5, 5-10,10-15,15-20)
20-Apr-03	A140	55901#2	III	all vertical fractions
				8 Pelosina removed (0-0.5 cm) by Gooday
21-Apr-03	A140	55901#8	VI	all vertical fractions
21-Apr-03	A140	55901#8	X	0-10, 10-20 cm
21-Apr-03	A140	55901#9	V	0-10, 10-20 cm
21-Apr-03	A140	55901#9	VII	all vertical fractions
22-Apr-03	A140	55901#10	I	all vertical fractions
22-Apr-03	A140	55901#10	IX	0-10, 10-20
				1 Pelosina removed (0-0.5 cm) by Gooday
23-Apr-03	A140	55901#14	XII,	all vertical fractions
23-Apr-03	A140	55901#14	II	0-10, 10-20
23-Apr-03	A140	55901#14	XI	0-10, 10-20
23-Apr-03	A140	55901#16	VIII	all vertical fractions
				4 Pelosina removed (0-0.5 cm) by Gooday
23-Apr-03	A140	55901#16	IX	0-10, 10-20
				4 Pelosina + 1 mud wall astrorhizid removed
23-Apr-03	A140	55901#16	VI	0-10, 10-20
				5 Pelosina removed from 0-0.5 cm.
25-Apr-03	A300	55902#2	I	all vertical fractions
25-Apr-03	A300	55902#2	II	0-10,10-20
25-Apr-03	A300	55902#2	III	0-10, 10-20
4-May-03	A1850	55904#5	VII	all vertical fractions 1 gromid removed by Gooday
4-May-03	A1860	55904#5	IX	0-10, 10-20
4-May-03		55904#5	I	0-10, 10-20
	A1860			

Date	Water	Station no.	Core no.	Vertical Fractions
4-May-03	A1860	55902#6	III	all vertical fractions
4-May-03	A1860	55902#6	VIII	0-10, 10-20 1 gromid removed by Gooday
4-May-03	A1860	55902#6	IV	0-10, 10-20
10-May-03	A1200	55911#7	5	all vertical fractions
10-May-03	A1200	55911#7	4	0-10, 10-20
10-May-03	A1200	55911#7	10	0-10, 10-20
11-May-03	A1200	55911#10	10	all vertical fractions Note cores labelled as 55911#11
11-May-03	A1200	55911#10	11	0-10, 10-20 Note cores labeled as 55911#11
11-May-03	A1200	55911#10	12	0-10, 10-20 Note cores labeled as 55911#11
15-May-03	A950	55918#2	?	all vertical fractions
15-May-03	A950	55918#2	?	0-10, 10-20
15-May-03	A950	55918#2	?	0-10, 10-20
16-May-03	A950	55918#4	8	all vertical fractions
16-May-03	A950	55918#4	6	0-10, 10-20
16-May-03	A950	55918#4	12	0-10, 10-20
16-May-03	A950	55918#5	10	all vertical fractions
16-May-03	A950	55918#5	11	0-10, 10-20
16-May-03	` A950	55918#5	9	0-10, 10-20
17-May-03	A950	55918#9	2	all vertical fractions 4 Pelosina removed by Gooday
17-May-03	A950	55918#9	9	0-10, 10-20
17-May-03	A950	55918#9	8	0-10, 10-20
17-May-03	A950	55918#10	12	all vertical fractions
17-May-03	A950	55918#10	6	0-10, 10-20
17-May-03		55918#10	10	0-10, 10-20

B. Fine Scale Transition Zone Sampling of Macrobenthos. (CSIO)

Megacore samples were collected from the following depths across the lower portion of the oxygen minimum zone, where oxygen starts to increase (0.1 to 0.3 ml/l): 712 m, 737 m, 800 m, 850 m, 900 m, 940 m, 1000 m, 1050 m and 1100 m. One or two cores were sectioned and preserved at each depth. A list of samples is provided in Table Levin-2. Faunal observations based on analysis of material sieved live and examined under the dissecting microscope are given in the section titled "Metazoan and Protozoan Assemblages on the Pakistan Margin".

Table I-B. List of macrobenthos samples collected for analysis at SIO
Samples were sectioned at 0-1,1-2, 2-5, 5-10, and 10-20 cm intervals.
Sections > 2 cm were sieved in a 300 μm mesh before preservation.

Date (2003)	Water depth	Station no.	Core Type	Core no.
24-Apr	A140	55901#14	Mega	5
24-Apr	A140	55901#16*	Mega	6
26-Apr	A300	55902#2*	Mega	XII
5-May	A1850	55902#6	Mega	9
7-May	A1100	55905#2	Mega	N/A
7-May	A1050	55906#1	Mega	N/A
7-May	A1000	55907#1	Mega	N/A
7-May	A950	55908#1	Mega	N/A
7-May	A900	55909#1	Mega	N/A
7-May	A900	55909#1	Mega	N/A
7-May	A1050	55906#1	Mega	6
7-May	A938	44908#1	Mega	N/A
9-May	A1850	55910#1*	Mega	1
12-May	A1200	55911#10 (11)	Mega	6
14-May	A950	55913#1	Mega	10
14-May	A850	55914#1	Mega	6
14-May	A800	55915#1	Mega	3
14-May	A600	55916#2	Mega	3
15-May	A1200	55917#4*	Mega	4
18-May	A950	55918#10	Mega	3
20-May	A700	55919#1	Mega	N/A
20-May	A1000	55920#1	Mega	3
21-May	A850	55921#1	Mega	1
21-May	A750	55922#2	Mega	5
22-May	A950	55929#1*	Mega	1

* = profiled for oxygen by Eric Breuer.

C. Background Metazoan Macrofaunal Communities:
Characterization and Samples for Biogeochemical Analyses (CBIO).

Large numbers of megacore samples were sieved on a 300 μm mesh and macrofauna (>300μm) were sorted live under the dissecting microscope to (a) obtain background macrofauna for biogeochemical analyses, and (b) provide information about changing community composition across the OMZ. Table Levin-3 lists cores collected for this work. In some cases samples were not sorted and had to be thrown away due to lack of person power. A separate log of faunal samples frozen for biogeochemical studies was created and is given in Table Levin -4. A total of 418 invertebrate samples, 15 bacteria samples and 9 plankton/phytoplankton samples were collected. Among the invertebrates there were 11 mixed meiofauna, 10 mixed macrofauna and 3 nematode samples. Polychaetes were dominant (258 samples), followed by crustaceans (47), molluscs (39), echinoderms (29), cnidarians (8), other vermes (6) porifera (4), and tunicates (3). These samples reflect the relative rate of encounter of different groups over the entire Pakistan margin, and indicate the clear dominance by polychaetes across all stations (62% of total fauna).

A preliminary characterization of the benthic macrofaunal communities is provided in the section titled "Metazoan and Protozoan Assemblages on the Pakistan Margin" by Larkin et al. Briefly, macrofauna were most abundant at the station above the OMZ (140 m; O_2 > 1.5 ml/l) and in the OMZ transition zone (850-950 m; O_2 = 0.25-0.35 ml/l). The shallow station was moderately diverse, and included a relatively large compliment of crustaceans (35% - amphipods and cumaceans) as well as polychaete species belonging to at least 10 families. Macrofauna were rare to absent in the OMZ core (300 m-700 m), with only 2 spionid individuals recovered. Macrofauna appear again at about 800-850 m with a very low diversity assemblage dominated by amphinomid and spionid polychaetes. This assemblage becomes moderately diverse and includes molluscs, echinoderms, cnidarians, crustaceans and other polychaetes by 940 m. Detailed observations at this site indicate infaunal dominance by amphinomid, cirratulid and spionid polychaetes and thyasirid bivalves, with high densities of ophiuroids on the surface. Faunal biomass appears to be highest at this station of all those examined. The OMZ

lower boundary (1200 m) exhibits a low density of macrofauna and very small macrofaunal body size (and biomass) in the upper 10 cm. The 1200 m sediments contain large, deep burrows and it is clear that several high biomass, bioturbating species are living deep in the sediment column. A single large, tube-building onuphid polychaete was found at this station, but no other large forms were recovered. Below the OMZ the better oxygenated 1850 m sediments (O_2 > 1.5 ml/l also exhibit low macrofaunal density, but higher diversity, with peracarid crustaceans, aplacophoran and bivalve molluscs, priapulids and other groups becoming more common. The Pakistan margin fauna differs substantially from that observed in 1994 off Oman in having much lower faunal densities at upper slope depths (400-850 m) and notably fewer large, tube building spionid polychaetes at these depths. Similarities included reduced macrofaunal diversity within the OMZ and dominance by polychaetes. Mudball-building cirratulid polychaetes were present on the Oman and Pakistan margins, but they appear to be different species and occur at different depths (850 m off Oman, 1850 m off Pakistan).

Table I-C
Samples processed for live sorting of macrofauna for biochemical analyses.

Date 2003	Water depth	Station no.	Core Type	Core no.	Vertical Fractions
20-Apr	137	55901#2	Mega	III	BULK - Top 20 cm, sieved 300 microns
21-Apr-	A140	55901#5	Multi	1,2,7	BULK - Top 10 cm combined, 300 micron sieve
23-Apr-	A140	55901#14	Mega	7	CBIO - Bulk sieved 0-10 cm
23-Apr-	A140	55901#14	Mega	8	CBIO - Bulk sieved 0-10 cm
23-Apr-	A140	55901#14	Mega	9	CBIO - Bulk sieved 0-10 cm
2-May	A400	55903#1	Mega	10	0-5, 5-10 CBIO
2-May	A400	55903#2	Mega	3	0-5, 5-10 CBIO
2-May	A400	55903#3	Mega	?	0-5, 5-10 CBIO
3-May	A1850	55904#2	Mega	1,2,3,6	Bulk
4-May	A1850	55902#6	Mega	2 cores	combined 0-2, 2-5, 5-10, > 10 cm
4-May	A1850	55902#7	Mega	9,10,12	CBIO BULK - Top 10 cm
5-May	A1850	55904#11	Mega	4	CBIO Bulk - residue fromx ray sieved 0-10 cm
6-May	A1050	55906#1	Mega	12	CBIO - Live sieved 0-10, 10-20 cm for picking on ship
6-May	A900	55909#1	Mega	4	CBIO - Live sieved 0-10, 10-20 cm for picking on ship
6-May	A1000	55907#1	Mega	3	CBIO - Live sieved 0-10, 10-20 cm for picking on ship
8-May	A1200	55911#2	Mega	7,9,10,12	CBIO: 0-2, 2-5, 5-10, > 10
9-May	A1200	55911#5	Multi	2,4,5,7,8,9	CBIO, 0-10, 10-20
10-May	A1200	55911#9	Multi	2,3,5,6,7,8, 9,10,12	CBIO - Live sieved 0-10, 10-20 cm for picking on ship
11-May	A1200	55911#10	Mega	4 cores	0-10 cm only sieved on 300 microns
16-May	A950	55918#4	Mega	6	CBIO - Live sieved 0-1,2-5,5-10,>10
16-May	A950	55918#5	Mega	4	CBIO - Live sieved 0-10 cm, residue from x ray core.
16-May	A950	55918#4	Mega	4	0-10 cm live sieved
17-May	A950	55918#9	Mega	5	0-5 cm (partial , live sieved)
17-May	A950	55918#9	Mega	3	sieved on 300 micron mesh: 0-2, 2-5, 5-10
17-May	A950	55918#10	Mega	5	from around x ray , 0-5 cm, sieved on 300 micron
18-May	A950	55918#12	Mega	9,12	0-10 cm,300 microns live sieved CBIO
19-May	A950	55918#14	Mega	3,8,10	0-10 cm,300 microns live sieved CBIO
19-May	A1000	55920#1	Mega	7	0-10 cm partial core, live sieved on 300 micron mesh
19-May	A1000	55920#1	Mega	12	0-2, 2-5, 5-10 cm live sieve, 300 micron mesh
20-May	A850	55921#1	Mega	3	0-10 cm live sieved, from around x ray slab
20-May	A750	55922#2	Mega	11	0-10 cm live sieved, from around x ray slab

Lisa Levin

10.22.2 Metazoan and protozoan assemblages

Observations on sediments and macrofauna (metazoans and foraminiferans)
This section includes observations made at each sampling depth. Systematic faunal observations were made on sieved fractions (usually >300μm) of incubated samples, opportunistic observations on other material, and examination of core surfaces. These revealed distinct trends in the structural and taxonomic characteristic of the faunal assemblages across the OMZ.

130-140 m (55901, 55931: 23º17'N 66º 42') *ABOVE OMZ*
Sediments: Sediments are muddy with shelly fragments, mainly from pelagic pteropods, and calcareous corals, echinoderms and other benthic invertebrate hard parts. Sediments > 300 μm include a large fraction of polychaete fecal pellets. The upper 12 cm of the sediment column are relatively homogeneous and fully bioturbated, with tube and burrow structures visible in x radiographs.
Metazoans: Macrofauna > 300 μm here are relatively abundant (Fig. 1B), on the order of 3,000 to 6000 ind./m^2. The macrofauna consisted mainly of polychaetes (about 60%) and ampeliscid amphipods (about 30%). At least 10 polychaete families were present; the most abundant were cirratulid and paraonid polychaetes. A large, tube building eunicid polychaete (about 1 per core) a maldanid polychaete are deep dwelling species that may transport carbon down the sediment column. Small ophiuroids, bivalves and gastropods were present at low densities in the upper cm of sediment. The macrofaunal assemblage at this site was among the most diverse of the stations sampled, despite high dominance by *Ampelisca*. Few metazoan meiofauna were observed in the > 300 μm residues.
Foraminifera: Large *Pelosina* specimens were common on core surfaces with between 1 and >10 specimens found in single cores (fig. 1A). Large 'mud-walled astrorhiziids' were occasionally visible and a single large, flat *Peneroplis*-like miliolid was observed. The >300 μm fraction of surface sediments from this shallow site were dominated by calcareous foraminifera. A species of *Rectuvigerina* that also occurs on the Oman margin was the most abundant and typically contained naturally red or olive green protoplasm. Also common were large multichambered lageniids (nodosariids and lenticulinids), *Globobulimina*, a triangular *Textularia*, *Oridoralis*, *Bathysiphon* spp., *Sigmoilopsis*, *Reophax* spp., *Cancris* and a variety of miliolids (*Quinquiloculina*, *Pyrgo*, *Ophthalmidium*, *Cornuspira*). Allogromiids, represented by several species, were uncommon. The only foraminifera present below the top 1cm were occasional *globobulimina* sp. And *Reophax* sp. Species of *Rectuvigerina* that appeared fresh and had some dark contents occurred in all sediment layers.

300m [295-305 m] (55902: 23º 12'N 66º 33'E) *WITHIN OMZ*
Sediments: Sediments are soupy with many detrital aggregates that do not pass through a 300 μm mesh. Clear color zonation was evident in cores, with a single (Fig. 1C) or double layer of orange Fe/Mn oxide within a few mm of the sediment surface. X rays indicate lamination occurs throughout the sediment column, but are relatively disturbed and appear wavy. Filamentous bacteria are also abundant.
Metazoans: Macrofauna are nearly absent. Only 2 spionid polychaetes were found in analysis of surface sediments from about 10 mega cores; both polychaetes were in the Elinor ^{13}C deployment (296 m 23º 12.936'N 66º 33.372'E). These were very small individuals, probably *Prionospio* (*Minuspio*) (Fig. 1D).
Foraminifera: *Pelosina* occurred on core surfaces and was less common (max density 4 per core) but larger than at 140 m. The most common foraminiferans in the >300μm fraction were relatively small and moderately diverse considering the highly dysoxic nature of this site. Many of these taxa were calcareous e.g. *Rectuvigerina, Cassidulina, Brizalina* and *Globobulimina*. However, a number of agglutinated taxa were also common, in particular a slender white *Bathysiphon,* two *Reophax* spp., a small *Ammodiscu*s sp. and *Leptohalysis* sp. Particularly notable was the discovery of a fairly diverse assemblage of monothalamous foraminifera. These included a variety (>10 species in single samples) of agglutinated and organic-walled monothalamous foraminifera, some of which were fairly common. Among them were long, cylindrical saccamininds (>1 species) with silvery surfaces and two terminal apertures, an elongate, irregularly-shaped white saccamminid, a thread-like allogromiid (?*Nemogullmia*), a small *Tinogullmia* sp., and various oval allogromiids. Several specimens of the recently described genus *Toxisarcon* (Cedhagen et al., 2002, Wilding, 2002) were found a few millimetres below the surface. Miliolids were represented by very occasional dead individuals.

Microscopic examination of cores revealed the presence of many foraminifera living either on or just below the surface of the crust-like surficial sediment layer. Taxa commonly observed in this microhabitat included *Ammodiscus* (sometimes partly uncoiled)*, Rectuvigerina, Reophax, Cassidulina* and the cylindrical saccamminids. *Globobulimina* spp. were usually found below the sediment surface together with *Reophax* and the elongate white saccamminids. *Globobulimina* sp. displayed a vivid array of protoplasm colours including bright red/ orange and brown. A phytoplankton sample from the top 50m of the water column at the 300m site was found to be rich in red radiolarian specimens suggesting that this species may include radiolarians in its diet.

390-410m (55903, 55927: 23º 09'N 66º 30'E) *WITHIN OMZ*

Sedimemts: Nearly identical to those observed at A300, with laminations downcore.
Metazoans: No macrofauna were observed, but relatively few cores were examined.
Foraminifera: The cores examined from these stations were devoid of *Pelosina.* Otherwise, the fauna was generally similar to that of Station 55902, except for the occurrence of an elongate saccaminid that was not present at 300m.

A600m (55916: 23 º 01'N 66 º 42'E) *WITHIN OMZ*
Sediments: X radiographs and photographs indicate fully laminated sediments
Metazoans: No metazoans were observed. (one megacore sorted).
Foraminifera: No *Pelosina* were observed in the few cores examined but a number of the species encountered at the 300m and 400m sites were present at this station. These included *Reophax* spp. and a number of monothalamous forams. A *Globobulimina* species with an orange tinted inner chambers was encountered for the first time at this depth.

712m and 737 m (55919, 55922: 23 º 60'N 66 º 42'E)
Sediments. X radiographs and photographs indicate, undisturbed, fully laminated sediments. There is a high detritus content, with radiolarians present.
Metazoans. The only macrofaunal organism present was a single unidentified, very small polychaete. Possibly a spionid or cossurid (palps missing).
Foraminifera. Pelosina occurred on the surface of one core from 712 m and were moderately common (average of 1-2 per core) on coretops from 737 m. In sieved residues, *Globobulimina* spp., *Bathysiphon* sp. and the 300 m *Reophax sp.* were abundant. Other elements of the 300 μm assemblage included elongate brownish saccamminids, the white saccamminid, and a white allogromiid species.

***OMZ TRANSITION ZONE* (800-1100 m)**
All sites have a layer of radiolarian phytodetritus on the sediment surface.

798 m (55915: 22 º 58'N 66 º 38'E).
Sediments. Sediments were laminated (0.5 to 1 mm-thick layers), but with burrows overlying laminations, particularly in the upper 6 cm.
Metazoans. Three megacores were sieved on a 300μm mesh. The only metazoan fauna observed were nematodes and 1 cm-long red amphinomid polychaetes (Fig. 1E). These worms have elaborate gill tufts on the dorsal surface, similar to those of amphinomid polychaetes. They often had very green gut contents at this site, suggesting ingestion of fresh phytodetritus. Fragments of another polychaete (a spionid?) were observed.
Foraminifera. Pelosina were common on core surfaces. No observations were made of sieved residues.

843-848 m (55914, 55921: 22 º 57'N 66 º 37'E)
Sediments. X- radiographs indicate laminations that are well developed, but there are burrows overlying these, to a depth of 6 cm. The sediment surface appears to have 'holes' that are burrow openings, but no other biogenic structures were visible.
Metazoans. The metazoan macrofauna consisted entirely of polychaetes. As at 800 m, large red amphinomids (Fig. 1E) were dominant (up to 7 ind./core). Also abundant were spionid polychaetes, *Prionospio*, and nematodes. Diversity was exceptionally low
Foraminifera. Pelosina was present on some cores. The sample residue contained rather sparse foraminifera, including the elongate white saccamminid noted earlier, a silvery-brown saccamminid, slender white *Bathysiphon, Globobulimina,* and a beautiful elongate yellow allogromid (*Cylindrogullmia?*).

897 m (55909: 22 º 56'N 66 º 37'E)
Sediments Soupy sediments in which cores overpenetrated. Thick (1 cm) laminations were evident, with a faint burrow network and mottling present to 5.5 cm. A high-density layer (possibly a flood event, seismic event or turbidity flow) occurred at 5cm.
Macrofauna. One dominant polychaete, an amphinomid (many gills) (Fig. 1E), polynoid (scale) worms, and several species of ampharetid polychaetes were present (Fig. 1J). Macrofaunal diversity was slightly higher than at 850 m, but was still quite low.
Foraminifera. Globobulimina was again common and the elongate white saccamminid also occurred, the deepest occurrence of this species. Other notable species included a cluster of branching tubules, somewhat resembling a komokiacean but with distinctly thicker tubules than is normal in this group, and a silvery-brown saccamminid.

938 m (55908: 22 º 56'N 66 º 36'E)
Foraminifera. *Pelosina* was present on core surfaces and a beautiful, complete, paper-thin specimen of the large, flat miliolid *Discospirina tenuissima* occurred on the surface of one core. A similar specimen had been obtained on the Oman margin during CD145.

937-945 m (55918: 22 º 53'N 66 º 36'E)
Sediments Radiolarian detritus was present on the surface. The sediment had a high water content in the upper 5 cm. Sediments were faintly laminated to 20cm depth (laminations 4-10 mm thick). The upper 6.5 cm contained many burrows, mainly vertical in orientation and probably belonging to the red worms described below.
Metazoans. The macrofaunal assemblage here was substantially more diverse than at 800-900 m. Annelids, crustaceans, molluscs and echinoderms are present. The dominant form remaied the red polychaete (1-2 cm long) occurring in the upper 5 cm – a hessionid or amphinomid (same as 850, 900 m) (Fig. 1E). Abundance of this species was typically 5 to 23 indiv./core (636-2921 ind./m^2), with animals evenly distributed between 0-2 and 2-5 cm, with few below. Tall ampharetid tubes are present (one to 4 per core, protruding 1 to 4 cm above the surface, 2 mm diameter) (Fig. 1K), short ampharetid tubes (0.5 to 1 cm above surface (1 to 4 per core). Also present were infaunal anemones (some drops) (Fig. 1F), cirratulids with dark tentacles (*Dodecaceria*?) (Fig1I, 2-5 per core), abundant thyasirid bivalves (Fig. 1G; 4-8 per core), ampeliscid amphipods (1-2 per core) (Fig. 1H), and sulfur bacteria in sheaths (Fig.1L). Small orange ophiuroids were common on the sediment surface (1-2 per megacore) (Fig. 1K), with density estimates of 191 to 157 individuals/m^2.
Foraminifera. The dominant genus was *Reophax,* which included three species, provisionally identified as *R. bilocularis, R. dentaliniformis,* and *R.* aff. *scorpiurus.* Many specimens of *R. bilocularis* and *R. dentaliniformis* appeared to be alive. A small orange *Karreriella,* not present at other stations, was also common together with other multilocular agglutinated species ('*Cyclammina', 'Cribrostomoides' scitulus, Labrospira?* and occasional *Ammodiscus*). The most common calcareous foraminiferan was *Uvigerina*. Other consistently occurring species included *Globobulimina* spp., *Bulimina exilis, Chilostomella oolina, C. ovoidea,* laterally compressed planispiral form (?*Pullenia* sp.), ?*Saracenaria, Hoeglundina* and occasional *Lenticulina* spp. in deeper layers. *Globobulimina* and *Chilostomella* spp. posed their usual challenge regarding the identification of live individuals. Many specimens contained dark granular material, although only a few from shallower sediment horizons were considered to be alive. Most other calcareous foraminiferans were dead but occasional *Uvigerina* from the top 1cm layer had long muddy threads extending from their apertures and were probably alive. As usual on this margin, the most common monothalamous foraminiferan was a slender, white *Bathysiphon.* A short stick-like mud-walled species and the komoki-like form seen at 900m also occurred. Soft-walled monothalamous taxa were rare and the elongate saccamminids that were typical of the core OMZ region finally disappeared at this station. Obviously live specimens were sparse at this site and more or less confined to the upper 1cm layer.

1000 m (55907: 22 º 54'N 66 º 34'E, 55920)
Sediments. Sediments are fully bioturbated, with no evidence of laminations.
Metazoans. Macrofaunal biomass is less than at the 850-940m stations. We observed approx. one ophiuroid per core (=127 ind./m^2) a large pink cnidarian (pennatulid like). Also present were cirratulid, cossurid and ampharetid polychaetes, aplacophorans and tunicates. Animals were observed to 7cm in the sediment column.
Foraminifera. Arborescent *Pelosina* were unusually abundant at this station. Small, grape-shaped, stercomata-filled gromiid/allogromiids were observed to be attached to the branches of several specimens and associations also occurred with white *Bathysiphon* specimens. A brief survey of a sieved residue yielded '*Cyclamina', Bathysiphon, Globobulimina, Chilostomella oolina,* a large *Nonionella*, the komokiacean-like form noted at 900m and a mud-walled astrorhiziid.

1048 m (55906: 22 º 53'N 66 º 34'E)
Sediments. Sediments were bioturbated throughout.
Metazoans. Ophiuroids were common (average 0.5/core = 64/m^2). Terebellid and ampharetid polychaetes and aplacophorans were present. Only a single core was examined.
Foraminifera. The usual arborescent *Pelosina* was absent but a stick-like species (?*Pelosina* sp.), not seen elsewhere on this margin, was fairly common. No observations were made on sieved residues.

1100 m (55905: 22 º 52'N 66 º 33'E)
Sediments. Cores had a highly burrowed, undulating surface, with high sand content and high water content in upper layers of mud. Sediments were fully bioturbated to at least 12 cm.
Metazoans. Ophiuroids were present. We observed 1-2 large burrows (> 1 cm diameter) per core; these look like shrimp burrows. Polychaetes included Flabelligeridae, Paraonidae, Lumbrineridae, and Phyllodocidae. Tanaids and cumaceans were also present.
Foraminifera. *Pelosina* was not observed on the few cores examined. Many *Bathysiphon* were present.

1200 m (55911: 23 º 00'N 66 º 24'E) – ***BOTTOM OMZ BOUNDARY***

Sediments. Sediments are fine mud with an overlying layer of radiolarian phytodetritus. Sediments are highly pelletized such that the only material retained on a 300-micron mesh are pelagic foraminiferan tests and fecal pellets (mainly polychaete and copeopod) (Fig 1M). There is a thin, light-coloured horizon at 5-5.5 cm depth.
Metazoans. The metazoan macrofauna consists of amphipods and bivalves in surface sediments, and capitellid, maldanid and paraonid polychaetes in deeper sediments. Paraonids have olive green phytodetritus in guts, distinct from maldanids, which have brown sediments. A number of thin- and thick-walled sediment tubes are found to 10 cm in the sediment. They may belong to a large onuphid polychaete (Fig. 1N).
Foraminifera. *Pelosina* was absent but large, sphaerical gromiids/allogromiids with one aperture occurred sparsely but regularly on core surfaces (typically one per megacore deployment). The foraminifera in sieved fractions were mainly small (< 1cm) and there was considerable overlap with species present at 950 m. Hormosinacean species (*Reophax* and similar genera) were abundant and diverse, with at least 8 species being recognised in the 0-0.5 cm layer. A slender species resembling *R. scorpiurus* was most common. The more abundant hormosinacean species persisted into deeper sediment layers; individuals of *R. dentaliniformis* that were clearly live occurred down to 4-5 cm depth. Several species of *Globobulimina* and two species of *Chilostomella* (*C. oolina* and *C. ovoidea*) occurred in all sediment layers, including 5-7 cm. Some were probably live, although the distinction between live and dead individuals is problematic in these genera. Uncommon but distinctive faunal elements at this station were a *Hyperamminia*-like species with a silvery, reflective surface and *Ammobaculites bacc…salsus.* The latter species has only been reported previously from off NW Africa and the Rockall Trough (Gooday and Hughes, 2002). *Bulimina marginata/aculeata* were uncommon and usually dead. Slender white *Bathysiphon* tubes were also rather uncommon. A single specimen of *Vanhoeffenella gaussi* was recorded, but soft-shelled monothalamous foraminifera were otherwise virtually absent. Live specimens of infaunal species such as *Reophax dentaliniformis, Globobulimina* spp., *Chilostomella* spp. tended to occur deeper in the sediment than at 950 m, possibly reflecting the better-oxygenated nature of this site.

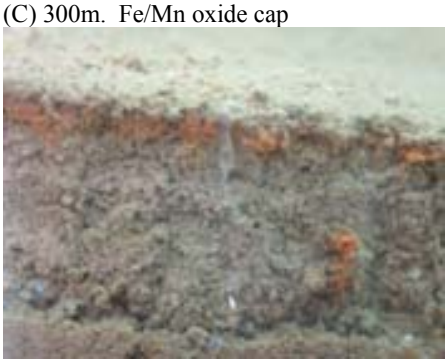
1850 (55904: 22 º 52'N 66 º 00'E) – *BELOW OMZ*
Sediments. Sediments consisted of a fine muddy layer with relatively high water content to about 8 cm, underlain by a compacted, sticky clay layer. Fine detritus is present on the surface and in bands below the surface (Fig. 1-O). Although large burrows were found throughout the core, with surface detritus present deep inside burrows (Fig 1P), no large burrowing animals were recovered.
Metazoans.. Densities were relatively low but diversity was high. Animals were very small, leading to low total biomass. The most common macrofauna included tanaids, bivalves (3 species), isopods, and mudball-building cirratulid polychaetes. Mudballs were about 1-1.5 cm tall (Fig. 1Q) and located just below the surface in the upper 2 cm of sediment. Other fauna retained on a 300-micron mesh included sabellid and flabelligerid polychaetes, priapulids, nematodes and harpacticoid copepods. Some large bacterial filaments were present.
Foraminifera. Single deployments of the megacorer at this site typically yielded one or two specimens of the large spherical gromiid *Gromia spherica* and gromiid-like protists (elongate and grape-like morphotypes). The sieved residues of cores were dominated by agglutinated foraminifera, notably komokiacean foraminiferans including *Rhizammina, Crambis, Lana* spp., *Edgertonia*-like mudballs and chain-like forms (several species). *Pelosina* spp., some large *Bathysiphon* tubes and various *Reophax* species were common and occasional large *Ammodiscus, Ammoscalaria* and needle-shaped *Chitinosiphon*-like allogromiids also occurred. Of particular interest were occasional specimens of a spectacular, brilliantly silver sacamminid with terminal apertures, similar to the elongate saccamminids that occurred within the OMZ but considerably larger. Live specimens of *Globobulimina* (3 species) and *Sphaeroidina bulloides* were present in deeper sediment layers and occasional *Hoeglundina elegans* in the surface 1 cm. Otherwise, live calcareous foraminifera were rare.

Figure II-A.

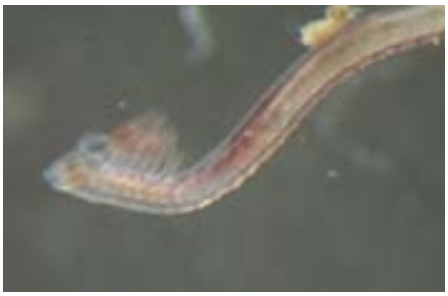
(A) 140m *Pelosina* spp. on core surface

(B) 140m. Macrofauna from a 78.5cm^2 core

(C) 300m. Fe/Mn oxide cap



(D) 300 m. *Prionospio* sp.



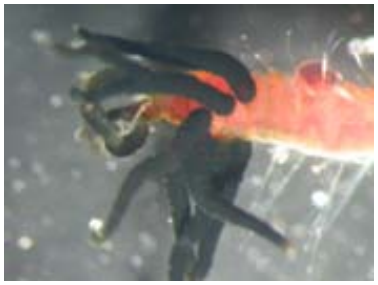
(E) 800-940m. Dominant polychaete Amphinomidae?

(F) 870 m Infaunal anemone 1 – 1.5 cm

(G) 940 m. Thyasirid bivalve 4 mm

(H) 940 m. Ampeliscid amphipod tube cap

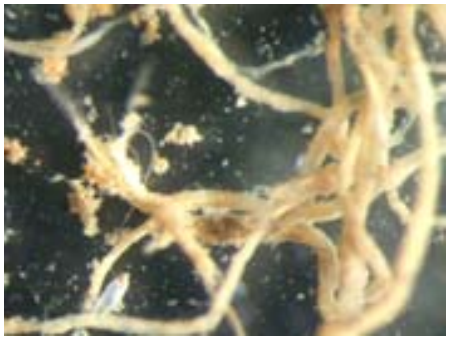
(I) 940 m. Cirratulid with black tentacles



(J) 940 m. Ampharetid polychaete

(K) 940 m Ampharetid tubes on the sediment surface with ophiuroid

(L) 940 m. Bacterial filaments in sheaths.



(M). 1200 m Capitellid fecal pellets

(N) 1200 m. Large, deep dweling onuphid polychaete

(O) 1850 m. Detritus on surface and in bands below.

(P) 1850 m. Detritus deep in burrow

(Q) 1850 m. Cirratulid mudballs (1-2 cm)

Fig. II-B Foraminifera trends across the OMZ
(Kate Larkin, Andy Gooday, Lisa Levin)

A140:

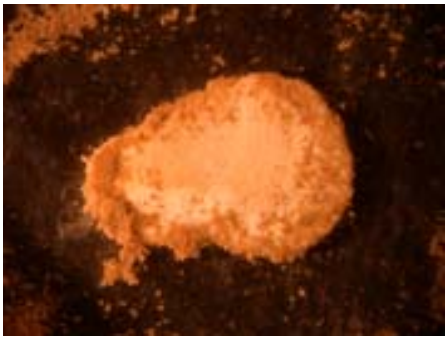


Fig. 1. Large *Peneroplis* like miliolid

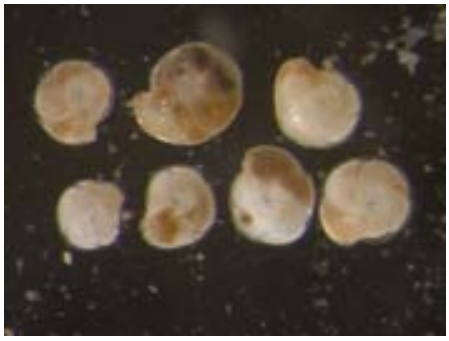


Fig. 2. *Lenticulina* sp. from 2-3cm with brown contents

A300:

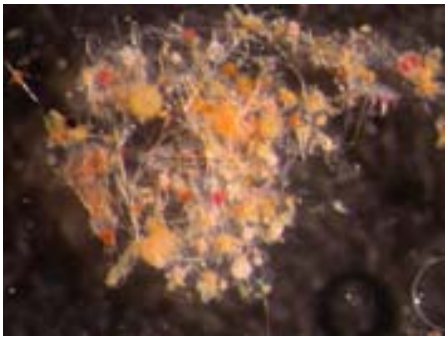


Fig. 3. Top 50m surface water column phytoplankton sample.

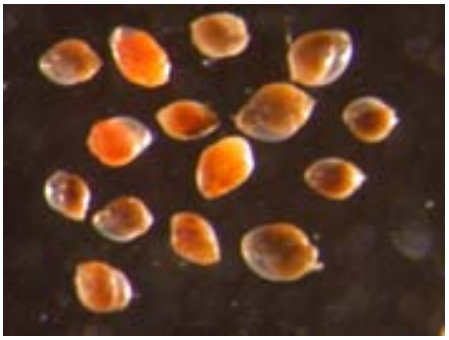


Fig. 4. *Globobulimina* sp. from 0-1cm.

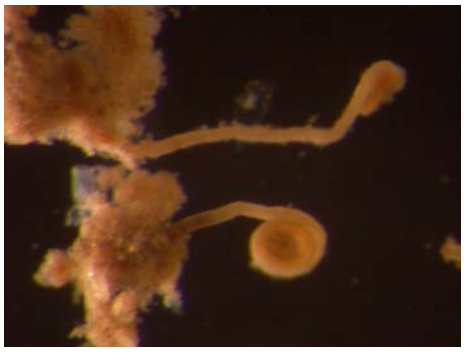


Fig. 5 Partly uncoiled *Ammmodiscus* sp.

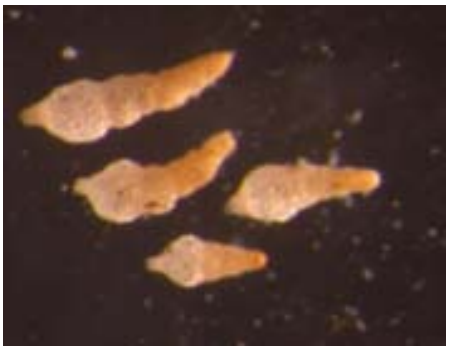


Fig. 6 Common *Reophax* sp.

A950m:

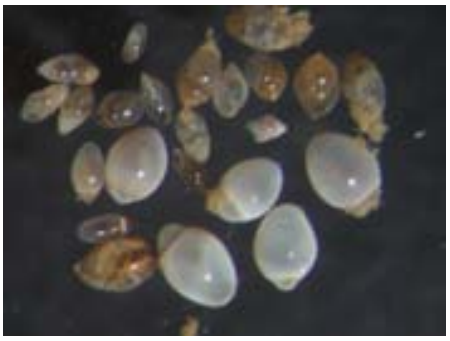


Fig. 7. *Chilostomella* spp. and *Globobulimina* spp.

Fig. 8. *Reophax dentaliniformis*

A1200m:

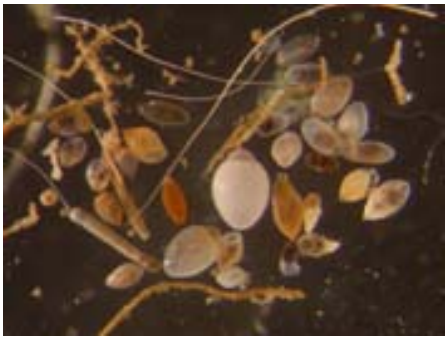


Fig. 9. Complete assemblage, including *Chilostomella* spp., *Globobulimina* spp., *Rectvigerina* sp., brown Saccaminid, *Pelosina*-like strands.

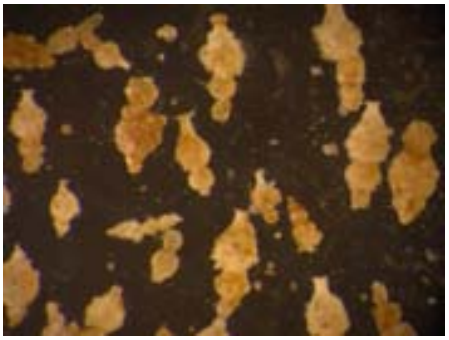


Fig. 10. *Reophax sp.*

A1850m:

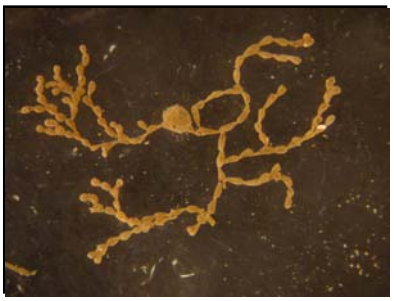


Fig. 11. Large chain-like agglutinated foraminiferan from 1-2cm depth

Fig. 12. Spherical gromiid on the surface

Kate Larkin, Andrew Gooday, Lisa Levin

10.22.3 Megabenthos (Agassiz Trawls)

Four trawl samples were taken, one at the 1850m site and the others at shallower depths (750-1050 m) not trawled during CD 145. The 1850m site was resampled, mainly in order to obtain more of the gromiids that were collected at this depth during CD145. The shallower hauls were intended to complement megafaunal samples from the zone of rapid macrofaunal change in the lower part of the OMZ. The samples were preserved, fixed and frozen for taxonomic, molecular and biochemical research. The catches were free from mud, small in volume, and dominated by small animals or, in the case of the deepest haul, large protozoans. The net always returned clean and did not require washing down before recovery. The capture of large numbers of anenomes at 878-890 m and tiny holothurians (?Pholas sp.) at 975-1075 m was particularly notable. Few diffculties were encountered during trawling, although the 2 tonne weak link broke on two occasions and the net was torn during the final haul. It was also difficult to make sense of the pinger traces which usually conveyed no useful information concerning the position of the net in relation to the bottom.

55910#3 (1875 m)

This trawl was taken at a similar depth to 55815#1 (CD145). The catch dominated by foraminifera and gromiids. The foraminifera included *Ammodiscus* sp. *Bathysiphon rusticus, B. filiformis, B. rufum, Cornuspira* sp., *Crithionina granum, Rhabdammina abyssorum, 'Reophax' gaussica*, a tangle of *Rhizammina* tubes, *Pelosina* spp., *Pilulina jeffreysii, Triloculina* sp., chain like komokiacens, *Lana* spp., mud-walled astrorhiziids. The gromiids consisted of grape- and sausage-like morphotypes. The catch also included a small number of metazoans: decapods (6), galatheids (3), ophiuroid (1), fish (1) and jellyfish (9). These were all frozen for biochemical analyses. The weak link broke during the haul but this probably did not affect the size of the catch.

55912#1 (878-890 m)

The catch was dominated by anenomes and also included numerous red polychaete worms (two species, an amphinomid and a scale worm), together with less common thysirid and thin-shelled pectinid bivalves and tube-building polychaetes (ampharetids, sabellids). Specimens were preserved in ethanol (molecular studies), frozen (biochemistry) or fixed in formalin. A subsample of the residue was frozen and the remainder fixed in formalin.

55918#14 (975-1075 m)

This haul was taken along a gently descending bathymetric gradient and therefore spanned a greater bathymetric range than other trawl samples. It yielded a small but interesting catch dominated by ophiuroids and tiny holothurians (?Psolus). Penatulids, tunicates and asteroids were common and gastropods, sponges, bivalves, stalked barnacles, ampharetid polychaetes, galatheids, a few fish and a small octopus were also caught. Material was frozen, preserved in alcohol, or returned to SIO for taxonomic identification. The residue was fixed in formalin.

55922#1 (758-777 m)

The purpose of this haul was to help identify the lower limit of macrofaunal and megafaunal life in the OMZ. It was preceded by a short swath bathymetric survey during which an area of seafloor suitable for trawling was identified. The trawl yielded 33 benthic fish ('tripod fish'), 29 jellyfish and an assortment of vertebrate bones, squid beaks, cuttlefish bones and pteropods. No benthic invertebrates were recovered. The 2 tonne weak broke near the end of the haul and the net was torn.

Figure III-A. 55912#1 (878-890 m). Anemones, with white coatings (symbiotic bacteria) were dominant in the trawl catch. Other taxa present included thyasirid bivalves, amphinomid and polynoid polychaetes.

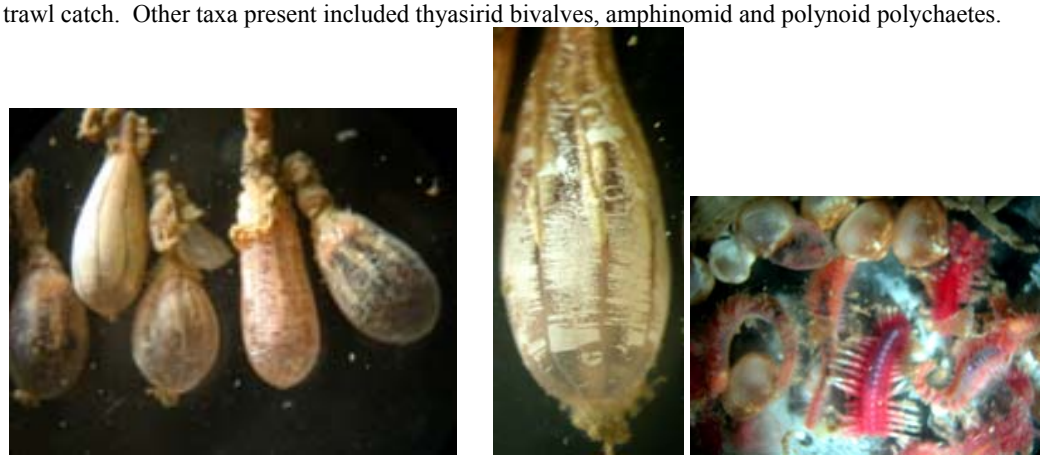
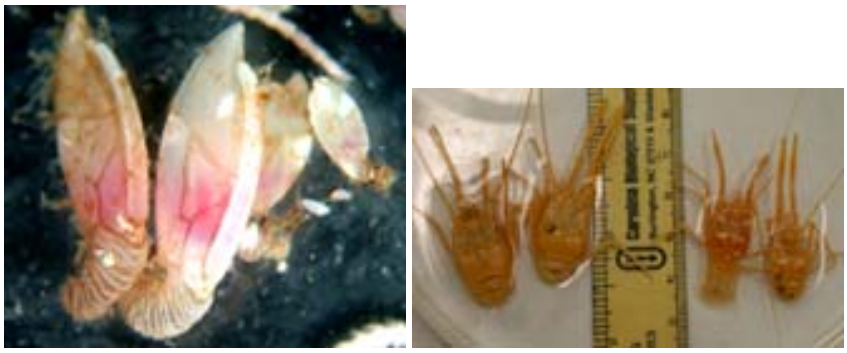


Fig. III- B.55918#14 (975-1075 m)
Plated holothurians (~1 cm long) were a dominant part of the trawl catch.
Small dog fish or sharks, gooseneck barnacles and galatheid crabs were also caught.



Andrew Gooday, Lisa Levin, Kate Larkin

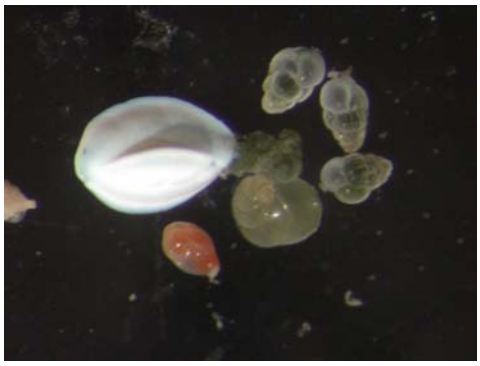
10.22.4 Preliminary observations from ^{13}C enrichment experiments: Shipboard and *in situ* incubations
Shipboard incubation experiments with ^{13}C-labeled *Thallasiosira* (diatom) were conducted at 140, 300, 850, 940, 1000, 1200 and 1850 m for periods of 2 to 5 days. In situ lander incubations were conducted for 2-2.5 days at the 300 m station. Replicate cores from each incubation/site received 1.25 g algae/core (in a slurry with 63-100 micron silica gel beads) and were kept at ambient temperature and oxygen using an oxystat system (see protocols and methods descriptions by Schwartz and Woulds). Half of each core was sectioned for faunal observations at intervals of 0-0.5, 0.5-1, 1-1.5, 1.5-2, 2-3, 3-4, 4-5, 5-7, and 7-10 cm. Macrofauna were examined from all intervals to 10 cm in each core except at the 300 m site (Table 4). Macrofauna were sampled from the experiments for bulk δ^{13}C, amino acid and lipid biochemistry. They are stored by species, major group or size group in numbered vials and pre weighed tin boats (Trays 130,131, 132). A complete list of samples can be made available upon request.

Macrofauna were abundant only at the shallowest site (140 m) and the transition-zone sites (850, 940 and 1000 m). No macrofauna were collected from experiments at 300 m, and very few were collected from 1200 and 1850 m. The fauna observed in ^{13}C incubation cores is listed in Table Levin-5. Several taxa exhibited evidence of rapid 13C-algal ingestion in the experiments. At 140 m, two replicate cores contained many species with green gut contents including, amphipods, cirratulids, spionids, paraonids, cossurids and possibly a maldanid. The maldanid was found in the 5-7 cm fraction, introducing the possibility of rapid deep subduction of detritus. At the 940 m site, the most voracious algal consumer was a relatively large (1-2 cm) amphinomid common in the 850 and 940 m experiments. Most individuals had tracer-green gut contents and often mucous bound, algae filled fecal packages were found to depths of 5 cm with the worms. Other 940-m species to show hints of green gut contents include a cirratulid with black tentacles and a spionid polychaete. None of the animals at the deeper station exhibited visual evidence of algal tracer ingestion, but they were small and few in number.

Foraminifera were sorted from the 140, 300, 940, 1200 and 1850 m shipboard incubations and the 300 m lander incubation. In most cases, time constraints limited sorting to the >300 micron fraction, although the 150-300 micron fraction was examined at 300 m. Individuals that may have been alive (i.e. with test contents) were selected and those that were obviously dead were ignored. Nevertheless, the sorted material inevitably comprised a mixture of live and dead specimens. The only clear indication for tracer uptake was at the 140 and 300 m sites where many *Uvigerina* tests contained bright, tracer-green protoplasm. Other species that appeared to have taken up the tracer included *Cancris* (both sites) and *Cassidulina* (300 m). These species lived on or just below the sediment surface. Most intriguingly, some specimens of the infaunal genus *Globocassidulina* (300 m) contained bright green material in the final chamber, or occasionally, in all chambers. A single individual of *Bulimina aculeata* from the 5 day 1200 m incubation (0-0.5 cm layer) was bright green but most foraminifera, including the various *Reophax* species that were abundant at all stations, exhibited no evidence of tracer uptake.

Fig. I. Foraminifera observations from ^{13}C algal tracer experiments (Andy Gooday, Kate Larkin)

A140m:



Green ^{13}C algal tracer uptake displayed in *Quinquiloculina* sp. (as detritus around the aperture) and *Rectuvigerina* sp. and *Cancris* sp. (green protoplasm). Note the contrast with the natural red protoplasm of *Globobulimina* sp.

A300m:

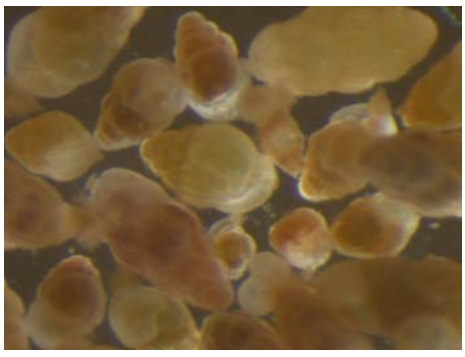


Fig. 2. *Rectuvigerina* sp. displaying a variety of protoplasm colours including the green ^{13}C algal tracer.

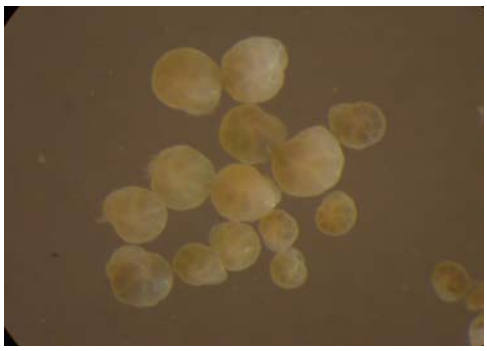


Fig. 3. *Cassidulina* sp. displaying ^{13}C algal tracer uptake.

Table Levin V

Table enumerating shipboard and *in situ* incubation experiments

	Metazoan macrofauna and meiofauna			
	Depth Sorted	Fraction Sorted	^{13}C uptake	No. metazoans
140 m				Rep A:Rep B
3 day shipboard	10 cm	300 micron	amphipod, cirratulid, cossurid, paraonid, maldanid	46:26
300 m				
2 day shipboard	1 cm	300 micron		0:0
5 day shipboard	1 cm	300 micron		0:0
2 day lander	1 cm	300 micron		0:2
850 m				
2.5 day shipboard	10 cm	300 micron	amphinomid	11:13
940 m				
5 day shipboard	10 cm	300 micron	amphinomid	14:12
1000 m				
2 day shipboard	10 cm	300 micron		4:10
1200 m				
5 da shipboard	10 cm	300 micron		1:1
1850 m				
2 da shipboard	10 cm	300 micron		6:4
5 da shipboard	10 cm	300 micron		7:5

L. Levin, A. Gooday, and K. Larkin

10.23 Porewater pH

pH was measured in the controlled temperature laboratory so no correction for temperature is necessary, but corrections to *in-situ* pressure have not been made on the data.

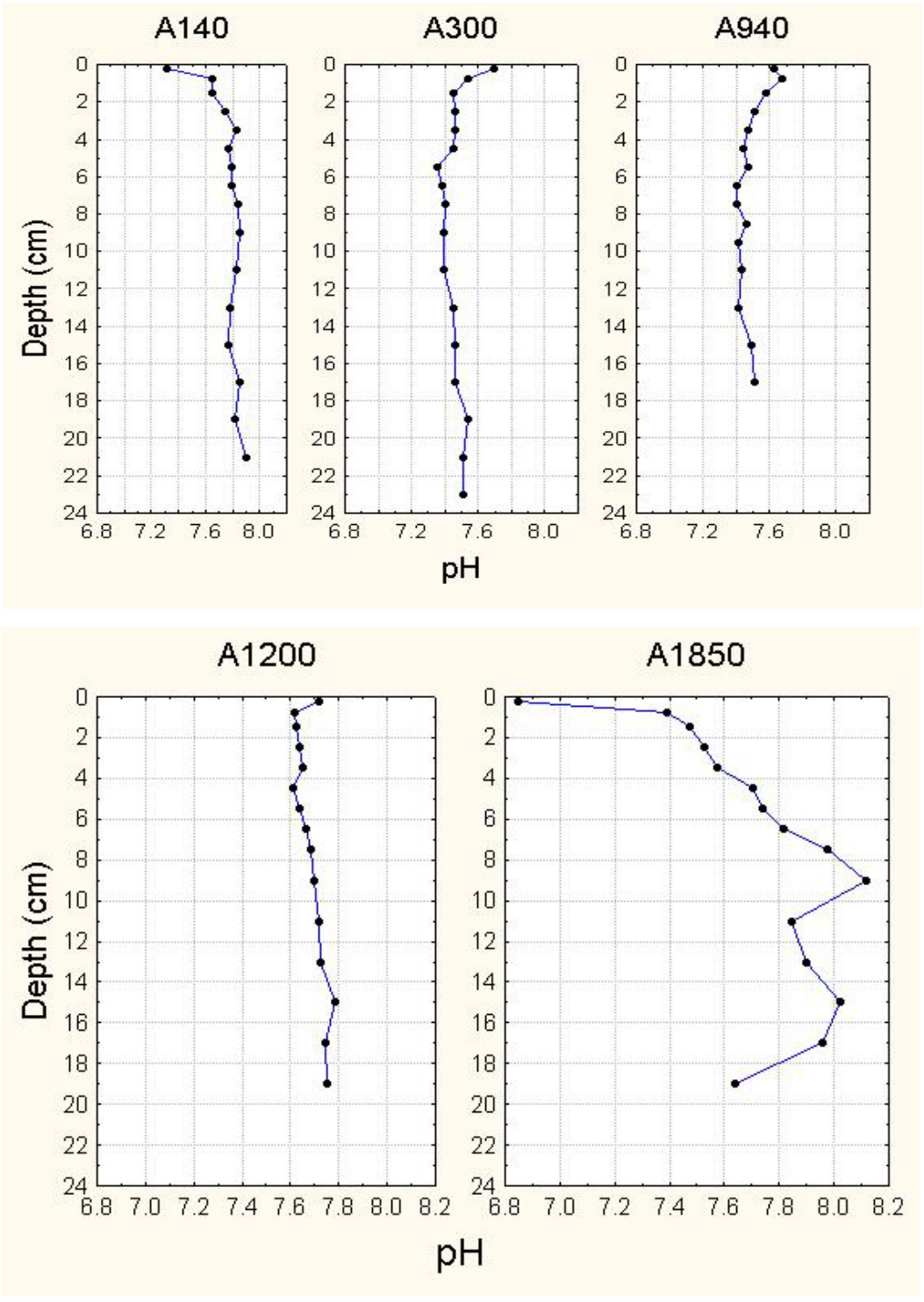


Fig. 1. CD146 porewater pH profiles.

NIOO Sample Catalogue

Table 1. Samples taken for δ^{13}DIC, DIC and pH
Intervals generally used for background porewaters are 0.5 centimeter in the top centimeter, one centimeter down to 8 cm and then two centimeters down to 20 cm.

Background Porewater Samples	
StationName	**Core**
A140	55901#10-3
A140	55901#2-1
A300	55902#9-6
A1850	55904#6-6
A1200	55911#4-7
A940	55918#5-7

Table 2 Intervals generally used for incubation porewaters are 0.5 centimeter in the top two centimeters, one centimeter down to 10 cm and then two centimeters down to 20 cm.

Incubation Pore water samples			
StationID	**StationName**	**Treatment**	**Duration**
55902	A300	EF13	2
55902	A300	EF13	2
55902	A300	SF13	2
55902	A300	SF13	2
55902	A300	SF13	5
55902	A300	SF13	5
55904	A1850	SF13	2
55904	A1850	SF13	2
55904	A1850	SF13	5
55904	A1850	SF13	5
55911	A1200	SF13	5
55911	A1200	SF13	5
55918	A940	SF13	5
55918	A940	SF13	5
55920	A1000	SF13	0
55920	A1000	SF13	2
55920	A1000	SF13	2
55921	A850	SF13	0
55921	A850	SF13	2
55921	A850	SF13	2
55931	A140	SF13	2
55931	A140	SF13	2

Table 3 Solid phase samples taken for δ^{13}PIC, same intervals as background porewaters.

Background Solid phase samples	
StationName	**Core**
A140	55901#10-3
A300	55902#9-6
A1850	55904#6-6
A1200	55911#4-7
A940	55918#5-7

Table 4 Water column samples taken for $\delta^{13}DIC$, $\delta^{18}O_2$

CTD samples			
StationName	CTDcast	Niskin nr	Depth
A1850	55910#1	24	2
A1850	55910#1	23	10
A1850	55910#1	22	20
A1850	55910#1	21	40
A1850	55910#1	20	60
A1850	55910#1	19	80
A1850	55910#1	18	100
A1850	55910#1	17	150
A1850	55910#1	16	200
A1850	55910#1	15	250
A1850	55910#1	14	300
A1850	55910#1	13	350
A1850	55910#1	12	400
A1850	55910#1	11	450
A1850	55910#1	10	500
A1850	55910#1	9	600
A1850	55910#1	8	800
A1850	55910#1	7	1000
A1850	55910#1	6	1200
A1850	55910#1	5	1400
A1850	55910#1	4	1600
A1850	55910#1	3	1800
A1850	55910#1	1	1857

Henrik Andersson

10.24 Porewater nutrients

Samples were collected at all primary stations, and in duplicate for sites A140 and A940. The majority of analyses (phosphate, silicate, nitrate, nitrite and ammonia) were conducted on board. However, a lack of time and reagents prevented completion of all analyses, and these and data processing will be completed post-cruise. Cores were sectioned under nitrogen and at ambient bottom-water temperature. Depth intervals were 0.5cm to 2cm depth, followed by 1-cm intervals to 30cm depth, and then 2-cm intervals to the core bottom. Samples were refrigerated prior to shipboard analyses or frozen for post-cruise analyses.

Greg Cowie (Tasos Anestis)

10.25 Porewater DOC-DON and molecular weight fractionation

Due to instrument failure, shipboard DOC and DON analyses were not conducted during CD146. Porewater samples were placed in 5-ml precombusted glass ampoules, and were then acidified prior to the ampoules being sealed and returned refrigerated to the UK for analysis. Porewater samples were collected under nitrogen at ambient bottom water temperatures at all primary sites and in duplicate at sites A140 and A940. Depth intervals were as described in section 8.7.

Cores were also sectioned for molecular- weight fracitonation of porewater DOM via ultracentrifugation (as described in Section 8.12). These samples were returned to the UK (Newcastle) as for the bulk DOC/DON samples, in precombusted glass ampoules (acidified and refrigerated). Table 1 summarises the cores processed for bulk DOC-DON analyses and ultracentrifugation.

Site	Station Number	Gear	Depths Sliced (cm)	Analysis
A 140	55901#14	Megacore 3	0-30	Ultracentrifugation DOC/TDN
A300	55902#12	Multicore 6	0-36	Ultracentrifugation DOC/TDN
A 300	55902#25	Megacore 7	0-24	Bulk DOC/TDN
A 1850	55904#11	Megacore 12	0-20	Bulk DOC/TDN
A 1200	55917#1	Megacore 9	0-34	Ultracentrifugation DOC/TDN
A 1200	55917#1	Megacore 1	0-32	Bulk DOC/TDN
A 940	55918#9	Megacore 1	0-32	Bulk DOC/TDN
A 940	55918#16	Megacore 4	0-32	Ultracentrifugation DOC/TDN

Table 1: Summary of CD146 core processing for DOC/DON and ultracentrifugation.

Tasos Anestis

10.26 Oxygen determinations (Winkler titrations and shipboard microelectrode profiling)

Microwinkler titrations

Bottom water oxygen concentrations were obtained from all sites cored by using water collected from megacore overlying water, mini Nisken bottles attached to the landers and from normal Niskens attached to the CTD. The data from these determinations are presented in Table 1. Water-column oxygen samples were also collected from the CTD to compare the Winkler method to the CTD sensor (see Section 10.12, Fig. 1)

Table 1 data shows variations between samples taken at the same station and unexpected variations in concentration with depth. This is preliminary data and will need to be looked at more thoroughly back at that lab to ascertain if the variations are artefacts of sampling, Winkler methodology or are real.

Table 1. Bottom water oxygen concentrations

	Core Top	CTD BW	Lander BW
Station	**Oxygen (ml/L)**	**Oxygen (ml/L)**	**Oxygen (ml/L)**
A140m	1.51	2.48	1.58
A300m	1.80	0.38	0.63
A600m	1.71		
A750m	0.56		
A800m	0.67		
A900m	0.56		
A940m	0.34	0.31	0.26
A1000m	1.04		
A1050m	0.46		
A1100m	1.07		
A1200m	0.67	0.28	0.99
A1850	1.87	1.87	1.58

Shipboard microelectrode profiles.

Preliminary workup of the profiling data shown in Figurea-e show a decrease in oxygen concentration with depth in the sediment at all stations. Initial inspection of the data would indicate that diffusion coupled with the breakdown of organic matter seem to be the dominant factors affecting the oxygen distribution within the sediments. The overall similarity of penetration, and the relative values of oxygen concentrations at the interface are surprising for sites with such differing sediment types, organic matter contents and, in principle, differences in bottom-water redox conditions. An example is the relatively low bottom-water concentration and short penetration depth at site A1200, where CTD casts show higher bottom-water oxygen concentrations and more bioturbated sediments relative to shallower sites A300 and A940 in the OMZ. Another is the short penetration depth at station A1850, which is even more heavily bioturbated, has higher bottom water oxygen concentrations and, based on previous studies, would be expected to have comparatively low sedimentary organic matter content. Comparison with profiles determined in situ with *Profilur* and O_2 consumption rates determined by *Elinor* and shipboard incubations will provide clarification of the extent to which these profiles are impacted by pressure and temperature changes during recovery and possibly by oxygen exposure during shipboard profiling.

Eric Breuer

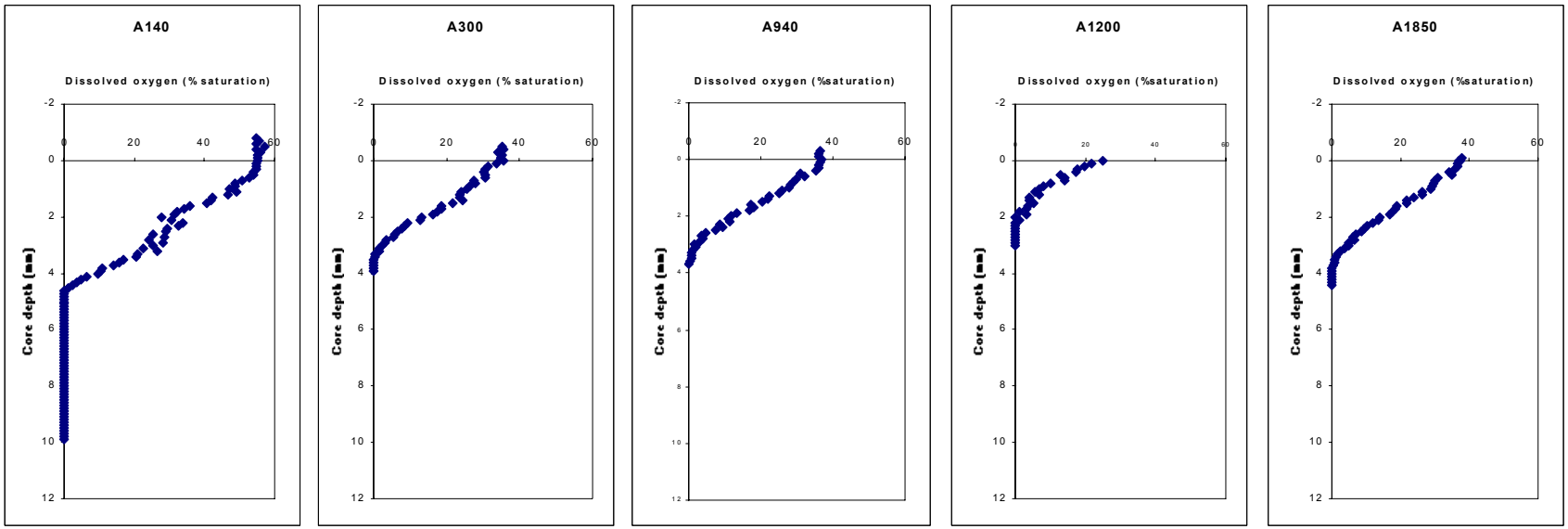


Figure 1. Dissolved oxygen concentration profiles at CD146 stations, obtained by shipboard microelectrode profiling.

10.27 Radiochemistry

The gamma spectrometer functioned well on board and only needed re-filling with approx. 5 litres of liquid nitrogen every 2-3 days. Samples were counted for c. 10+ hours to obtain enough counts for ^{234}Th. This was far longer than initially anticipated. ^{234}Th was present in all the surface core samples (0.25 cm) from each site with A1200 showing the highest count.

Date Core taken	Station	Sediment	Depth in pot	Start time	Stop time	Real Time	Net Area ^{234}Th	Net counts ^{210}Pb	File Name
22/04/03	A140 55901 #16	Sed 0.75	15mm	0438 220403	0705 230403	94784.10			CD146 A140 0.5-1
" "	A140 55901 #16	Sed 0.25	12mm	0715 230403	0810 240403	89631.29			CD146 A140 0-0.5
" "	A140 extra 55903	Sed	10mm	0825 250403	1157 260403	98390.59			Cd146 a140 Extra 0-0.5
" "	A140 extra 55903	sed	10mm	0003 260403	0713 270403	155096			Cd146 a140 Extra 0.5-1
SHIP	LOST	ALL	POWER	0838 270403 RECAL	0610 280403 IBRATE				
	RE-RUN A140	SED O.25	5mm	0625 280403	0732 290403	45467.92			Cd146
	A140	Sed 0.25	5mm	0739 290403	0618 300403	92282.30			Cd 146 A140 0-0.5(2)
24/03/03	A150	SED 0.25	18mm	1026 300403	0710 010503	78349.89			Cd 145 A150 0-0.5
28/04/03	A300 55902	Sed 0.25	10mm	07.46 01/05/03	06.31 02/05/03	81923.84			Cd 146 A300 0-0.5
``	A300	Sed 0.75	10mm	06.39 02/05/03	06.53 03/05/03	83634.23	153		Cd 146 A300 0.5-1
``	A300	Sed 1.25	7mm	07.15 03/05/03	04.51 04/05/03	81241.26	19	142	Cd 146 A300 1-1.5
``	A300	Sed 1.75	9mm	04.59 04/05/03	17.21 04/05/03	44516.93	12	98	Cd 146 A300 1.5-2
	A140	Sed 1.25	10mm	17.37 04/05/03	04.22 05/05/03	38594.40	30	43	Cd 146 A140 1-1.5
	A140	Sed 1.75	17mm	04.35 05/05/03	16.31 05/05/03	42730.51	36	85	Cd 146 A140 1.5-2
05/05/03	A1850 55904	Sed 0.25	10mm	16.39 05/05/03	03.20 06/05/03	38406.73	61	76	Cd 146 A1850 0-0.5
``	A1850	Sed 0.75	10mm	03.30 06/05/03	12.51 06/05/03	33656.12	22	58	Cd 146 A1850 0.5-1
``	A1850	Sed 1.25	12mm	13.01 06/05/03	07.28 07/05/03	65807.82	34	154	Cd 146 A1850 1-1.5
``	A1850	Sed 1.75	15mm	07.41 07/05/03	10.20 08/05/03	95518.92	46	239	Cd 146 A1850 1.5-2

Date Core taken	Station	Sediment	Depth in pot	Start time	Stop time	Real Time	Net Area ^{234}Th	Net counts ^{210}Pb	File Name
	A140	Sed 1.25	15mm	10.53 08/05/03	02.52 09/05/03	57474.39	25	65	Cd 146 A140 1-1.5
	A140	Sed 1.75	5mm	03.00 09/05/03	09/05/03	83240.61	33	80	Re-Do
	A140	Sed 1.75	5mm	02.15 09/05/03	17.21 11/05/03	140659.28	69	168	Cd 146 A140 1.5-2 (b)
09/05/03	A1200 55911	Sed 0.25	12mm	17.59 11/05/03	09.51 12/05/03	53440.31	161	184	Cd 146 A1200 0-0.5
``	A1200	Sed 0.75	8mm	10.00 12/05/03	22.30 12/05/03	44912.53	24	141	Cd 146 A1200 0.5-1
``	A1200	Sed 1.25	13mm	21.35 13/05/03	21.30	49418.84	25	142	Cd 146 A1200 1-1.5
``	A1200	Sed 1.75	13mm	11.30 13/05/03	06.35 14/05/03	68701.14	32	164	Cd 146 A1200 1.5-2
	A140	Sed 2.25	12mm	14/05/03	02.44 15/05/03	71996.50	46	114	Cd 146 A140 2-2.5
	A1850	Sed 1.75	15mm	02.55 15/05/03	04.30 16/05/03	91919.35	41	236	Cd 146 A1850 1.5-2 (b)
	A140 Extra	Sed 1.25	13mm	04.39 16/05/03	16.37 16/05/03	43003.20	42	77	Cd 146 A140(E)
16/05/03	A940 55918	Sed 0.25	14mm	16.44 16/05/03	02.15 17/05/03	34213.19	101	125	Cd 146 A940 0-0.5
``	A940	Sed 0.75	15mm	02.24 17/05/03	00.33 18/05/03	79638.25	101	364	Cd 146 A940 0.5-1
``	A940	Sed 1.25	20mm	00.44 18/05/03	15.44 18/05/03	53949.51	37	290	Cd 146 A940 1-1.5
``	A940	Sed 1.75	15mm	15.46 18/05/03	05.56 19/05/03	50380.36	30	240	Cd 146 A940 1.5-2
18/05/03 A.Trawl	A940 55918	Whole Samples Holithurians	Sm Pot Full Not Gutted	06.17 19/05/03	08.40 19/05/03	8576.30	4	4	Cd 146 AG Trawl A940
``	A940	Whole Samples Ophiura	Sm Pot Full Not Gutted	08.48 19/05/03	04.23 20/05/03	70439.01	18	18	Cd 146 AG Trawl A940
	A140 Extra	Sed 1.75	10mm	04.35 20/05/03	05.49 21/05/03	90745.56	83	174	Cd 146 Extra A140 1.5-2
23/05/03	A140 S Extra 55931	Sed 0.25	11mm	09.38 23/05/03	06.02 24/05/03	73282.98	511	115	Cd 146 S.Ext A140 0-0.5

Date Core taken	Station	Sediment	Depth in pot	Start time	Stop time	Real Time	Net Area ^{234}Th	Net counts ^{210}Pb	File Name
``	A140 S.Extra	Sed 0.75	12mm	06.11 24/05/03	04.51 25/05/03	81493.58	114	97	Cd 146 S.Ext A140 0.5-1
``	A140 S.Extra	Sed 1.25	17mm	05.00 25/05/03	04.48 26/05/03	85549.74	132	86	Cd 146 S.Ext A140 1-1.5
``	A140 S.Ext	Sed 1.75	10mm	05.01 26/05/03	06.30 27/05/03	91688.45	60	126	Cd 146 S.Ext A140 1.5-2
		GAMMA	DETECTOR	SHUT	DOWN	27/05/03			

Sue McKinlay

10.28 Sedimentary denitrification rates: Nitrogen/Argon ratio method in O_2 consumption incubations; Shipboard and Lander

Due to the failure of the gas chromatograph fitted with a thermal conductivity detector (GC-TCD) during CD146, very few samples were analyzed for N_2/Ar. The completed analyses are summarized below. Samples from all SO and EO incubations were collected and preserved for N2/Ar analysis. Samples collected after the failure of the GC-TCD were preserved in 12 mL evacuated vials (evacutainers) and poisoned with 20 µL of $HgCl_2$. So and EO samples were collected at stations A300, A940, A1200, and A1850,a s well as at the second visit to station A140. These samples will be analyzed when the GC-TCD is operational.

One effect of the early failure of the GC-TCD is that no standards could be analysed on CD146. Therefore, no accurate standard curves were generated. The data shown in the following graphs represent peak areas, not concentrations. These peak areas will be converted to concentrations when a suitable standard curve can be generated on the GC-TCD.

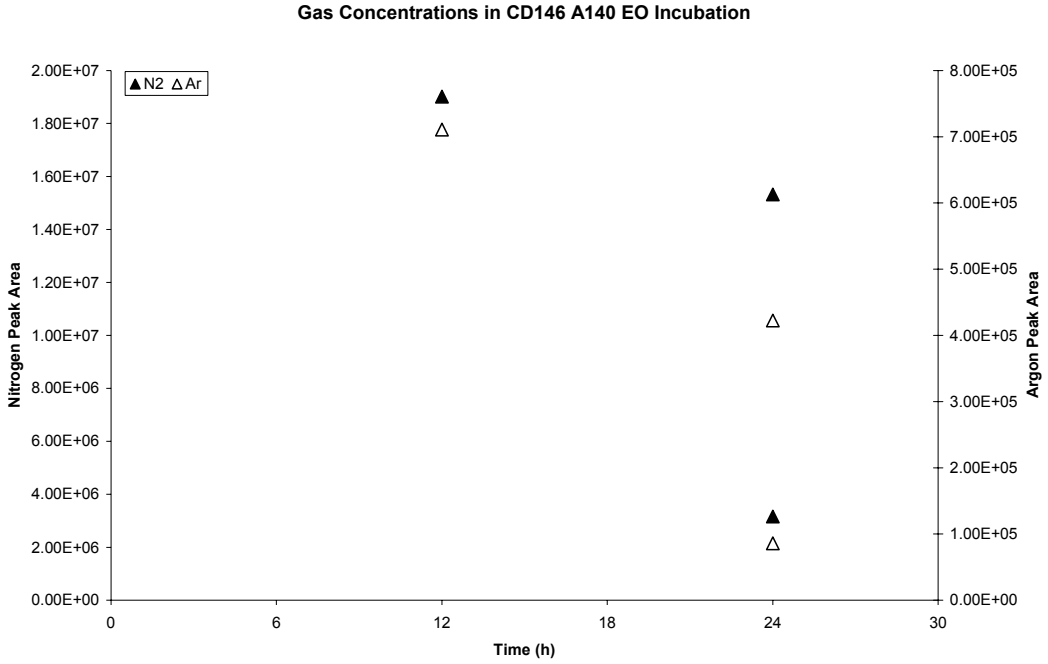


Figure 1: Nitrogen and argon peak areas vs time (h) during an in situ (lander) sediment incubation at site A140.

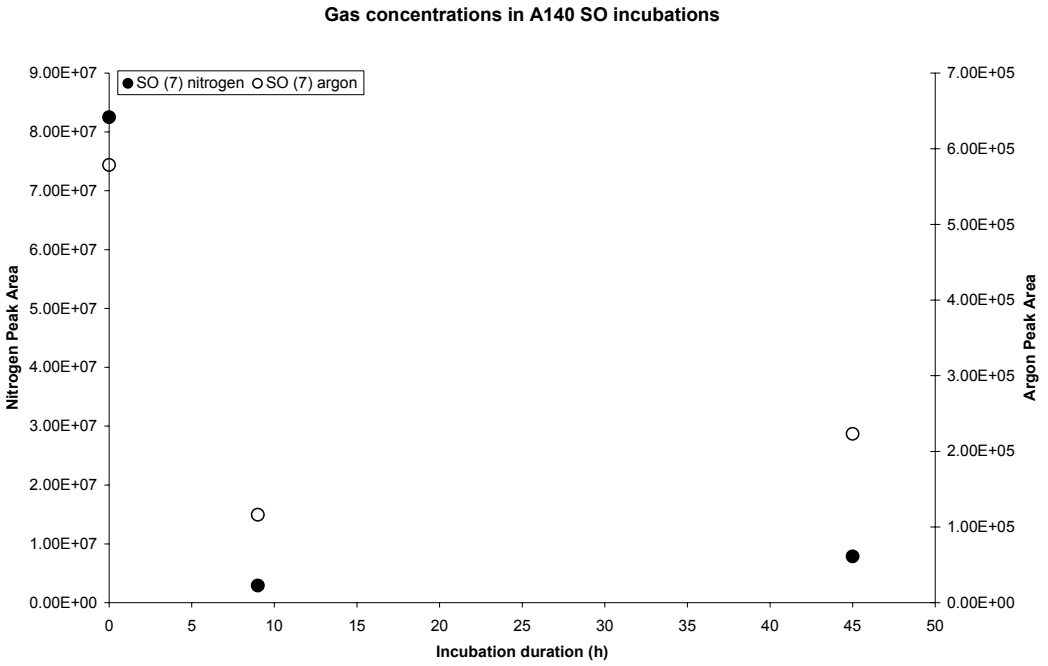


Figure 2: Nitrogen and argon peak areas vs time (h) during a shipboard sediment incubation at site A140.

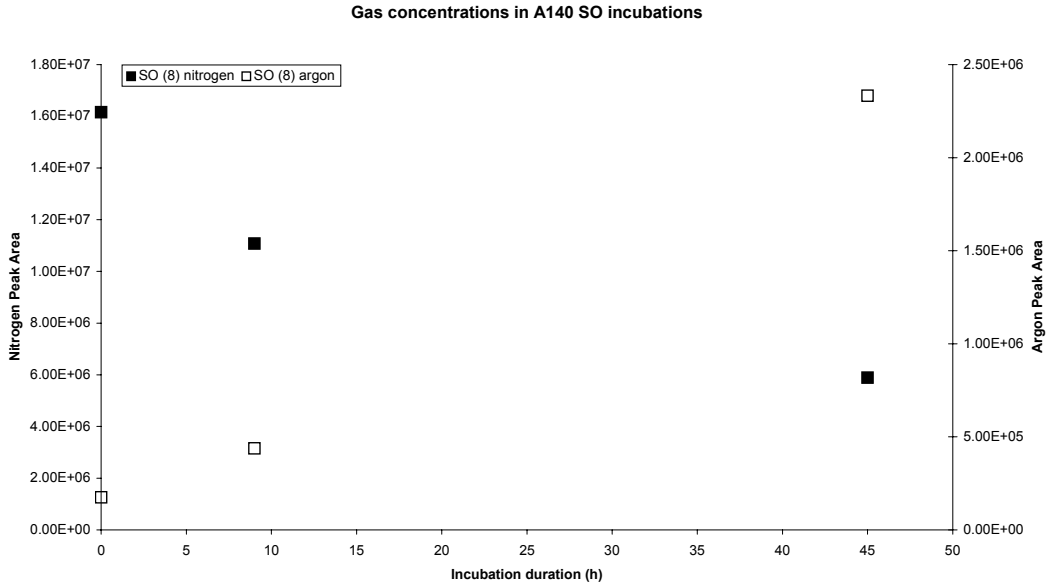


Figure 3: Nitrogen and argon peak areas vs time (h) during a shipboard sediment incubation at site A140.

Matt Schwartz

10.3 Lander studies

10.31 Profilur

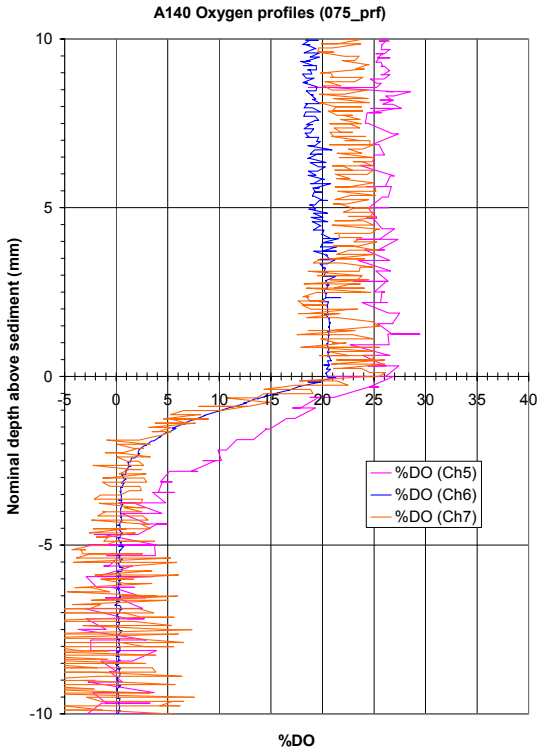
Oxygen micro-electrode profiles

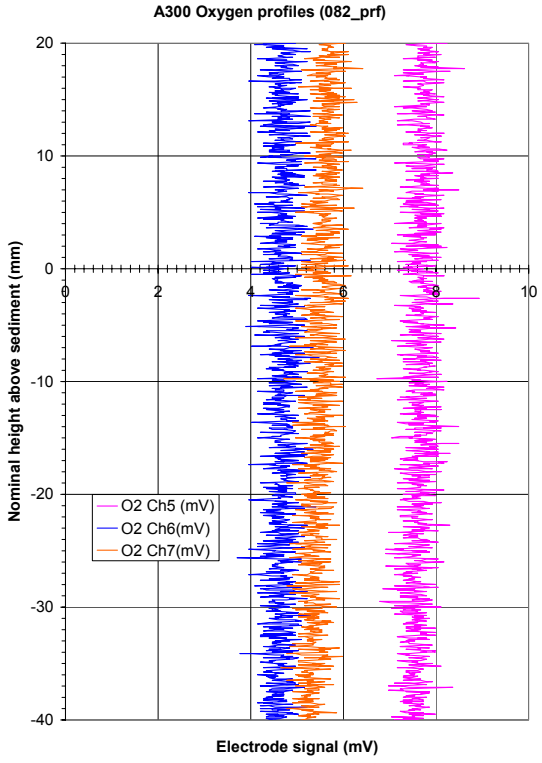
Despite some technical difficulties with the *Profilur* early on in the cruise, good oxygen data was obtained, with 2 successful deployments at each of the main stations except A140. The profiles obtained are shown in the graphs below. Each graph represents one deployment and shows the profiles for all "good" electrodes. %DO values are calculated from the lander water bottle winkler titrations and CTD measured bottom temperature and salinity. Note that at A300 there is no discernible change in oxygen level across the sediment water interface and the graphs have been left in raw electrode signals, rather than %DO, because of the lack of an in-situ calibration.

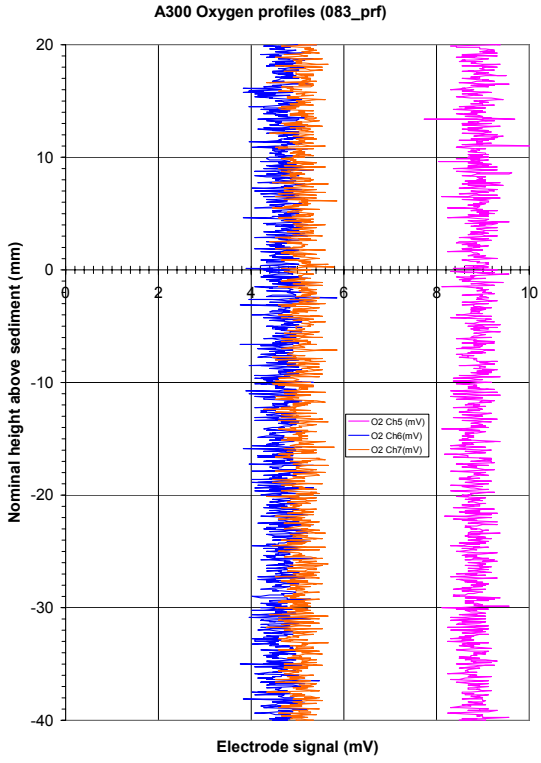
pH and Resistivity

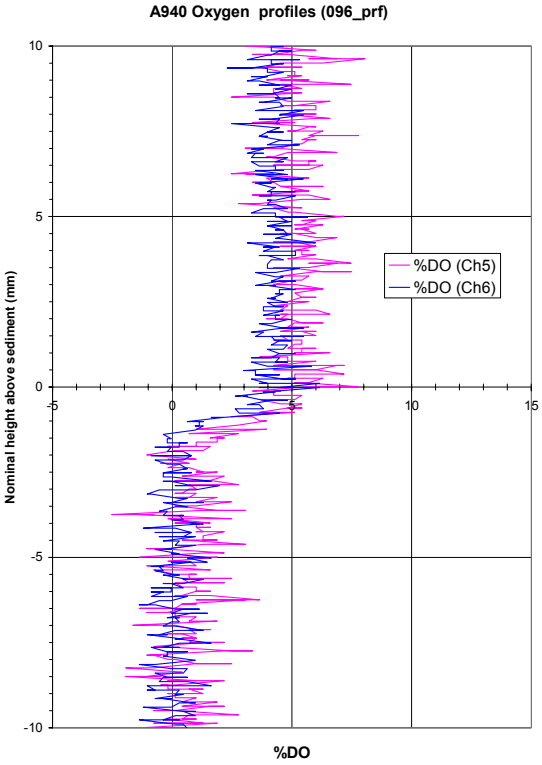
At the time of writing the pH data have not been analysed. However pH readings appeared to be stable and reliable (unlike on previous cruises) and show some slight variations which correlate with the oxygen profiles.

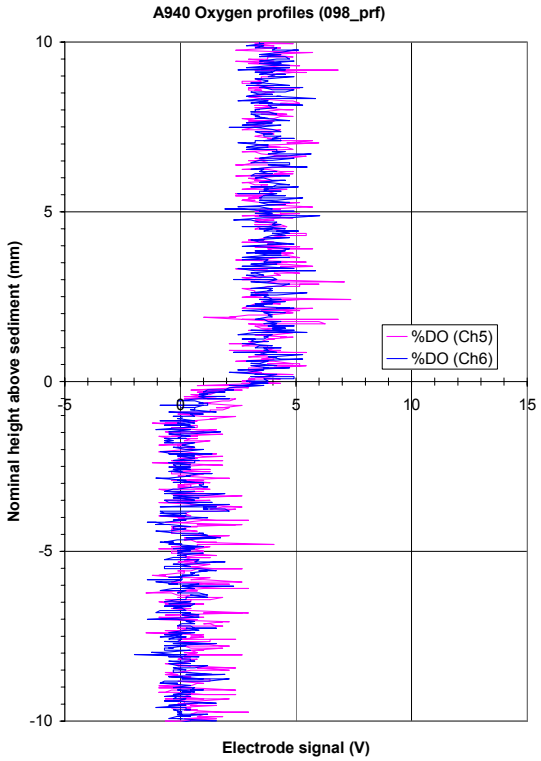
The resistivity probe worked reliably throughout, and at the end of the cruise we had the chance to perform a test deployment of the *Profilur* at A940 (099_prf) using the new sediment detection code to start high resolution profiling just above the sediment surface. The deployment was a success, and gives confidence that this could become a standard method in the future.

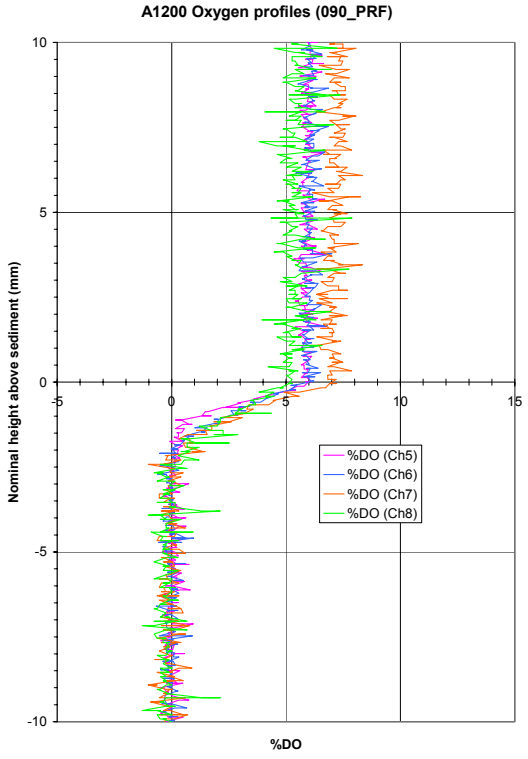


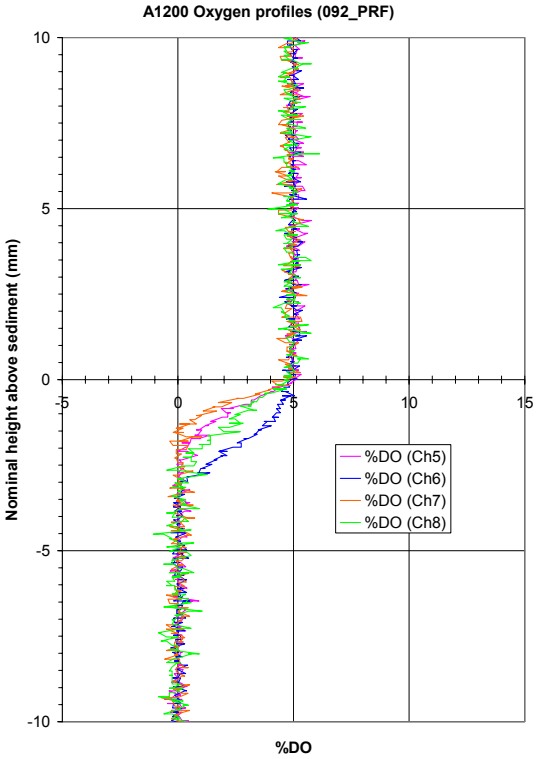


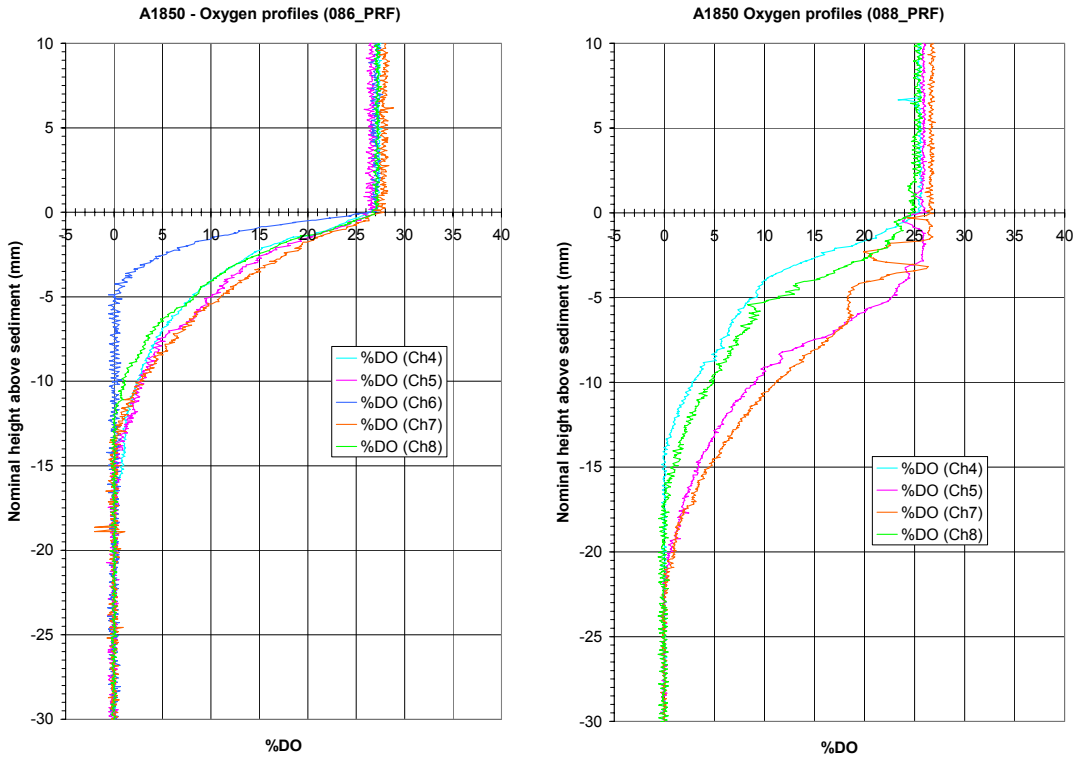



A940 Oxygen profiles (096_prf)
Nominal height above sediment (mm)
%DO
%DO (Ch5)
%DO (Ch6)


A940 Oxygen profiles (098_prf)
Nominal height above sediment (mm)
Electrode signal (V)
%DO (Ch5)
%DO (Ch6)


A1200 Oxygen profiles (090_PRF)
Nominal height above sediment (mm)
%DO
%DO (Ch5)
%DO (Ch6)
%DO (Ch7)
%DO (Ch8)


A1200 Oxygen profiles (092_PRF)
Nominal height above sediment (mm)
%DO
%DO (Ch5)
%DO (Ch6)
%DO (Ch7)
%DO (Ch8)



10.32 Elinor

The *Elinor* deployments were highly variable in producing valid data. Because the camera was not fitted until A1200, and because of the problems with lid closure that were highlighted after this, all data from deployments at A140, A300 and A1850 must be treated with some caution as there can be no certainty when the lid closed, if it closed at all. Details of the samples and data obtained from each *Elinor* deployment, together with an indication of their integrity are given in Appendix xx.

Bottom temperature

Temperature loggers were fitted to the landers for the first time, and mean, min and max bottom temperatures are given in Table 2. There is significant variation in temperatures over the course of deployments, especially at A140 and A300. A brief inspection of the oxygen and temperature data for an *Elinor* deployment at A140 shows close correlation between the temperature and the ambient oxygen signal.

10.33 Technical summary

The cruise was unusually bad for equipment failures and failed deployments. The major issues are outlined in the this section. It is possible that one of the reasons for the high number of failures was the extreme temperatures on deck.

A. Profilur

Early on in the cruise a failed connector resulted in the computer unit being severely burnt out. The spare electronics was then brought into service, but after a few deployments the pressure housing was found to be leaking around the electrode connectors. This was traced to the o-ring grooves on the housing end-cap being off centre with the threaded holes for the connectors. The end-cap and connectors from the old housing was then fitted to the new unit, after which no further problems were encountered.

Some trouble was experienced with the absolute height measurements of the *Profilur* unit, with significant errors being introduced in small profiling steps. The unit was calibrated for the three commonly used step sizes to ensure accurate data. The calibrations were:

Nominal step size	Actual step size	% error
50 µm	65 µm	30%
100 µm	125 µm	25%
250 µm	288 µm	15%

Problems were also experienced with the Interocean release system fitted to the *Profilur*. On deck some hours after a recovery the release motor unit suddenly started leaking oil. On close inspection two of the three

aluminium bolts securing the housing had sheared off, and were found lying on deck under the frame. The unit was later refilled with liquid paraffin (as we didn't have enough of the original oil (Silicone oil DOW DC200/5CS)) and successfully tested.

B. Elinor

Water sampler
Initially water sample volumes were fairly poor (mostly around 20 – 30ml). Some improvements were made by applying small amounts of silicone grease to the syringe plungers and to the rods on the sampler. However the biggest improvement was achieved by replacing some of the springs with fractionally longer ones bought as spares. These proved to be much better, and the remaining springs were then lengthened with a few extra coils, which proved to be almost as good as the new springs. After this these modifications the water volumes were consistently above 45ml, and often at the maximum 55ml.

Lid closure
Previous to the cruise diver footage had been obtained of the lid closing, and it was always assumed this was reliable. However camera footage at A1200 indicated that the lid was not always closing. The cables connecting the oxygen electrodes to the computer are new, and being shielded they are stiffer than the old cables. It is possible that this is the cause of the problem. Extra weight was added to the front of the lid to ensure reliable closure. This worked, but in rough weather the burnwire was then prone to breaking during deployment because of the extra weight.

Mud retrieval
The hydraulic shovel system was extensively overhauled prior to the cruise, and got good cores in the shallow sites. However at A940 and below no mud was retrieved. The camera showed that the problem is likely to be a pressure effect as at A1200 the shovel didn't close until 10 – 15 mins after the lander left bottom. At A940 it closed a couple of minutes or so off bottom. The system was stripped down on several times, and seals replaced. However despite all efforts, it proved impossible to bleed the system and then cock the shovel without introducing air into the reservoir. The system will be shipped back to UK for further work prior to CD151.

Electrodes
A new configuration for the chamber oxygen electrodes was being used, with no pre-amplifier at the chamber lid, and a shielded cable linking the electrode to the computer. This proved to be a lot more reliable than the previous system, and gave relatively clean and stable signals throughout.

Table 1: Deployment summary

Deployment #	**074_eli**	**075_prf**	**076_eli**	**077_prf**	**078_eli**	**079_prf**	**080_eli**	**081_eli**	**082_prf**	**083_prf**
Site	A140	A140	A140	A140	A300	A300	A300	A300	A300	A300
SOC series #	55901#3	55901#4	55901#12	55901#15	55902#3	55902#10	55902#11	55902 #15	55902#16	55902#19
Configuration	*Elinor* (EO), moored	*Profilur*, moored	*Elinor* (EF), moored	*Profilur*, moored	*Elinor* (EO), moored	*Profilur*, moored	*Elinor* (EF), moored	*Elinor* (EF), moored	*Profilur*, moored	*Profilur*, moored
Comments on data & samples obtained	Failed – lander on its side	2 good & 3 noisy profiles	Got "EO" data & mud. Water samples OK.	Failed – blown electronics	OK , no mud, good water sample vols.	Failed – lander moving on bed	Aborted to change mooring	Good core, Water sample vols low.	Good – but no discernible change in O2	Good – but no discernible change in O2
Deployment date	21/04/03	21/04/03	22/04/03	23/04/05	25/04/03	26/04/03	27/04/03	27/04/03	27/04/03	28/04/03
Deployment time (UTC)	0122	0258	1407	0921	1029	1107	0313	1235	1331	1211
Deployment position	23°17.153'N 66°42.427'E	23°17.397'N 66°42.085'E	23°17.133'N 66°42.441'E	23°17.443'N 66°42.065'E	23°12.780'N 66°33.468'E	23°13.384'N 66°33.153'E	23°12.865'N 66°33.427'E	23°12.858'N 66°33.428'E	23°13.448'N 66°33.323'E	23°13.485'N 66°33.221'E
Deployment Water depth	132m	132m	133m	134m	303m	295m	~300m	303m	295m	296m
Mooring line length (m)	225	225	170	170	340	350	340	450	440	440
Recovery date	22/04/03	23/04/03	25/04/03	24/04/03	26/04/03	27/04/03	27/04/03	30/04/03	28/04/03	29/04/03
Recovery time	0509	0130	0134	0447	1240	0618	1010	0134	0938	0524
Time on bottom (hrs)	27.5	46.5	59.3	18.8	25.8	19.0	6.7	59.8	19.7	16.8
Weight on descent (kg)	80	65	80	65	80	65	80	90	90	90
Weight on ascent (kg)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Descent speed (m/min)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ascent speed (m/min)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Est. height of sediment above lander feet (mm)	n/k	50	15	n/k	n/k	>90	n/k	20	25	30
Est. max. penetration of O2 electrodes or chamber into sediment (mm)	0	60	190	0	n/k	n/k	n/k	210	60	65

Note: *Dep. time:* time system reset prior to deployment
D*ep. pos.:* position of ship when lander released, or mooring released
Rec. time: time lander completely in-board

Deployment #	**084_eli**	**085_eli**	**086_prf**	**087_eli**	**088_prf**	**089_eli**	**090_prf**	**091_eli**	**092_prf**	**093_eli**
Site	A300	A1850	A1850	A1850	A1850	A1200	A1200	A1200	A1200	A1200
SOC series #	55902#24	55904#3	55904#4	55904#9	55904#13	55911#3	55911#6	55911#8	55911#12	n/a
Configuration	*Elinor* (EF13), moored	*Elinor* (EO), autonomous	*Profilur*, autonomous	*Elinor* (EF), autonomous	*Profilur*, autonomous	*Elinor* (EO), autonomous	*Profilur*, autonomous	*Elinor* (EO), autonomous	*Profilur*, autonomous	*Elinor*, autonomous for test
Comments on data & samples obtained	Good all round	No mud, good water samples	5 good O2 profiles	No mud, 10/14 good water samples	4 good O2 profiles	Failed – lid didn't close. No mud.	4 good O2 profiles	Failed – lid seal lost. No mud.	4 good O2 profiles	Lid & shovel test.
Deployment date	30/04/03	03/05/03	03/05/03	04/05/03	05/05/03	09/05/03	10/05/03	10/05/03	11/05/03	12/05/03
Deployment time (UTC)	1119	0313	1011	1302	1245	0231	0305	1245	1216	0207
Deployment position	23°12.936'N 66°33.372'E	22°51.792'N 65°59.787'E	22°51.207'N 65°59.854'E	22°51.775'N 66°00.125'E	22°51.070'N 65°59.934'E	22°59.759'N 66°24.795'E	22°59.577'N 66°25.176'E	22°59.770'N 66°24.758'E	22°59.549'N 66°25.139'E	22°59.775'N 66°24.807'E
Deployment Water depth	301m	1859m	1877m	1859	1866	1181	1178	1184	1178	1182
Mooring line length (m)	450	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Recovery date	02/05/03	04/05/03	05/05/03	07/05/03	06/05/03	10/05/03	11/05/03	11/05/03	12/05/03	12/05/03
Recovery time	1059	0535	0200	1329	0254	0510	0450	1330	0319	0915
Time on bottom (hrs)	47.3	24.9	41.1	71.0	12.5	25.6	24.5	23.8	13.9	5.0
Weight on descent (kg)	90	52	44	52	31	46	41	51	40	51
Weight on ascent (kg)	n/a	-110	-86	-110	-87	-107	-91	-107	-83	-107
Descent speed (m/min)	n/a	56	53	55	44	51	49	56	47	51
Ascent speed (m/min)	n/a	80	69	~80?	69	79	74	74	69	79
Est. height of sediment above lander feet (mm)	50	n/k	0	n/k	0	30	35	30	50	n/k
Est. max. penetration of electrodes or chamber into sediment (mm)	220	n/k	65	n/k	60	200	110	190	120	n/k

Note: *Dep. time:* time system reset prior to deployment
D*ep. pos.:* position of ship when lander released, or mooring released
Rec. time: time lander completely in-board

Deployment #	**094_eli**	**095_eli**	**096_prf**	**097_eli**	**098_prf**	**099_prf**	**100_eli**	**101_eli**		
Site	A1200	A940	A940	A940	A940	A940	A140	A140		
SOC series #	55911#17	55918#3	55918#6	55918#11	55918#15	55923#1	55931#2	55931#5		
Configuration	*Elinor* (EF), autonomous	*Elinor* (EO), autonomous	*Profilur*, autonomous	*Elinor* (EF), autonomous	*Profilur*, autonomous	*Profilur*, autonomous	*Elinor* (EF13), moored	*Elinor* (EF), moored		
Comments on data & samples obtained	Lid OK, no mud, good water samples	Lid OK, no mud, good water samples	4 good O2 profiles	Lid OK, no mud, good water samples	4 good O2 profiles	4 good O2 profiles	Failed – lid didn't shut. Good mud and water.	Lid, mud & water good. No electrode data…		
Deployment date	13/05/03	15/05/03	16/05/03	17/05/03	18/05/03	20/05/03	22/05/03	25/05/03		
Deployment time (UTC)	0307	1434	0718	1241	1340	1408	1323	1148		
Deployment position	22°59.700'N 66°24.554'E	22°53.239'N 66°36.939'E	22°52.924'N 66°37.198'E	22°53.211'N 66°36.943'E	22°52.907'N 66°37.324'E	22°52.898'N 66°37.240'E	23°17.084'N 66°42.444'E	23°17.110'N 66°42.641'E		
Deployment Water depth	1194m	941m	940m	940m	937m	938m	133m	133m		
Mooring line length (m)	n/a	n/a	n/a	n/a	n/a	n/a	220	220		
Recovery date	15/05/03	17/05/03	18/05/03	19/05/03	20/05/03	21/05/03	25/05/03	27/05/03		
Recovery time	0316	0230	0703	1325	0500	0321	0155	1358		
Time on bottom (hrs)	47.1	35.5	46.6	47.6	38.3	12.2	60.4	49.9		
Weight on descent (kg)	51	42	38	51	39	39	140	140		
Weight on ascent (kg)	-107	-107	-83	-107	-82	-82	n/a	n/a		
Descent speed (m/min)	54	52	45	55	47	n/k	n/a	n/a		
Ascent speed (m/min)	80	78	67	n/k	67	67	n/a	n/a		
Est. height of sediment above lander feet (mm)	25	n/k	40	40	40	35	10	15		
Est. max. penetration of electrodes or chamber into sediment (mm)	200	n/k	80	210	50	80	210	190		

Note: *Dep. time:* time system reset prior to deployment
D*ep. pos.:* position of ship when lander released, or mooring released
Rec. time: time lander completely in-board

Table 2 – Summary of bottom temperature records from lander deployments (~0.5m above bottom)

Deployment #	Station	Max temp (C)	Min temp (C)	Mean temp (C)
074_eli	A140	21.46	19.98	20.75
075_prf	A140	21.52	19.92	20.87
076_eli	A140	22.60	20.32	21.78
077_prf	A140	22.08	20.36	21.39
078_eli	A300	15.18	14.79	14.97
079_prf	A300	15.27	14.85	14.98
081_eli	A300	15.23	14.66	14.90
082_prf	A300	15.32	14.90	14.99
083_prf	A300	15.13	14.90	15.04
084_eli	A300	15.58	14.98	15.26
085_eli	A1850	3.40	3.40	3.40
086_prf	A1850	3.40	3.38	3.38
087_eli	A1850	3.41	3.37	3.38
088_prf	A1850	3.39	3.38	3.39
089_eli	A1200	7.54	7.27	7.37
090_prf	A1200	7.57	7.32	7.44
091_eli	A1200	7.57	7.23	7.36
092_prf	A1200	7.51	7.36	7.41
094_eli	A1200	7.48	7.22	7.34
095_eli	A940	9.12	8.89	8.95
096_prf	A940	9.03	8.87	8.95
097_eli	A940	8.99	8.88	8.93
098_prf	A940	9.04	8.83	8.95
099_prf	A940	8.98	8.79	8.86
100_eli	A140	18.69	17.95	18.41
101_eli	A140	18.59	17.72	18.21

Oli Peppe

10.34 Elinor deployment logs.

Lander deployment no.	**076_ELI**
Station	**A140**
SOC No.	**55901 #12**
Elinor Mode	**EF (in theory - but EO in practice….)**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments, details of mud and cores etc.
Lid closed	22/04/03 15:40	0.0	
Stirrer start	22/04/03 15:40	0.0	
Oxystat pump on	n/a		wrong program - Oxystat never turned on
Oxystat pump off	n/a		
Stirrer off	23/04/03 16:20	24.7	
Shovel & water bottles fired	23/04/03 16:20	24.7	Got mud. 4 "test" cores taken. One sliced for TMs (Breuer) Estimated overlying water vol: 13.5 l

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	22/04/03 15:39	0.0	1B3Y	29 (+ 1 air)	TM
#02	22/04/03 15:39	0.0	2B	40	TM
#03	23/04/03 03:51	12.2	4B	33	TM - mud in tube
#04	23/04/03 03:51	12.2	5B	40	TM - mud in tube
#05	23/04/03 15:52	24.2	1B4Y	55	TM
#06	23/04/03 15:59	24.3	n/a	53	KBr inject
#07	23/04/03 16:09	24.5	n/a	29 (+ 6 air)	KBr sample
#08	23/04/03 15:52	24.2	3B	21 (+ 8 air)	TM - tube disconnected
#09	23/04/03 15:52	24.2	1B	19 (+ 18 air)	TM - mud in tube
#10	23/04/03 15:52	24.2	#02	14 (+ 20 air)	Nutrients
#11	22/04/03 15:39	0.0	#01	33	Nutrients
#12	22/04/03 15:39	0.0	#04	32	Nutrients
#13	23/04/03 03:51	12.2	#03	24	Nutrients - mud in tube; tube disconnected
#14	23/04/03 03:51	12.2	#05	0	Nutrients - tube disconnected
#15	23/04/03 15:52	24.2	#06	32	Nutrients - mud in tube

ote disconnected tubes all at male luer to stop cock fitting - not used for subsequent deployments

Lander deployment no.	**078_ELI**
Station	**A300**
SOC No.	**55902 #3**
Elinor Mode	**EO**

Event	**Date / time (UTC)**	**Time from incubation start (hrs)**	**Comments**
Lid closed	25/04/03 12:03	0.0	
Stirrer start	25/04/03 12:03	0.0	
Oxystat pump on	n/a		
Oxystat pump off	n/a		
Stirrer off	26/04/03 08:43	20.7	
Shovel & water bottles fired	26/04/03 08:43	20.7	Small amount of mud but mostly washed out Estimated overlying water vol: n/k

Water samples

Syringe port	**Date / time (UTC)**	**Time from incubation start (hrs)**	**Vial / Tube Nos.**	**Sample Vol (ml)**	**Water sample analytes / Comments**
#01	25/04/03 12:01	0.0	A01	39	DO
#02	25/04/03 12:01	0.0	A06	43	DO
#03	25/04/03 22:13	10.2	A02	42	DO
#04	25/04/03 22:13	10.2	A08	48	DO
#05	26/04/03 08:14	20.2	#03	55	N2
#06	26/04/03 08:21	20.3	n/a	53	KBr Inject
#07	26/04/03 08:32	20.5	n/a	18 (+20 air)	KBr sample
#08	26/04/03 08:14	20.2	A04	41	DO
#09	26/04/03 08:14	20.2	A03	48	DO
#10	26/04/03 08:14	20.2	A05	46	DO
#11	25/04/03 12:01	0.0	B25	31	DO
#12	25/04/03 12:01	0.0	#05	35	N2
#13	25/04/03 22:13	10.2	B05	46	DO
#14	25/04/03 22:13	10.2	#06	43	N2
#15	26/04/03 08:14	20.2	#01	33	N2

Lander deployment no.	**081_ELI**
Station	**A300**
SOC No.	**55902 #15**
Elinor Mode	**EF**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments
Lid closed	27/04/03 14:13	0.0	
Stirrer start	27/04/03 14:13	0.0	
Oxystat pump on	27/04/03 14:29	0.3	
Oxystat pump off	30/04/03 00:28	58.3	
Stirrer off	30/04/03 00:28	58.3	
Shovel & water bottles fired	30/04/03 00:28	58.3	Good core, one subcore taken for TMs. Estimated overlying water vol: 13.0 l

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	30/04/03 00:01	57.8	2B	43	TM
#02	30/04/03 00:01	57.8	1B3Y	34	TM
#03	27/04/03 14:13	0.0	5B	51	TM
#04	27/04/03 14:13	0.0	1B	48	TM
#05	28/04/03 12:19	22.1	1B4Y	50	TM
#06	30/04/03 00:08	57.9	n/a	53	KBr inject
#07	30/04/03 00:18	58.1	n/a	29 (+ 6 air)	KBr sample
#08	29/04/03 06:10	39.9	3B	10	TM
#09	29/04/03 06:10	39.9	4B	16	TM
#10	29/04/03 06:10	39.9	#07	21	Nutrients
#11	30/04/03 00:01	57.8	#03	36	Nutrients
#12	30/04/03 00:01	57.8	#05	9	Nutrients
#13	27/04/03 14:13	0.0	#04	19	Nutrients
#14	27/04/03 14:13	0.0	#02	15	Nutrients
#15	28/04/03 12:19	22.1	#06	29	Nutrients

Lander deployment no.	**084_ELI**
Station	**A300**
SOC No.	**55902 #24**
Elinor Mode	**EF13**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments
Lid closed	30/04/03 14:27	0.0	NB Slurry addition starts simultaneously
Stirrer start	30/04/03 14:57	0.5	(Some stirring during slurry addition, prior to settling period
Oxystat pump on	30/04/03 14:57	0.5	
Oxystat pump off	02/05/03 09:28	43.0	
Stirrer off	02/05/03 09:28	43.0	
Shovel & water bottles fired	02/05/03 09:28	43.0	Good core, 2 subcores taken for 13C analysis Estimated overlying water vol: 10.4 l

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	30/04/03 14:37	0.2	n/a	53	Slurry inject (1284 mg slurry + ballast)
#02	30/04/03 15:57	1.5	#01	44	Nutrients
#03	01/05/03 05:59	15.5	#10	44	Nutrients
#04	01/05/03 20:00	29.6	#06	40	Nutrients
#05	02/05/03 09:01	42.6	#09	51	Nutrients
#06	02/05/03 09:07	42.7	n/a	53	KBr inject
#07	02/05/03 09:17	42.8	n/a	46	KBr sample
#08	30/04/03 14:27	0.0	#11	51	Nutrients
#09	02/05/03 09:01	42.6	#07	35	Nutrients
#10	02/05/03 09:01	42.6	#08	38	Nutrients
#11	30/04/03 14:27	0.0	#02	50	Nutrients
#12	30/04/03 15:57	1.5	#04	40	Nutrients
#13	30/04/03 15:57	1.5	#05	45	Nutrients
#14	01/05/03 05:59	15.5	#03	37	Nutrients
#15	01/05/03 20:00	29.6	#12	47	Nutrients

Lander deployment no.	**085_ELI**
Station	**A1850**
SOC No.	**55904 #3**
Elinor Mode	**EO**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments
Lid closed	03/05/03 06:16	0.0	
Stirrer start	03/05/03 06:16	0.0	
Oxystat pump on	n/a	n/a	
Oxystat pump off	n/a	n/a	
Stirrer off	04/05/03 03:56	21.7	
Shovel & water bottles fired	04/05/03 03:56	21.7	No mud retrieved. Estimated overlying water vol: n/k

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	03/05/03 06:16	0.0	A08	41	DO
#02	03/05/03 06:16	0.0	A06	55	DO
#03	03/05/03 16:56	10.7	B04	55	DO
#04	03/05/03 16:56	10.7	B25	55	DO
#05	04/05/03 03:28	21.2	#02	52	N2
#06	04/05/03 03:35	21.3	n/a	53	KBr Inject
#07	04/05/03 03:45	21.5	n/a	0	KBr sample (not triggered correctly)
#08	04/05/03 03:28	21.2	A04	53	DO
#09	04/05/03 03:28	21.2	A03	55	DO
#10	04/05/03 03:28	21.2	A02	46	DO
#11	03/05/03 06:16	0.0	A05	55	DO
#12	03/05/03 06:16	0.0	#04	55	N2
#13	03/05/03 16:56	10.7	A01	55	DO
#14	03/05/03 16:56	10.7	#06	45	N2
#15	04/05/03 03:28	21.2	#07	55	N2

Lander deployment no.	**087_ELI**
Station	**A1850**
SOC No.	**55904 #9**
Elinor Mode	**EF**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments
Lid closed	04/05/03 16:41	0.0	
Stirrer start	04/05/03 16:41	0.0	
Oxystat pump on	04/05/03 16:56	0.3	
Oxystat pump off	07/05/03 11:56	67.3	
Stirrer off	07/05/03 11:56	67.3	
Shovel & water bottles fired	07/05/03 11:56	67.3	No mud retrieved. Estimated overlying water vol: n/k

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	04/05/03 16:40	0.0	2B	55	TM
#02	04/05/03 16:40	0.0	1B4Y	55	TM
#03	05/05/03 21:26	28.8	3B	55	TM
#04	07/05/03 11:28	66.8	5B	53	TM
#05	07/05/03 11:28	66.8	4B	49	TM
#06	07/05/03 11:35	66.9	n/a	0	KBr inject, not fired
#07	07/05/03 11:46	67.1	n/a	0	KBr sample, not fired
#08	06/05/03 16:27	47.8	1B3Y	0	TM, not fired
#09	06/05/03 16:27	47.8	1B	0	TM, not fired
#10	06/05/03 16:27	47.8	#06	0	Nutrients, not fired
#11	04/05/03 16:40	0.0	#05	55	Nutrients
#12	04/05/03 16:40	0.0	#04	36	Nutrients
#13	05/05/03 21:26	28.8	#01	33	Nutrients
#14	07/05/03 11:28	66.8	#02	55	Nutrients
#15	07/05/03 11:28	66.8	#07	53	Nutrients

Lander deployment no. **094_ELI**
Station **A1200**
SOC No. **55911#17**
Elinor Mode **EF**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments
Lid closed	13/05/03 08:00	1.3	Lid closed fully sometime between 06:45 & 08:02
Stirrer start	13/05/03 06:45	0.0	
Oxystat pump on	13/05/03 07:01	0.3	
Oxystat pump off	15/05/03 01:45	43.0	
Stirrer off	15/05/03 01:45	43.0	
Shovel & water bottles fired	15/05/03 01:45	43.0	No mud retrieved Estimated overlying water vol: 12.6 l

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	13/05/03 06:45	0.0	2B	40	TM
#02	13/05/03 06:45	0.0	3B	40	TM
#03	13/05/03 21:06	14.3	1B	56	TM
#04	15/05/03 01:18	42.5	1B4Y	54	TM
#05	15/05/03 01:18	42.5	5B	56	TM
#06	15/05/03 01:25	42.7	n/a	53	KBr inject
#07	15/05/03 01:35	42.8	n/a	40	KBr sample
#08	14/05/03 11:12	28.4	1B3Y	48	TM
#09	14/05/03 11:12	28.4	4B	49	TM
#10	14/05/03 11:12	28.4	#01	55	Nutrients
#11	13/05/03 06:45	0.0	#07	44	Nutrients
#12	13/05/03 06:45	0.0	#04	35	Nutrients
#13	13/05/03 21:06	14.3	#02	32	Nutrients
#14	15/05/03 01:18	42.5	#06	55	Nutrients
#15	15/05/03 01:18	42.5	#05	49	Nutrients

Lander deployment no.	**095_ELI**
Station	**A940**
SOC No.	**55918#3**
Elinor Mode	**EO**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments
Lid closed	15/05/03 14:46	-3.4	Lid closed as lander entered water
Stirrer start	15/05/03 18:07	0.0	
Oxystat pump on	n/a	n/a	
Oxystat pump off	n/a	n/a	
Stirrer off	17/05/03 00:58	30.8	
Shovel & water bottles fired	17/05/03 00:58	30.8	No mud retrieved. Estimated overlying water vol: n/k

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	15/05/03 18:07	0.0	A06	55	DO
#02	15/05/03 18:07	0.0	A04	46	DO
#03	16/05/03 09:23	15.3	A05	56	DO
#04	16/05/03 09:23	15.3	B25	56	DO
#05	17/05/03 00:30	30.4	#01	54	N2
#06	17/05/03 00:37	30.5	n/a	53	KBr Inject
#07	17/05/03 00:47	30.7	n/a	55	KBr sample
#08	17/05/03 00:30	30.4	B05	55	DO
#09	17/05/03 00:30	30.4	A02	55	DO
#10	17/05/03 00:30	30.4	A08	55	DO
#11	15/05/03 18:07	0.0	B04	32	DO
#12	15/05/03 18:07	0.0	#05	43	N2
#13	16/05/03 09:23	15.3	A03	44	DO
#14	16/05/03 09:23	15.3	#06	51	N2 - top tube disconnected during removal.
#15	17/05/03 00:30	30.4	#04	56	N2

Lander deployment no.	**097_ELI**
Station	**A940**
SOC No.	**55918#11**
Elinor Mode	**EF**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments
Lid closed	17/05/03 16:19	0.0	Confirmed closure.
Stirrer start	17/05/03 16:19	0.0	
Oxystat pump on	17/05/03 16:35	0.3	
Oxystat pump off	19/05/03 11:19	43.0	
Stirrer off	19/05/03 11:19	43.0	
Shovel & water bottles fired	19/05/03 11:19	43.0	No mud retrieved Estimated overlying water vol: 11.3 l

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	17/05/03 16:19	0.0	5B	28	TM
#02	17/05/03 16:19	0.0	1B	41	TM
#03	18/05/03 06:40	14.3	1B3Y	56	TM
#04	19/05/03 10:51	42.5	1B4Y	56	TM
#05	19/05/03 10:51	42.5	2B	55	TM
#06	19/05/03 10:58	42.7	n/a	53	KBr inject
#07	19/05/03 11:08	42.8	n/a	56	KBr sample
#08	18/05/03 20:45	28.4	3B	56	TM
#09	18/05/03 20:45	28.4	4B	56	TM
#10	18/05/03 20:45	28.4	#06	51	Nutrients
#11	17/05/03 16:19	0.0	#04	32	Nutrients
#12	17/05/03 16:19	0.0	#07	56	Nutrients
#13	18/05/03 06:40	14.3	#01	56	Nutrients
#14	19/05/03 10:51	42.5	#02	56	Nutrients
#15	19/05/03 10:51	42.5	#05	51	Nutrients

Lander deployment no.	**101_ELI**
Station	**A140**
SOC No.	**55931#5**
Elinor Mode	**EF**

Event	Date / time (UTC)	Time from incubation start (hrs)	Comments
Lid closed	25/05/03 15:26	0.0	Confirmed closure.
Stirrer start	25/05/03 15:26	0.0	
Oxystat pump on	25/05/03 15:42	0.3	
Oxystat pump off	27/05/03 12:26	45.0	
Stirrer off	27/05/03 12:26	45.0	
Shovel & water bottles fired	27/05/03 12:26	45.0	Mud retrieved – one subcore taken for TMs (Breuer) Estimated overlying water vol: 13.5 l

Water samples

Syringe port	Date / time (UTC)	Time from incubation start (hrs)	Vial / Tube Nos.	Sample Vol (ml)	Water sample analytes / Comments
#01	25/05/03 15:26	0.0	4B	40	TM
#02	25/05/03 15:26	0.0	1B	40	TM
#03	26/05/03 06:42	15.3	5B	45	TM
#04	27/05/03 11:54	44.5	1B4Y	38	TM
#05	27/05/03 11:54	44.5	1B3Y	44	TM
#06	27/05/03 12:01	44.7	n/a	53	KBr inject
#07	27/05/03 12:11	44.8	n/a	40	KBr sample
#08	26/05/03 21:48	30.4	2B	50	TM
#09	26/05/03 21:48	30.4	3B	45	TM
#10	26/05/03 21:48	30.4	#06	40	Nutrients
#11	25/05/03 15:26	0.0	#07	56	Nutrients
#12	25/05/03 15:26	0.0	#03	42	Nutrients
#13	26/05/03 06:42	15.3	#05	41	Nutrients
#14	27/05/03 11:54	44.5	#02	34	Nutrients
#15	27/05/03 11:54	44.5	#04	44	Nutrients

10.4 Shipboard incubation experiments:

Introduction
The shipboard incubation rig and oxystat system was used to carry out experiments on 48 megacores during CD 146. The system is new and therefore adjustments to the setup and protocols were required throughout.

The oxystat system was generally successful in maintaining barrel dissolved O_2 levels at or near *in situ* ambient levels (Figure 1). The system was able to deal with O_2 "contamination" induced by the processing of cores under atmosphere (e.g., unloading cores from the megacorer unit) and O_2 demand within the cores. However, we did encounter several problems related to the regulation of O_2 concentrations within the oxystat reservoir, the operation of the peristaltic pump, sampling-induced O_2 contamination via bubbles and possible porewater squeezing.

10.41 Technical Summary

Here follows a summary of the successful and problematic aspects of the rig together with planned and implemented improvements.

Replacement Water
Initially, withdrawal of water samples was to be accompanied by replacing the volume withdrawn with filtered bottom water, the biogeochemical composition of which would be analysed along with the samples. The first problem encountered here stemmed from the lack of good seals between sampling lines and stopcocks. This prevented automatic replacement from the bottom water reservoir, as air was drawn into the system instead of water. Using a syringe to manually replace the withdrawn volume during sampling surmounted this problem.

The second problem arose because the oxystat reservoir lid also does not have a gas-tight seal. It was planned to use the gas exhaust from the oxystat reservoir to sparge the bottom water replacement reservoir, maintaining its dissolved O_2 concentration similar to ambient. Without a gas-tight lid seal, the exhaust gas escaped the oxystat reservoir and thus could not be used for this purpose. Consequently, water used for replacement was typically more oxygenated than ambient bottom water (and, therefore, core top water). Thus, sampling and sample replacement prompted a spike in core top dissolved O_2 (Figure 2). For most experiments this was rapidly ameliorated by the oxystat system; however, it represents a major problem for quantification of O_2 consumption as the absolute amount of O_2 introduced was not known or controlled. This problem will be solved by the improvement of lid and stopcock seals, and, possibly, by the use of Winkler titrations and an O_2 electrode to monitor the bottom water replacement reservoir.

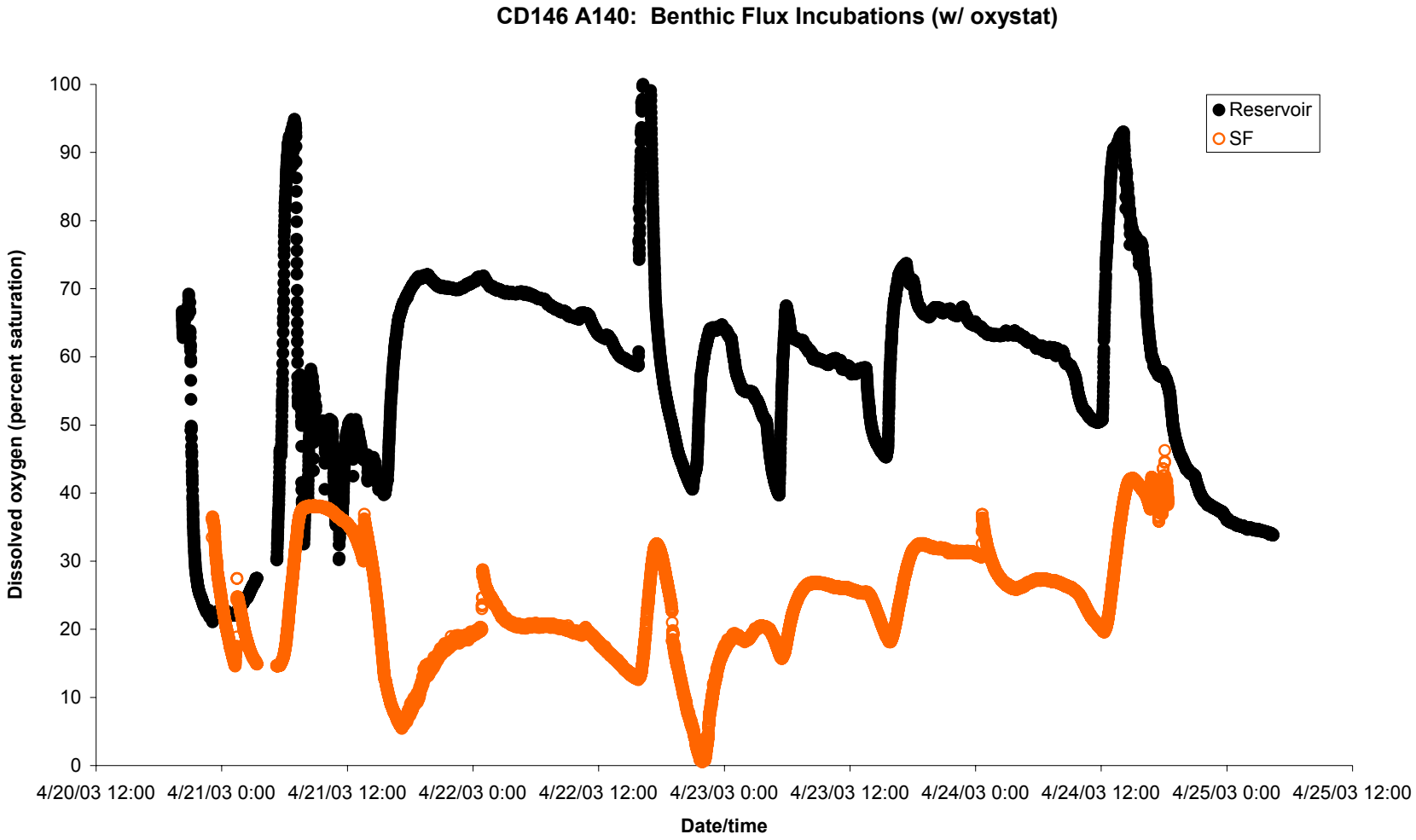


Figure 3. CD146 A140 Benthic Flux Incubations. Note that SF incubation tracks the changes in dissolved oxygen in the oxystat reservoir.

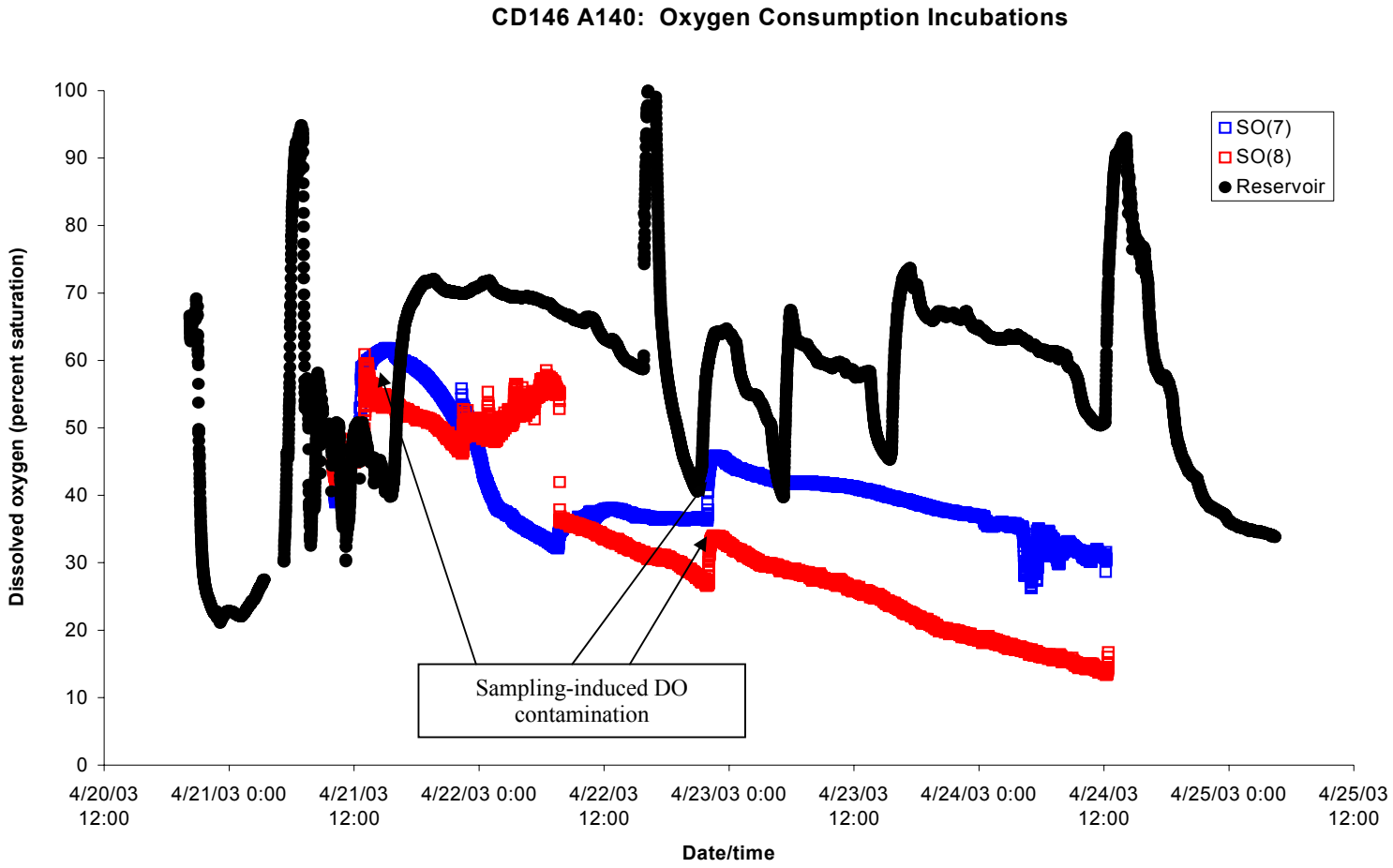


Figure 4. CD146 Oxygen Consumption Incubations. General decrease in incubation DO is interrupted by sampling-induced conamination, resulting from replacing sampled volume with water that is equilibrated with atmospheric oxygen.

Porewater Squeezing

For the purpose of this cruise, the replacement water problems described above were eliminated by ceasing to replace the sample volumes with GFF-filtered bottom water. Instead, we pushed the cores up their barrels at each sampling to reduce overlying water volume. This practice may introduce a further problem. Water was observed issuing from a burrow during sampling, raising concerns that porewater was being forced upwards through the sediment and across the sediment water interface. Such migration would almost certainly produce an artifact in the biogeochemical fluxes which the experiments are designed to measure. As described above, this issue will be tackled by improving the replacement water system.

Seals

As has been mentioned above there has been a general problem with maintaining gas tight seals between different types of tubing. The poorest seal occurs when connecting stopcocks to rigid Kynar sample withdrawal lines. This can cause air bubbles to enter the sampling syringe as sample water is withdrawn. Exposure of samples to CO_2 and N_2 in particular could seriously contaminate DIC and N_2/Ar samples. Efforts will be made to improve the integrity of these connections. This would also allow the automatic replacement from the bottom water reservoir and the maintenance of bottom water reservoir dissolved oxygen levels to function properly.

Reservoir Gas Sparging

Dissolved O_2 concentration of the oxystat reservoir is maintained at the desired level by sparging with air and nitrogen. During initial tests, gas bottles and flow meters were used to achieve relative stability. During the cruise, gas generators were used instead. The air generator was however incapable of delivering low enough flow (<1.2 L min^{-1}) to allow the use of a flow meter. The N_2 generator did not produce at a constant rate and its maximum output was only just enough to maintain OMZ low O_2 conditions. The consequences of this are firstly that controlling dissolved oxygen by adjusting the airflow had to be done on a trial and error rather than an informed basis. This often produced large fluctuations in reservoir O_2 levels during the first 12 hours on station (see oxystat reservoir trace in Figures 1and 2). Secondly, even once the gas flows had been adjusted, the constant switching on and off of the generators (a normal part of their functioning) produced a large, rapid but constant fluctuation around the desired mean. Although this did not feed back to the core tops, it is an undesirable feature. In the future, these problems may be solved by either 1) installing a step-down regulator in the downstream from the air generator and increasing the N_2-gereator output or 2) using bottled gases.

Pump Failure

The weakest part of the oxystat system proved to be the peristaltic pump. The tubing chosen to connect core barrels to the reservoir and pump has a larger outer diameter than the tubing which is supposed to run through the pump. New, large outer diameter silicone tubing was chosen to use with the pump instead of its original tubing; this is not, however, ideal and can cause problems. Firstly the tubing can creep through the pump, forming a kink at the downstream end and preventing flow. Secondly the pump has to work very hard to draw water up hydraulic gradients, (e.g., returning it from a gill at the bottom of the reservoir) especially during priming when there is a lot of air in the line. Increasing the tension of the pump clip on a particular line increases the strength of pumping but also increases wear on the tubing causing it to collapse. Applying high tension to any more than about four lines puts too great a load on the pump and the cartridge ceases to turn. If any kinking, tube collapse, or pump failure occurs during an experiment the dissolved oxygen levels in any oxystat barrels tends to fall, (Figure-3) with potential implications regarding biogeochemistry and the lifetime of fauna. The silicone tubing is also very time consuming to replace. Thinner walled Tygon tubing was also tried with the pump. This also had kinking and collapse problems and also tended to split when worn; however, it could be changed very easily. More types of tubing will be researched and tested, there is also the possibility of fitting the original, smaller diameter pump tubing to the larger outer diameter Kynar.

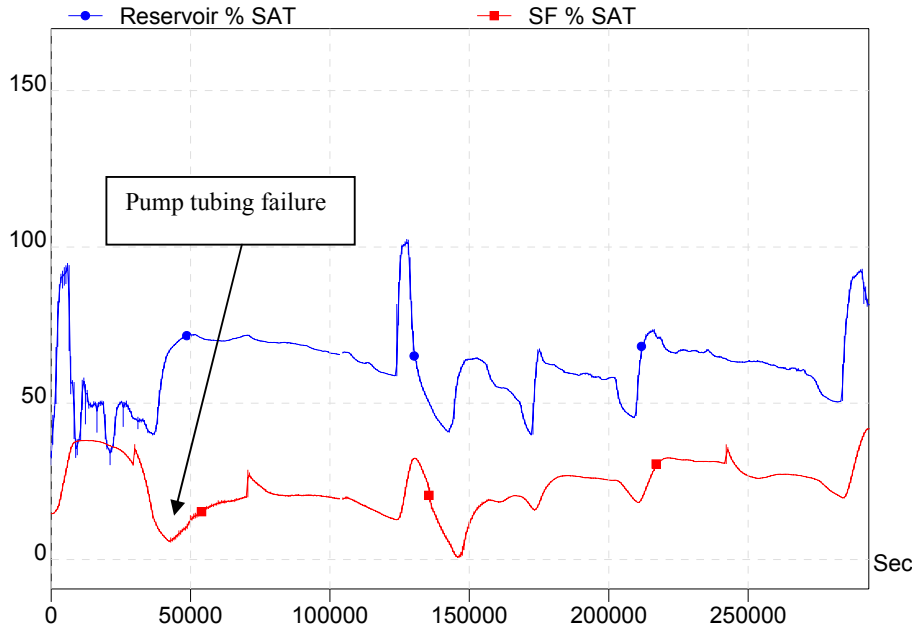


Figure 6. CD146 A300 Benthic Flux Incubation. Note marked decrease in dissolved oxygen due to pump tubing failure at point indicated in figure.

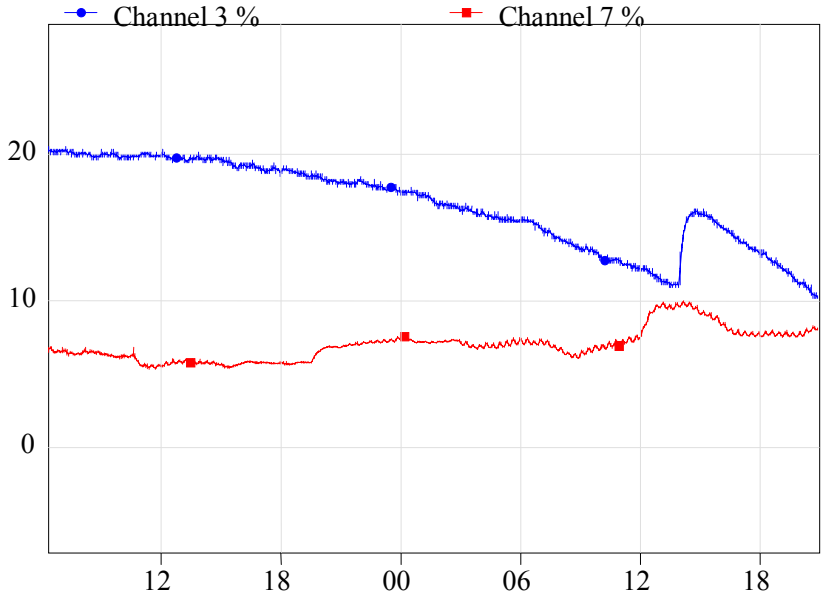


Figure 5. CD146 A900 Benthic flux (SF) incubation. Note: dissolved O_2 in SF incubation (Channel 3) remained above oxystat reservoir dissolved O_2 level for first 30 hours of incubation. This was due to coretop comtamination and pump tubing failure.

Core Top Oxygen Contamination

The process of taking cores from the megacorer and setting them up for incubation can take several hours, during which time the core top water is exposed to (a limited amount of) air. Despite efforts to flush any core headspace with nitrogen it was noticed that, especially at very low oxygen sites, core top dissolved oxygen levels at the start of an incubation were significantly greater than that of ambient bottom water. The first effect of the oxystat system was often to return the overlying water to seafloor conditions (Figure 4). There is very little to be done about this effect, and indeed the oxystat system is perhaps the most practical way of dealing with it, however as discussed below it has possible implications for the oxygen consumption experiments.

The Wendy Hut

A black plastic covered frame was constructed over the rig such that it would shut out light but could be taken apart for sampling or core setup/removal. It was not possible to build this large enough for work to be performed inside, thus it frequently had to be taken apart for significant periods of time. Apart from being rather impractical this plainly exposed the incubating cores to light. Indeed such were the gaps in the plastic where the

two halves joined that light was never totally excluded. The "Wendy Hut" will be replaced by black plastic sleeves round each core, as a more practical and effective way of keeping cores dark.

Clare Woulds, Matthew Schwartz

10.42 Fluorescent bead Incubations

As described earlier, shipboard core incubations were carried out with the objective of determining the particle size dependence of biological sediment mixing. Briefly, slurry containing three types of beads was added to the sediment, which was incubated for 2-3 days and then sectioned. The three bead types each had a unique colour and particle size distribution so that the preferential subduction of a certain colour of beads represents also the preferential mixing of a certain particle size range.

It is intended that the number of beads of each colour in each vertical fraction be counted using flow cytometry. This quantitative data is yet to be collected, thus the following interpretation is based only on qualitative observations.

Figure 1. Initial bead coverage on 940m site megacore.

Figure 2. Smearing of beads during sectioning of a 940m megacore/

Experimental Design

Every effort was made to achieve an initial even distribution of bead slurry over the sediment surface. Figure 1 shows that these efforts were as successful as could be hoped. The same core was sectioned without incubation as a control to quantify any downcore bead mixing caused by the extrusion process. Figure 2 shows the core after being moved up the core barrel. Smearing is clearly visible to about 4cm depth. Care was taken in all bead experiments to trim core section edges to minimise this effect.

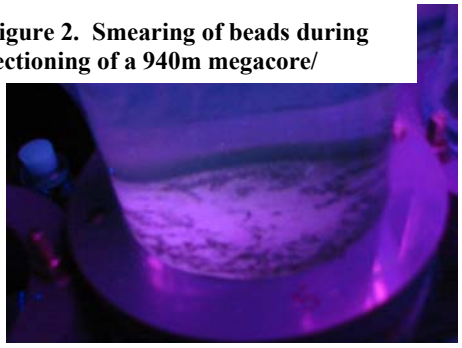


Figure 3. Only magenta beads visible even under uv light.

It was hoped that bead cores could be split longitudinally and photographed under uv light so that the downcore penetration of different coloured beads may be recorded visually. This was unfortunately not possible, firstly as the split barrels did not willingly fit the incubation rig or sectioning tables, and secondly because the magenta beads are so dominant that even when fluorescing they are the only visible type (figure 3). One final potential problem with these experiments is the visible flocculation of beads when the slurry is prepared due to their hydrophobic nature. This could alter the actual sizes of the added particles away from that intended. This will be investigated and corrected for through later particle size analysis of fluorescent bead slurry.

Figure 4. 140m site T Final 1

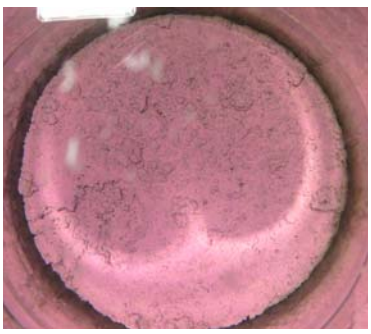
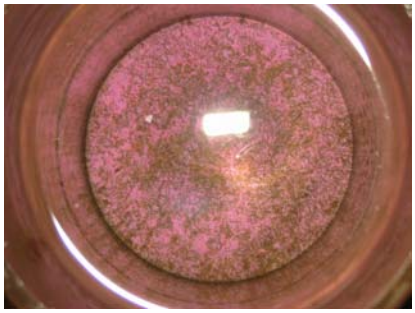


Figure 5. 300m site T Final. 1

Results

Comparing the appearance of core tops at the end of experiments at different sites allows a certain amount of interpretation.



These observations can also be related to the abundance of fauna at the sites.

Figure 6. 1850m siteT Final 1

Figure 7. 940m site T Final 1

A comparison of figures 4 and 7, both displaying cores from sites with abundant fauna, with figure 5, a core from a site with very little fauna, suggests that the abundance of fauna makes a visible difference to the final distribution of beads on the sediment surface. Bead treated surfaces in cores with abundant macrofauna show a less uniform bead distribution after incubation. As seen in figure 7, beads are also observed to form a sub-surface layer and to fall/be drawn down burrows. The first two of these features may be due to sub-surface feeders excreting a layer of faecal pellets onto the surface, which covers the beads. Figure 5 shows the final distribution of beads from the 300m OMZ site where macrofauna was almost totally absent. It can be seen that without the presence of bioturbating fauna the beads remained practically undisturbed and evenly distributed.

Below is a summary of the animals extracted from bead cores. Any observed interaction between beads and fauna is described.These early observations are promising and the quantitative results are eagerly awaited.

Clare Woulds

BEAD CORE OBSERVATIONS – BIOLOGY

Summary:

There was little evidence of bead ingestion at any station, though a few beads were found in a cirratulid foregut at 940 m (Fig. 1c). Beads were found incorporated into tube exteriors (Fig. 1a), tube linings, and mucous sheaths (Fig. 1b). The low number, small size and near-surface orientation of animals at stations 1200 and 1850 suggests that vertical mixing of beads by organisms will be minimal in these experiments. The absence of large red hesionids in the 940 m is notable, as these worms are typically abundant at this station and would be the most likely to mix particles to depths of 5-6 cm.

STATION A140 SB5 (2.5 d [54 h incubation)

0-1 cm: 1 phyllodocid, paranoid polychaetes, pink and yellow beads agglutinated to tube tops
1-2 cm: nemerteans, Nephtyidae with yellow beads? (photos taken), 2 Capitellidae, few loose beads visible
2-5 cm: 1 cirratulid
5-10 cm 1 oligochaete, 1 large nematode, 1 capitellid, cirratulid part
10-15 cm: 1 cirratulid, no beads
15-20 cm: no animals, no beads

STATION A300 – No macrofaunal bead observations made

STATION A950 – 2.5 da Rep A (half core)

0-1 cm: 4 bivalve A, 1 Ampelisca, 1 live black tentacled cirratulid with yellow and pink beads in foregut (Fig. 1c) (+ 1 dead cirratulid). 1 mucous tube with beads.
1-2 cm: 2 black tentacled cirratulid anteriors, no beads
2-5 cm: no animals
5-10 cm: no animals

STATION A1200 2.+ da. Rep A 55911#4

0-1 cm: no macrofauna. Sediment completely palletized. Appears to be capitellid fecal pellets.
1-2 cm. Some yellow and pink beads in worm tube lining (photo). 1 spionid or cirratulid palp present
2-5 cm: 1 large und. tube building polychaete. Sediment in gut but no evidence of beads.
5-10 cm 2 cirratulid anteriors, 1 capitellid middle

Rep B. Capitellid polychaete on surface (Fig. 1b). Made a mucous sheath of pink and yellow beads (photographed). Core not sectioned for biology.

STATION A1850 - No beads observed in guts
0-1 cm: mucous tubes with beads incorporated (Fig. 1a)
1 tanaids, 1 paraonid polychaete, 1 unid. polychaete
1-2 cm: 1 bivalve, 1 anemone
2-5 cm: no animals
5-10 cm: 1 polychaete fragment

Figure 8.
a. 1850 m. Mucous sheath with beads

b. 1200 m. Capitellidae with pink bead coat

c. 940 m. Pink and yellow beads in a cirratulid polychaete foregut.

Lisa Levin

10.43 Shipboard incubation studies: Sample inventories

Table 1: Sediment Samples

Station	Series	Mega #	Barrel #	Water Ht Start (cm)	Water Ht Finish (cm)	Time Start	Date Start	Time Term.	Date Term.	Core Proc.	*Slurry Injected*	*Notes*
55901	8	4	8	14.2	13	1610	21-Mar			none		
55901	8	3	7	10.1	8.5	1550	21-Apr			none		
55901	2	4	9	9.6	9.2	0330	21-Apr			none		
55901	2	6	10	12.6	11.9	0445	21-Apr			none		
55901	10	11	5	9.4	?	1355	22-Apr			Beads		
55901	10	10	6	14.5	?	1355	22-Apr			Beads		
55902	8	7	1	10.3	10.3	1945	26-Apr			13C		
55902	8	6	2	13.4	13.6	2000	26-Apr			13C		
55902	7	8	3	6.8-9.6 (slanted)	6.8-9.6	0055	26-Apr			13C	102.9mg 13C at 0000 26/04	
55902	7	4	4	18.2	18.2	0110	26-Apr			13C	102.7mg 13C at 0000 26/04	
55902	9	9	5	16.4	16.4?	1700	26-Apr			Beads		
55902	9	11	6	15.8	15.8?	1700	26-Apr			Beads		
55902	8	5	9	12.3	12.3?	1545	26-Apr			none		
55902	8	9	10	13.9	13.9?	1545	26-Apr			none		
55902	25	9	7	12.7	7.6	1600	01-May			none	water height 10.7 cm before adding 162 mL	
55902	25	10	8	13.1	7.6	1600	01-May			none	water height 10.5 cm before adding 296 mL	
55904	2	10	2	15.4	10.9	1500	03-May	1510	05-May	13C	100.3mg 13C (vial 15)	
55904	2	9	3	12.8	?	1315	03-May	0950	08-May	13C	146.3mg 13C (vial 12)+8ml mili-Q before T0 given here	
55904	2	7	4	12.3	?	1325	03-May	1000	08-May	13C	152.1mg 13C (vial 13)	
55904	5	6	5	17	17.4	1145	04-May	0905	07-May	Beads	Beads at 1145 04/v/03	
55904	5	3	6	16.1	16	1330	04-May	0915	07-May	Beads	Beads at 1330 04/v/03	
55904	5	9	9	12.1	?	1000	04-May	1140	08-May	none		Burrow visible to 4 cm depth
55904	5	10	10	11.3	?	1010	04-May	1420	08-May	none		Initial height measured AFTER first sampling (oops)
55904	14	3	7	13.4	7.5	1040	06-May	1050	07-May	none		After T24 water column reduced to 6.2cm at 1125h, t=35407s
55904	14	6	8	14.9-17.7	9.9-12.7	1050	06-May	1110	07-May	none		After T24 water column reduced to 6.0-9.8cm at 1135h, t=354777s
55904	2	4	1	12.4	7.4	1455	30-May	1500	05-May	13C	100.9mg 13C (vial 14)+6.2 ml mili-Q	
55911	4	3	3	16	10.8	1515	09-May	0940	14-May	13C	vial 16 injected 1345 09/v/03 + 6.2ml mili-Q	Start sectioning 1030h
55911	4	10	4	14.8	10.8	1525	09-May	0950	14-May	13C	vial 13A injected 1400 09/v/03 + 6.0ml mili-Q	Start sectioning about 1400h
55911	4	1	5	15	?	1540	09-May	0730	12-May	Beads	Beads at 1540 09/v/03	
55911	4	12	6	15.2	?	1550	09-May	0900	12-May	Beads	Beads at 1550 09/v/03	
55911	7	6	7	11.8-13	5.6-7.7	1630	10-May	2000	14-May	none		no replacement (vol. Reduced after T24?)
55911	7	1	8	12.6	5.4	1645	10-May	2010	14-May	none		no replacement (vol. Reduced after T24?)
55911	7	8	9	14.9	8.7	1535	10-May	1510	14-May	none		no replacement
55911	7	2	10	16.5	10.2	1600	10-May	1530	14-May	none		no replacement
55918	2	5	3	14.7	8.9	1715	15-May	0920	20-May	13C	vial 12A, 102.8mg + 7.2ml mili-Q at 1615 15/v/03	Start sectioning 1030h
55918	2	8	4	14.7	10.5	1730	15-May	0930	20-May	13C	vial 17, 100.4mg + 7.3ml mili-Q at 1625 15/v/03	Start sectioning 1405h
55918	4	2	5	14	?	1410	16-May	0950	19-May	Beads	Beads at 1410 16/v/03	
55918	4	9	6	15.8	?	1415	16-May	1345	19-May	Beads	Beads at 1415 16/v/03	Incubated in position 1 as line 6 not pumping well
55918	4	4	7	12.6	6.5	1120	16-May	1400	19-May	none	Water column reduced after T24	
55918	4	5	8	13	6.7	1140	16-May	1420	19-May	none	Water column reduced after T24	
55918		12	9	14.6	?	1150	17-May	1145	21-May	none	Terminated at 1300h (and profiled)	

Station	Series	Mega #	Barrel #	Water Ht Start (cm)	Water Ht Finish (cm)	Time Start	Date Start	Time Term.	Date Term.	Core Proc.	*Slurry Injected*	*Notes*
55918		6	10	13.3	8.2	1205	17-May	1200	21-May	none	Terminated at 1400h (and profiled)	
55920	1	10	1	14.8	8.3	2250	19-May	0720	22-May	13C	vial 18 (99.9mg)injected 2210 19/v/03 + 9.8ml mili-Q	
55920	1	6	2	13.9	10.9	2305	19-May	0730	22-May	13C	vial 19 (100.6mg) injected 2225 19/v/03 + 6.6ml mili-Q	
55921	1	6	3	11.1	6.5	1610	20-May	1355	22-May	13C	vial 6 (149.3mg)injected 1515 20/v/03 + 10ml mili-Q	This is an SF13-2 (not 5) incubation
55921	1	7	4	11.1	6.8	1620	20-May	1405	22-May	13C	vial 7 (150.6mg) injected 1525 20/v/03 + 8ml mili-Q	This is an SF13-2 (not 5) incubation
55931	4	9	1	13.8	7	1245	23-May	0850	26-May	13C	~100mg non pre-wieghed slurry injected 1135h 23/v/03 + 6.2ml mili-Q	
55931	4	1	2	9.6	5.5	1255	23-May	0857	26-May	13C	~100mg non pre-wieghed slurry injected 1150h 23/v/03 + 5.6ml mili-Q	
55931	4	12	7	10.1	6	1335	23-May	1540	26-May	none	Winkler performed? At T final	
55931	4	10	8	10.2	6.2	1350	23-May	1600	26-May	none	Winkler performed? At T final	

Table 2: Water samples.

				Timepoint		Sampling			Analyte Sample ID						
Station	**Depth**	**Incubation Type**	**Barrel Position #**	**Intended**	**Actual**	**Date**	**Time**	**DIC**	**DIC-13**	**Nut**	**DOC**	**TM**	**N2/Ar**	**total volume (ml)**	**Notes**
55901	140	SF	9	T0		21-Apr	0330	1	606	SI 1	y	n		?	
55901	140	SF	9	T12		21-Apr	1620	5	678	SI 5	y	n		58	
55901	140	SF	9	T24		22-Apr	0350	9	616	SI 9	y	n		88	No DIC filter
55901	140	SF	9	T48		24-Apr	0335	15	644	SI 20	y	n		71	replaced water
55901	140	SF	9	T96		24-Apr	1950	19	687	SI 24	y	n		74	terminated
55901	140	SF	10	T0		21-Apr	0445	2	612	SI 2	y	n		?	
55901	140	SF	10	T12		21-Apr	1640	6	679	SI 6	y	n		68	
55901	140	SF	10	T24		22-Apr	0355	10	613	SI 10	y	n		78	No DIC filter
55901	140	SF	10	T48		24-Apr	0340	16	645	SI 23	y	n		87	replaced water
55901	140	SF	10	T96		24-Apr	1950	20	663	SI 25	y	n		77	terminated
55901	140	SO	7	T0		21-Apr	1550	3	651, 660	SI 3	n	n	y	?	
55901	140	SO	7	T3		22-Apr	0115	7	626, 602	SI 7	n	n	N2 1	87	t=61680s on 55902b.plw (since re-named 55901 (poss. B)
55901	140	SO	7	T6		22-Apr	1035	11	683	SI 19	n	n	n	60	No replacement, push top down
55901	140	SO	7	T12		23-Apr	0100	13	691, 692	SI 21	n	n	y	93	No replacement, push top down
55901	140	SO	7	T24		Not Taken									
55901	140	SO	8	T0		21-Apr	1610	4	661,662	SI 4	n	n	y	?	
55901	140	SO	8	T3		22-Apr	0115	8	608, 615	SI 8	n	n	N2 2	87	No DIC filter
55901	140	SO	8	T6		22-Apr	1035	12	681	SI 16	n	n	n	65	Stirring motor off, turned on
55901	140	SO	8	T12		23-Apr	0105	14	693, 697	SI 15	n	n	N2 2	85	No replacement, push top down
55901	140	SO	8	T24		Not Taken									
55902	300	SF 13-5	3	T0		26-Apr	0055	21	629	SI 27	y	n		68	
55902	300	SF 13-5	3	T24		27-Apr	0815	31	609	SI 36	y	n		73	
55902	300	SF 13-5	3	T48		28-Apr	0700	41	618	SI 43	y	n		77	
55902	300	SF 13-5	3	T96		28-Apr	2318	44	624	SI 50	y	n		79	Marked T96, but are in fact T72
55902	300	SF 13-5	3	T120		01-May	0820	50	643	SI 55	y	n		90	Gas headspace due to leaking tubing, replaced AFTER sampling with 78ml. KBr inject 0820 giving KBr5
55902	300	SF 13-5	4	T0		26-Apr	0110	22	605	SI 26	y	n		64	
55902	300	SF 13-5	4	T24		27-Apr	0815	32	601	SI 37	y	n		74	
55902	300	SF 13-5	4	T48		28-Apr	0715	36	614	SI 44	y	n		119	Extra 6ml added here when pump tubing changed
55902	300	SF 13-5	4	T96		28-Apr	2330	45	610	SI 49	y	n		85	Marked T96, but are in fact T72

				Timepoint		Sampling			Analyte Sample ID						
Station	Depth	Incubation Type	Barrel Position #	Intended	Actual	Date	Time	DIC	DIC-13	Nut	DOC	TM	N2/Ar	total volume (ml)	Notes
55902	300	SF 13-5	4	T120		01-May	0825	51	676	SI 56	y	n		?	Inject 30ml KBr 0830, collect KBr 6
55902	300	SF13-2	1	T0		26-Apr	1945	26	604	SI 30	y	n	n	74	
55902	300	SF13-2	1	T12		27-Apr	0730	30	607	SI 34	y	n	n	98	
55902	300	SF13-2	1	T24		27-Apr	2000	38	654	SI 42	y	n	n	78	
55902	300	SF13-2	1	T36		28-Apr	0730	40	698	SI 45	y	n	n	77	
55902	300	SF13-2	1	T48		29-Apr	0910	46	621	SI 51	y	n	n	76	KBr sample collected at 1010h; terminated at t=~221400s on 55902b4.PLW
55902	300	SF13-2	2	T0		26-Apr	2000	25	627	SI 31	y	n	n	~76	
55902	300	SF13-2	2	T12		27-Apr	0730	27	673	SI 35	y	n	n	96	
55902	300	SF13-2	2	T24		27-Apr	2000	37	665	SI 41	y	n	n	75	
55902	300	SF13-2	2	T36		28-Apr	0745	39	617	SI 46	y	n	n	76	
55902	300	SF13-2	2	T48		29-Apr	0920?	47	620	SI 52	y	n	n	74	KBr sample collected at 1025h; terminated at t=~221400s on 55902b4.PLW
55902	300	SF	9	T0		26-Apr	1545	23	639	SI 28	y	y	n	100	
55902	300	SF	9	T12		27-Apr	0700	28	603	SI 32	y	y	n	102	
55902	300	SF	9	T24		27-Apr	1555	33	700	SI 38	y	y	n	100	
55902	300	SF	9	T48		28-Apr	1635	43	619	SI 47	y	y	n	103	
55902	300	SF	9	T96		30-Apr	1615	48	650	SI 53	y	y	n	101	
55902	300	SF	10	T0		26-Apr	1545	24	652	SI 29	y	y	n	100	collected KBr at 1900h
55902	300	SF	10	T12		27-Apr	0700	29	682	SI 33	y	y	n	94	
55902	300	SF	10	T24		27-Apr	1600	34	688	SI 39	y	y	n	100	
55902	300	SF	10	T48		28-Apr	1700	42	628	SI 48	y	y	n	100	
55902	300	SF	10	T96		30-Apr	1630?	49	695	SI 54	y	y	n	100	collected KBr at 1900h
55902	300	replacement	NA	NA		27-Apr	1620	35	675	SI-40	?	n	n		water that was added to replace sample volume withdrawn
55902	300	SO	7	T0		01-May	1600	53	684, 690	SI 58	n	n	N2-1	77.5	162 ml added to increase water column height
55902	300	SO	7	T3		01-May	1945	54	685, 686	SI 59	n	n	N2-1	83.3	
55902	300	SO	7	T6		01-May	2200	57	689, 666	SI 61	n	n	N2-1	78.5	
55902	300	SO	7	T12		02-May	0415	59	671, 653	SI 63	n	n	N2-2	74.4	
55902	300	SO	7	T24		02-May	1600	61	649, 680	SI 65	n	n	N2-2	75.3	
55902	300	SO	8	T0		01-May	1600	52	640, 645	SI 57	n	n	N2-2	75.7	296 ml added to increase water column height
55902	300	SO	8	T3		01-May	1955	55	677, 696	SI 60	n	n	N2-2	79.3	
55902	300	SO	8	T6		01-May	2210	56	672, 642	SI 62	n	n	N2-2	77	
55902	300	SO	8	T12		02-May	0425	58	653, 664	SI 64	n	n	N2-1	74.3	
55902	300	SO	8	T24		02-May	1620	60	658, 634	SI 66	n	n	N2-1	76.6	terminated at t= 449970s
55904	1850	SF13-5	3	T0		03-May	1315	62	631	SI 68	y	n	n	81	at 1150h, added 146.3 mg of C-13 slurry with 8 mL of Milli-Q; no replacement, push up core to replace sampled water
55904	1850	SF13-5	3	T24		04-May	1330	70	656	SI 76	y	n	n	76	no replacement, push core up to replace sampled water
55904	1850	SF13-5	3	T48		05-May	1330	80	630	SI 85	y	n	n	79	no replacement, push core up to replace sampled water
55904	1850	SF13-5	3	T96		07-May	1335	96	545	SI 101	y	n	n	74	no replacement, push core up to replace sampled water
55904	1850	SF13-5	3	T120		08-May	0950	98	589	SI 103	y	n	n	70	no replacement, push core up to replace sampled water
55904	1850	SF13-5	4	T0		03-May	1325	63	633	SI 67	y	n	n	75	at 1150h, added 152.1 mg of C-13 slurry; no replacement, push up core to replace sampled water
55904	1850	SF13-5	4	T24		04-May	1350	71	669	SI 75	y	n	n	72	no replacement, push core up to replace sampled water
55904	1850	SF13-5	4	T48		05-May	1345	81	623	SI 86	y	n	n	67	no replacement, push core up to replace sampled water

				Timepoint		Sampling			Analyte Sample ID						
Station	Depth	Incubation Type	Barrel Position #	Intended	Actual	Date	Time	DIC	DIC-13	Nut	DOC	TM	N2/Ar	total volume (ml)	Notes
55904	1850	SF13-5	4	T96		07-May	1345	97	528	SI 102	y	n	n	72	no replacement, push core up to replace sampled water
55904	1850	SF13-5	4	T120		08-May	1000	99	583	SI 104	y	n	n	70	no replacement, push core up to replace sampled water
55904	1850	SF13-2	1	T0		03-May	1455	65	668	SI 70	y	n	n	77	at 1350h, add 100.9 mg of C-13 slurry with 6.2 mL Milli-Q; no replacement, push up core to replace sampled water
55904	1850	SF13-2	1	T12		03-May	2200	66	648	SI 71	y	n	n	73	no replacement, push core up to replace sampled water
55904	1850	SF13-2	1	T24		04-May	1510	73	637	SI 77	y	n	n	73	no replacement, push core up to replace sampled water
55904	1850	SF13-2	1	T36		05-May	0700	76	670	SI 81	y	n	n	74	no replacement, push core up to replace sampled water
55904	1850	SF13-2	1	T48		05-May	1500	82	657	SI 87	y	n	n	76	no replacement, push core up to replace sampled water
55904	1850	SF13-2	2	T0		03-May	1500	64	667	SI 69	y	n	n	75	at 1400 h, add 100.3 mg of C-13 slurry; no replacement, push up core to replace sampled water
55904	1850	SF13-2	2	T12		03-May	2215	67	694	SI 72	y	n	n	72	no replacement, push core up to replace sampled water
55904	1850	SF13-2	2	T24		04-May	1520	72	635	SI 78	y	n	n	74	no replacement, push core up to replace sampled water
55904	1850	SF13-2	2	T36		05-May	0710	77	636	SI 82	y	n	n	71	no replacement, push core up to replace sampled water
55904	1850	SF13-2	2	T48		05-May	1510	83	632	SI 88	y	n	n	74	no replacement, push core up to replace sampled water
55904	1850	SO	7	T0		06-May	1040	86	575	SI 89	n	n	N2-2	77.6	no replacement, push core up to replace sampled water, GFF filter, not disposable used
55904	1850	SO	7	T3		06-May	1400	88	505	SI 93	n	n	N2-2	75	no replacement, push core up to replace sampled water
55904	1850	SO	7	T6		06-May	1700	90	570, 592	SI 95	n	n	N2-2	86.4	no replacement, push core up to replace sampled water
55904	1850	SO	7	T12		06-May	2230	92	581, 512	SI 97	n	n	N2-2	84	no replacement, push core up to replace sampled water
55904	1850	SO	7	T24		07-May	1030	94	503, 529	SI 99	n	n	N2-2	79	no replacement, push core up to replace sampled water, GFF filter, not disposable used
55904	1850	SO	8	T0		06-May	1050	87	577	SI 90	n	n	N2-1	71.8	no replacement, push core up to replace sampled water, GFF filter, not disposable used
55904	1850	SO	8	T3		06-May	1420	89	588	SI 94	n	n	N2-1	72	no replacement, push core up to replace sampled water
55904	1850	SO	8	T6		06-May	1709	91	569, 571	SI 96	n	n	N2-1	84.1	no replacement, push core up to replace sampled water
55904	1850	SO	8	T12		06-May	2240	93	582, 584	SI 98	n	n	N2-1	82.2	no replacement, push core up to replace sampled water
55904	1850	SO	8	T24		07-May	1110	95	509, 554	SI 100	n	n	N2-1	80.1	no replacement, push core up to replace sampled water, GFF filter, not disposable used
55904	1850	SF	9	T0		04-May	1000	68	647	SI 73	y	y	n	101	no replacement, push core up to replace sampled water, T=84930s on oxystat computer
55904	1850	SF	9	T12		04-May	2220	74	625	SI 79	y	y	n	103	no replacement, push core up to replace sampled water
55904	1850	SF	9	T24		05-May	1020	79	638	SI 83	y	y	n	103	no replacement, push core up to replace sampled water
55904	1850	SF	9	T48		06-May	1100	85	600	SI 92	y	y	n	102	no replacement, push core up to replace sampled water
55904	1850	SF	9	T96		08-May	1140	100	587	SI 105	y	y	n	91	no replacement, push core up to replace sampled water
55904	1850	SF	10	T0		04-May	1010	69	622	SI 74	y	y	n	104	no replacement, push core up to replace sampled water, T=90120s on oxystat computer
55904	1850	SF	10	T12		04-May	2230	75	641	SI 80	y	y	n	103	no replacement, push core up to replace sampled water
55904	1850	SF	10	T24		05-May	1030	78	659	SI 84	y	y	n	102	no replacement, push core up to replace sampled water
55904	1850	SF	10	T48		06-May	1125	84	508	SI 91	y	y	n	100	no replacement, push core up to replace sampled water
55904	1850	SF	10	T96		08-May	1420	101	585	SI 106	y	y	n	101? Not rec.	no replacement, push core up to replace sampled water
55911	1200	SF13-5	3	T0		09-May	1515	102	535	SI 107	y	n	n	71	no replacement, push core up to replace sampled water
55911	1200	SF13-5	3	T24		10-May	1550	105	520	SI 112	y	n	n	71	no replacement, push core up to replace sampled water
55911	1200	SF13-5	3	T48		11-May	1520	118	513	SI 123	y	n	n	72	no replacement, push core up to replace sampled water

				Timepoint		Sampling			Analyte Sample ID						
Station	Depth	Incubation Type	Barrel Position #	Intended	Actual	Date	Time	DIC	DIC-13	Nut	DOC	TM	N2/Ar	total volume (ml)	Notes
55911	1200	SF13-5	3	T96		13-May	1515	126	517	SI 131	y	n	n	74	no replacement, push core up to replace sampled water
55911	1200	SF13-5	3	T120		14-May	0940	128	572	SI 133	y	n	n	72	no replacement, push core up to replace sampled water
55911	1200	SF13-5	4	T0		09-May	1525	103	514	SI 108	y	n	n	71	no replacement, push core up to replace sampled water
55911	1200	SF13-5	4	T24		10-May	1620	107	547	SI 111	y	n	n	75	no replacement, push core up to replace sampled water
55911	1200	SF13-5	4	T48		11-May	1530	119	525	SI 124	y	n	n	73	no replacement, push core up to replace sampled water
55911	1200	SF13-5	4	T96		13-May	1525	127	534	SI 132	y	n	n	74	no replacement, push core up to replace sampled water
55911	1200	SF13-5	4	T120		14-May	0950	129	590	SI 134	y	n	n	74	no replacement, push core up to replace sampled water
55911	1200	SO	7	T0		10-May	1630	109	546, 501	SI 114	n	n	y	74.9	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	7	T3		10-May	1935	115	549, 539	SI 115	n	n	y	84	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	7	T6		10-May	2300	111	538, 511	SI 117	n	n	y	90.1	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	7	T12		11-May	0410	112	510, 527	SI 119	n	n	y	84.9	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	7	T24		11-May	1545	120	556, 580	SI 125	n	n	y	83.3	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	7	Tfinal		14-May	2000	132	536, 543	SI 137	n	n	y	82.1	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	8	T0		10-May	1645	108	515, 526	SI 113	n	n	y	108.1	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	8	T3		10-May	1950	116	568, 530	SI 116	n	n	y	84.6	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	8	T6		10-May	2315	110	552, 566	SI 118	n	n	y	84	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	8	T12		11-May	0425	113	544, 558	SI 120	n	n	y	82.2	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	8	T24		11-May	1555	121	537, 559	SI 126	n	n	y	86.9	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SO	8	Tfinal		14-May	2010	133	519, 531	SI 138	n	n	y	84	no replacement; N2/Ar poisoned with 20 uL of HgCl
55911	1200	SF	9	T0		10-May	1535	104	523	SI 109	y	y	n	101	no replacement
55911	1200	SF	9	T12		11-May	0435	117	521	SI 121	y	y	n	103	no replacement
55911	1200	SF	9	T24		11-May	1612	122	594	SI 127	y	y	n	101	no replacement
55911	1200	SF	9	T48		12-May	1540	124	563	SI 129	y	y	n	101	no replacement
55911	1200	SF	9	T96		14-May	1510	130	567	SI 135	y	y	n	98	no replacement
55911	1200	SF	10	T0		10-May	1600	106	506	SI 110	y	y	n	97	no replacement
55911	1200	SF	10	T12		11-May	0445	114	502	SI 122	y	y	n	96	no replacement
55911	1200	SF	10	T24		11-May	1520	123	593	SI 128	y	y	n	101	no replacement
55911	1200	SF	10	T48		12-May	1550	125	553	SI 130	y	y	n	101	no replacement
55911	1200	SF	10	T96		14-May	1530	131	562	SI 136	y	y	n	98	no replacement
55918	940	SF13-5	3	T0		15-May	1715	134	591	SI 139	y	n	n	73	no replacement
55918	940	SF13-5	3	T24		16-May	1650	140	586	SI 145	y	n	n	73	no replacement
55918	940	SF13-5	3	T48		17-May	1700	148	596	SI 153	y	n	n	80	no replacement
55918	940	SF13-5	3	T96		19-May	1730	160	709	SI 165	y	n	n	70	no replacement terminated
55918	940	SF13-5	3	T120		20-May	0920	164	712	SI 69	y	n	n	73	no replacement
55918	940	SF13-5	4	T0		15-May	1730	135	560	SI 140	y	n	n	73	no replacement
55918	940	SF13-5	4	T24		16-May	1700	141	574	SI 146	y	n	n	73	no replacement
55918	940	SF13-5	4	T48		17-May	1715	149	561	SI 154	y	n	n	68	no replacement
55918	940	SF13-5	4	T96		19-May	1735	161	710	SI 166	y	n	n	72	no replacement
55918	940	SF13-5	4	T120		20-May	0930	165	711	SI 170	y	n	n	72	no replacement collected nutrients and DOC blank at 0940
55918	940	SO	7	T0		16-May	1120	137	599, 504	SI 141	n	n	y	83.4	no replacement, N2/Ar poisoned with 20ul HgCl2
55918	940	SO	7	T3		16-May	1435	138	542, 550	SI 143	n	n	y	80	no replacement, N2/Ar poisoned with 20ul HgCl3
55918	940	SO	7	T6		16-May	1715	142	522, 579	SI 147	n	n	y	98.5	no replacement, N2/Ar poisoned with 20ul HgCl4
55918	940	SO	7	T12		16-May	2320	144	532, 565	SI 149	n	n	y	75.5	no replacement, N2/Ar poisoned with 20ul HgCl5
55918	940	SO	7	T24		18-May	1345	154	564, 597	SI 159	n	n	y	83.7	no replacement, N2/Ar poisoned with 20ul HgCl6

				Timepoint		Sampling			Analyte Sample ID						
Station	Depth	Incubation Type	Barrel Position #	Intended	Actual	Date	Time	DIC	DIC-13	Nut	DOC	TM	N2/Ar	total volume (ml)	Notes
55918	940	SO	7	Tfinal		19-May	1400	158	703, 704	SI 163	n	n	y	75.8	no replacement, N2/Ar poisoned with 20ul HgCl7
55918	940	SO	8	T0		16-May	1140	136	507, 595	SI 142	n	n	y	73.9	no replacement, N2/Ar poisoned with 20ul HgCl8
55918	940	SO	8	T3		16-May	1445	139	576, 518	SI 144	n	n	y	77.3	no replacement, N2/Ar poisoned with 20ul HgCl9
55918	940	SO	8	T6		16-May	1725	143	551, 533	SI 148	n	n	y	85	no replacement, N2/Ar poisoned with 20ul HgCl10
55918	940	SO	8	T12		16-May	2330	145	557, 524	SI 150	n	n	y	75.4	no replacement, N2/Ar poisoned with 20ul HgCl11
55918	940	SO	8	T24		18-May	1400	155	540, 516	SI 160	n	n	y	83.5	no replacement, N2/Ar poisoned with 20ul HgCl12
55918	940	SO	8	Tfinal		19-May	1420	159	705, 706	SI 164	n	n	y	78.3	no replacement, N2/Ar poisoned with 20ul HgCl13
55918	940	SF	9	T0		17-May	1150	146	578	SI 151	y	y	n	115	no replacement
55918	940	SF	9	T12		18-May	0005	150	573	SI 155	y	y	n	101	no replacement
55918	940	SF	9	T24		18-May	1240	152	548	SI 157	y	y	n	92	no replacement
55918	940	SF	9	T48		19-May	1130	156	701	SI 161	y	y	n	105	no replacement
55918	940	SF	9	T96		21-May	1145	176	719	SI 181	y	y	n	97	no replacement, terminated at 1300h
55918	940	SF	10	T0		17-May	1205	147	555	SI 152	y	y	n	108	no replacement
55918	940	SF	10	T12		18-May	0020	151	598	SI 156	y	y	n	98	no replacement
55918	940	SF	10	T24		18-May	1305	153	541	SI 158	y	y	n	100	no replacement
55918	940	SF	10	T48		19-May	1140	157	702	SI 162	y	y	n	99	no replacement
55918	940	SF	10	T96		21-May	1200	177	720	SI 182	y	y	n	96	no replacement, terminated at 1440h
55920	1000	SF13-2	1	T0		19-May	2250	162	708	SI 167	y	n	n	69	Nutrients acidified with H3PO4 (so phosphate ruined) as forgot filter at first, no replacement
55920	1000	SF13-2	1	T12		20-May	1120	166	713	SI 171	y	n	n	74	no replacement
55920	1000	SF13-2	1	T24		20-May	2310	170	721	SI 175	y	n	n	70	no replacement
55920	1000	SF13-2	1	T36		21-May	1115	174	783	SI 179	y	n	n	71	no replacement
55920	1000	SF13-2	1	T48		22-May	0720	180	730	SI 185	y	n	n	68	no replacement
55920	1000	SF13-2	2	T0		19-May	2305	163	707	SI 165	y	n	n	71	no replacement
55920	1000	SF13-2	2	T12		20-May	1130	167	714	SI 172	y	n	n	74	no replacement
55920	1000	SF13-2	2	T24		20-May	2320	171	731	SI 176	y	n	n	68	no replacement
55920	1000	SF13-2	2	T36		21-May	1125	175	791	SI 180	y	n	n	72	no replacement
55920	1000	SF13-2	2	T48		22-May	0730	181	740	SI 186	y	n	n	66	no replacement
55921	850	SF13-3	3	T0		20-May	1610	168	715	SI 173	y	n	n	74	slurry still partially suspended, no replacement
55921	850	SF13-2	3	T12		21-May	0635	173	792	SI 177	y	n	n	70	no replacement
55921	850	SF13-2	3	T24		21-May	1620	178	723	SI 183	y	n	n	68	no replacement 5ml DOC
55921	850	SF13-2	3	T36		22-May	0745	182	717	SI 187	y	n	n	67	no replacement 10ml DOC
55921	850	SF13-2	3	T48		22-May	1355	184	729	SI 189	y	n	n	63	no replacement
55921	850	SF13-2	4	T0		20-May	1620	169	716	SI 174	y	n	n	70	slurry still partially suspended, no replacement
55921	850	SF13-2	4	T12		21-May	0645	172	793	SI 178	y	n	n	72	no replacement
55921	850	SF13-2	4	T24		21-May	1625	179	724	SI 184	y	n	n	68	no replacement 5ml DOC
55921	850	SF13-2	4	T36		22-May	0752	183	718	SI 188	y	n	n	69	no replacement 10ml DOC
55921	850	SF13-2	4	T48		22-May	1405	185	728	SI 190	y	n	n	66	no replacement
55931	140	SF13-2	1	T0		23-May	1245	186	782	SI 191	y	n	n	66	no replacement
55931	140	SF13-2	1	T12		23-May	2135	192	781	SI 197	y	n	n	56	no replacement
55931	140	SF13-3	1	T24		24-May	1500	196	725	SI 201	y	n	n	71	no replacement
55931	140	SF13-2	1	T36		25-May	0845	198	797	SI 203	y	n	n	69	no replacement
55931	140	SF13-2	1	T48		26-May	0850	200	738	SI 205	y	n	n	69	no replacement
55931	140	SF13-2	2	T0		23-May	1255	187	794	SI 192	y	n	n	63	no replacement

				Timepoint		Sampling			Analyte Sample ID						
Station	**Depth**	**Incubation Type**	**Barrel Position #**	**Intended**	**Actual**	**Date**	**Time**	**DIC**	**DIC-13**	**Nut**	**DOC**	**TM**	**N2/Ar**	**total volume (ml)**	**Notes**
55931	140	SF13-2	2	T12		23-May	2145	193	774	SI 198	y	n	n	66	no replacement
55931	140	SF13-2	2	T24		24-May	1510	197	7??	SI 202	y	n	n	~70	no replacement
55931	140	SF13-2	2	T36		25-May	0855	199	789	SI 204	y	n	n	69	no replacement
55931	140	SF13-2	2	T48		26-May	0857	201	785	SI 206	y	n	n	69	no replacement
55931	140	SO	7	T0		23-May	1335	188	744, 722	SI 193	n	n	y	78.1	use GFF, poison N2/Ar, no replacement
55931	140	SO	7	T3		23-May	2120	190	771, 751	SI 195	n	n	y	82.7	no replacement
55931	140	SO	7	T6		24-May	0930	194	770, 780	SI 199	n	n	y	82.4	no replacement
55931	140	SO	7	T12											No Sample Taken
55931	140	SO	7	T24		26-May	1540	202	733, 768	SI 207	n	n	y	79	no N2/Ar, no replacement
55931	140	SO	8	T0		23-May	1350	189	764, 772	SI 194	n	n	y	78.2	use GFF, poison N2/Ar, no replacement
55931	140	SO	8	T3		23-May	2130	191	773, 784	SI 196	n	n	y	82.2	no replacement
55931	140	SO	8	T6		24-May	0940	195	799, 800	SI 200	n	n	y	79.9	no replacement
55931	140	SO	8	T12											No Sample Taken
55931	140	SO	8	T24		26-May	1600	203	765, 798	SI 208	n	n	y	83	no N2/Ar, no replacement

11. CD146 Station list

Station	Series #	Site	Gear	Gear #	Start Date (03)	Time (utc)	Latitude DN	Latitude MN	Longitude DE	Longitude ME	Depth (m)	End Date (03)	Time (utc)	Comment
55901	1	A140	CTD	1	20/04	18.06	23	16.88	66	42.79	120			24 bottles fired, 132 & 45m (Chl max)
55901	2	A140	MEGA	1	20/04	3.01	23	16.87	66	42.56	136			7/8 good cores
55901	3	A140	EO	1	21/04	1.26	23	17.12	66	42.43	132	22/04	4.39	moored, no mud
55901	4	A140	PROF	1	21/04	3.01	23	17.80	66	42.18	132	23/04	1.20	moored, successful
55901	5	A140	MC	1	21/04	4.52	23	16.65	66	42.75	134			12/12 good cores
55901	6	A140	MC	2	21/04	5.34	23	16.87	66	42.60	135			FAILED
55901	7	A140	MC	3	21/04	6.31	23	16.87	66	42.55	134			12/12 good cores
55901	8	A140	MEGA	2	21/04	7.23	23	16.77	66	44.58	136			8/8 good cores
55901	9	A140	MEGA	3	21/04	8.43	23	16.85	66	42.72	135			8/8 good cores
55901	10	A140	MEGA	4	22/04	6.23	23	16.78	66	42.89	133			8/8 good cores
55901	11	A140	MC	4	22/04	9.33	23	16.61	66	42.30	135.5			12/12 good cores
55901	12	A140	EF	1	22/04	14.15	23	17.13	66	42.24	133	25/04	1.28	moored deployment (EF), got mud
55901	13	A140	MC	5	23/04	5.08	23	16.71	66	42.94	133			12/12 good cores
55901	14	A140	MEGA	5	23/04	7.15	23	16.75	66	42.63	133			11/12 good cores
55901	15	A140	PROF	2	23/04	9.28	23	17.44	66	42.07	134	24/04	4.40	moored, failed, blown electronics
55901	16	A140	MEGA	6	23/04	10.27	23	16.66	66	42.72	135			9/12 good cores
55901	17	A140	CTD	2	24/04	6.59	23	16.74	66	42.59	133	24/04	7.30	24 bottles fired, profile
55901	18	A140	BBLS	1	24/04	12.06	23	16.91	66	42.36	136			all 5 bottles fired, mud in boittom
55902	1	A300	CTD	3	25/04	5.44	23	12.50	66	33.77	302			6 bottles at 295m
55902	2	A300	MEGA	7	25/04	7.17	23	12.50	66	34.02	300			12/12 good cores
55902	3	A300	EO	2	25/04	10.43	23	12.78	66	33.47	303	26/04	12.28	hit side on recovery, water spls OK
55902	4	A300	MC	6	25/04	12.10	23	12.40	66	33.79	304			11/12 good cores
55902	5	A300	MC	7	25/04	13.34	23	12.32	66	33.98	304			11/12 good cores
55902	6	A300	CTD	4	25/04	15.43	23	12.33	66	33.51	300			24 bottles at 295m
55902	7	A300	MEGA	*	25/04	17.07	23	12.40	66	33.40	302			6 misfires/12
55902	8	A300	MEGA	8	26/04	6.20	23	12.47	66	33.92	301			11/12 good cores
55902	9	A300	MEGA	9	26/04	7.25	23	12.50	66	33.66	305			9/12, ship dragged corer
55902	10	A300	PROF	3	26/04	11.21	23	13.37	66	33.30	295	27/04	6.05	moored, dud deployment (swell)
55902	11	A300	EF	2	27/04	3.25	23	12.87	66	33.43	300	27/04	10.04	moored, aborted deployment
55902	12	A300	MC	8	27/04	4.57	23	12.74	66	33.90	298.5			10/12 good cores
55902	13	A300	MEGA	10	27/04	9.09	23	12.34	66	33.96	303			8/12 good cores
55902	14	A300	EF	3	27/04	12.50	23	12.86	66	33.43	303	30/04	1.19	moored, successful deployment
55902	15	A300	PROF	4	27/04	13.47	23	13.45	66	33.32	295	28/04	9.27	moored, successful deployment
55902	16	A300	CTD	5	28/04	5.35	23	12.30	66	34.23	300			24 bottle profile

Station	Series #	Site	Gear	Gear #	Start Date (03)	Time (utc)	Latitude DN	Latitude MN	Longitude DE	Longitude ME	Depth (m)	End Date (03)	Time (utc)	Comment
55902	17	A300	MC	9	28/04	7.03	23	12.37	66	34.26	300			10/12 good cores
55902	18	A300	MEGA	11	28/04	10.51	23	12.53	66	33.95	301			10/12 good cores
55902	19	A300	PROF	5	28/04	12.24	23	13.49	66	33.22	296	29/04	5.05	moored, successful deployment
55902	20	A300	MEGA	12	29/04	9.34	23	12.51	66	33.97	301			6/8 good cores
55902	21	A300	BBLS	2	29/04	10.54	23	12.56	66	33.79	304			successful deployment
55902	22	A300	CTD	6	29/04	15.01	23	12.57	66	34.05	300			12 @ 297m, 1ea at 100, 50, 11m
55902	23	A300	MEGA	13	30/04	9.26	23	12.49	66	33.96	301.5			8/8 good cores
55902	24	A300	EF13	1	30/04	11.31	23	12.94	66	33.37	296	02/05	10.48	Sediment and water recovered.
55902	25	A300	MEGA	14	01/05	9.23	23	12.54	66	33.61	305			7/8 good cores
55902	26	A300	MC	10	01/05	11.29	23	12.61	66	34.05	309			10/12 good cores
55902	27	A300	MC	11	02/05	5.16	23	12.54	66	33.94	301			10/10 good cores
55903	1	A400	MEGA	15	02/05	13.09	23	9.53	66	30.90	410			8/8 no mats
55903	2	A400	MEGA	16	02/05	14.50	23	9.40	66	30.80	418			6/8 no mats
55903	3	A400	MEGA	17	02/05	15.40	23	9.50	66	30.88	414			8/8 no mats
55903	4	A400	MEGA	18	02/05	16.22	23	9.61	66	31.09	405			8/8 no mats
55904	1	A1850	CTD	7	02/05	21.43	22	52.42	66	0.17	1853			8 bottles fired at 1850m (incubations)
55904	2	A1850	MEGA	19	03/05	1.36	22	52.38	65	59.85	1854			8/8 cores
55904	3	A1850	EO	3	03/05	3.19	22	51.79	65	59.79	1859	04/05	4.44	Autonomous, no mud, lowered feet
55904	4	A1850	PROF	6	03/05	10.54	22	51.15	65	59.87	1865	05/05	1.05	Autonomous mode, successful
55904	5	A1850	MEGA	20	04/05	2.48	22	52.38	66	0.12	1853			8/8 cores
55904	6	A1850	MEGA	21	04/05	7.07	22	52.45	66	0.04	1854			8/8 cores
55904	7	A1850	MEGA	22	04/05	8.56	22	52.51	65	59.70	1856			8/8 cores
55904	8	A1850	MC	12	04/05	11.57	22	52.21	66	0.04	1857			11/12 good cores
55904	9	A1850	EF	4	04/05	13.40	22	51.78	66	0.13	1859	07/05	12.40	No mud
55904	10	A1850	MC	13	05/05	3.22	22	52.28	66	0.00	1855			12/12 good cores
55904	11	A1850	MEGA	23	05/05	5.25	22	51.97	66	0.02	1858			7/8 cores
55904	12	A1850	BBLS	3	05/05	10.17	22	52.06	65	59.89	1856			successful deployment, autonomous
55904	13	A1850	PROF	7	05/05	12.50	22	51.03	65	59.98	1866	06/05	2.03	successful deployment, autonomous
55904	14	A1850	MC	14	05/05	15.41	22	52.62	65	59.93	1851			6/6 good cores
55904	15	A1850	MEGA	24	06/05	4.08	22	52.37	66	0.13	1855			8/8 cores
55905	1	A1100	CTD	8	06/05	9.51	22	52.80	66	32.90	1099			sound velocity profile
55905	2	A1100	MEGA	25	06/05	12.07	22	52.75	66	33.01	1099			8/8 cores
55906	1	A1050	MEGA	26	06/05	13.35	22	53.60	66	34.00	1048			8/8 cores
55907	1	A1000	MEGA	27	06/05	15.06	22	54.73	66	34.93	1000			7/8 cores
55908	1	A950	MEGA	28	06/05	16.30	22	55.90	66	36.10	938			6/8 cores
55909	1	A900	MEGA	29	06/05	18.25	22	56.80	66	37.01	897.5			6/8 cores

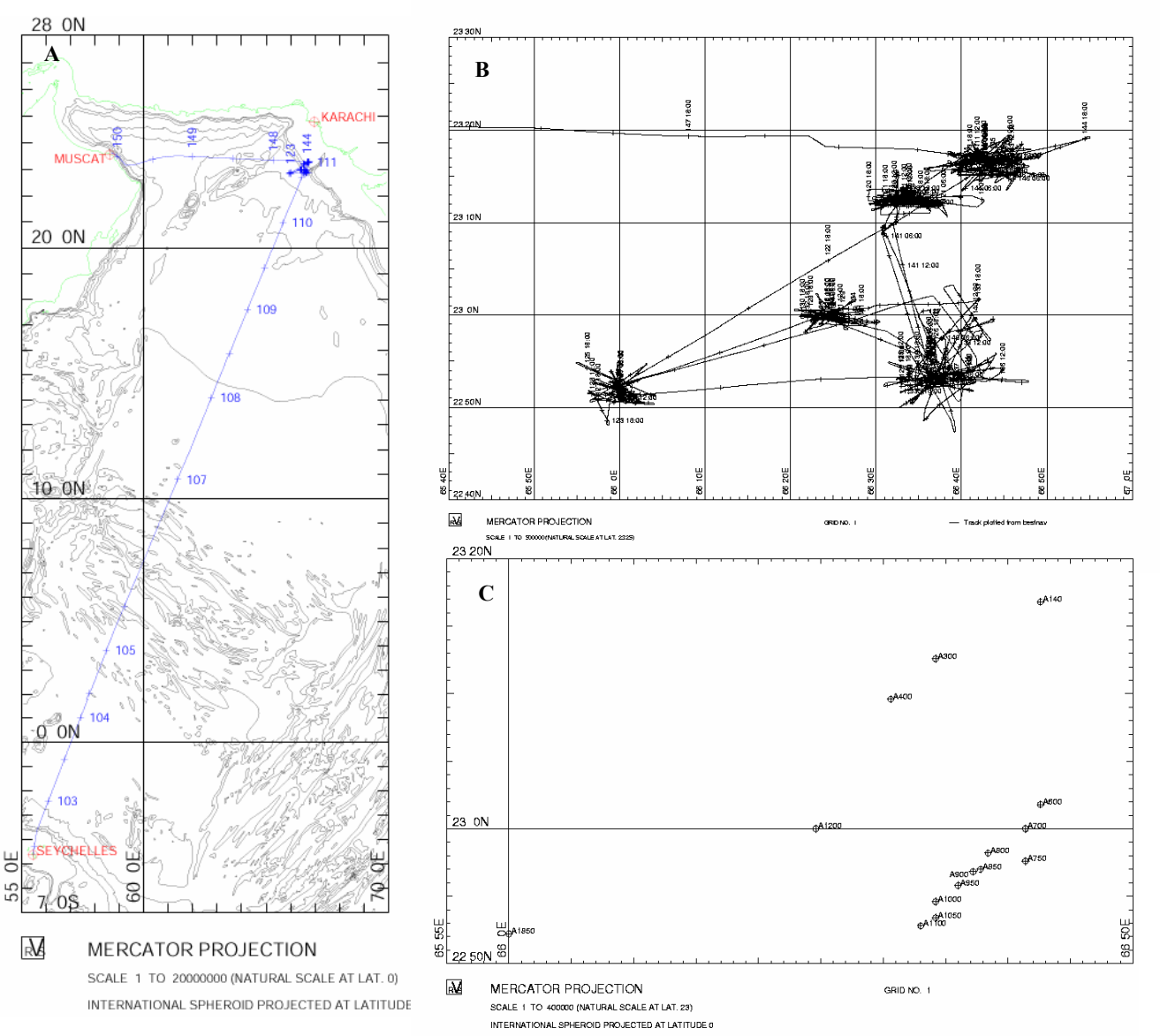
Station	Series #	Site	Gear	Gear #	Start Date (03)	Time (utc)	Latitude DN	Latitude MN	Longitude DE	Longitude ME	Depth (m)	End Date (03)	Time (utc)	Comment
55910	1	A1850	CTD	9	07/05	7.26	22	52.20	66	0.02	1855			24 bottle profile
55910	2	A1850	MEGA	30	08/05	5.57	22	52.24	66	0.09	1850			7/8 cores
55910	3	A1850	TRAWL	1	08/05	9.20	22	50.75	66	1.38	980	08/05	11.20	Successful
55911	1	A1200	CTD	9	08/05	16.04	23	0.00	66	24.30	1196			bottom waters for incubations
55911	2	A1200	MEGA	31	08/05	18.03	23	0.08	66	24.30	1194			8/8 cores
55911	3	A1200	EO	4	09/05	2.35	22	59.76	66	24.78	1181	10/05	4.33	FAILED, lid did not close
55911	4	A1200	MEGA	32	09/05	5.37	23	0.07	66	24.40	1191			12/12 cores
55911	5	A1200	MC	15	09/05	9.15	23	0.09	66	24.39	1191			12/12 good cores
55911	6	A1200	PROF	8	10/05	3.09	22	59.57	66	25.11	1178			Successful
55911	7	A1200	MEGA	33	10/05	6.35	23	0.01	66	24.47	1188			12/12 cores
55911	8	A1200	EO	5	10/05	12.49	22	59.77	66	24.76	1184	11/05	12.55	FAILED, lid seal lost, no mud
55911	9	A1200	MC	16	10/05	15.42	23	0.03	66	24.47	1189			12/12 good cores
55911	10	A1200	MEGA	34	11/05	5.57	23	0.07	66	24.57	1184			12/12 cores
55911	11	A1200	CTD	10	11/05	8.16	23	0.15	66	24.60	1184			24 bottle profile
55911	12	A1200	PROF	9	11/05	12.20	22	59.55	66	25.14	1178	12/05	2.40	Successful
55911	13	A1200	BBLS	4	12/05	5.16	22	59.93	66	24.35	1197			Successful
55911	14	A1200	MC	17	12/05	7.14	22	59.97	66	24.49	1189.5			12/12 good cores
55911	15	A1200	MEGA	35	12/05	10.57	22	59.99	66	24.58	1186.5			8/8 cores
55911	16	A1200	CTD	16	12/05	15.37	22	59.98	66	24.43	1194			14 bottles at 40, 1 at 594, 1 at 249
55911	17	A1200	EF	5	13/05	3.11	22	59.70	66	24.56	1194	15/05	2.40	good water samples, no mud
55911	18	A1200	MEGA	36	13/05	4.57	23	0.64	66	24.40	1191			8/8 cores
55912	1	A950	TRAWL	2	13/05	8.44	22	54.10	66	38.88	879	13/05	9.30	Successful
55913	1	A950	MEGA	37	13/05	11.53	22	55.89	66	36.17	946			6/8 cores
55914	1	A850	MEGA	38	13/05	13.26	22	57.47	66	37.69	848			4/8 cores
55915	1	A800	MEGA	39	13/05	15.05	22	58.27	66	38.61	798			8/8 cores
55916	1	A600	MEGA	40	13/05	16.59	23	1.69	66	42.07	598			4/8 cores
55916	2	A600	MEGA	41	13/05	17.49	23	1.65	66	42.97	601			4/8 cores
55917	1	A1200	MEGA	42	14/05	10.40	23	0.03	66	24.49	1188			7/8 cores
55918	1	A940	CTD	17	15/05	6.00	22	55.00	66	36.31	937			10 bottles fired
55918	2	A940	MEGA	43	15/05	9.41	22	53.50	66	36.63	941			9/12 cores
55918	3	A940	EO	6	15/05	14.38	22	53.24	66	36.94	941	17/05	2.00	good water samples, no mud
55918	4	A940	MEGA	44	16/05	5.05	22	53.56	66	36.69	941			12/12 cores
55918	5	A940	MEGA	45	16/05	6.25	22	53.50	66	36.71	944			12/12 cores
55918	6	A940	PROF	10	16/05	7.22	22	52.92	66	37.20	940	18/05	6.19	Successful
55918	7	A940	MC	18	16/05	9.20	22	53.58	66	36.65	944			11/12 good cores
55918	8	A940	MC	19	17/05	3.39	22	53.52	66	36.65	943			10/12 good cores

Station	Series #	Site	Gear	Gear #	Start Date (03)	Time (utc)	Latitude DN	Latitude MN	Longitude DE	Longitude ME	Depth (m)	End Date (03)	Time (utc)	Comment
55918	9	A940	MEGA	46	17/05	5.23	22	53.54	66	36.64	944			12/12 cores
55918	10	A940	MEGA	47	17/05	7.26	22	53.48	66	36.68	945.5			8/8 good cores
55918	11	A940	EF	6	17/05	12.46	22	53.21	66	36.94	940	19/05	12.39	no mud, good water samples
55918	12	A940	MEGA	48	18/05	4.24	22	53.62	66	36.44	947.5			4/8 good cores, some bubbled
55918	13	A940	MC	20	18/05	8.16	22	53.45	66	36.49	950.5			10/12 cores
55918	14	A940	TRAWL	3	18/05	10.00	22	52.51	66	37.55	938	18/05	11.43	Successful
55918	15	A940	PROF	11	18/05	13.43	22	52.91	66	37.32	937	20/05	4.20	Successful
55918	16	A940	MEGA	49	19/05	5.09	22	53.63	66	36.54	940			8/8 cores, 3 bubbled
55919	1	A700	MEGA	50	19/05	10.50	22	59.96	66	41.20	711.5			4/8 good cores, overpenetration
55920	1	A1000	MEGA	51	19/05	16.18	22	54.67	66	34.90	1002			6/8 good cores, 2 bubbled
55921	1	A850	MEGA	52	20/05	6.25	22	57.61	66	37.66	843.5			7/10
55922	1	A750	TRAWL	4	20/05	9.10	22	58.83	66	41.75	762	20/05	10.10	torn net, weak link went at ~980mwo
55922	2	A750	MEGA	53	20/05	12.00	22	57.57	66	41.63	737.5			8/8 good cores
55923	1	A940	PROF	12	20/05	14.18	22	52.90	66	37.24	938	21/05	2.48	Successful
55923	2	A940	BBLS	5	20/05	15.47	22	53.56	66	36.57	950			hit interface at angle, cloudy waters
55924	1	A430	MEGA	54	21/05	6.28	23	8.78	66	30.99	432			bacterial mat hunting, no finds
55925	1	A440	MEGA	55	21/05	7.28	23	8.75	66	30.63	446			Ibid
55926	1	A435	MEGA	56	21/05	8.12	23	8.85	66	30.82	436.5			Ibid
55927	1	A390	MEGA	57	21/05	9.17	23	9.60	66	31.69	391.5			Ibid
55928	1	A370	MEGA	58	21/05	10.14	23	10.24	66	32.39	364			Ibid
55928	2	A370	MEGA	59	21/05	10.57	23	10.04	66	32.35	369.5			Ibid
55929	1	A940	MEGA	60	21/05	14.32	22	53.56	66	36.71	940			11/12 good cores
55929	2	A940	CTD	18	21/05	18.10	22	53.50	66	36.70	956			4 bottles fored at 942,500,275,14m
55929	3	A940	BBLS	6	22/05	5.17	22	53.52	66	36.61	944			Successful
55930	1	A400	MEGA	61	22/05	8.57	23	9.50	66	30.94	412			no mats, cores discarded
55931	1	A140	CTD	19	22/05	12.30	23	16.70	66	42.90	134			bottom waters for incubations
55931	2	A140	EF13	2	22/05	13.32	23	17.08	66	42.44	133	25/05	1.46	no lid closure, burn wire problem
55931	3	A140	MEGA	62	23/05	5.24	23	16.70	66	42.70	135			Failed
55931	4	A140	MEGA	63	23/05	5.51	23	16.75	66	42.50	133			8/8 good cores
55931	5	A141	EF	7	25/05	11.57	23	17.11	66	42.63	133	27/05	13.50	successful

Station list abbreviations and notes

Station	Unique deployment identification number
Site	Site name
Gear	Equipment used (see below)
Start	Start of sampling operation
Date	Date of operation
(03)	2003
Time	Time of operation
(utc)	utc / Grenwich meantime
Position	Ship's position (or estimated net position for trawls)
DN	Degrees north
MN	Minutes north
DE	Degrees east
ME	Minutes east
Depth	Depth of sampling operation
(m)	Metres (corrected)
End	End of sampling operation
Comment	Results
TRAWL	Agassiz trawl
BBLS	Benthic boundary layer sampler (water bottles)
BC	Box corer
BSNAP	Bathysnap - timelapse seabed camera
CTD	Conductivity, temperature, depth probe (with oxygen, fluorescence, transmission) and water bottles
MC	Multiple corer
MEGA	Megacorer
WASP	Wide-angle Seabed Photography system (video and still photography)

12. Charts



A: CD146 full cruise track (Seychelles to Muscat).

B: CD146 work area cruise track.

C: CD146 primary sampling stations.