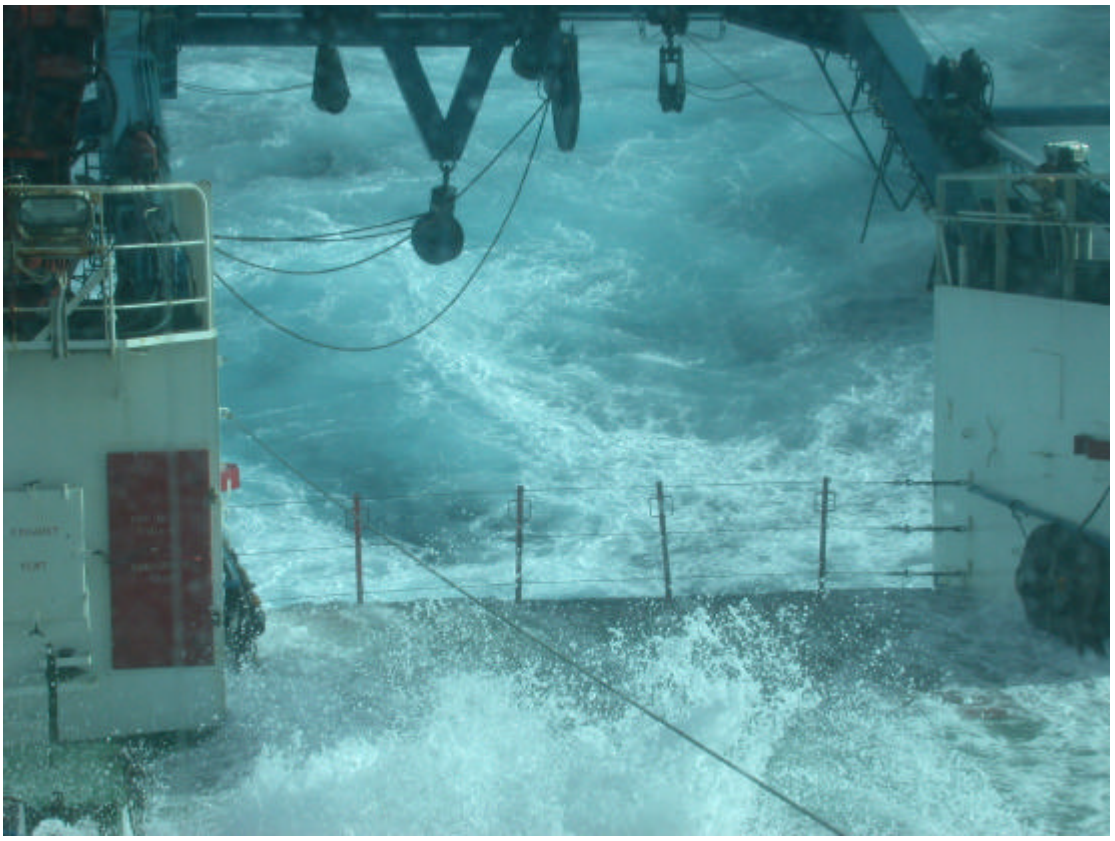
RRS *Discovery* Cruise 260

Metabolism, activity and distribution patterns in demersal deep-sea fish



6th-24th March 2002

Principal Scientist: Dr Martin A Collins

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Cover picture: A wave breaking over the stern of Discovery during cruise 260 (Ian Hudson).

Discovery 250 Scientific Party

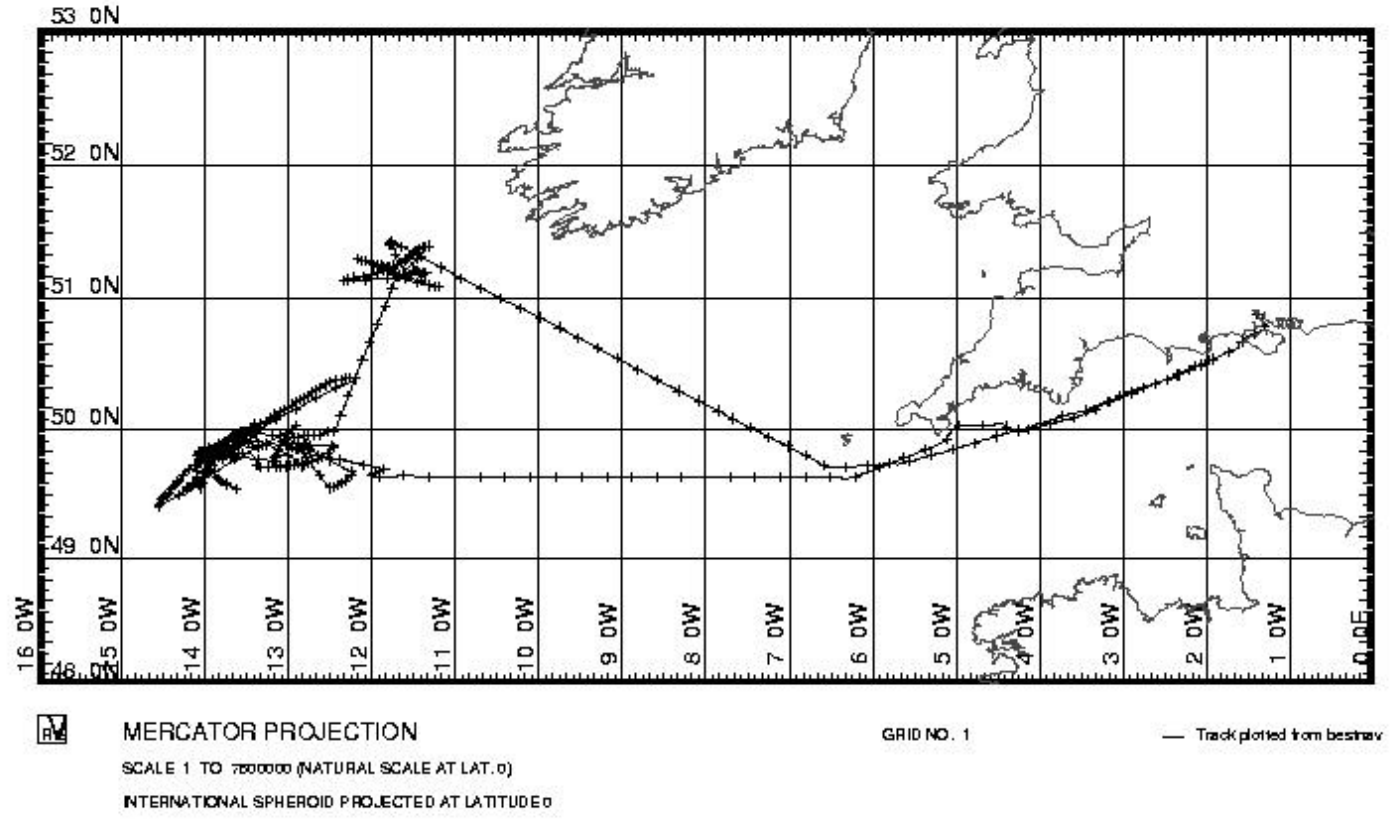
Martin Collins	Aberdeen University
Monty Priede	Aberdeen University
Phil Bagley	Aberdeen University
David Bailey	Aberdeen University
Camila Henriques	Aberdeen University
Kirsty Kemp	Aberdeen University
Richard Paterson	Aberdeen University
Emma Battle	Aberdeen University
Steve Hoskin	Aberdeen University
Rob McAllen	Aberdeen University
Alan Jamieson	Aberdeen University
Kostas Christodoulou	IMBC, Crete/ Aberdeen University
Ben Boorman	Southampton Oceanography Centre
Ian Hudson	Southampton Oceanography Centre
Rhian Waller	Southampton Oceanography Centre
Francisco Benitez	Southampton Oceanography Centre
Dan Mayor	Southampton Oceanography Centre
Sandrine le Polain	University of Louvain
Bertrand Genard	University of Louvain
Amanda Brindley	Queen Mary College, London
Hans-Joachen Wagner	University of Tübingen
Uli Mattheus	University of Tübingen
Xiaohong Deng	University of Maryland
Darren Young	UKORS (TLO)
Jeff Bicknell	UKORS
Rob Mclaughlan	UKORS
Phil Taylor	UKORS
Simon Dodd	UKORS

Ships Company

Robin Plumley	Master
Peter Seargeant	Chief Officer
John Mitchell	2nd Officer
Peter Reynolds	3rd Officer
Jet Jethwa	Chief Engineer
Ian Slater	2nd Engineer
Steve Bell	3rd Engineer
John Harnett	3rd Engineer
Dave Stewart	ETO
Mick Trevaskis	CPOD (Bosun)
Peter Bennet	POD
Dave Buffery	SG1A
John Dale	SG1A
Steve Day	SG1A
Nigel Tuppenney	SG1A
John Smyth	Motorman
Eddie Staite	Catering Manager
Peter Lynch	Chef
Geoff Osbourne	Steward
Winston Isby	Steward

RRS *Discovery* Cruise 260 scientific party and crew

Discovery 260 Scientific Party, left to right: Phil Bagley, Monty Priede, Sandrine le Polain, Kostas Christodoulou, Kirsty Kemp, Rob McLaughlin, Emma Battle, Rhian Waller, Jeff Bicknell, Camila Henriques, Steve Day, Uli Mattheus, Xiaohong Deng, Dan Mayor, Amanda Brindley, Ian Hudson, Francisco Benitez, Robin Plumley (Master), Steve Hoskin, Bertrand Genard, Simon Dodd, David Bailey, Jochen Wagner, Richard Paterson, Rob McAllen, Martin Collins, Mick Trevaskis, Darren Young, Ben Boorman, Phil Taylor, Alan Jamieson.



Discovery 260 Cruise Track

Itinerary
Depart: Southampton, Empress Dock Wednesday March 6th 2002
Arrive: Southampton, Empress Dock Sunday March 24th 2002

Background

The cruise was funded (14 days) by a NERC grant (GR3/12789: Metabolism, activity and distribution patterns of deep-sea demersal fishes: *In situ* oxygen consumption, activity and fast-starts in relation to depth, season and temperature in the NE Atlantic and Eastern Mediterranean) awarded to Priede, Collins & Bagley. It was the fourth in a series of 5 cruises planned over three years. The main objectives of the project are:

1. **Determine routine metabolism and activity of demersal fishes in relation to seasonal and environmental parameters.** This objective to be achieved using autonomous lander vehicles to conduct experiments *in situ* on the ocean floor. The Aberdeen University Deep Ocean Submersible (AUDOS) will collect data on routine swimming speed and three new systems will collect data on resting metabolism (FRESP), fast-starts (SPRINT Lander) and long-term scavenger abundance and activity (DOBO).
2. **Temporal changes in demersal fish populations in the Porcupine Seabight**. This objective will be achieved using trawl sampling (OTSB) and baited camera data (AUDOS) to examine seasonal and inter-annual changes in the composition of the ichthyofauna.

An additional two days sea-time were funded by Dave Billet's group at SOC to allow time for sampling on the coral mounds in the NE of the Seabight.

Specific Objectives

1. Deploy the FRESP lander at 4000m, to investigate routine oxygen consumption of *Coryphaenoides armatus*.
2. Deploy the SPRINT at 4000 m and 2500 m to determine fast start performance of *Coryphaenoides armatus* and *Antimora rostrata*.
3. Deploy the ISIT lander to investigate baited bioluminescence on the coral mounds and get seasonal profiles of stimulated bioluminescence.
4. Recover and service the DOBO lander, deployed during cruise 255 in September 2001.
5. Use the OTSB to determine the distribution and abundance of fish and invertebrates in the PSB (800-4200 m). In addition samples will be used for molecular analysis, enzyme assays and work on brain morphology.
6. Use a box core to collect samples of live coral from the Teresa Mounds in the NE of the Seabight

Cruise Narrative

Wednesday 6th March

0900: Departed SOC.
10:15: Pilot off. Weather overcast, westerly F5-F6. Lander being prepared and moorings assembled.
11:00: Brief drill with coast guard helicopter lowering crew member on to the deck then recovering him.
1300: Health and safety meeting with Master, 1st Mate & Ben Boorman to discuss trawling at. Bar committee meeting at 1430.
1500: Scientific meeting in the bar.
1615: Boat drill

Thursday 7th March

07:00: Off the Scilly Isles, with light to moderate breeze, but large swell.
09:00: Briefing meeting (PS, Master, Chief Engineer, OED TLO, Bosun, 1st Officer and Monty Priede) to discuss the cruise programme and manning levels etc.
Lander and trawl preparation continued through the day.

Friday 8th March

0630: Arrived at Theresa Mounds. CTD deployed to test 3 releases for ISIT, collect water and attempt (unsucessfully) to catch amphipods (14297).
08:52: CTD inboard. Commenced sounding run across Theresa mound to identify coral area.
09:00: Formalin spilt in deck lab from aspirator not secured on the bench.
09:50 Sounding run complete. Head for ISIT location. ISIT moved out to deck, but wind increased (>25 knots) preventing deployment. Wind and swell also prevent box-coring activities.
13:00: Vertical plankton hauls undertaken (14298#1,#2).
15:15: Weather moderated sufficiently to attempt box-coring. First attempt (14299#1) produced small amount of live *Lophelia*, second attempt produced good sample of live *Lophelia*.
18:00: Box-coring finished, head to ISIT location.
21:00: ISIT deployed at location that previously produced good bioluminescence at bait.
21:40: Plankton sampling undertaken (14301#1,2,3) until wind increased and work stopped.

Saturday 9th March

0630: Planned ISIT release postponed due to wind and sea state. 50 knot winds overnight had moderated to 30 knots, but still too much to consider recovery. Wind remained strong for much of the day, moderating towards evening.
17:30: Considered ISIT release but conditions marginal so decide to try again in the morning.

Sunday 10th March

Storm force winds for much of the day. Moderated during the afternoon.

Monday 11th March

06:45: Wind dropped away, but large swell from W. ISIT released
07:10: ISIT on surface, on board at 08:00. Excellent bioluminescence on video.
08:15 Heading south-west in good weather towards the DOBO location.
16:45: Reached trawl station to the east of the DOBO site at 16:45.
17:00: Trawl shot away (14302) at depth of 2350-2450 m.

Tuesday 12th March

00:15: Trawl recovered and decks clear by 0100. Lazy decky had slightly strangled the cod end, but otherwise good catch of fish, but no holothurians. Heading west to DOBO site.
04:30: At DOBO site, but weather deteriorating so head off towards deeper water to put the CTD over to test the releases.
08:15: CTD abandoned due to poor weather. Wind increased to 40 knots from NE preventing further work.

Wednesday 13th March

NE gales continue.

Thursday 14th March

07:00: Weather moderated slightly overnight, so headed out towards the 4000m location to test the release on the CTD wire.
14:50 First CTD (14303#1) over.
18:40: CTD on deck.
19:10: Second CTD (14303#2) outboard.

22:23: CTD inboard, but the weather deteriorated so no further work was possible after completion of CTD.

Friday 15th March

07:00: Weather improved slightly, so SPRINT lander prepared.
09:20: SPRINT (14304) deployed at 4000m.
10:50: ISIT lander deployed (14305) 2 miles east of the SPRINT.
13:15: FRESP deployed (14306).
14:00: SPRINT lander released and 3 plankton hauls (14307) undertaken while it rose to the surface.
16:20: SPRINT on surface.
16:45: SPRINT grappled and the ISIT immediately released to allow recovery in daylight.
17:15: SPRINT on board and another plankton haul (14308) carried out whilst waiting for the ISIT to surface. SPRINT camera had flooded.
18:20: ISIT on surface.
18:50: ISIT grappled and on board at 19:05.
20:20: A sounding run was undertaken in preparation for a trawl at 3100m, however the ground was too rough, so an alternative location (2000 m) was selected.
22:50: Trawl shot away (14309).

Saturday 16th March

04:45: Trawl brought to surface, but a problem with cable haulers on the main winch delayed bringing in inboard by 30 minutes.
05:45: Net on board. Good catch of fish and holothurians. Decks cleared headed towards the DOBO location.
09:20: DOBO released and on surface at 10:40.
11:10: DOBO on deck. Nothing left of the porpoise, and the camera and current meters had worked. There had been considerable corrosion on the stainless steel parts of the lander.
14:55: ISIT deployed at 4000 m (14310) in profile mode.
16:50: ISIT released as soon as it touched down. Plankton tows (14311) undertaken whilst ISIT below the surface.
18:25: ISIT on surface and recovered just before dusk. Weather deteriorated slightly, but trawl prepared.
2120: Trawl shot at 4000m (14312), but weather continued to deteriorate.
22:55: Trawl aborted having not touched the bottom.

Sunday 17th March

00:30: Trawl brought on board in 40 knot winds. Jeff's birthday celebrated in the bar.
07:15: Weather moderated from 04:00, allowing the FRESP to be released.
09:35: FRESP on surface, but the weather had deteriorated again.
10:10: FRESP on deck. No fish in the trap, but the video showed a fish had been trapped but the trap did not fully close as a fish was trapped as it came down. Went to the location of the AUDOS lost on cruise 255.
12:30: Interrogated the releases of the AUDOS, but could not fire release code because of poor weather. Transferred FRESP camera to the SPRINT and prepared for deployment.
15:00: All set to deploy, but stopped at last minute due to high winds and swell. Headed north, to put the SPRINT down closer to the proposed DOBO location to save time later.
17:23: Deployed SPRINT (14313) in only 9 minutes from start to finish.
19:12: Undertook a sounding run over potential trawling ground (3200 m) en route to the DOBO site, but ground poor.
21:30:On location for DOBO.
23:30: Deployed DOBO (14314).

Monday 18th March

00:15: Attempted another sounding run over ground at 3000 m, ground not great but attempted a trawl.
03:45: Trawl shot away (14315) in very calm conditions. Wind increased and during a squall paying out ceased in case there was a need to bring it all back, however weather improved and trawl continued.
13:10: Trawl in board with a good catch of fish, with about 60 *C. armatus.*
13:45: Proceeding to SPRINT location.
15:00: SPRINT released.
17:30: SPRINT on board.
20:35: FRESP (14316) deployed in good weather.
22:30: Trawl prepared and shot away (14317, 4200 m).

Tuesday 19th March

10:40: Net in board, with good catch of holothurians, but poor fish catch. Proceeding to ISIT location.
14:15: ISIT deployed (14318).
14:50: Main warp deployed with weight to test winch.
15:45: ISIT released whilst in mid-water.
16:53: Winch testing complete.
17:32: ISIT on surface.
18:20: ISIT on deck.

18:42: All secure and heading for trawl site.
23:55: Commenced trawl (14319).

Wednesday 20th March

08:10: Commenced trawl recovery.
08:30: Trawl on board.
09:10: All secure and heading to ISIT site.
13:20: ISIT deployed (14320).
14:33: ISIT released.
15:36: ISIT on surface.
16:05: ISIT on board and FRESP released.
18:20: FRESP on surface.
18:55: FRESP on deck, fish had been caught but trap was damaged. Proceeding to SPRINT deployment location.

Thursday 21st March

00:40: SPRINT (14321) deployed at 2500 m.
02:25: Trawl (14322) shot away (2200 m).
08:40: Commenced trawl recovery.
09:20: Net in board. Deck secured by 10:00, proceeding to SPRINT position.
11:10: SPRINT released.
12:23: SPRINT on surface.
12:45: SPRINT grappled, but dhan buoy broken and radio, strobe and two syntactic floats lost.
13:05: SPRINT on board.
13:20: Brief attempt to recover floats not successful.
16:25: Commenced shooting trawl (14323; 1400 m).
21:00: Began trawl recovery.
21:25: Net inboard and all secure by 22:15. Good catch of fish and invertebrates.

Friday 22nd March

01:15: SPRINT deployed (14324) at 2500 m. Initially began heading towards trawl location, but decided to wait and release SPRINT at first light.
05:36: SPRINT released
06:55: SPRINT on surface.
06:32: SPRINT on deck having surprised a few fish. Heading towards final trawl station at 1000 m.
12:00: Commenced deployment of trawl (14325) at 1050 m.
15:20: Net in board with good catch of fish.
15:26: PES fish inboard.
15:35: All secure on deck and heading home.

Saturday 23rd March

On route to Southampton.

0900: Cruise debrief meeting (MAC, Master, C/O, TLO & IGP).
10:45: Pass Bishop Rock.
15:45: Boat transfer off Falmouth to allow Mick Trevaskis to leave.
20:00: RPC.

Sunday 24th March

05:00: Pass Portland Bill.
11:50: End of passage.
15:00: Tied up at Empress Dock.

Scientific Reports

1 OTSB Operations and Catch Processing

Richard Paterson, Ben Boorman, Martin Collins & Amanda Brindley

Background

An important aspect of the work carried out by Aberdeen University on this series of cruises is to investigate any seasonal patterns in the distribution, abundance, metabolism and reproductive cycles of deep-sea fish. The OTSB (semi-balloon otter trawl) is the standard gear for sampling fish and megafaunal invertebrates in the deep-sea and has been used throughout this series of cruises.

OTSB Operations

The OTSB was rigged in the same way as previous cruises, however since cruise 255 the deck working rules have changed meaning that anyone working in the red (afterdeck) area when the rails are down must wear a safety harness. As a consequence of this it was necessary to have three men on deck (in addition to the winch and crane drivers) one in a harness to remove the safety rails and two without harnesses to handle the gear as it goes out-board or comes in-board. The rails are put up as soon as the trawl doors enter the water on deployment and come down once the trawl is transferred to the deck winches on recovery. The new system generally worked well, but required some fine movement of the A-frame and cranes during shooting to achieve the transfer to the main winch. The trawl was fished without a monitor during the cruise.

Catch Processing

Fish were separated from the invertebrate catch on deck and taken to the deck lab where they were identified, weighed, measured and given an individual identification number. Once numbered the fish were distributed to the other working groups so specific tissue, eye, and brain samples could be recovered. Fish were kept on ice at all times to help maintain tissue samples. Following the removal of tissue samples each fish was sexed and the level of reproductive maturity assessed. Mature animal gonads were removed and preserved in formalin. Stomach content level was determined and any full stomachs were frozen for later analysis. Otoliths were recovered from a sample of all species except eels.

The invertebrate catch was logged but not all processed further, but selected taxa were retained.

2 Fish catch composition

Martin Collins

Background

An important objective of the NERC grant GR3/12789 (Metabolism, activity and distribution patterns of deep-sea demersal fishes) is to investigate seasonal patterns in the distribution, abundance and metabolism of deep-sea fishes. The OTSB trawls provide one of the main methods of determining distribution and abundance of the deep-sea fish and provide material for studies of enzyme activities, condition indices, diet, growth and reproduction.

Fish Catches

A total of 42 species of demersal fish were caught in the 8 trawls. Numbers of each species caught at each station are given in Table 2.1. Catches of fish were disappointing at some stations, notably 14317, but this may have been due to the slow trawling speed at this station.

14302 (2365-2456 m): This station included 13 species, dominated by the grenadier *Coryphaenoides guentheri*. The catch also included 20 *Halosauropsis machrochir* and an unusually large catch of the alepocephalid *Conacara macroptera*. The catch of *Antimora rostrata* was disappointing, as this depth is usually where they are most common.

14309 (2011-2218 m): This trawl had a reasonable catch of fish, with 14 species dominated by *Coryphaenoides guentheri* and *Synaphobranchus kaupi.* Also in the catch was a large mature *female Cataetyx laticeps.* This species is a live bearer and was releasing small larvae from the ovary.

14315 (3030-3168 m): A speculative trawl over previously untried ground yielded an excellent catch of large *Coryphaenoides armatus,* with *H. machrochir*, *C. leptolepis* and *C. carapinus,* also caught in good numbers.

14317 (4190-4263m): Poor fish catch with just sixteen individuals, dominated by *Coryphaenoides armatus*.

14319 (2555-2590 m): Another trawl at mid-slope depths yielded a small catch of the target species *A. rostrata*. Ten species in total with the most abundant *Coryphaenoides guentheri.*

14322 (2177-2230 m): Poor fish catch in terms of numbers and diversity, dominated by *Coryphaenoides guentheri.*

14323 (1419-1440 m): A good, diverse fish catch, with 19 species, numerically dominated by the eel *Synaphobranchus kaupi.*

14325 (1100-1119 m): The final trawl yielded a good catch of *Lepidion eques* and *Nezumia aequalis.*

Table 2.1 Fish species caught and numbers at each station during Discovery Cruise 260.

	Station Number							
	14302	14309	14315	14317	14319	14322	14323	14325
Antimora rostrata	15	9			6			
Lepidion eques							22	67
Halargyreus johnsonii							8	
Coryphaenoides armatus	9		69	13	13			
Coryphaenoides brevibarbis	18	1			7	1		
Coryphaenoides guentheri	142	47			26	19	21	
Coryphaenoides leptolepis			11					
Coryphaenoides rupestris							26	4
Coryphaenoides carapinus			13	1				
Coryphaenoides mediterraneus						1		
Coelorinchus occa							22	3
Nezumia aequalis								33
Trachyrinchus murrayi							6	
Alepocephalus australis		1						
Alepocephalus rostratus							3	2
Alepocephalus bairdii							11	
Narcetes stomias		1			2	6		
Bellocia michaelsarsi	1		1					
Bellocia koefedi			1					
Bathtytroctes microlepis		1						
Conacara macroptera	19						3	
Conacara murrayi		1			1			
Xenodermichthys copei						1		
Bathypterois dubius							10	5
Bathysaurus ferox	2	1			2	4	1	
Halosauropsis machrochir	21	10	20	1	3	6		
Notacanthus bonapartei	1							1
Polyacanthanotus rissoanus		1					11	1
Polyacanthanotus challengeri	1		1					
Cottunculus thompsoni							3	1
Hoplostethus atlanticus							2	
Spectrunculus grandis	6	4		1	4	1		
Cataetyx laticeps		1					2	
Pachycara crassiceps	1							1
Synaphobranchus kaupi		31					76	41
Histiobranchus bathybius	2		2		7			
Bathyraja richardsoni	1							
Raja fyllae							1	
Raja bigelowi							1	
Chimaera monstrosa							1	1
Hydrolagus mirabilis								3
Myxine ios								1

3 Invertebrate Fauna From OTSB Trawls

Rhian Waller, Ian Hudson, Rob McAllen, Francisco Benitez & Martin Collins

This cruise saw a total of eight trawls around the Porcupine Seabight at a variety of depths. All were successful in obtaining both invertebrate and vertebrate fauna.

14302 (2365-2456 m)

This trawl was dominated by the ophuroid *Ophiomusium lymani,* and a small orange asteroid. Unusually there were no holothurians present within the catch. Several solitary corals were also present, around 30 *Flabellum angulare*, 6 *Caryophyllia ambrosia* and 1 *Fungiacyathus marenzelleri* were preserved, as well as one very large *Sicyonis* (*biotrans*?) anemone. An unusual large orange nematean was also retained, and several large ?*Hymenaster* asteroids. Several large slabs of clinker were also present.

14309 (2011-2218m)

The trawl was dominated by the holothurian *Benthiagone rosea* and the actinarian *Phelliactis robusta*. There were also many echinothurid urchins, including *Phorostoma placentae* and possibly a *Hygrosoma* sp. Also present were several small orange asteroids (also found in previous trawl), *Glyphocrangon*, ?*Troschelia* gastropods (some live, some just the shell), two species of large asteroid, the ophuroid *Ophiomusium lymani,* a large *Actinoscyphia aurelia,* several pycnogonids (Colossendeis family) and many small echinus urchins. A small amount of clinker was present, as well as glass bottles, cans and a large White Star Line platter.

14315 (3030-3168m)

This trawl was noticeable for the abundance of clinker and the large fishing net that was recovered, making animal extraction difficult. The catch was dominated by a small Hormathiidae actinarian, *Amphianthus* (?*bathybium*), several holothurian species (mainly *Benthothuria purelopsis*) and a small orange asteroid (as in previous trawls). Unusually fourteen large spider crabs, *Neolithoides grimaldi* were recovered. Also present were several cirripede barnacles, echinothurid urchins (*Phorostoma placentae* and ?*Hygrostoma*), pagurus hermit crabs with ?*Adamsia carcinus* attached and several *Atolla* sp. jellyfish. Also of note was a Red Star Line beaker found amongst the clinker.

14317 (4190-4263 m)

This trawl returned with large amounts, of small pieces of clinker and mud, as well as many species of invertebrates. The small holothurian *Amperima rosea* was present in very large numbers, along with numerous other species of holothurian such as *Pseudostichopus villosus*,

Molpadia blakei, and *Oneirophanta mutabilis*. Several species of actinarian were present in large numbers, including *Phelliactis robusta, P. hertwigi, Amphianthus bathybium, Actinaugi abyssorium, Daeontesia porcupinus, Sicyonis (?biotrans)* and the commensal *Adamsia carcinus* on *Parapagurus* hermit crabs. There were also many large scaphopods (?*Fissidentalium*), many *Munidopsis*, and several species of asteroid, including *Freyella* and an unusual small black species.

The total catch was hard to ascertain in this trawl, due to the large amount of mud present. An early deck accident meant there were no sieving facilities available to look at the entire mud catch, and so it was sub-sampled to gain an overview of the total invertebrate fauna.

14319 (2555-2590 m)

This was a small catch overall, with the major invertebrate fauna being made up of a small red species of asteroid, two species of ophuroids, including *Ophiomusium lymani*, and echinus urchins. Several holothurians were also recovered, *Psychropotes depressa, Molpadia blakei* and an unknown pink variety. The catch also yielded a variety of anthozoans, the anemone *Amphianthus bathybium*, the scleractinia *Flabellum angulare* and *Caryophyllia ambrosia*, which were frozen for molecular work, and there was an abundance of an orange octocoral.

14322 (2177-2230 m)

The net became heavily twisted at some point during this trawl, after becoming tangled in conducting wire. This catch was dominated by *Ophiomusium lymani* (and 3 other species of ophuroids) and the holothurian *Benthiagone rosea*. Among the actinarians there were many *Phelliactis robusta, Amphianthus* sp. and an *Actinoscyphia aurelia*. 5 species of asteroid were present, as well as the echinothurid urchin *Phorostoma placentae* and echinus urchins. Among the invertebrates there were also large scaphopods (?*Fissidentalium*), two species of gastropod, many *Munidopsis* and *Glyphocrangon*, and several cirripede barnacles.

14323 (1419-1440 m)

This large catch was vastly dominated by holothurians, species included *Paroriza patens, Laetmogone violacea* and *Bathyplotes natens*. Three species of octopod were also found, a large *Stauroteuthis syrtensis*, two *Opisthoteuthis* and two *Benthoctopus*. Surprisingly there were very few crustaceans present in the haul, just a few mid-water prawns. Three species of asteroid, few *Ophiomusium lymani* and two *Colossendeis* pycnogonids. Three species of Scleractinian were also present, *Flabellum alabastrum, Stephanocyathus moselyanthus* and *Caryophyllia sequenzae*.

14325 (1100-1119m)

This final trawl had a small catch, again dominated by holothurians (*Laetmogone violacea* and *Bathyplotes natens*). Other fauna included echinus and cidaris urchins, echinothurid urchins (*Phormotstoma placentae* and *Calverostoma hystrix*), several *Nephropsis* two species of asteroid and five large gastropod shells (?Troschelia). A large red ?*Kophoblemnon* pennatulid and a single parapagurus hermit crab with *Epizoanthus paguriphilus* zoanthid made up the entire cnidarian catch. Two exceptionally large *Opisthoteuthis massyae* octopods were also recovered in the haul.

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4 Fish Tissue Sampling For Fatty Acid Analysis

Camila Henriques

Background

Studies of the trophic ecology of deep-sea fish are hampered by regurgitation as a consequence of the expansion of the swim-bladder when the animals are brought to the surface. Even those that arrive with full stomachs, or lack swim bladders may have been feeding in the net and hence it is difficult to obtain an accurate picture of the diet of the fish. Analysis of fatty acids from the muscle and liver provide an alternative means of identification of the prey.

Sampling

Small samples of muscle and liver tissue were collected from specimens caught by the OTSB trawl at depths ranging from 1100 to 4100 metres. From each specimen white muscle was sampled from the dorsal region and approximately one third of the liver was collected. The samples were individually packed and frozen at –70°C for future analysis of fatty acid content at the University of Aberdeen.

Table 3.1 – Number of muscle (M) and liver (L) samples of *Antimora rostrata* (ANR), *Coryphaenoides armatus* (COA), *C. guentheri* (COG), *C. rupestris* (COR) and *Halosauropsis macrochir* (HAM) collected from trawl catches from different depths.

	1100m	**1400m**	**2000m**	**2200m**	**2300m**	**2500m**	**3000m**	**4100m**
ANR			8M, 5L		9M + L	5M + L		
COA						7M + L	20M+ L	10M, 7L
COG			20M+L	4M + L	20M+ L	10M+ L		
COR	4M + L	14M+ L						
HAM				6M + L			10M+ L	

5 Metabolic analysis and seasonal variation of enzymatic activity of demersal deep-sea fish

Bertrand Genard

Deep-sea fish live in a food-limited environment. Several studies have shown that the metabolic enzyme activities in muscles of active pelagic swimmers decrease with increasing depth. In order to determine whether this also occurs in deep-sea demersal fishes, the level of the metabolic enzymes will be measured in red and white muscles. The sampling has targeted some specific species established at different depths and has been carried out during the cruises D250 (September), D252 (April) and D255 (August). We selected the following seven species (with min. and max. depth in meters): *Coryphaenoides armatus* (2000-4800), *Antimora rostrata* (1000-3000), *Coryphaenoides rupestris* (700-2000), *Coryphaenoides guntheri* (1000-3000) and *Synaphobranchus kaupi* (250-2500). Two shallower demersal species have been selected to allow us to compare enzyme activity from deep-sea demersal fish to the enzyme activity from shallower demersal fish from the same area. Those two species are *Nezumia aequalis* (500-1500) and *Lepedion eques* (400-1750).

The activities of lactate dehydrogenase, pyruvate kinase, malate dehydrogenase, citrate synthase and cytochrome-c oxidase have been assayed in supernatant at 4°C. The scaling of these activities with the size of the fish has been studied within each species. It will help us to learn about feeding habits and locomotion of those species throughout their growth. The protein content of each tissue will also be determined. Moreover, samples of muscles of these species were fixed for electron microscopy. These will be used for analysing mitochondrial density, and see how this correlates to the activity of metabolic enzymes.

This cruise, D260, in the Porcupine Seabight allowed us to complete our sample collection. With the same metabolic enzyme assays, we will be able to observe whether any seasonal variation in metabolism exists due to variations in food supply. For all those species, a various number of specimens have been dissected within a large range of size (Table 5.1); we sampled red and white muscles, heart and liver.

Table 5.1. Fish sampled during cruise D260

Species	14302 2500m	14309 2000m	14315 3000m	14317 4000m	14319 2500m	14322 2200m	1432 1400m	14325 1200m	TOT
COA	7		15	5	5				32
COG	12	8			13	10	5		48
COR							18	4	22
ANR	7	8			4				19
SYK		9					4	10	23
NEA								12	12
LEE							8	5	13
								Sum:	169

6 Tissue culture of deep-sea fishes (*Coryphaenoides armatus*, *Antimora rostrata* and *Synaphobrancus kaupi*)

Sandrine le Polain

Tissues of deep-sea fish have developed many adaptations to deep-sea life. For example, several studies have been carried out to show the adaptation to high pressure and low temperature. But many properties are unknown (e.g. antioxidant properties). So it will be attractive to develop a culture system to study these properties. That's why we want to grow cells from deep-sea fish.

In this cruise, we selected three species each representing of a specific depth range: *Coryphaenoides armatus* (2000-4800), *Antimora rostrata* (1000-3000) and *Synaphobrancus kaupi* (250-2500). Tissue explants of skin and muscle were taken and frozen (in liquid nitrogen) with various doses of serum (foetal calf serum), culture medium (DMEM) and cryoprotectants (dimethyl sulfoxide or glycerol). These will be thawed in the laboratory and kept at low temperature. The possible outgrowth of cells from explants to the surface of the culture vials will be monitored. This method allows us to find a successful freezing medium with specific concentration on serum, culture medium and cryoprotectant for each selected species. Samples of *C. armatus*, *A. rostrata* and *S. kaupi* have been taken respectively during the trawls 14315, 14319 and 14322.

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7 Melatonin distribution in the brains of deep-sea fish

Emma Battle

Background

During Challenger cruise C134 (August 1997) a total of 101 brains, from 14 species, were collected and frozen to examine melatonin receptor distribution in deep-sea fish living in the absence of solar light. Priede *et al.* (1999) showed binding of radioactive melatonin (2-[^{125}I]iodomelatonin) in the optic tectum as well as melatonin receptors throughout the visual structures of all the brains studied. (Priede *et al*, 1999. Proc. Roy. Soc. **266**. 2295-2302).

Brains were collected from 3 species (*Coryphaenoides armatus, C. guentheri* and *C. rupestris*) during D252 (April 2001). Brains from *C. armatus* and *C. guentheri* were obtained during D255 (August 2001). Analysis of these brains collected in April and August is in progress. During D260 the aim was to collect further species for comparison to allow seasonal

comparison of melatonin distribution (using 2-[^{125}I]iodomelatonin binding and *in-situ* hybridisation studies) at the Rowett Institute on return to Aberdeen.

Work undertaken

The brains were removed as soon as possible after initial processing (identification, measuring and weighing) had occurred. Dissecting scissors were used to cut the nerves connected to the brain. Each brain was removed with forceps and placed in a beaker of iso-pentane that was kept on dry ice (or in liquid nitrogen) throughout. Once frozen, the brains were wrapped in aluminium foil and placed in universal tubes, before transfer to the -70°C freezer.

Eight brains of *Antimora rostrata* were collected over trawls 14302 and 14319. Poor catches of this species prevented a bigger sample being taken. A total of 10 brains of *C. rupestris* were collected from trawl 14323.

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8 Decapod crustaceans: Physiological adaptations to the deep-sea

Rob McAllen

Background

This study continues work started last year aboard cruise D255 to investigate the adaptations of deep-sea benthic decapod crustaceans, by measuring how metabolically related variables change with depth and season. Variables investigated in this study include protein and lipid content of the tail muscle and the haemocyanin (by Cu and protein analysis) and ionic content (namely Mg, Ca, and Mn) of the haemolymph of deep-sea decapods. In addition, samples will be collected to allow further morphometric and feeding ecology studies to be undertaken back in Aberdeen.

Work on board *RRS Discovery*

Deep-sea benthic decapod crustaceans were obtained by semi-balloon otter trawls (OTSB) at depths ranging from 1000 to 4300m. Individuals were immediately immersed in cold seawater and taken to the constant temperature room. Haemolymph samples were removed immediately from individuals by hypodermic needle through the arthrodial membrane of the legs and frozen at -20ºC, for later analysis of haemocyanin and ionic content at the University of Glasgow in collaboration with Dr Alan Taylor. Tissue samples were removed from the abdomen and flash frozen in liquid nitrogen before storage at -70ºC for protein and lipid analysis at Aberdeen University (see Table 8.1 for sample collection summary). Morphometric measurements were made on all collected individuals and a number of

additional individuals from several species were frozen whole to allow for feeding ecology studies to be performed back at Aberdeen University at a later date.

In addition to the physiological studies outlined above, several additional collections were performed. A number of decapods from all sample depths were preserved for later analysis. Amphipods were collected from the FRESP and ISIT landers for a Scanning Electron Microscopy study on position maintenance capabilities and the extent of microbial biofouling. Three sediment samples were collected from the OTSB and stored in filtered seawater at 4ºC for microbial analysis by Dr Fiona Hannah, a collaborator from the University Marine Biological Station, Millport. Furthermore, Fifteen seawater samples from depths of 500 – 4000m were obtained from a CTD deployment for Dr Hannah also.

Table 8. 1: Summary of Crustacean samples collected for haemolymph and tissue analysis during Discovery Cruise 260 (6/3/02 to 24/3/02).

Depth (m)	Station	Number of haemolymph samples collected	Number of tissue samples collected	Key genus Sampled
1079-1145	14325	7	7	Nephropsis
1380-1480	14323	1	1	*Polycheles*
2026-2286	14310	24	19	*Polycheles, Glyphocrangon, Geryon*
2200	14322	18	10	*Munidopsis, Glyphocrangon, Geryon*
2412	14302	13	16	*Polycheles, Glyphocrangon*
2500	14319	12	12	*Glyphocrangon, Munidopsis*
3085-3350	14315	31	18	*Neolithoides, Parapagurus*
4075-4386	14317	20	14	*Parapagurus, Munidopsis*
Total		**126**	**97**	

9 Seasonal changes in the sensory modes of the brains of deep-sea fish

H.-J. Wagner, U. Mattheus

Most of the activities during this cruise were extensions and follow-ups of projects started on Discovery Cruise 250. The general background of the various topics was discussed in the last cruise reports and will not be mentioned here in detail.

Main project:

Melatonin as possible mediator of cyclic changes in the behaviour of demersal fish

Preliminary results of melatonin contents in *C. (N.) armatus* and *S. kaupi* from last year's cruise seem to indicate differences between fish caught at night and during the day. Interestingly, and unlike in terrestrial or shallow water vertebrates, the melatonin content in *S.*

kaupi was higher during the day than at night. This might indicate the influence of alternative zeitgebers such as the tide. It would also confirm the role of the pineal in the control of biological rhythms in the abyss. Therefore one may expect differences between the pineals sampled in autumn and those collected spring (Wagner, H.-J. and U. Mattheus (2002) Pineal organs in deep demersal fish. Cell Tissue Res. 307, 115-127).

In order to dissociate the impact of seasonal and circadian (tidal) rhythms the secretion of melatonin can be measured in isolated pineal organs kept in long term culture systems. Since this requires living tissue, such experiments can only be done in *S. kaupi.* Furthermore, such experiments need to be performed in the dark (or under red light) in order to exclude the inhibitory influence of light on the melatonin synthesis of pineal photoreceptors.

Since not only pineal photoreceptors are capable of melatonin synthesis, but also those in the retina, and since the volume of retinal photoreceptors is orders of magnitude higher than that of the pineal, we want to compare the melatonin content as well as the melatonin release of pineals and isolated retinae in the same specimens of *C. armatus* and *S. kaupi.*

Ideally, the sampling times for the determinations of cyclic events should occur at fixed intervals, or at identical time points in a given phase. Such requirements are, however difficult to meet in the practice of trawling on board ship; again the *in vitro* (culture) may provide a solution for this problem.

Material collected and experiments done

For the determination of melatonin content we collected isolated pineal organs and retinae of *C. armatus* (day, night, dawn) and *S. kaupi* (night, dusk). At each time point between 12 and 25 samples were dissected, quickly frozen and stored until further biochemical analysis in Tübingen. Furthermore, we pooled 5 groups of 5 pineals each and dissected 4 isolated retinae of *S. kaupi* and kept them in long term culture for 52h. At intervals of 4h, culture medium was collected and renewed. Melatonin should be liberated into the culture medium and assays will allow us to determine whether any cyclic changes can be detected in the release pattern.

Further projects

1. Retinal ganglion cells: Preliminary results from last year's cruise have shown successful labelling of ganglion cells via retrograde axonal transport with fluorescent labelled dextranes as marker molecules. We have been able to identify on and off-centre populations of ganglion cells, and at least three different other subtypes based on the ramification pattern of their dendrites. Additional information was obtained by microinjecting fluorescent dyes into

lightly fixed cells in a retinal wholemount preparation in a dedicated set up in Tübingen. Suitable material was obtained mostly from *C. armatus* during this cruise and will be used to complete the inventory of ganglion cells in all-rod retinae. Apart from contributing to an understanding of intraretinal signal processing, the results of this study will also allow to evaluate the visual capabilities of deep-sea fishes in grater detail than before.

2. Barbels: In view of the distinct "pole dancing behaviour " of adult *C. armatus* on the scaffold of the SPRINT lander we fixed two barbels of adult specimens and two barbels of smaller specimens for electron microscopy. Ultrastructural analysis will show whether mechanoreceptors or taste receptors (or both) are present on the barbel and may help to explain the sensory basis of this behaviour.

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10 *In situ* studies of deep-sea fish physiology using the fish respirometer (FRESP) and fast-start performance (Sprint) landers.

David Bailey, Alan Jamieson and Phil Bagley

Background

A key aim of the NERC grant is to quantify the metabolic rates and swimming performances of deep living fishes. As these animals do not survive capture to the surface these studies must be carried out *in situ*.

Fish Respirometer (FRESP)

Cruise D260 was the fourth to utilise the FRESP lander, following successful deployments during D255. Due to the adverse weather conditions the lander was only deployed twice (Stations 14306 and 14316). At both these 4000m stations *Coryphaenoides armatus* were captured in the chamber (see Fig 10.1 below), with a single individual at Station 14306 and five animals at Station 14316.

Figure 10.1. Five Coryphaenoides armatus captured during FRESP station 14316.

Due to problems with latch mechanisms the trapping respirometer chamber was unable to seal completely resulting in poor oxygen consumption measurements. The continuing efficiency of the FRESP lander in capturing deep-sea fish is encouraging, with the remaining technical difficulties being apparently solvable.

Fast-start performance lander (SPRINT)

It has been speculated that the low metabolic rates of deep-sea fish relate to relaxed selection for muscle performance at low light levels. By stimulating and videoing the escape responses of deep-sea fish whole-animal burst swimming performance can be quantified, and a range of muscle performance parameters estimated.

Cruise D260 was the first opportunity to test the new Sprint lander. This vehicle comprised a housed digital video camera mounted on a large (2.8m high) tripod frame. Fish were attracted to the lander by mackerel bait and at pre-set intervals electrical pulses were delivered between two stainless steel electrodes held just above the seabed and spaced one metre apart.

The vehicle was deployed twice at 4000 m (Stations 14304 and 14313) and twice at 2500 m (14321 and 14324). Due to a camera flood no data were obtained from the first 4000 m deployment. Pulse width and amplitude were varied (10-40 v, 1-5 ms) during the second and third deployments in order to determine the optimum pulse characteristics for the initiation of escape responses. In the final deployment pulses were always 40v for 2 ms.

Several good sequences of escape responses and burst swimming were obtained for *Antimora rostrata* (see Fig 10.2 below), *Coryphaenodes armatus* and *Histiobranchus bathybius*. Figure 10.2 shows a sequence of stills from the Sprint video system. One fish (*A. rostrata*, large black fish, top centre) is stimulated by the electrical field and makes and escape response, this scares a small *C. armatus* which subsequently also escapes. The mackerel bait is visible towards the centre of the frame with the two electrodes running from left to right.

Figure 10.2 Escape response in *Antimora rostrata*.

The sprint camera is succeeding in producing useful and important data on fish swimming and will be upgraded with a higher frame-rate camera system ready for future deployments.

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11 AUDOS Deployments

Camila Henriques

Four AUDOS deployments were planned for this trip, two at 3500m and one each at 2000m and 1500m. These specific depths would complete the work carried out in the previous cruises of this series. The AUDOS lander was to share a video camera with the SPRINT lander throughout the cruise. Since the camera housing flooded during the first deployment of the SPRINT (Station 14304) no AUDOS deployments were achieved.

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12 Reproductive Biology of Deep-Water Anthozoans

Rhian Waller

In April 2000, the multidisciplinary European project 'Atlantic Coral Ecosystem Survey' (ACES) began with the aims of surveying, studying and conserving the deep-water reefs around the European margin. The fishing industry has increasingly turned to deeper waters to find commercial fish, such as the Orange Roughy and the Grenadier, which are commonly found amongst the coral reefs. Trawling has been shown to damage the reef areas, and the research of the ACES project is intended to find the extent of this damage.

Thérèsa Mound within the eastern Porcupine Seabight forms one of the main research areas within this project. The main faunal constituent of the deep-water reefs is the hermatypic, reef building scleractinian, *Lophelia pertusa.* This coral is found at depths of between 50m (Kosterfjord, Sweden) and 1000m (Thèrèsa Mound), and is found in the Atlantic, Pacific, Indian and Antarctic oceans.

Many vertebrate and invertebrate species have been found amongst the reef areas, 400 different species to date, this figure is comparable to shallow-water reefs around the world. It is thought the coral forms important nursery habitats and feeding areas for these species.

Several other species of scleractinian are also found within Europe's deep waters, such as the hermatypic reef builder *Madrepora occulata*, and the many non-reef building solitary corals, such as *Fungiacyathus marenzelleri*, *Caryophyllia ambrosia* and *Flabellum angulare*.

My project under the ACES grant is to investigate the reproductive processes of various deep-water scleractinians and their associated anthozoans. Very little is known of the reproduction of deep-water cnidarians at present. This project will include their reproductive periodicity using histological processing, and spawning and larval development using live cultures. This cruise has given me the invaluable opportunity to collect live samples of *Lophelia pertusa* to bring back to Southampton Oceanography Centre (SOC) for further research, as well as several species of solitary corals which have been preserved. Collections of scleractinia have also been made for Marie LeGoff (SOC), who is working on the population genetics of scleractinians in the NE Atlantic, and for André Friewald, who is working on stable isotope analysis at Tübingen University. Both are also funded under the ACES grant.

On board experimentation

During the course of the cruise I performed two, one day spawning experiments using two of the live *L. pertusa* colonies collected during box coring. For the first experiment the two colonies were subjected to a slow increase in temperature to try and induce spawning behaviour. This experiment was done solely within the CT lab on board. This was done by slowly replacing (1 litre every half hour) the chilled ambient seawater, with seawater at room temperature. This was done for 2 hours until the temperature of the ambient seawater within the tanks was at 9°C (4°C higher than normal). Colonies were then observed for evidence of spawning for a further 6 hours, until the temperature had returned to normal.

For experiment two (one week after exp. one) the same two colonies were subjected to a decrease in temperature by placing the tanks within the walk in freezer set at 0°c. These colonies were observed until the ambient seawater had reached just 1°C and then were moved back to the CT lab. They were then observed for a further 6 hours for evidence of spawning. No spawning occurred during either of these experiments, or for the duration of the cruise. It is hypothesised that the colonies need a period of time to recover from the stress of being collected before reproduction may continue as normal.

Coral collections during cruise D260

St. No.	Method	Species	No.	Preservation	Use
14299#1	BC	*L. pertusa*		formalin	Hist
		L. pertusa	7 polyps	ethanol	Mol
		M. occulata		formalin	Hist
		M. occulata	2 polyps	ethanol	Mol
		E. norvegica	2	ethanol	Mol
14299#2	BC	*L. pertusa*		formalin	Hist
		L. pertusa	4 colonies	Live culture	Spawning
		L. pertusa	2 polyps	ethanol	Mol
		M. occulata	1 polyp	ethanol	Mol
		E. norvegica	3	ethanol	Mol
		Polynoidea	2	ethanol	Mol
14302#1	OTSB	*F. angulare*	30	formalin	Hist
		C. ambrosia	4	formalin	Hist
		F. marenzelleri	1	formalin	Hist
14317#1	OTSB	*F. marenzelleri*	9	ethanol/frozen	Mol
14319#1	OTSB	*F. angulare*	10/20	ethanol/frozen	Mol
		F. angulare	2	dried	Isot
		C. ambrosia	10/8	ethanol/frozen	Mol
		F. marenzelleri	1	ethanol	Mol
14322#1	OTSB	*F. angulare*	10	ethanol/frozen	Mol
		F. angulare	1	dried	Isot
		C. ambrosia	10/15	ethanol/frozen	Mol
		C. ambrosia	5	dried	Isot
14323#1	OTSB	*F. alabastrum*	1	formalin	Hist
		S. moselyanthus	1	formalin	Hist
		C. sequenzae	5	formalin	Hist

13 Deep-Sea Bioluminescence

Emma Battle

Background

The ISIT lander has been successfully deployed on Discovery cruises 250, 252 and 255 to examine the presence of bioluminescence in the water column (profile mode) and just above the sea floor (baited mode) using an ISIT (Intensified Silicon Intensifying Tube) camera. The primary aim of this cruise was to deploy the ISIT in its baited mode at 1000m in a region of coral that has provided fantastic bioluminescent displays on previous cruises (D250, D255). A series of amphipod traps would be used to collect animals thought to luminescence at this depth, for analysis with the ISIT camera in the darkened CT lab on board.

Analysis of results from profile deployments in April and August 2001 has shown a seasonal difference both in the maximum number of bioluminescent events (higher in April) and the

depth at which this occurs (deeper in August). During this cruise it was hoped to perform profile deployments to depths of 4000m to extend the data series and see how March data for this deep bioluminescent layer compares with those from April.

Work undertaken

A total of 5 deployments were performed using the ISIT in both the baited (500g of mackerel) and profile configurations. The first was a baited deployment at 1000m in the same location as has given excellent results previously. Again a large amount of luminescence was observed, more than usual seemed to be due to planktonic organisms drifting into the field of view rather than benthic organisms attracted to the bait.

The next four deployments were in the profile mode at 4000m. The data was confined to a one hour DV tape, so recording was varied either to record intermittently from approximately 500m to the sea floor or continuously from the surface for one hour (to about 2500m only). Concurrent CTD deployments and echo-soundings were made to analyse both physical factors (such as temperature and salinity) and the position of the deep scattering layer for later comparison with the deep bioluminescent layer

Future work

The baited deployments showed the presence of bioluminescence on the 1000m contour in Spring. During the next cruise in September 2002, further deployments at 1000m will again try to repeat and clarify the results obtained during this cruise, D250 and D255. Further profile deployments will enable a four-month (March-April, August-September) data series to be established.

Hopefully the weather will permit the capture of amphipods or smaller planktonic organisms from a baited deployment for examination in a dark room on board with the ISIT camera. Thanks to Phil Taylor for setting up the CTDs and echo soundings during the cruise.

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14 Molecular adaptations to high pressure and low temperature in deep-sea fish

Amanda Brindley

This is a joint project with **Professor Martin J Warren**, School of Biological Sciences, Queen Mary, University of London, **Professor David M Hunt**, Department of Molecular Genetics, Institute of Ophthalmology, University College London and **Dr Julian C**

Partridge, School of Biology, University of Bristol. This project is funded by the BBSRC for three years from September 2000.

Background

The physical properties of the deep-sea create an environment that is characterised by high pressures and low temperatures. Very little is known about the molecular changes that allow the proteins of deep-sea fish to function in such an environment, although it is clear that molecular adaptations have taken place, leading to alterations in the thermal and kinetic properties of proteins.

Previous studies have shown that proteins of deep-sea fish have increased resistance to thermal denaturation and lower catalytic efficiencies relative to shallow-water homologs. Thermal stability is thought to be due to the evolution of especially rigid proteins that are able to resist disruption of tertiary and quaternary structure under high pressure. Thermal compensation in cold-adapted enzymes is reached through improved turnover number and catalytic efficiency. This optimisation of catalytic parameters can originate from a highly flexible structure. It would appear that there is a dichotomy between adaptations for high pressure and those for low temperature.

The objective of this project is to contribute to the understanding of the structural adaptations of certain deep-sea fish enzymes that permit them to operate at both high pressures and low temperatures. Two enzymes from the liver of *Coryphaenoides armatus*, lactate dehydrogenase B (ldhB) and 5-aminolaevulinic acid dehydratase (ALAD), have been cloned, expressed, partially characterised and crystallised. It has also been possible to clone and express lactate dehydrogenase B from cod liver as a direct comparison of a recombinant shallow water equivalent. Preliminary CD (circular dichroism) experiments suggest these two enzymes are structurally dissimilar even though they share over 90% amino acid sequence homology.

The ldh B cDNA has been sequenced from 8 deep-sea fish, 6 *Coryphaenoides sp.*, 1 other Macrouridae; *Trachyrincus murryai* and 1 Alepocephalid; *Narcetes stomias*, and from 2 shallow water fish, Atlantic cod and whiting. The sequences reflect their phylogenetic relationships. Work is underway to create mutants of the *Coryphaenoides armatus* ldhB based on the sequence of the cod cDNA in order to determine if a specific sequence can account for pressure adaptation or whether it is a more global affect across the whole amino acid sequence.

5-Aminolaevulinic acid dehydratase is the second enzyme in the haem biosynthesis pathway, it has been characterised from several sources, human, various plants, yeast and several bacteria. In eukaryotes it is an octamer that requires zinc for activity apart from some higher plants that utilise magnesium instead. The *Coryphaenoides armatus* enzyme, after preliminary experiments, appears to be a hexamer or less and is 4 times as active in the presence of magnesium than in zinc. As no other fish ALADs have been investigated it is important to establish if these differences are indicative of all fish ALADs or just of those from the deep-sea, experiments continue to clone the enzyme from cod and *Danio rerio* (zebra fish).

Our laboratory is interested in the tetrapyrrole biosynthesis pathways specifically those for haem and vitamin B12. Certain enzymes in the pathways are of special interest including ALAD and ferrochelatase that we have characterised from many sources. On the basis of the ALAD success it now seems feasible to investigate the rest of the haem pathway.

Work on board ship

Small tissue samples from the kidney and whole spleen of *Coryphaenoides armatus* were taken and stored in RNAlater ™ at 4°C. These tissue samples will be used to isolate the haem biosynthesis genes, specifically ferrochelatase. Whole *C.armatus* eyes were also taken and stored at -70°C for Dr David Hunt.

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15 Hearing and Sound Production in Deep Sea Fish

Xiaohong Deng

Background

Deep-sea fish live in an environment without any sunlight. This potentially makes underwater vision difficult. Since acoustic signals travel efficiently for considerable distance in the marine environment, hearing and sound communication may play an important role in the deep-sea fish's life, especially for finding mates. Following from this idea, we started anatomical studies of several deep-sea gadiform fish species obtained from Discovery Cruise 252. This species include *Antimora rostrata* and four *Coryphaenoides* species, *C. rupestris, C. armatus, C. guentheri* and *C. mediterraneus*. The data was presented as a poster in 2002 at the ARO (Association for Research in Otolaryngology) meeting in Florida, United States.

Many interesting features in the inner ear structure were found in these species. *Antimora* has extra thick walls in the three otolithic end organs and the sacs are partially rigid. The sensory

epithelium in the saccule is exceptionally thin and long and it has a more complex hair cell bundle orientation pattern than in other fishes. The *Coryphaenoides* species feature very special lagenae in which the sensory epithelia are often two or three times larger than their otolith. Extra long kinocillia can be found in all lagenar maculae in these species. Yet we still need further studies in the relationships between the otolith, otolith membrane and the hair cells.

The goals of joining this cruise were:

1) To get access to fresh fishes and verify the structures we've observed from fixed specimens in fresh ears.
2) To look for any possible sonic structure in these fishes that can serve for sound production device.
3) To collect inner ear samples for transmission electron microscopic studies and fish body samples for further analyses.

We collected specimens from the following gadiform species:
Antimora rostrata, Coryphaenoides armatus, C. brevibarbis, C. guentheri, C. leptolepis, C. mediterraneus, C. rupestris , Coelorhyncus occa, Nezumia aequalis.

Also some samples from other species:
Spectrunculus grandis, Synaphobranchus kaupi, Histiobranchus bathybius

Fish heads and some whole fish bodies were fixed on board for electron microscopic study. Dissections of fish heads and swim bladders from *Antimora* and *Coryphaenoides* were also done on board. Preliminary observation found no sonic muscles on the swim bladders of these species. Inside the swim bladder chamber there are different numbers of muscle-like red bundles in different species, with one end attached to the interior wall the other end embedded in the foam.

In *Antimora rostrata*, the swim bladder makes two connections to the bony capsule of each saccule. Although there is no foramen on the bone, the lateral wall of saccule is tightly attached to the part of bone that is connected to the swim bladder. This leads to the suggestion that an acoustic coupling between the ears and the swim bladder is possible. The two muscle bundles that move the upper pharyngeal teeth share the same attachment to the vertebral column with the anterior chamber of the swim bladder. One may speculate that the pharyngeal teeth and swim bladder together could serve as a sound production device. However more anatomical and behavioural evidence is needed before we can state that.

In *Coryphaenoides*, which has only one swim bladder chamber, no connection was found between the ears and swim bladder. There are also two muscle bundles that connect to the upper pharyngeal teeth in all species examined. Although there is an overlap in the positions of the swim bladder and pharyngeal teeth muscle, no firm attachment was seen between them. However, we still need to look closer into an intact fish body to determine if there is any contact between the muscles and the swim bladder wall.

In future studies, we will continue the electron microscopic survey of the ears and peripheral acoustic structures in these gadiform species. We also suggest including acoustic recording in future deployment of deep-sea landers. Several acoustic behaviour experiments can be designed on the landers we already have:

1) Record the feeding sounds of *Coryphaenoides armatus* and *Antimora rostrata* when there is bait on the landers. By comparing these sounds with those from other sound producing fishes we may learn if there is any sound produced by the pharyngeal teeth in these fishes, and whether the swim bladder can resonate to this sound.
2) Record during the SPRINT experiments to see if these species make sounds when they are frightened or aggressive, and if these sounds are different from those produced in normal situations.
3) Compare recordings from different seasons to find out if any "breeding signals" existing in these species. DOBO lander can also be equipped with recorders synchronised with the still cameras.
4) Replay different recorded sounds (if we get them!) back to the baited fishes, let's see if they can hear and what's their response: escaping from the frightening signals or attracted by the feeding sounds.

This is the first research cruise I've ever joined. I am enormously grateful to those persons who worked together to provide me this opportunity and make this cruise a successful and delightful one: Jochen and Arthur Popper (my mentor) introduced me into the deep-sea fish research. The Aberdeen people provided me the place on the ship. Martin brought me the dissecting scope. Ben, Ian and Rhian helped me with those "hazardous goods." Jochen and Uli helped me in every way during this cruise and managed to spare their aluminium box for my fish samples. Emma, Amanda and Kirsty were always patient with me during the fish sampling. Robin the Master generously allowed me to use the cold-room for three more days when everybody should debark the ship. Also thanks to the friends in the galley to help me gain weight and to Jeff for the nice connection between home, friends and the ocean.

With all the nice and welcome people around even the bad weather became enjoyable: Dan and Steve always made funny noises during lunch and dinner. Alan, Amanda, David and Jochen educated me on totally different aspects of British alcohol culture. I liked all the inspiring discussions with Jochen and the Southampton and Discovery history stories from Monty. Camila, Sandrine, Bertrand and Francisco, your dancing was wonderful.

I treasure the memories from Discovery cruise 260 and wish I could come back again. I believe we will continue to have cooperation in deep-sea research. I also look forward to meeting all of you everywhere in the world sometime in the future. And when you come to China or United States, please be sure to get in touch with me.

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16 The Feeding Ecology of Bathyal and Abyssal Holothurians of the NE Atlantic.

Ian Hudson & Francisco Benitez

Background

The order Holothuroidea first described by Thiel in 1872 during the Challenger Round the World Voyage of 1872-1876, is one of the major components of abyssal and bathyal megafauna in terms of both biomass and abundance, with hadal depths of > 6000m being called the "Realm of the Holothurian" (Belyaev, 1970). Although most holothurians are deposit feeders, members of this order act as filter feeders, particulate suspension feeders and a combination of both suspension and deposit feeders. It is the deposit feeding animals that present one of the most interesting paradoxes in the Deep-sea. There are over 30 species classed as deposit feeding holothurians in the NE Atlantic and these all seem to exist on the one simple food source, deposited mud on the ocean floor (Billett, 1991). How can this be so when little or no dietary overlap has been observed? Is a question that has been asked by Echinoderm biologists for over 100 years and is still a hot topic today in the light of sediment turnover rates and climate change.

Suggestions have been made as to a behavioural partitioning of the resources through differences in feeding tentacles, feeding behaviours, and also different gut morphologies, all these are certainly plausible options but yet to be proven. In light of this a different approach needs to be taken and this centres on the biochemical composition and biochemical processing of this simple food source. The surficial sediments on the bottom of the ocean are fed by upper-ocean flux of material aggregates, mainly plankton based, complete with attached bacterial communities and faecal debris from the pelagic zone. All this adds together to form a bio-chemically complex mixture of phytodetritus, mud, POM, DOM and bacteria,

which in turn provides a substrate for a range of meiofaunal communities. All these sections of the sediment are available for selection and use by the megafauna, especially the holothurian component.

This study aims to sample the tissues, mainly gonad and muscle along with gut sediment to determine the fatty acid, sterol, carotenoid and bacterial composition of these tissues and gut sediments, In combination with sampling gut morphology, tentacle structures & gonad histology.

Methodology

All animals used in this study were collected using an Otter Trawl Semi-Balloon with a 14m head rope (OTSB14) (Merret and Marshall, 1985). This system is a simple and effective method of collecting holothurians, fish and other invertebrates, with the main drawback being that a large catch has a tendency to crush the more delicate animals.

Internal cell lysis and subsequent contamination of tissue/gut contents with anomalous labile compounds was slowed by placing individuals into chilled seawater (4^{o}C) and taken to the constant temperature (CT) laboratory (also 4^{o}C) immediately after the trawl was retrieved.
Here the species selected are dissected from anterior to posterior to expose the gut tract and internal organs. A sample of gut sediment is collected from the anterior and posterior sections of the digestive tract and placed into pre-wrapped and sterile petri dishes to be frozen at –70oC. The guts are then removed completely, coelomic fluid extracted by pipette, prior to taking a gonad sample and longitudinal muscle band, these are replicated 2x, one sample into Chloroform:Methanol for Fatty Acid Analysis by GC-MS (Gas Chromatograph-Mass Spectrometry) and the others into -70^{o}C bags for HPLC (High Performance Liquid Chromatography) Carotenoid analysis and sterol analysis by GC-MS. The gut morphology is examined initially by digital image and later image analysis with tentacle ultra-structure by Transmission Electron Microscopy. It is hoped that these analyses will help to develop compositional pigment and biochemical data that will be species specific and depth range/habitat specific. These methods in conjunction with the samples taken on the previous cruise D 255, will provide valuable seasonality data for both pigment and reproductive data, along with seasonal and site abundance changes.

Species Collected

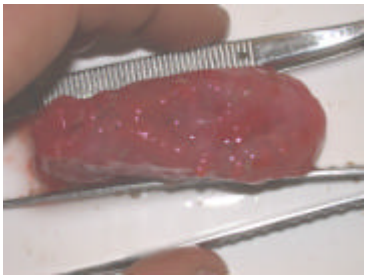
On the Porcupine Abyssal Plain, one trawl was shot at a depth of 4078-4300m (St:14317#1). In this depth range a number of common holothurian species were collected and a few less common specimens also sampled. The more common species were: *Oneirophanta mutabilis*,

Psychropotes longicauda, *Pseudostichopus villosus*, *Paroriza prohoui*, *Deima validum*, *Molpadia blakei* and most notably *Amperima rosea* in large numbers (Thanks to Rhian and Dan for picking those out!!). The less common specimens were *Bentodytes sordida* (A large specimen of 60cm), *Mesothuria candelabri* and *Peniagone diaphana*. The trawl was interesting, with a large majority of the species in a near reproductive state with very ripe or ripening gonads, and very full guts.

Figure 16.3 Sample Images of Holothuroidea and Gut/Internal Morphologies

(left: *Oneirophanta mutabilis* internal morphology (4100m). Right: *Benthogone rosea* ventral view (2100m))

From the trawl taken at 3100m (St:14315#1) on the bathyal slope of the Porcupine Seabight, a trawl containing a good sample of *Benthothuria funebris* and *Benthothuria* sp were collected and sampled. Other species noted were *Paelopatides grisea*, found a 800m deeper than is currently written, *Mesothuria* sp & *Deima validum* also in this trawl a strange new red holothurian was found with very distinct and delicate tentacles, a picture is shown left (*Peniagone sp*., new species to be described).



The Trawl from 2100m (14309#1) contained a good sample of *Benthogone rosea* (As seen above), which showed a good range of sizes and provided an excellent biological and morphological sample. This was the only species to be found in this trawl, which is common at this depth range.

A Trawl shot at 2500m (St:14319#1) contained a catch of *Psychropotes depressa*, a species rarely seen thus providing an opportunity to collect a full sample from 10 specimens, also within this trawl was a pink *Mesothuria* sp, which again has not be recorded for the past few cruises, two welcome sights of interesting holothurians.

Two trawls towards the end of the cruise, the first at 1400m (St:14322) produced an excellent catch of *Paroriza pallens*, *Laetmogone violacea*, *Bathyplotes natans*, *Mesothuria* sp and *Molpadia* sp. From this catch 3 species were processed fully with the remainder being

retained for further I.D to species level. The last trawl of the this cruise was shot at a depth of 1100m (St:14325#1) Contained a catch of one species, *Bathyplotes natans* only.

Figure 16.2 Left: *Paroriza pallens* and Right: *Laetmogone violacea*

Conclusions

Overall on this cruise the number of holothurian species collected was 22 known and several unknown (To be identified at SOC by D.S.M. Billett). Many specimens of rare and infrequently sampled holothurians were gathered on this cruise and hopefully the new data will help to update the records of these species, helping to keep an accurate and up to date list of species numbers, distributions and seasonal change.

The analyses of the specimens collected will be used in my PhD and hopefully they will provide the data set for a time of year with no associated Phytodetritus flux event, although the weather tried it's best to disrupt proceedings the trawls shot gave varied and exciting samples, some of which may yield new data in the search to solve the holothurian paradox, see you all again for some fun in October.

A special thanks to Rhian Waller for her help on deck and in the CT Lab. Yet more members of SOC and Aberdeen are touched by the world of holothurians!!!!!

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17 The Chemical Composition of Grenadiers

Kirsty Kemp

Liver, muscle and gonad samples were collected from macrourids *Coryphaenoides guentheri, Coryphaenoides armatus,* and *Coryphaenoides rupestris,* and the morid *Antimora rostrata* as part of an ongoing investigation of chemical composition. Samples will be analysed for total lipid, total protein, water and ash content and compared to spring samples already analysed from 2001, and autumn samples to be collected in 2002.

These seasonal and annual comparisons of body composition aim to determine whether energy allocation within the body changes in response to food availability and reproductive status. Specifically, is there a detectable change in chemical composition following the seasonal flux of carbon to the deep sea which may indicate accelerated growth or feeding, or are the effects of this nutritional input diminished in higher predators?

The reproductive ecology of these species will also be reviewed in light of the allocation of energy reserves in the bodies of reproductively mature fish. Due to the rarity of ripe specimens in trawl catches the energetic requirements of reproduction in deep-sea fish are poorly understood. Any developed gametes collected will be analysed for energy content in an attempt to determine an egg-energy content for grenadiers comparable to that determined by Wooton (1979) for shallow water teleosts.

Table 17.1 Shipboard collections

Depth	Species			
1000	COR			
1400	COR,	COG		
2000		COG,		ANR
2200		COG		
2300		COG,	COA,	ANR
2500		COG,	COA,	ANR
3000			COA	
4100			COA	

Liver, muscle and gonad samples from above fish
Total liver weights when possible
Total gonad weights when possible

Ripe eggs from one *Cataetyx laticeps*, and larval fish from another that had reached spawning stage where collected at 1400m. The energy content of these will be determined for comparison to any grenadier samples collected from similar depths.

Laboratory Techniques

Bradford protein estimation Assay will to used to determine total protein.

Chloroform/ethanol lipid extraction will be used to determine total lipid.

Water and ash content is determined following freeze drying and burning.

18 Nutritional regulation of egg production of *Calanus* spp. in the North Atlantic

Daniel Mayor

Background

It is well known that in the North Atlantic, the abundance of *Calanus* spp. nauplii is closely linked to the survivorship of many juvenile fish of commercial importance. Food type is known to strongly affect the fecundity of *Calanus* spp., and recent research has illustrated the importance of nutritional quality over quantity, replacing the classical diatom-*Calanus* link with an emphasis on the role of dietary diversity. Food quality is often described by elemental stoichiometric ratios, but their use is somewhat limited in that fecundity is not always limited by the bulk elemental composition (C or N) of the diet. The importance of micronutrients, particularly polyunsaturated fatty acids (PUFAs), is becoming increasingly known, and their absence in the diet can influence both fecundity and the viability of the eggs and nauplii. By comparing ratios of substrates in consumer tissues and ingested food, and assuming that the component in least supply relative to the demand is limiting, elemental stoichiometry can be extended to micronutrients (e.g. fatty acids), providing a more detailed understanding of the animals nutritional requirements. When considering micronutrients, additional attention has to be paid to the possibility that *Calanus* spp. may poses the (limited) ability to synthesise certain micronutrients, rather than obtaining them directly from their food.

A key concern of contemporary research is the knock-on effects of global warming. Should this cause a change in the timing and speciation of phytoplankton blooms, how will this alter the flux of different PUFAs up the food chain, thus influencing the reproductive success of zooplankton and the survival of larval fish? Understanding both the trophic transfer efficiency and the degree to which *Calanus* spp. can synthesise PUFA's will help understand the flow of key nutrients in the marine food web, and ultimately modelling the relationship between phytoplankton, zooplankton and larval fish.

Objectives

To determine the quantity and quality of food consumed when presented a natural diet, and the efficiencies with which C,N and essential fatty acids are used for egg production.

To understand the relationship between the biochemical composition of copepod eggs and that of ingested food. Does the fatty acid composition of the eggs change in response to the availability in food?

To examine the ability of copepods to elongate fatty acids and thus biosynthesise 'essential' fatty acids (PUFA's).

Methods

Animals were collected with a WP2 net (500 µm) from 200 m to the surface (vertical hauls) at stations 14298#1,2, 14301#1,2,3 and 14311#1,2,3,4,5,6,7. The contents of the cod-end was poured into a 20 l bucket of sea water (from non-toxic supply), and female *Calanus* were subsequently sorted into groups of ten under the dissection microscope. It is note worthy that the majority of the catch consisted of *Calanus* stage 4 and 5 copepodites. Also present were chaetognathes (*Sagitta* sp?), trachymedusae (*Aglantha digitale*), polychaetes, euphausids, hyperids (*Themisto* sp.) and various other copepod species. Each catch was preserved in 4% formalin for later observation. In addition to experimental animals, replicate samples of females were frozen for later carbon/nitrogen (C/N) and lipid analysis (initial animals). Of all those sorted (>150), only 3 females were clearly mated.

Water from the non-toxic seawater supply (pumped from 4m below the water line) was collected in a large bin (110l polyethylene). This was gently 'inverse filtered' (90µm mesh) and poured into 14 Duran bottles (2200 ml each) via a funnel and silicone tubing. Care was taken when pouring the water to minimise disturbance (splashing and swilling damages ciliates and other micro-organisms). Each bottle was filled a little at a time to ensure maximum homogeneity between bottles. Ten females were placed in five of the experimental bottles (bottles #1-5), with those remaining (bottles #6-10) serving as control bottles to assess the impact of microzooplankton grazing during the experimental period. All bottles were placed on a water-cooled plankton wheel (1 rev.min $^{-1}$) and maintained at ambient temperature (11-12º) and light regime.

At the same time, a single (200 ml) sample of the 90 µm 'inverse filtered' water (taken from bottle #14) was preserved in Lugols iodine (10% v/v) for later microzoo- and phyto-plankton identification and enumeration (initial plankton). In addition, six 1000 ml samples were taken (from bottles #11-13) for C/N and lipid analysis (initial C/N and lipid). Each sample was vaccuum filtered through GF/F filters. Filters for lipid analysis were stored in 2 ml vials with solvent (chloroform:methanol 2:1 v/v). All samples were stored at –70º.

After 24 hours, females were removed via a dip-tube and placed into bottles with fresh seawater (as above) and placed on the plankton wheel for a further 24 hours. Initial plankton, lipid and C/N samples were taken every day from the fresh water. The water in each bottle from the previous day was initially 'immersion filtered' (50 µm) to remove eggs and faecal pellets, and then sampled (100 ml) for microzoo- and phyto-plankton (final plankton). Two 1000 ml samples were filtered (GF/F) for C/N and lipid analysis (final C/N and lipid). Control replicates (bottles 6-10) were sampled in exactly the same format. Due to a shortage,

eggs were pooled from all experimental bottles and stored in 1 ml vials with solvent for lipid analysis. No eggs were sampled for C/N analysis.

This procedure continued for 5 days. At the end of the experimental period, half the animals were stored in 1 ml vials with solvent for lipid analysis and frozen at -70º, with the remainder were frozen in tin capsules later C/N analysis (final animals). Two complete experimental trials were completed during the cruise.

In addition, during the second experimental trial, three replicates of the initial plankton (300 ml each) were taken and preserved with Lugols iodine at 0.3, 2 and 10%. These will serve to illustrate and compare the differences in preservation quality of the microzooplankton.

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19 Deep Ocean Benthic Observertory (DOBO)

Kirsty Kemp, David Bailey, Phil Bagley, Monty Priede & Alan Jamieson

The DOBO lander is a long-term vehicle designed to operate for up to 6 months a year. The lander is currently being operated to investigate the fate of large food falls and identify possible biological responses to physical time signals in the deep-sea.

The DOBO was first deployed on a long-term experiment from the RRS *Discovery* on 29/08/01 at 49º 59'00N, 13º 32'59W (2710m) due to be recovered on D260. This experiment used a naturally stranded harbour porpoise carcass in view of the camera. The camera was set at intervals of 3 hours. Throughout the deployment the hydrographic conditions (current velocity and direction in 3D) and extent of the benthic boundary layer were recorded at 30 minute intervals

Recovery (station 14160)

The lander was recovered on 16/03/02. After 6 months in the deep-sea the lander had suffered relatively severe corrosion on stainless steel parts and three sources of marine fouling were observed and sampled. The camera had taken approx. 1500 colour 35mm still photographs. ADCP and current meter data was obtained successfully. No remains of the harbour porpoise carcass remained on the lander after recovery.

Deployment (station 14314)

The second long-term DOBO deployment was at 19º 58' 05 N, 13º 31'07W on 17/03/02 at 2755 metres. The camera was set to 3-hour intervals and ADCP/current meter was set to 30-minute intervals. The porpoise was replaced with a dolphin carcass. The corroded stainless

steel parts were replaced with all non-metallic parts and sacrificial stainless steel anodes were added.

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20 ISG Report

Jeff Bicknell

Data Logging

Data was logged using the ISG ABC System. The Level A system collects data from individual pieces of scientific equipment. The Level B collects each of the Level A SMP messages and writes them to a disk, monitoring the frequency of the messages and warns the operator when messages fail to appear. The Level C system takes these messages and parses them into data streams.

The following list shows the data collected on D260

Chernikeef Log	LOG_CHF	MkII Level A
Ships Gyro	GYRONMEA	MkII Level A
Trimble GPS	GPS_4000	MkII Level A
SeaStar	GPS_G12	MkII Level A
Ashtec ADU	GPS_ASH	MkII Level A
Ashtec Glonass GPS	GPS_GLOS	MkII Level A
Echo-Sounder	EA500D1	MkII Level A
Surface Logger	SURFMET	SIG PC
Neil Brown CTD	CTD_12C	MkII Level A
Bottles	BOTTLES	MkII Level A
Winch	WINCH	Clam PC

Problems during the cruise

A small problem with Discovery 2 having used up all its space on one portion of the disk this fault was rectified by Paul Duncan during an E-mail transfer. The winch system caused a small problem with the level B which I believe resulted in a level B failure early in the cruise, this was reset and has worked well since

Email System:

This has worked well during the cruise with the only problem being that there appeared on occasions to be a large delay in the incoming data with the system dropping out partway through the transfer. This was when we were on an easterly course.

GroupWise and Arcserve

The Novell system had one small fault on it and this was rectified by increasing the sys disk size.

Data Processing

Data extraction was used for the CTD profiles and for the positional information of deployed equipment.

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20 Instrumentation Report

Phil Taylor

SIMRAD EA500 ECHO SOUNDER

The echo sounder was used continuously throughout the cruise. The 10 khz transceiver was used with the fish transducer for monitoring lander operations and echo sounding. The NMEA and serial outputs were set up so that depth information was displayed on the ship display system and recorded on the ships computer system.

The fish cable was inspected and serviced after recovery.

CHERNIKEEF EM LOG

The log worked well throughout and gave no problems.

SURFMET

The surfmet system was used to monitor and log met data only, no surface instruments were enabled. The system worked fine and gave no problems.

CTD SYSTEM

The system comprised of the following components :-

a) Neil Brown Mk3c ctd (s/n 02-0535) with oxygen sensor.

b) General Oceanics 1016 (24-way) rosette system with go-fire electronics and GO battery pack.

c) 6 x 10litre GO (x-type) teflon lined Niskin water sampling bottles.

d) Sea Tech ST20D transmissometer.

e) Stainless 12-way ctd frame with GO 12-way anodised aluminium adapter plates.

Three casts were completed to collect bottom water samples for the landers and to test acoustic releases. Four Oceano release transponders were fitted to the ctd frame during each cast.

All performed ok.

Discovery 260 Station List

		Start				End						
Station	Gear	Date	Time	Latitude	Longitude	Date	Time	Latitude	Longitude	Depth	Sample Depth	Comments
14297	CTD	8/3/2002	6:54	51 26 N	11 46 W	8/3/2002	8:52	51 26 N	11 46 W	998 m		Test 3 releases, 6 water bottle, 4 poddie traps
14298#1	WP	8/3/2002	13:51	51 25.4 N	11 47.6 W	8/3/2002	14:09	51 25.4 N	11 47.6 W	1050	0-100m	Vertical haul for *Calanus*
14298#2	WP	8/3/2002	14:13	51 25.4 N	11 47.7 W	8/3/2002	14:34	51 25.4 N	11 47.7 W	1056	0-200m	Vertical haul for *Calanus*
14299#1	BC	8/3/2002	15:15	51 25.8 N	11 46.3 W	8/3/2002	16:20	51 25.8 N	11 46.5 W	870		Small amounts of live *Lophelia*
14299#2	BC	8/3/2002	16:37	51 25.8 N	11 46.3 W	8/3/2002	17:55	51 25.8 N	11 46.5 W	870		Good sample of live *Lophelia*
14300	ISIT	8/3/2002	21:00	51 10.0 N	11 40.6 W	11/3/2002	6:43	51 10.0 N	11 40.6 W	1015		On deck at 08:00.
14301#1	WP 2	8/3/2002	21:41	51 10.0 N	11 40.9 W	8/3/2002	22:05	51 10.0 N	11 40.9 W	1015	0-200	Vertical haul for *Calanus*
14301#2	WP 2	8/3/2002	22:09	51 10.1 N	11 41.0 W	8/3/2002	22:34	51 10.1 N	11 41.0 W	1015	0-200	Vertical haul for *Calanus*
14301#3	WP 2	8/3/2002	22:38	51 10.1 N	11 41.1 W	8/3/2002	23:01	51 10.1 N	11 41.1 W	1015	0-200	Vertical haul for *Calanus*
14302	OTSB	11/3/2002	20:03	49 57.8 N	12 42.8 W	11/3/2002	22:25	49 40.6 N	12 50.1 W	2365-2456		Good fish catch, mostly C. guntheri
14303#1	CTD	14/3/2002	14:50	49 47.3 N	14 00.1 W	14/3/2002	18:40	49 49.5 N	13 58.3 W	4000	0-4000	Test 4 releases
14303#2	CTD	14/3/2002	19:12	49 49.8 N	13 58.2 W	14/3/2002	22:36	49 50.7 N	13 56.2 W	4000	0-3863	Test 4 releases
14304	SPRINT	15/3/2002	9:21	49 45.0 N	14 00.0 W	15/3/2002	14:10	49 45.0 N	14 00.0 W	3946		Camera flooded
14305	ISIT	15/3/2002	10:52	49 45.1 N	13 56.7 W	15/3/2002	16:45	49 45.1 N	13 56.7 W	4043		Profile deployment
14306	FRESP	15/3/2002	13:08	49 40.2 N	13 59.6 W	17/3/2002	7:15	49 40.2 N	13 59.6 W	4018		Lid failed to close properly when fish trapped.
14307#1	WP 2	15/3/2002	14:20	49 45.1 N	14 00.7 W	15/3/2002	14:32	49 45.1 N	14 00.7 W	4094		Vertical haul for *Calanus*
14307#2	WP 2	15/3/2002	14:33	49 45.1 N	14 00.4 W	15/3/2002	14:44	49 45.1 N	14 00.4 W	4046		Vertical haul for *Calanus*
14307#3	WP 2	15/3/2002	14:45	49 45.0 N	14 00.1 W	15/3/2002	14:57	49 45.0 N	14 00.1 W	4049		Vertical haul for *Calanus*
14308	WP 2	15/3/2002	17:35	49 45.5 N	13 57.9 W	15/3/2002	17:58	49 45.5 N	13 57.9 W	4018		Vertical haul for *Calanus*
14309	OTSB	16/3/2002	0:35	49 43.2 N	13 10.4 W	16/3/2002	2:35	49 43.3 N	13 03.4 W	2011-2218		Good catch of fish and holothurians
14160	DOBO	29/8/2001	0:18	49 59.0 N	13 33.0 W	16/3/2002	9:20	49 59.0 N	13 33.0 W	2698		Good film, but corrosion on stainless parts
14310	ISIT	16/3/2002	14:55	49 51.4 N	13 57.7 W	16/3/2002	16:50	49 51.4 N	13 57.7 W	3900		Profile deployment
14311#1	WP 2	16/3/2002	15:04	49 51.4 N	13 57.7 W	16/3/2002	15:26	49 51.4 N	13 57.7 W	3900	0-200 m	Vertical haul for *Calanus*
14311#2	WP 2	16/3/2002	15:27	49 51.5 N	13 57.7 W	16/3/2002	15:48	49 51.5 N	13 57.7 W	3900	0-200 m	Vertical haul for *Calanus*
14311#3	WP 2	16/3/2002	15:49	49 51.5 N	13 57.6 W	16/3/2002	16:12	49 51.5 N	13 57.6 W	3900	0-200 m	Vertical haul for *Calanus*
14314#4	WP 2	16/3/2002	16:13	49 51.6 N	13 57.6 W	16/3/2002	16:35	49 51.6 N	13 57.6 W	3900	0-200 m	Vertical haul for *Calanus*

14311#5	WP 2	16/3/2002	16:36	49 51.7 N	13 57.5 W	16/3/2002	16:55	49 51.7 N	13 57.5 W	3900	0-200 m	Vertical haul for *Calanus*
14311#6	WP 2	16/3/2002	16:56	49 51.7 N	13 57.5 W	16/3/2002	17:18	49 51.7 N	13 57.5 W	3900	0-200 m	Vertical haul for *Calanus*
14311#7	WP 2	16/3/2002	17:19	49 51.7 N	13 57.6 W	16/3/2002	17:40	49 51.7 N	13 57.6 W	3900	0-200 m	Good copepod catch from series
14312	OTSB	16/3/2002	21:30	49 43.1 N	14 05.9 W	17/3/2002	1:00			N/A	N/A	Trawl aborted due to high winds
14313	SPRINT	17/3/2002	17:23	49 44.7 N	13 58.5 W	18/3/2002	15:00	49 44.7 N	13 58.5 W	4040		*C.armatus* twitches!!
14314	DOBO	17/3/2002	23:30	49 58.5 N	13 31.7 W					2755		Deployed in clam conditions.
14315	OTSB	18/3/2002	6:20	49 56.6 N	13 30.9 W	18/3/2002	7:50	49 53.9 N	13 34.5 W	3030-3168		Good catch of fish.
14316	FRESP	18/3/2002	20:35	49 50 .0 N	14 04.1 W	20/3/2002	16:08	49 50 .0 N	14 04.1 W	3974		Caught 5 fish, but trap damaged
14317	OTSB	19/3/2002	2:55	49 39.4 N	14 15.5 S	19/3/2002	5:45	49 35.7 N	14 20.2 W	4190-4263		Good invertebrate catch, few fish
14318	ISIT	19/3/2002	14:15	49 33.3 N	14 11.0 W	19/3/2002	16:00	49 33.3 N	14 11.0 W	4271	0-4000	Profile, released at 4000 m (before touchdown)
14319	OTSB	20/3/2002	2:20	49 52.4 N	13 01.0 W	20/3/2002	4:20	49 54.0 N	13 04.5 W	2555-2590		Small catch of *C. guntheri/A. rostrata*
14320	ISIT	20/3/2002	13:24	49 48.4 N	14 03.9 W	3/20/2000	14:23	49 49.0 N	14 04.4 N	3993		Profile deployment.
14321	SPRINT	21/3/2002	0:33	49 53.0 N	12 48.4 W	21/3/2002	11:11	49 53.0 N	12 48.4 W	2473		Escape responses from *Antimora*
14322	OTSB	21/3/2002	4:10	49 49.5 N	12 32.3 W	21/3/2002	5:50	49 47.1 N	12 38.5 W	2177-2230		Tangled due to discarded conducting cable tangling main swivel on sea-floor
14323	OTSB	21/3/2002	18:30	49 36.6 N	12 11.8 W	21/3/2002	20:00	49 35.0 N	12 23.2 W	1419-1440		Good catch of fish, COR, SYK, alepocephs & rugby ball holothurians
14324	SPRINT	22/3/2002	1:16	49 51.4 N	12 53.8 W	22/3/2002	5:36	49 51.4 N	12 53.8 W			More escape responses from *Antimora*
14325	OTSB	22/3/2002	13:30	49 40.3 N	11 55.7 W	22/3/2002	14:20	49 40.0 N	11 57.3 W	1100-1119		Good catch included *C.rupestris* & 2 very large *Opisthoteuthis*

KEY TO GEAR USED

WP	WORKING PARTY NET
OTSB	OTTER TRAWL (SEMI-BALLOON)
DOBO	DEEP OCEAN BENTHIC OBSERVATORY
BC	BOX CORE
ISIT	BIOLUMINESCENCE LANDER
FRESP	FISH RESPIROMETER LANDER
SPRINT	FISH FAST START LANDER

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