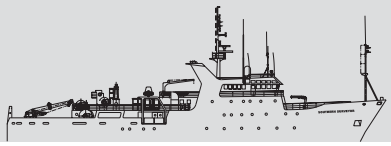

MARINE
NATIONAL FACILITY

2004 program

RV *Southern Surveyor*

CSIRO
MARINE RESEARCH

voyage summary SS07/2004

SS07/2004

Characterising the winter oceanic environment off the west coast of Tasmania.

Itinerary

Depart Hobart 0800 hrs, Friday 23rd July 2004
Arrive Hobart 1000hrs, Friday 6th August 2004

Principal Investigators

• Rudy Kloser (Chief Scientist)

CSIRO Marine Research, CMR Marine Laboratories, PO Box 1538, Hobart, Tasmania 7001.
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Scientific Objectives

The research voyage had two aims, firstly, it would further develop acoustic remote sensing methods to help determine the population size, species discrimination and spatial gradients, applied to the dominant acoustic species and their dynamics on the west coast of Tasmania. Secondly, it would provide underpinning observations of the physical and biological environment of the west coast of Tasmania's winter spawning blue grenadier population and the relationship with key oceanographic and bathymetric (canyons) features within the region. The research voyage will be part funded by a 3 year collaborative FRDC/CSIRO/ Fishing Industry (Oceanfresh Pty Ltd and Petuna Seafoods-Sealords) project to develop a long-term sustainable observation strategy using industry vessels on the west coast of Tasmania.

Voyage Objectives

Development of acoustic remote sensing technology and environmental indicators of fisheries recruitment.

1. Develop the acoustic methodology to estimate blue grenadier stock size and environmental parameters by:

- Measuring the in-situ target strength of the dominant acoustic groups in the ecosystem for absolute and relative biomass assessments and trophodynamic models.
- Investigate methods to remotely determine species composition and map biotic distributions.
- Develop the new swath mapper raw data capture facility to provide water column measurements and 3D maps of nekton distributions.

2. Characterise the dominant physical oceanographic processes and biotic associations at broad and fine scale on the west coast of Tasmania (150 – 1500 m) to assist in the development of blue grenadier recruitment variability hypotheses and baseline ecological data. Additionally:

- Collect deep-water slope and canyon corals for paleooceanographic studies.
- Collect larvae from selected oceanic features and compare inside and outside canyon age classes.
- Map the canyon currents using an ADCP at fine scale.
- Collect data to validate satellite ocean colour measurements.

The *Southern Surveyor's* scientific sampling program was complemented by industry vessels *FV Petersen* and *FV Aoraki* that carried out the following activities:

- 38kHz vertical acoustic data collection
- trawl shots (both commercial shots for blue grenadier and as directed by RV *Southern Surveyor* to identify echosounder school marks)
- biological data of blue grenadier and bycatch species.

Voyage Track

The vessel departed Hobart and spent one day carrying out acoustic towed body trials and acoustic calibrations within the Hobart ports area. The vessel then proceeded to the west coast of Tasmania and carried out an acoustic synoptic survey of the upper slope and outer shelf with zig-zag transects. Physical, chemical, biological and acoustic sampling were then carried out at (Fig.1):

- designated cross shelf transects A and B, days 3 - 5;
- Pieman Canyon blue grenadier population size and acoustic target strength measurements (transect B), days 6- 8;
- warm core eddy outside, edge and inner physical and biological stations, days 9 - 11;
- cross shelf transect C, days 11 -12;
- Pieman Canyon blue grenadier population size and acoustic target strength measurements (transect B), days 13;
- blue grenadier larvae sampling and steaming day 14
- benthic and larvae sampling day 15.

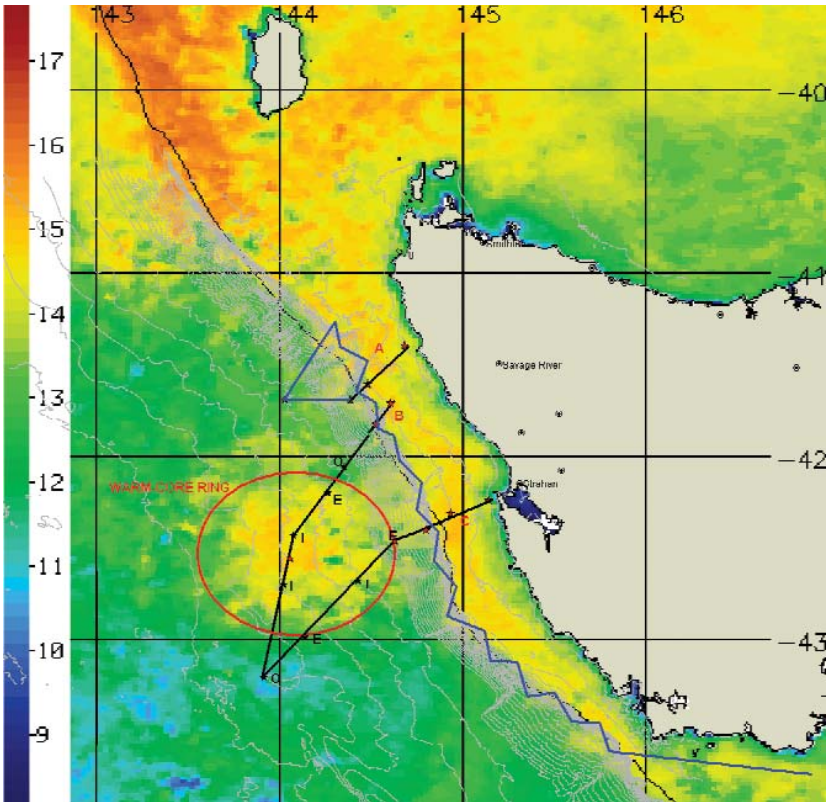

Figure 1. Major areas of operation during the voyage being the upper slope and outer shelf of the west coast of Tasmania zig-zag transects (blue) with specific cross shelf and slope transects at A (outside canyon upper), B (Pieman Canyon), C (outside canyon lower) and investigations of a warm core eddy with physical and biological stations on the inner (I), outer (O) and edge (E). Satellite image composite of 15 days © CSIRO Marine Research.

Results

1. Develop the acoustic methodology to estimate blue grenadier stock size and environmental parameters by:

At the start of the voyage we successfully tested, calibrated (at depth) and adjusted where necessary a new 4 frequency (18, 38, 70, 120 kHz) towed body (MUFTI 2) connected to the vessel with 3000 m of optical fibre cable. MUFTI 2 enabled new multi-frequency measurements to be carried out on a variety of species on the west coast of Tasmania and to explore their spatial and temporal distributions. The MUFTI was targeted on blue grenadier schools and ecological features in the region with associated capture of organisms obtained with a multiple opening/closing pelagic trawl (MIDOC) and commercial trawling. It was possible to resolve single fish and obtain their target strength at a variety of frequencies by deploying the MUFTI towed body to depths of 500 m. Many examples of species specific frequency differences were observed, resolved either as single targets or as independent schools at depth.

Significantly, data were collected to calculate the target strength of blue grenadier at the spawning grounds as well as a number of fine scale acoustic surveys of blue grenadier aggregations in the Pieman Canyon. To provide "ground truthing" and ecological interpretation to the acoustic data several thousand fish, crustaceans and squids were measured, and selected specimens photographed and samples retained for isotope, lipid, buoyancy and acoustic reflectivity experiments. Four new species to science were recorded as well as new Australian records of species. Difficulty was experienced in sampling the highly mobile species with the equipment available on *Southern Surveyor*; the fishing vessel Aoraki targeted a number of specific locations to verify species.

Blue grenadier schools were found to be widely distributed along the west coast during the survey with highest concentrations observed at the Pieman Canyon. The blue grenadier schools proved to be highly dynamic with schools appearing to form and disperse within the Pieman Canyon over several hours

The new Simrad EM300 swath mapper was used to map schools on an opportunistic basis and the raw data from the 132 beams recorded for subsequent processing. Initial processing on board showed that the system had a high noise level.

2. Characterise the dominant physical oceanographic processes and biotic associations at broad and fine scale on the west coast of Tasmania (150 - 1500 m) to assist in the development of blue grenadier recruitment variability hypotheses and baseline ecological data.

The dominant features of the west coast oceanographic system as related to the blue grenadier were the interactions with warmer Zeehan current water (SACW) and colder southern water (SASW) as well as fresh water outflow from the Pieman River and Maquarie Harbour, and their interactions with bathymetric features such as the coast, shelf break and canyons. Prior to the voyage a month of high westerly winds established a large warm core eddy off the west coast of Tasmania providing an opportunity to sample this type of feature for the first time (Fig. 1). The sampling included a detailed physical oceanographic section as well as targeted chemical and biological sampling on the outside at the edges and inside the eddy. The biological sampling focused on plankton, mesopelagic and acoustic sampling. Results showed that the warm core eddy using XBT and CTD casts was 300 m deep at its centre and had a surface cross section of approximately 100 km (Fig. 2). Fine scale biological and physical sampling outside, inside and on the edges of the warm core eddy will help to establish the significance of this feature for dispersal of blue grenadier larvae and distribution of prey species. At first inspection no blue grenadier larvae or eggs were captured within the warm core eddy although concentrations of mesopelagics appeared to be similar both outside and inside the feature. The vertical distribution of the mesopelagics was markedly different in the warm core eddy as well as the food web. Lipid and isotope samples retained will assist in determining the trophic differences between inside and outside the warm core eddy. As expected the edges of the warm core eddy showed the highest abundance of organisms.

Blue grenadier eggs and larvae were sampled throughout the voyage with highest concentrations of eggs found on the outer shelf near a spawning site and highest numbers of larvae found near shore at the mouth of Maquarie Harbour. No dominant retention of larvae within the Pieman Canyon was evident during the voyage although a single 2 cm larvae caught within the canyon feature indicates that retention on the around the feature. An offshore site at the edge of the warm core eddy caught numerous blue grenadier eggs supportive of an offshore transport mechanism. Difficulty in analysing plankton samples at sea makes any results expressed here preliminary.

During the voyage a total of 161 operations were carried out from the vessel using 11 different types of gear (Table 1). In summary 50 plankton, 23 physical oceanographic, 23 acoustic, 13 mesopelagic and 26 benthic operations were carried out to achieve the voyage objectives(Table 1).

Voyage Narrative

23rd July

Departed Hobart at 08:00 hrs with Mathew Horsham, Neil McQeen and Lindsay McDonald on board to carry out some MUFTI trials. Required several hours of preparation of the back deck and winch to deploy the MUFTI system. A swath map off Bruny Island (Op 1) was carried out to test the shallow water performance of the EM300 whilst equipment was readied. Hydrodynamic trials of MUFTI (Op2) showed a marked stability problem and required alteration of the towing position and tail fin size. Initial trials were completed by 15:00 hrs and we anchored in North west bay to calibrate the vessel and towed acoustic transducers (Op 3-5).

24th July

Calibration of the MUFTI system was carried out till 09:00 hrs followed by a short stability tow trial (Op 6). A phase problem detected for the 38 kHz transducer was corrected. A cruise debriefing was held at 11:00 hrs followed by a MUFTI tow trials changing the tail fin size (Op 6-8). The change in fin size improved the stability but a significant roll instability was evident. Swath transects were run parallel to previous lines around south east cape to south west cape. Weather conditions were fine and mild with glassy seas, very welcome for this region. The views of the Maatsuyker region were very much appreciated at night fall and the start of the cross slope zig-zag south to north transects began (Op 9).

25th July

Continued acoustic surveys during the morning zig-zag pattern – marked day to night acoustic scatter transition observed with fish moving from the shelf to the upper slope and schooling. Continued to see high backscatter in the 250 to 400 m depth ranges. Several MUFTI tow trials (Op 10-11) were undertaken with trim tabs to improve stability. Final test showed that good performance was possible for a range of speeds and the winch was also finally fixed. Appears that the MUFTI is now ready for use. Completed two transects in the Pieman Canyon during daylight hours and no fish observed confirming the observation from the fishing vessel Aoraki. Good BG type fish marks observed just south of Sandy Cape Canyon in 300 to 400 m water depth. Continued to acoustic transect the 200 – 700 m contours past Sandy Cape Canyon completing them late evening. The day ended with trawl warp wire streaming and a bottle test CTD (Op 12) to the salinity minimum west of Sandy Cape Canyon.

26th July

MIDOC deployed on Transect A 500 m station during the night with a good catch. Unfortunately the nets did not fire and only an oblique sample was obtained (Op 13). A successful oblique MUFTI tow was carried out at dawn (Op14). The sediment grab deployed at 500 m was aborted when the winch spooling failed with the grab out at 500 m. Several hours were required to fix the spooling. Another grab successfully fired in the same location but did not retrieve any material (Op 16). The CTD station (Op17) was successful with good samples for CDOM, pigments, nutrients and isotopes. Fluorescence max was at 40 to 60 m. Communication with fishing vessel Aoraki to let them know of fish to our north and to clarify target tows. A day time EZ net successful with large catches of eggs in nets < 200 m and krill in nets > 200 m. At dusk two sediment grabs in the 500 m were successful (finally) and isotope samples obtained. A night time 400 m EZ net obtained another good catch with all nets operating (Op 22). This was followed by a MIDOC net that obliquely fished along the 400 - 550 m depth contours. Unfortunately the nets did not fire again so this represented another repeat oblique tow. Several specimens of Blue Grenadier and Warahou were caught in the trawl. The problem with the net firing was isolated and repaired.

27th July

Through the day a successful acoustic cross shelf transect was obtained as well as the night time EZ net at 100 m and day time at 50 m. These tows contained numerous eggs presumably from Blue Grenadier. CTD casts at both the 100 and 50 m stations were completed as well as sediments, Fluorescence max was at 30 – 50 m and water well mixed. Due to deteriorating weather (40 - 45 knot winds) we ceased sampling at 13:00 hrs and hove too till late evening. During the day a mishap with the lowered ADCP batteries rendered them unserviceable and the lowered ADCP could not be used for the rest of the voyage. Steamed slowly to Pieman Canyon and prepared for an EZ net plankton tow. Surface temperature was 2 degrees cooler off the shelf and cooler water was close to the canyon. An aurora of white pulsating light was enjoyed by all during the evening.

28th July

At the Pieman Canyon a night EZ net at both the 500 m and 150 m stations (Op 38 - 41). Due to a net tripping problem the 150 m EZ net day station needed to be repeated. The 500 m EZ net day was thought to have been successful. One small BG larvae was caught in an EZ net but due to the triggering problem could not be allocated to a depth. A CTD station (Op 49) inside the canyon showed a high degree of stratification with depth whilst the 150 m CTD showed a highly mixed water profile. Targeted several peaks in the fluorescence and will return to target these in more detail with another CTD. Conditions improved throughout the day with light winds and decreasing seas. The Aoraki fishing vessel arrived and caught a good catch of blue grenadier to keep the factory going. They then targeted a mark in 430 to 380 m at 550 – 650 m depth and caught 6 boxes of warehou. A successful MIDOC tow from the SE to the NW along the canyon floor only caught small amounts and missed the main layers. Several large schools of blue grenadier were observed on the canyon floor. The day ended with an acoustic transect of the canyon and preparation of the MUFTI for an oblique tow.

29th July

During the night at the Pieman Canyon we carried out a targeted MUFTI tow through Blue Grenadier aggregations and obtained target strength information of a range of acoustic groups. A targeted MIDOC tow was then obtained to validate the acoustic groups. Good catches were obtained of the dominant micronekton species although the MIDOC did not retain any large nekton. A seal was captured in the MIDOC tow during the evening and appropriate measurements were obtained and authorities notified. Several targeted sediment grabs for isotope analysis in the canyon failed to fire due to the sloping ground. A series of CTD drops within the canyon showed that the water column had changed from the previous day to be very uniform from surface to 400 m consistent with Zeehan current water. Due to the good weather conditions the opportunity to calibrate the MUFTI at depth was undertaken. The calibration was carried out over a Blue Grenadier school enabling simultaneous collection of fish target strengths. Following the MUFTI calibration/TS drop a targeted MIDOC tow was undertaken of the region resulting in a good catch of the targeted acoustic groups including some Blue Grenadier.

30th July

The early morning of the 30th started with an acoustic survey of the Pieman Canyon that showed several large schools in the region. One school was targeted with the MUFTI in drop mode and then followed with a targeted MIDOC tow. This series of targeted MUFTI and MIDOC tows completed our requirement for Blue Grenadier and associated target strength information from this voyage. During the night the Aoraki reported landing a 40 tonne catch of Blue Grenadier through the aggregations. Two sediment grabs were obtained in the SE corner at 200 m followed by targeted EZ net tows for larvae and eggs in 500 and 150 m water depths completing the sampling for transect B. Prior to leaving the region a swath map of the canyon was undertaken with the vertical acoustics synchronised.

We commenced the start of the warm core eddy study by steaming SW to the core centre. An XBT line was carried out to characterise the dominant changes in temperature. CTD casts were placed in the dominant features as well as EZ nets. An EZ net in a cold region prior to the warm core collected a number of blue grenadier eggs that had been transported offshore. The warm core eddy was situated in approximately the same location as an old (three weeks) satellite image.

31st July

The vessel steamed inside the warm core eddy and carried out a combined CTD, and MIDOC sampling program during night hours. An EZ net sample was obtained during the day with a large quantity of gelatinous material. The vessel steamed further SW to find the approximate centre of the core using the ADCP, underway temperature and XBT profiles. At the approximate centre a CTD and EZ net sampling program was undertaken with no visible blue grenadier eggs or larvae. The CTD and XBT sections showed the centre of the warm core was ~300 m deep at 12.7 degrees. Continued to steam SW to find the extent of the warm core using XBT and underway temperature sampling. After steaming 40 n.mile we found 10.5 degree water and started an outside warm core sampling program of EZ and surface plankton nets, MIDOC, MUFTI, and CTD sampling.

1st August

Good samples at the cold region site was obtained and an acoustic yo-yo transect with the MUFTI showed a variety of life with many characteristic multi-frequency differences. The day time aggregations in the 0 - 300 m were showing clear euphausiid like multi-frequency properties. The yo-yo transect characterised the transition between the cold and warm regions with characteristic high fluorescence at the frontal zone. A transect of CTD and EZ net deployments was carried out towards transect C with no noticeable trace of blue grenadier eggs or larvae. Arrived at the outer transect C station and deployed the acoustic mooring to observe diurnal movement. The mooring was deployed in 500 m water depth and the local fishers were informed of its location.

2nd August

A night time MIDOC and MUFTI oblique tows were attempted but due to a net twist and poor 120 kHz frequency both stations need to be repeated. Acoustics showed that the biomass of animals in the region was low. After completing the CTD and sediment samples a day-time acoustic transect was undertaken from the outer to inner station. The ground was hard and rough from the 160 m to 60 m depth contour with many isolated clumps (presumably limestone). At the 50 m station near the mouth of Macquarie Harbour a fresh water lens of 32 ppt water lay on the surface with high fluorescence at 12 m depth. The EZ tow at this station caught a high number of young (~ 5 day old) blue grenadier larvae. A swath transect was repeated on the out journey to the mid-depth station. Unfortunately the EZ plankton net at this station hit the seafloor and bent the frame. The EZ was successfully recovered but could not be used for the remainder of the trip. The 1 m ring net was rigged to sample in oblique mode for the rest of the voyage. Another swath and night acoustic transect was carried out in the evening with a MIDOC repeated at the outside station. The swath mapper highlighted the rugged shelf bathymetry with hard ground from approximately 40 m to 170 m depth.

3rd August

During the early morning tow MIDOC sampling stations were targeted at the upper slope and outer shelf. A relative small sample of upper slope micronekton was captured and reflected the lower levels of acoustic backscatter observed in the region. Of note, a small number of BG eggs captured in the net. A MUFTI oblique tow characterised the micronekton in the upper slope region. A high backscatter mark in the 350 to 450 m depth range was typical of a blue grenadier school. We returned to the acoustic mooring at 10:00 hrs only to find it had drifted 1 n.mile to the SE. On recovery the acoustic system and large float were missing and we mounted a search to the SE in the direction of the 0.5 to 1.0 knot current. It was assumed that the acoustic device 'fat boy' detached soon after deployment. After 23 n.miles of steaming the float with acoustic device was spotted and successfully recovered. An opportunistic plankton (bg larvae station) was conducted in the 100 and 50 m depth contours near Pt Hibbs with a large amount of young 4-8 day larvae recovered.

Returned to transect C undertaking a swath transect and carried out an acoustic MUFTI tow over the shelf then continued to Strahan Canyon in the 350 – 500 m depth range.

4th August

Carried out a MUFTI trawl on the shelf / shelf break and ground truthed with the MIDOC trawl catching a range of shelf / slope species. Steamed to the Pieman Canyon and undertook a day time acoustic survey with a swath fill in line. After lunch the vessel steamed offshore to carry out two plankton tows (oblique to 200 m) in cooler water to the north of the warm core eddy. No blue grenadier egg or larvae were caught in these tows. Returned to the Pieman canyon at 18:30 hrs with both the *FV Peterson* and *FV Aoraki* carrying out trawling in the canyon catching 30 to 40 tonne per shot. An acoustic survey showed there were many schools of fish in the canyons predominantly on the NW and SE slopes.

5th August

MUFTI was targeted at the NW slope of the canyon flying 50 to 100 m off the seabed. A large aggregation of blue grenadier 50 m high and 300 m long was passed. Very few individual targets were obtained due to the high density. Of interest was a defined scattering layer at 500 m which proved to be a transition zone between 13.2 degree Zeehan Current water and the 10.5 degree Sub-Antarctic mode water. The biota were clearly layered at the transition to the colder water. A sled tow in the 1100 m depth range targeted a high backscatter region but failed to retrieve any benthic specimens. Steaming for Hobart commenced at 07:00 hrs whilst carrying out swath acoustics underway. At South West cape a sled was deployed targeting the 1000 m contour to obtain corals for ageing and temperature signatures. Unfortunately despite the rough terrain as observed on the swath mapper and the damage to the benthic sled only 4 starfish a hermit crab and mud were retained.

6th August

At South west cape an oblique plankton tow was carried out near Maatsyker Island with no blue grenadier larvae retained. Significant amounts of single targets and layers were observed on the echosounder indicating a large biomass of scatterers. The vessel then completed to swath map the seafloor adjacent to existing tracks to Hobart where we docked at 9:15.

Summary

The voyage on the west coast of Tasmania described the physical, chemical and biological attributes of the system relevant to the blue grenadier winter spawning fishery. A diverse range of equipment was deployed from the vessel and its availability prior to the voyage was due to much preparation by the CMR staff. Of note was the construction of the MUFTI towed body that is a revolution in obtaining measurements of marine biota with only a handful of compatible systems world wide. The system was designed and constructed over a six month period and a credit to the team at CMR. During the voyage the captain, mates and crew were always helpful and enthusiastic to carry out our science objectives. Often ship members would be found in the operations room or fish laboratory investigating the latest images or fishes collected. Of special note was the high standard of food on the voyage prepared by the cooks that kept moral high. The voyage would not have been possible without the dedicated national facility staff and fellow scientific party contributing to a high standard throughout. We thank the master, mates and crew for their professional attitude and friendly manner throughout the voyage. It was a pleasure sailing with them.

Personnel

Scientific Personnel

Rudy Kloser – CMR, Chief Scientist, bioacoustics
Tim Ryan – CMR, Shift leader, bioacoustics (logistics coordinator)
Alan Williams – CMR, Lead biologist (midwater fishes specialist)
Mark Lewis – CMR, Gear officer, biologist
Gordon Keith – CMR, Swath mapper analyst
Karen Gowlett-Holmes – CMR, Crustacean specialist, photographer
Dy Furlani – CMR Larvae, zooplankton ecologist
Paul Sandery – Flinders Uni, Oceanographer
Matt Sherlock – CMR, Marine Instrumentation
Rebecca Crowley – NatFac, Hydrochemistry
Stephen Thomas – NatFac, Electronics, Voyage Manager
Bob Beattie – NatFac, Computing

Marine Crew

Ian Taylor – Master
John Boyes – Chief Officer
Drew Meincke – 2nd Officer
John Morton – Chief Engineer
Dave Jonker – First Engineer
John Hinchliffe – Second Engineer
Peter Williams – Chief Steward
Andy Goss – Chief Cook
Alan Sessions – Second Cook
Tony Hearne – Bosun
Mark Spearritt – IR: 0000-1200
Michael Chalk – R: 0000-1200
Bryan Messenger – IR: 0000-1200
Graham McDougall – IR:1200-2400
Fiona Perry – IR: 1200-2400
Malcom Cleworth – IR: 1200-2400
Malcolm McDougall – Greaser

Rudy Kloser
Chief Scientist

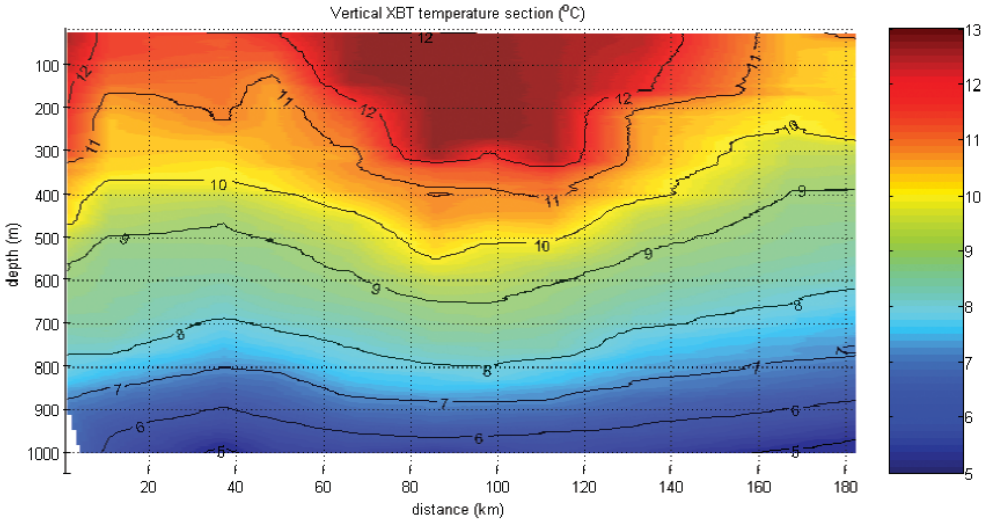

Figure 2. Preliminary vertical structure of the temperature across the warm core eddy from an XBT transect.

Table 1. Summary of operations during SS07/2004

Operation	Number
CTD cast	19
EZ plankton net	20
Multi-beam survey	5
Surface Plankton 1m ring	24
Oblique Plankton 1 m ring	6
MIDOC trawl net	13
Sediment Grab	24
Benthic Sled	2
XBT's	14
MUFTI towed body	18
Acoustic survey	10
Mooring	2
Other	6
Total operations	**163**

Table 2. Operations carried out during the voyage with start time and position

Operation number	Type	Area	Start time	UTC	Start Latitude	Start Longitude
1	Swath Survey	Storm Bay	23-Jul-04	2:30	-43.133	147.438
2	MUFTI trials	Storm Bay	23-Jul-04	3:30	-43.133	147.438
3	Vessel echosounder calibration	North West Bay	23-Jul-04	6:30	-43.072	147.312
4	CTD Cast	North West Bay	23-Jul-04	14:18	-43.072	147.313
5	MUFTI Callibration	Tinderbox	23-Jul-04	14:40	-43.072	147.313
6	MUFTI trial deployment	Underway	23-Jul-04	14:40	-43.072	147.313
7	MUFTI trials	Underway	23-Jul-04	14:50	-43.072	147.313
8	MUFTI trials	South West Cape	24-Jul-04	7:54	-43.685	146.152
9	West Coast S-N acoustic transects	West Coast	24-Jul-04	10:37	-43.595	145.813
10	MUFTI trials	Pieman Canyon	25-Jul-04	2:22	-41.960	144.625
11	MUFTI	Pieman Canon	25-Jul-04	4:00	-41.865	144.563
12	CTD Cast	Deep water CTD	25-Jul-04	13:38	-41.468	144.124
13	MIDOC Sampling	Transect A	25-Jul-04	17:02	-41.668	144.436
14	MUFTI Tow	Transect A	25-Jul-04	20:25	-41.579	144.377
15	Sediment Grab	Transect A	25-Jul-04	23:07	-41.571	144.405
16	Sediment Grab	Transect A	26-Jul-04	2:00	-41.572	144.406
17	CTD Cast	Transect A	26-Jul-04	2:30	-41.572	144.407
18	EZ Net Cast	Transect A	26-Jul-04	4:24	-41.623	144.435
19	Sediment Grab	Transect A	26-Jul-04	7:48	-41.540	144.398
20	Sediment Grab	Transect A	26-Jul-04	8:42	-41.542	144.401
21	EZ Net Cast	Transect A	26-Jul-04	9:43	-41.592	144.405
22	Plankton Sample	Transect A	26-Jul-04	10:30	-41.559	144.400
23	Plankton Sample	Transect A	26-Jul-04	10:53	-41.544	144.390
24	MIDOC Sampling	Transect A	26-Jul-04	12:49	-41.504	144.412
25	Acoustic Cross Shelf Transect	Transect A	26-Jul-04	16:30	-41.580	144.333
26	EZ Net Cast	Transect A	26-Jul-04	17:43	-41.529	144.515
27	Surface plankton tow	Transect A	26-Jul-04	18:12	-41.506	144.497
28	Acoustic Cross Shelf Transect	Transect A	26-Jul-04	19:29	-41.524	144.476
29	Sediment Grab	Transect A	26-Jul-04	20:40	-41.440	144.714
30	Sediment Grab	Transect A	26-Jul-04	20:57	-41.439	144.711
31	Sediment Grab	Transect A	26-Jul-04	21:09	-41.439	144.711
32	CTD Cast	Transect A	26-Jul-04	22:22	-41.440	144.710
33	EZ Net Cast	Transect A	26-Jul-04	23:09	-41.438	144.706
34	Surface plankton tow	Transect A	26-Jul-04	23:34	-41.424	144.683
35	CTD Cast	Transect A	27-Jul-04	2:20	-41.528	144.491
36	Sediment Grab	Transect A	27-Jul-04	4:09	-41.555	144.495
37	Swath Survey	Transect A	27-Jul-04	5:03	-41.531	144.436
38	EZ Net Cast	Transect B	27-Jul-04	15:17	-41.848	144.524
39	Plankton Sample	Transect B	27-Jul-04	17:35	-41.743	144.580
40	EZ Net Cast	Transect B	27-Jul-04	18:56	-41.716	144.606
41	Plankton Sample	Transect B	27-Jul-04	19:28	-41.692	144.619
42	Sediment Grab	Transect B	27-Jul-04	20:32	-41.687	144.622
43	Sediment Grab	Transect B	27-Jul-04	20:40	-41.686	144.621

Operation number	Type	Area	Start time	UTC	Start Latitude	Start Longitude
44	Sediment Grab	Transect B	27-Jul-04	21:00	-41.686	144.621
45	Sediment Grab	Pieman Canyon	27-Jul-04	21:25	-41.697	144.608
46	Sediment Grab	Pieman Canyon	27-Jul-04	22:52	-41.774	144.550
47	Sediment Grab	Pieman Canyon	27-Jul-04	23:10	-41.773	144.550
48	Sediment Grab	Pieman Canyon	27-Jul-04	23:40	-41.777	144.557
49	CTD Cast	Transect B	28-Jul-04	0:07	-41.780	144.558
50	EZ Net Cast	Transect B	28-Jul-04	0:07	-41.780	144.558
51	EZ Net Cast	Transect B	28-Jul-04	0:07	-41.780	144.558
52	EZ Net Cast	Transect B	28-Jul-04	4:57	-41.703	144.620
53	Plankton Sample	Pieman canyon	28-Jul-04	5:31	-41.676	144.626
54	CTD Cast	Pieman Canyon	28-Jul-04	6:48	-41.692	144.613
55	MIDOC Sampling	Transect B	28-Jul-04	6:50	-41.692	144.613
56	MIDOC Sampling	Transect B	28-Jul-04	9:25	-41.834	144.530
57	Acoustic Survey	Pieman Canyon	28-Jul-04	12:25	-41.727	144.592
58	MUFTI MIDOC profile	Pieman Canyon	28-Jul-04	15:52	-41.733	144.584
59	MIDOC Sampling	Pieman Canyon	28-Jul-04	18:27	-41.873	144.502
60	MIDOC Sampling	Transect B	28-Jul-04	23:14	-41.710	144.600
61	CTD Cast	Pieman Canyon	29-Jul-04	2:44	-41.772	144.554
62	CTD Cast	Pieman Canyon	29-Jul-04	3:47	-41.769	144.560
63	CTD Cast	Pieman canyon	29-Jul-04	4:44	-41.802	144.557
64	MUFTI	Transect B	29-Jul-04	5:59	-41.805	144.544
65	MIDOC Sampling	Transect B	29-Jul-04	11:21	-41.848	144.605
66	Acoustic Survey	Pieman Canyon	29-Jul-04	15:05	-41.820	144.555
67	MUFTI TS drift	Pieman Canyon	29-Jul-04	17:47	-41.772	144.516
68	Sediment Grab	Transect B	29-Jul-04	22:43	-41.830	144.573
69	Sediment Grab	Transect B	29-Jul-04	23:09	-41.831	144.577
70	Sediment Grab	Transect B	29-Jul-04	23:26	-41.832	144.580
71	EZ Net Cast	Transect B	30-Jul-04	0:36	-41.823	144.538
72	Plankton Sample	Transect B	30-Jul-04	2:23	-41.742	144.569
73	EZ Net Cast	Transect B	30-Jul-04	3:56	-41.694	144.629
74	Acoustic Transect	Transect B	30-Jul-04	7:00	-41.737	144.564
75	Sediment Grab	Transect B	30-Jul-04	10:18	-41.793	144.547
76	Acoustic transect	Warm core eddy	30-Jul-04	11:05	-41.796	144.537
77	XBT	Warm core eddy	30-Jul-04	11:47	-41.909	144.449
78	XBT	Warm core eddy	30-Jul-04	12:19	-41.993	144.383
79	CTD Cast	Warm core eddy	30-Jul-04	13:07	-42.093	144.301
80	EZ Net Cast	Warm core eddy	30-Jul-04	14:03	-42.100	144.301
81	Plankton Sample	Warm core eddy	30-Jul-04	14:30	-42.117	144.286
82	Plankton Sample	Warm core eddy	30-Jul-04	14:53	-42.132	144.272
83	XBT	Warm core eddy	30-Jul-04	16:20	-42.192	144.218
84	XBT	Warm core eddy	30-Jul-04	17:05	-42.284	144.138
85	MIDOC Sampling	Warm core eddy	30-Jul-04	17:23	-42.319	144.103
86	XBT	Warm core eddy	30-Jul-04	20:15	-42.416	144.024

Operation number	Type	Area	Start time	UTC	Start Latitude	Start Longitude
87	EZ Net Cast	Warm core eddy	30-Jul-04	21:45	-42.369	144.065
88	Plankton Sample	Warm core eddy	30-Jul-04	22:31	-42.384	144.052
89	Plankton Sample	Warm core eddy	30-Jul-04	22:53	-42.391	144.047
90	Plankton Sample	Warm core eddy	30-Jul-04	23:17	-42.399	144.038
91	Plankton Sample	Warm core eddy	30-Jul-04	23:40	-42.406	144.028
92	CTD Cast	Warm core eddy	31-Jul-04	0:45	-42.419	144.025
93	XBT	Warm core eddy	31-Jul-04	2:50	-42.533	143.928
94	XBT	Warm core eddy	31-Jul-04	3:10	-42.568	143.903
95	XBT	Warm core eddy	31-Jul-04	4:02	-42.669	143.946
96	CTD Cast	Warm core eddy	31-Jul-04	4:54	-42.590	143.980
97	EZ Net Cast	Warm core eddy	31-Jul-04	5:58	-42.586	143.986
98	Plankton Sample	Warm core eddy	31-Jul-04	6:12	-42.587	143.979
99	Plankton Sample	Warm core eddy	31-Jul-04	6:37	-42.587	143.962
100	XBT	Warm core eddy	31-Jul-04	9:13	-42.771	143.833
101	XBT	Warm core eddy	31-Jul-04	10:25	-42.949	143.763
102	EZ Net Cast	Warm core eddy	31-Jul-04	12:13	-43.223	143.682
103	Plankton Sample	Warm core eddy	31-Jul-04	12:21	-43.223	143.689
104	Plankton Sample	Warm core eddy	31-Jul-04	12:40	-43.224	143.708
105	XBT	Warm core eddy	31-Jul-04	14:20	-43.258	143.803
106	MIDOC Sampling	Warm core eddy	31-Jul-04	14:51	-43.267	143.828
107	XBT	Warm core eddy	31-Jul-04	17:56	-43.180	143.637
108	MUFTI MIDOC Replica	Warm core eddy	31-Jul-04	19:18	-43.205	143.658
109	CTD Cast	Warm core eddy	31-Jul-04	22:10	-43.237	143.746
110	MUFTI Yo Yo	Warm core eddy	31-Jul-04	23:17	-43.235	143.760
111	XBT	Warm core eddy	01-Aug-04	1:17	-43.053	143.925
112	CTD Cast	Warm core eddy	01-Aug-04	3:44	-42.884	144.142
113	EZ Net Cast	Warm core eddy	01-Aug-04	4:45	-42.881	144.153
114	Plankton Sample	Warm core eddy	01-Aug-04	5:08	-42.873	144.178
115	XBT	Warm core eddy	01-Aug-04	7:44	-42.654	144.479
116	CTD Cast	Warm core eddy	01-Aug-04	8:57	-42.519	144.618
117	EZ Net Cast	Warm core eddy	01-Aug-04	10:30	-42.513	144.619
118	Plankton Sample	Warm core eddy	01-Aug-04	11:00	-42.509	144.649
119	TS buoy deployment	Transect C	01-Aug-04	13:54	-42.492	144.851
120	MIDOC Sampling	Transect C	01-Aug-04	14:57	-42.488	144.853
121	MUFTI Equipment Deployment	Transect C	01-Aug-04	18:59	-42.386	144.831
122	Sediment Grab	Transect C	01-Aug-04	21:54	-42.468	144.841
123	Sediment Grab	Transect C	01-Aug-04	22:30	-42.469	144.847
124	EZ Net Cast	Transect C	01-Aug-04	23:27	-42.464	144.851
125	Plankton Sample	Transect C	02-Aug-04	0:05	-42.437	144.841
126	CTD Cast	Transect C	02-Aug-04	1:15	-42.381	144.808
127	Acoustic transect	Transect C	02-Aug-04	1:48	-42.380	144.813
128	CTD Cast	Transect C	02-Aug-04	3:46	-42.231	145.144
129	Sediment Grab	Transect C	02-Aug-04	4:07	-42.232	145.145

Operation number	Type	Area	Start time	UTC	Start Latitude	Start Longitude
130	Sediment Grab	Transect C	02-Aug-04	4:13	-42.232	145.146
131	EZ Net Cast	Transect C	02-Aug-04	4:36	-42.229	145.147
132	Plankton Sample	Transect C	02-Aug-04	5:00	-42.219	145.128
133	Sediment Grab	Transect C	02-Aug-04	6:51	-42.305	144.965
134	Sediment Grab	Transect C	02-Aug-04	7:08	-42.305	144.968
135	CTD Cast	Transect C	02-Aug-04	7:56	-42.305	144.967
136	EZ Net Cast	Transect C	02-Aug-04	8:21	-42.302	144.963
137	Plankton Sample	Transect C	02-Aug-04	8:27	-42.297	144.967
138	Plankton Sample	Transect C	02-Aug-04	8:52	-42.285	144.982
139	MIDOC Sampling	Transect C	02-Aug-04	12:42	-42.352	144.806
140	MUFTI tow	Transect C	02-Aug-04	16:50	-42.471	144.851
141	MIDOC Sampling	Transect C	02-Aug-04	18:48	-42.376	144.819
142	Plankton Sample	Transect C	02-Aug-04	22:01	-42.307	144.977
143	Swath Transect	Transect C	02-Aug-04	22:58	-42.300	144.992
144	TS buoy recovery	Transect C	03-Aug-04	0:15	-42.482	144.971
145	Search for gear	West Coast	03-Aug-04	1:45	-42.526	144.864
146	Plankton Sample	Pt Hibbs	03-Aug-04	6:00	-42.760	145.241
147	Plankton Sample	Pt Hibbs	03-Aug-04	6:57	-42.664	145.300
148	Swath Survey	Pt Hibbs	03-Aug-04	7:26	-42.662	145.282
149	Mufti deployment	Strahan Canyon	03-Aug-04	11:34	-42.370	144.844
150	MUFTI tow	Strahan Canyon	03-Aug-04	11:47	-42.374	144.825
151	MIDOC Sampling	Strahan Canyon	03-Aug-04	16:15	-42.125	144.840
152	Acoustic Survey	West Coast	03-Aug-04	19:04	-42.207	144.705
153	Acosutic Survey	Pieman Canyon	03-Aug-04	22:08	-41.851	144.561
154	Swath Survey	Pieman Canyon	04-Aug-04	0:45	-41.744	144.561
155	Swath Line	Pieman Canyon	04-Aug-04	1:56	-41.731	144.514
156	Plankton Sample	Warm core eddy	04-Aug-04	4:44	-41.859	144.126
157	Plankton Sample	Warm core eddy	04-Aug-04	7:45	-42.005	144.378
158	Acoustic survey of Pieman canyon	Pieman Canyon	04-Aug-04	10:37	-41.715	144.597
159	MUFTI tow	Pieman Canyon	04-Aug-04	14:40	-41.715	144.597
160	Benthic Dredge	Pieman Canyon	04-Aug-04	18:02	-41.866	144.473
161	Swath transit home!	West Coast	04-Aug-04	22:03	-42.027	144.677
162	Benthic Dredge	South west Cape	05-Aug-04	10:13	-43.599	145.856
163	Plankton Sample	South West Cape	05-Aug-04	15:08	-43.711	146.246