VOYAGE SUMMARY SS02/2004

Title
Dynamics of the Perth Canyon, Western Australia — Linking oceanographic drivers, plankton, fish communities and seasonal blue whale aggregations.

Itinerary
Departed Fremantle 1000 hrs, Thursday 29 January, 2004
Arrived Fremantle 1043 hrs, Wednesday 4 February, 2004

Principal Investigators
Dr. Robert McCauley (Chief Scientist)
Centre for Marine Science and Technology
Curtin University
GPO Box U 1987 Perth, 6845, Western Australia
Phone 08 9266 7460, fax 08 9266 4799
Email R.McCauley@cmst.curtin.edu.au
Dr. Doug Cato
Defence Science and Technology Organisation
PO Box 44 Pyrmont, NSW 2009
Phone 08 9692 1483

Scientific Objectives
This project will contribute to linking observations of oceanography, zooplankton, fish choruses and blue whales in the Perth Canyon, a biological 'hotspot'. Specific aims of the voyage were to carry out fine scale sampling of the Perth Canyon, as per:

- carry out oceanographic measurements at the eastern canyon end to link with modelling;
- map and discriminate zooplankton communities about the canyon using acoustic backscatter;
- physically sample zooplankton and pelagic fish communities about the canyon;
- study the sources of evening choruses known to occur around the canyon.

Blue whales aggregate in the Perth Canyon through November to May with highest numbers sighted during February to March. Blue whales using the canyon are primarily engaged in feeding, with animals seen surfacing with krill streaming from their mouths. The voyage entailed oceanographic measurements within the region commonly visited by blue whales, physical sampling of zooplankton communities using pelagic nets and an investigation of regular evening fish noise sources, using passive and active acoustic systems, and pelagic nets. The measurements are part of a project to understand the dynamics of the Perth Canyon and why blue whales aggregate their.

Voyage Objectives

Morning 02:00-14:00

Morning / daytime work was allocated to oceanographic casts with the lowered CTD rosette, water sampling bottles and lowered ADCP (LADCP) on a set grid around the Perth Canyon. Our primary area of interest was near to the Canyon head or eastern end as shown on Figure 1. Oceanographic cast locations were to replicate those successfully taken during voyage SS09/2003 down the canyon axis, plus include a uniform grid about the eastern Canyon end. Water sampling measurements were taken to gauge levels of productivity below the Leeuwin current and to understand what is supporting krill aggregations the blue whales utilise. Oceanographic casts entailed use of the lowered rosette with CTD and light measuring electronics, water sampling from Niskin bottles and the lowered ADCP attached to the rosette. Casts were made to full water column depths although the light meter only read to 200 m depth and needed to be removed for deeper casts.

Afternoon 14:00 — 02:00

Afternoon / early morning work entailed targeted net sampling using the EZ net system for zooplankton (krill) and the Engel net for pelagic fish. Net sampling was concentrated into the eastern end of the canyon (since this is where blue whales are primarily seen feeding) as shown by the shaded region on Figure 1 and was targeted at layers seen on the echosounders. Three sets of drifting gear, comprising temperature loggers and sea noise logging equipment were deployed through the trip. The configuration of this gear is shown on Figure 2. The ships echo sounders plus the ES60 logged the entire voyage for biomass assessment.

Voyage Track

The area of operation is shown on Figure 1, while specific tracks for each day are shown on Figure 3 and Figure 4.

Results

In total 41 casts of the CTD rosette were made at 38 sites, ten EZ and six Engel net tows were completed and three sets of drifting gear were made. Locations of the EZ and Engel net tows, and the drifting sets are shown on Figure 5, while the CTD cast locations are shown on Figure 6. Note that at several sites the CTD rosette was lowered and retrieved twice, once to full water column depth and once to 200 m depth for light measurements only. The voyage was considered highly successful in the amount and quality of data collected. It is expected that the voyage will result in a relatively detailed exploratory examination of the Perth Canyon dynamics.

A summary for each objective is listed below.

Oceanographic casts

The CTD rosette was used for obtaining measurements of: depth; temperature; conductivity; nutrients (multiple measures); productivity (using an array of measures); plankton communities (filtered water); light; fluorescence; and on selected casts, current profiles using a lowered ADCP. At the time of writing this document none of this data has been worked up.

Of the 41 casts, four were light measurements only. The light sensor was only rated to 200 m depth thus where light measures were required, the rosette was deployed to 200 m depth, retrieved, the light sensor removed, and the rosette lowered again for the full array of measures. At one site the light measurement needed to be repeated due to shading by the ship.

A total of 38 sites were sampled with the CTD rosette. This was above our expectations, with 34 sites initially planned. The grid of measurements about the Canyon was successfully sampled, as was a transect down the Canyon axis, which replicated samples made in August 2003. An extra transect of three samples was made along the 500 m depth contour on the last shift.

Two confounding factors with the oceanographic measures were the weather and the fact that transects were not completed continuously. The weather in the Perth Canyon for the week immediately prior SS02/04 was calm with winds mostly < 10-15 kn. The weather picked up substantially during the first two days of this voyage, with winds of 40-45 kn SW experienced on the evening of the 30-Jan-2004 and the vessel having to heave to for 7.5 hours from 20:00 hours 30-Jan to 05:30 hours 31-Jan. Strong winds (15-30 kn) persisted through to the 2-Feb. This sudden and sustained burst of SW winds may have caused the circulation in the Canyon to change or to have been in a state of change, during the cruise. The second confounding factor with oceanographic measures was that several of the transects were not completed in a continuous fashion due to the split shifts used to achieve the cruises' multiple aims. While these two factors may make interpreting the data more difficult, they may also provide a snapshot into how the Canyon circulation responded to a strong burst of SW forcing.

EZ net tows & plankton sampling

Of the ten EZ net tows five were taken during daylight and five were taken after dusk. Two sets of tows were replicated across the same transects, each with one tow in daylight and one tow in darkness (see Figure 5 for overlapping tows). There was a strong day / night disparity in the stratification of zooplankton evident from the sounder records which this sampling was aimed at delineating. An example of this can be seen in Figure 7 which shows the 12 kHz sounder records for tows 8 and 10 over 15:14 to 16:16 and 22:18 to 23:04 on the 3-Feb, respectively (Figure 7). A feeding blue whale was working the area at the end of tow 8, possibly targeting the dense patches which can be seen (Figure 7 top, centre of plot around 220 m depth). These patches were sampled with the EZ net and contained a large krill species (~ 20 mm). All tows were made across areas where the blue whales are known to aggregate, or along the Canyon eastern flanks. Each tow successfully sampled plankton, with most samples containing krill. There appeared to be several krill species present, although samples have yet to be thoroughly examined. Several dense zooplankton patches seen on the ships sounders were sampled with the EZ net.

Fish choruses, Engel net tows and drifting sets

Engel pelagic fish trawls (Figure 5) were made in an attempt to identify sources of evening fish choruses heard from the Canyon. Two chorus types had been previously recorded about the Canyon. These include a high frequency chorus (2-3 kHz) occurring each evening year round from the 500 m plateau on the northern Canyon side and a lower frequency chorus (1-2 kHz) heard during the evening from shallow water approximately 5 mile east of the Canyon head in summer 2000. Drifting sea noise loggers were deployed throughout this cruise to sample any fish choruses present.

The Engel tows were spectacular in the paucity of fish they recovered. The first tow of one hour duration came back almost completely empty. The second tow of four hours duration resulted in 4 kg of Mytophiformes, primarily two species of ~ 100 mm length (possibly Neoscopelus sp. and Diapus sp.) and a few surface-pelagic fish, several squid and a 1.4 m length sun fish (Mola sp.) which was returned alive. Subsequent tows each returned approximately 1 kg of Mytophiformes, small numbers of surface-pelagic fish, a few squid and several other fish species (including several Macroudidae from a near bottom tow in 500-600 m depth. The Western Australian Museum sub-sampled all species and will provide species lists. All the Neoscopelus which were opened had stomachs full of krill.

The sea noise logger drifts spanned five evenings (although the first evening set was not deployed until 21:00 hours and was not free of vessel noise until 22:00 hours). The locations of the sea noise loggers at 22:30 each evening were shown on Figure 5. The higher frequency fish chorus was evident in all evening sea noise samples. This can be seen on Figure 8 where the sea noise for drifts 2 & 3 are shown as time (x-axis), log frequency scale to the logger bandwidth (y-axis) and intensity (colour). The evening choruses were evident from 21:00 to 24:00 each evening at 2-3 kHz. There were differences in the chorus level recorded between sites, with the evening sampled with the logger over the 1000 m depth shown on Figure 5, having a maximum chorus level ~ 2-3 dB lower than other sites.

The Engel tows were concentrated along the eastern Canyon flanks, with the rationale being that: the chorus sources were believed to be zooplanktivorous fishes; and this was an area known to be rich in zooplankton. The dominance of the Mytophiformes in all samples and the lack of any other potential chorus sources suggests that: 1) the Mytophiformes are the chorus sources; or 2) that the chorus source completely avoided the Engel nets. A collection of Mytophiformes have been kept to look for morphological structures capable of producing sounds (swimbladder musculature). If such structures do exist then this would strengthen the argument for these fishes being the source of the high frequency evening choruses.

It is believed that the spatial scale of sampling was not sufficient to determine if significant level differences in these high frequency choruses do occur (ie. the choruses are spatially diffuse possibly reflecting the zooplankton patchiness). Given the small differences in evening chorus level seen (2-3 dB) over the scale of sampling carried out, then a set of samples running 20-50 mile seaward may be required to determine if the presence of these choruses can act as an acoustic 'beacon' for regions of rich zooplankton, or whether the choruses are relatively uniform on large scales.

The drifting sets 2 & 3 had a string of temperature loggers attached at 25 m intervals starting from 133 m depth. Drift 1 only had a single logger set at 310 m depth. Drifts 2 & 3 each show signs of internal waves (Figure 9). Drift 3 showed a warming trend over its 32 hour deployment.

There is considerable information on the noise of the Southern Surveyor in the drifting sea noise records. This information can be used to describe the noise produced by the SS under various operational conditions and also can be used in to examine sound transmission in the local region.

Voyage Narrative

A chronological outline of the voyage is given below. All ships meteorological gear, the ships ADCP and echo sounders (12 & 38 kHz Simrad EA & EK respectively, 70, 120 & 200 kHz Simrad ES60) were run continuously. Unless specified below, all CTD casts logged depth, temperature, conductivity, fluorescence and involved nutrient and productivity sampling. Light measurements were made on all sites < 200 m depth and at selected deeper sites to 200 m depth. LADCP deployments were restricted to sites where the target cast depth was greater than the ships ADCP effective depth of 200 m. All times listed below are WST.

29-Jan-2004
10:00 Departed Fremantle, steamed to eastern end of Canyon.
14:03-15:55 CTD casts 1-2;
19:35-20:47 Engel tow 1
22:09 Drifting gear 1 set
22:50-23:35 EZ tow 1
30-Jan-2004

00:41-01:18 EZ tow (2)
01:30-3:00 steam CTD site
03:00-06:15 CTD casts 3-5; LADCP on 5
06:43 recover drifter 1
08:53-15:35 CTD casts 6-11; 6, 7, 10 Light only; LADCP on 8, 9, 11
16:00 prepare for first EZ then Engel tow but abort as weather 35 kn steady and increasing
16:30 start a grid of echosounder traverses
22:00 abort echosounder traverses as too many bubbles, ship hove to into sea until 05:30 31-Jan
31-Jan-2004
05:30-14:40 CTD casts 12-16; LADCP on 12, 13
16:05 Drifting set 2 deployed
17:10-18:45 EZ tow 3
20:44 Engel tow 2 deployed
01-Feb-2004
01:27 Engel tow 2 recovered
0130-03:00 steam CTD site
03:09-14:36 CTD casts 17-24; 21 light only; LADCP on 17, 18, 19, 20, 22, 23, 24
15:21-16:23 EZ tow 4
17:50-19:56 Engel tow 3
21:18-22:38 EZ tow 5
02-Feb-2004
01:05 Drifting set 2 recovered
02:12-13:40 CTD casts 25-33; LADCP on 28, 29, 30, 31
14:36-15:40 EZ tow 6
16:37 Drifting set 3 deployed
17:46-18:23 EZ tow 7
18:50-20:24 sampling with Tracor Acoustic Profiling system
20:40-22:28 Engel tow 4
23:16 Engel tow 5 deployed
03-Feb-2004
00:58 Engel tow 5 recovered
02:39-12:11 CTD casts 34-37; LADCP on 34, 35, 36, 37
12:15-15:00 steam eastern end Canyon
15:14-16:16 EZ tow 8
17:19-19:49 Engel tow 6
20:31-21:10 EZ tow 9
22:18-23:04 EZ tow 10
04-Feb-2004
00:30 Drifting set 3 recovered
02:11-06:12 CTD casts 38-41; LADCP on 39
06:15 steam Fremantle

Summary

The voyage was extremely successful. A large amount of very diverse information was collected. This will give us a comprehensive 'snapshot' of the Canyon over a short time period. Given this short time frame then the voyage can be considered as 'exploratory'. The strong burst of SW winds over the cruise, while making working conditions difficult, slowing operations and resulting in almost eight hours hove to, may provide an insight into how the Canyon circulation responds to such events.
The Southern Surveyor was admirably equipped to deal with the diversity of tasks performed. The back deck area was suitable for having the Engel and EZ nets rigged, so saving time in setting gear. The winch arrangements were the most sophisticated the PI has seen. There were experienced staff

on-hand to deal with the complexity of gear and electronic systems. The only sampling restriction encountered was the 200 m depth rating on the CTD rosette PAR light sensor. To take full water column casts and light measurements in depths greater than 200 m required the rosette to be deployed, lowered to 200 m, recovered, the light meter removed and the rosette re-deployed to the full water column depth.

Personnel

Scientific personnel are listed in Table 1 and the ships crew in Table 2.

Table 1: Ships scientific personnel for SS02/04. Note that NatFac = National Facility.

Name	Affiliation	position	Day / night
Rob McCauley	Curtin Uni	Chief Scientist, Watch Leader	N
Susan Rennie	Curtin Uni	oceanography, Watch Leader, ops. support	D
Christine Hanson	UWA	water sampling, radioisotopes, ops. support	D
Chandra Salgado	Curtin	oceanog. / acoust., ops. support	D
Sascha Gavrilov	Curtin	oceanography, water sampling	D
Glenn Moore	WA Museum	nets, ops. support	N
Chris Van Etten	Curtin	nets / acoustic, ops. support	N
Nick Mortimer	CSIRO (Perth)	nets & acoustics	N
Ron Plaschke	CSIRO NatFac	Voyage Manager, ops. Support	
Pamela Brodie	CSIRO NatFac	Computing	
Jeff Cordell	CSIRO NatFac	Electronics	
Mark Rayner	CSIRO NatFac	Hydrochemist	

Table 2: Ships crewmembers for SS02/04.

Position	Name	Position	Name
Master	Ian Taylor	I.R.	Graham Mcdougall
Chief Officer	John Boyes	Greaser	Phillip French
2nd Officer	Drew Meincke	Chief Steward	Peter Williams
Chief Engineer	John Morton	Chief Cook	Andy Goss
1st Engineer	David Jonker	2nd Cook	Angela Zutt
2nd Engineer	John Hinchliffe	Extra Ir	Fiona Perry
Bosun	Malcolm Mcdougall	Extra Ir	Mark Spearritt
I.R.	Manfred Germann	Extra Ir	Les Kearns
I.R.	Tony Hearne		

We wish to express our appreciation of the effort put into the cruise by National Facility staff, CSIRO staff and the ships crew. The trip involved multiple sets of complex gear, each with its own set of idiosyncrasies. The efforts of Ron Plaschke in organising shore based logistics was vitally important. The CSIRO and National Facility staff of Ron Plaschke, Pamela Brodie, Jeff Cordell, Mark Rayner and Nick Mortimer were crucial in deploying and maintaining gear throughout the cruise. The dedication of Mark Rayner to process the seemingly never ending stream of water samples is greatly appreciated. Nick Mortimer of CSIRO Perth provided a continual sense of humour whilst always striving to improve the efficiency of gear. Susan Wijffels of CSIRO Hobart was instrumental in supply and assistance with the LADCP. The ships crew were always helpful. In particular the assistance of the fishing master John Boyes with the Engel pelagic fish deployments was crucial, as was the skill of the Captain Ian Taylor and mate Drew Meincke in recovering the drifting gear in open sea conditions of 25-35 knots at night. The assistance of Tony Koslow's group at CSIRO Perth in allowing Nick Mortimer to participate in the voyage, for supplying the Simrad ES60 echosounder system and the TAPS (Tracor Acoustic Profiling System) are greatly appreciated.

Dr. Rob McCauley
Chief Scientist

Figures

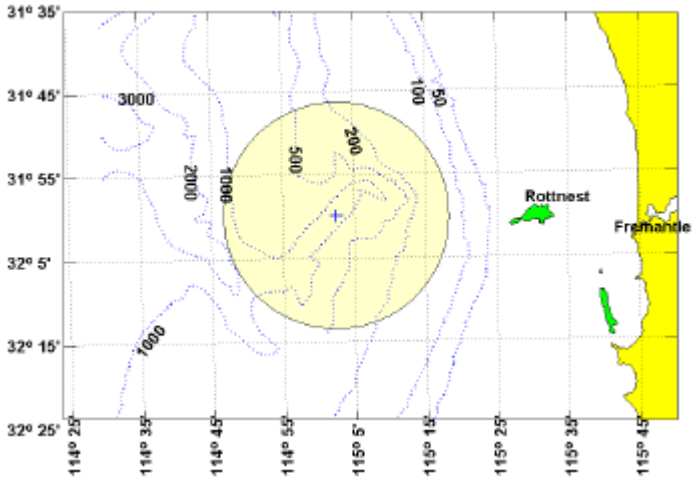


Figure 1: Location of eastern end of Perth Canyon, with primary area of interest shown within the shaded circle. The shaded region is that favored by blue whales.

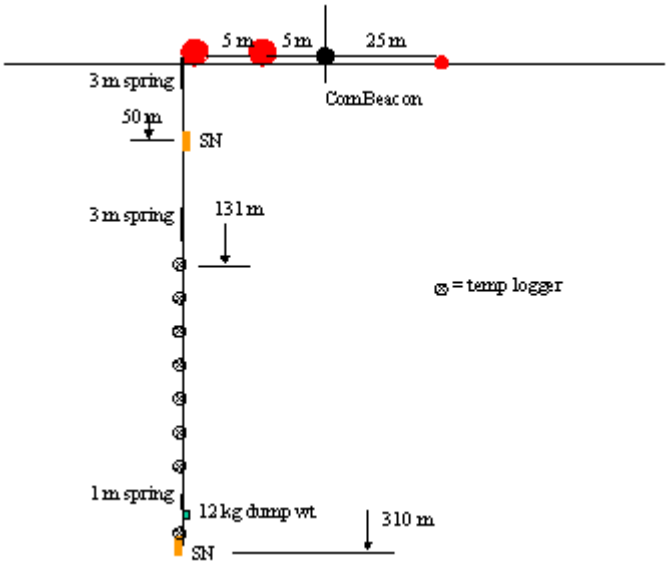
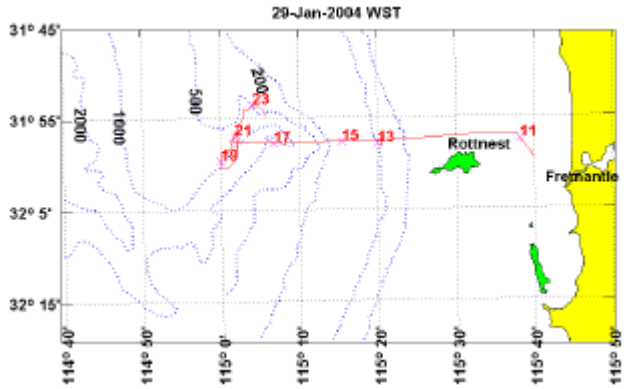


Figure 2: Mooring arrangement for the drifting gear. Buoys were two fender buoys, ~ 0.75 m dia plus one 360 mm hard buoy; GPS beacon was ComBeacon with aerial linked to bridge (radio GPS to bridge every 20 minutes); springs were 8 mm bungee cord doubled over, 3 m lightly stretched with a 6 m safety line of 7 mm poly line; SN = sea noise logger, top unit was 4 hr. DAT tape, bottom 60 s every 120 s at 22 kHz, bottom logger was 20 kg in-water weight, each logger calibrated with Massa TR1025-C hydrophone; Vemco temperature loggers were spaced every 25 m from 133 m, main line was 12 mm braided line in 100 m lengths.



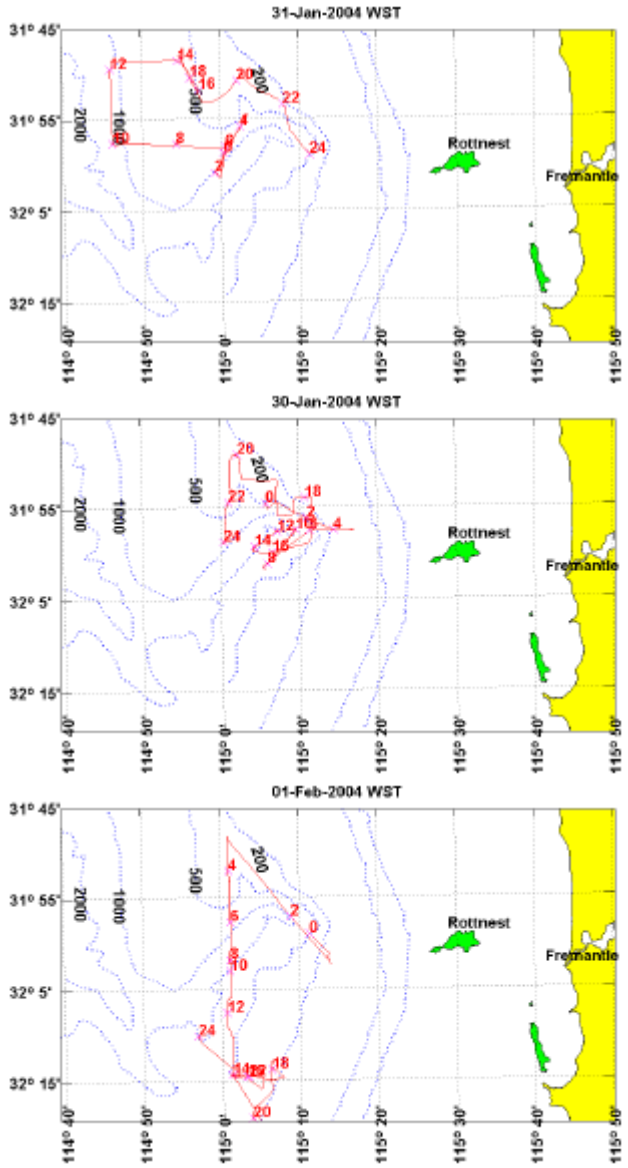
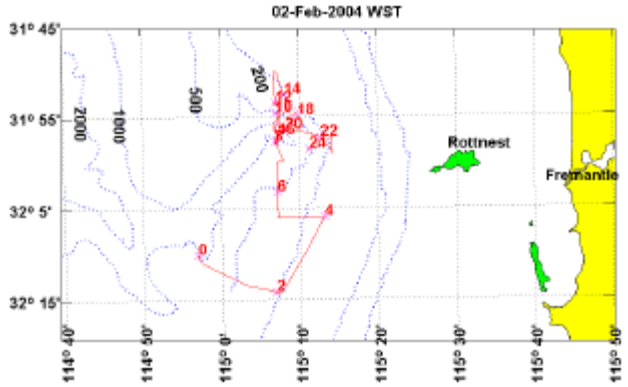


Figure 3: Vessel tracks for 29-Jan to 01-Feb with hours shown at 2 hour increment (local time).



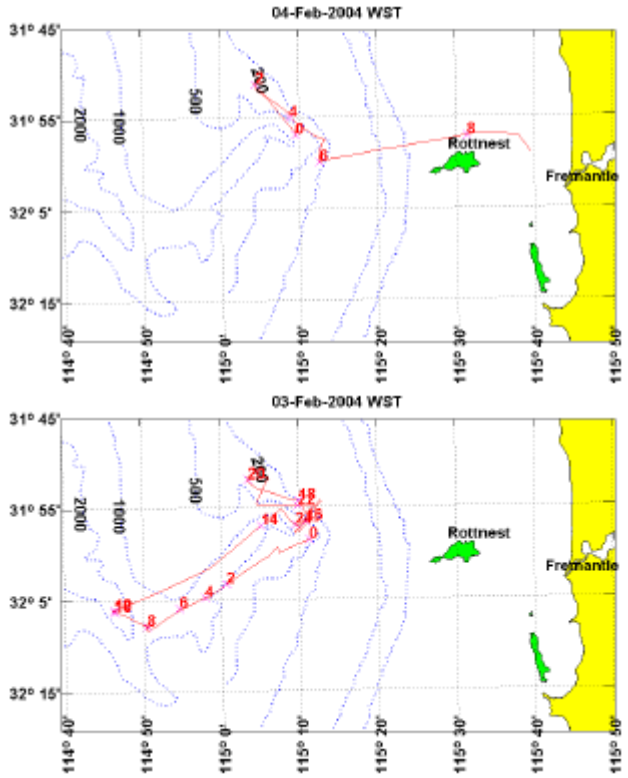
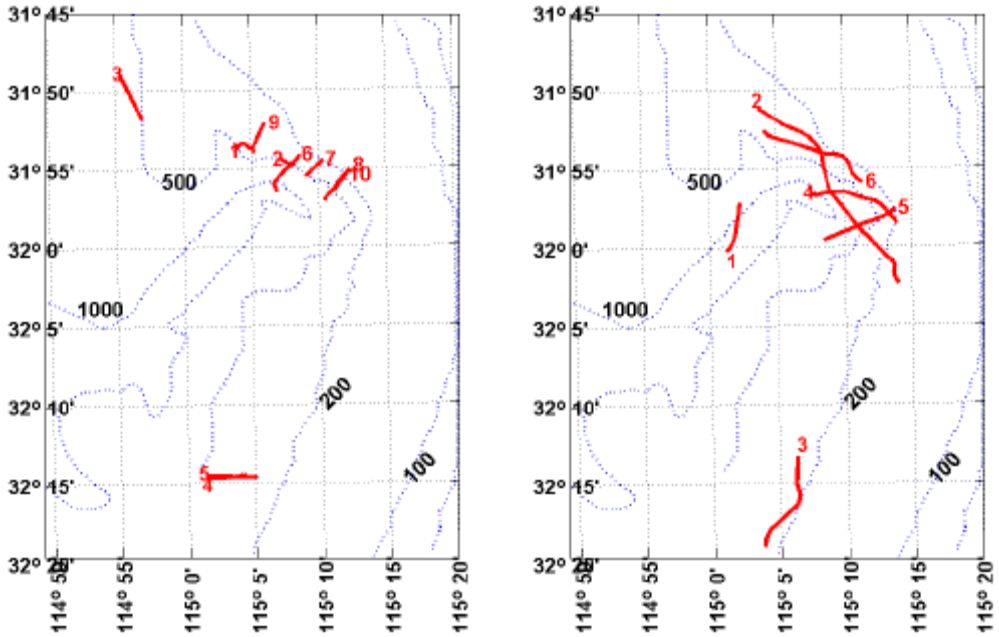


Figure 4: Vessel tracks for 02-Feb to 04-Feb with hours shown at 2 hour increment (local time).



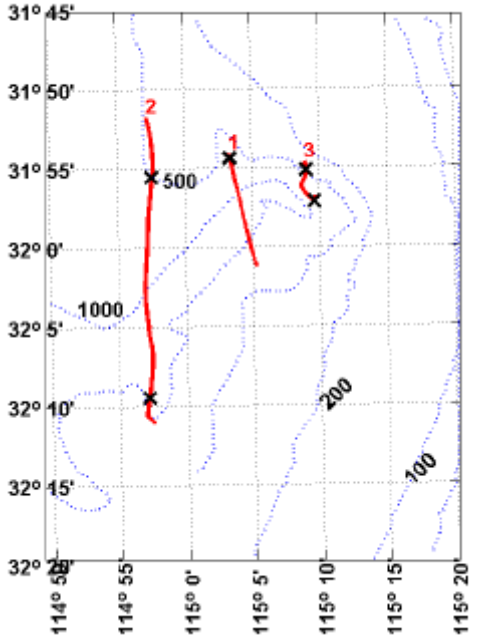


Figure 5: (Top Left) Location of EZ tows. Tows 4-5 and 8-10 were day-night comparisons replicated over the same lines and net-opening depths. (Top Right) Location of Engel pelagic fish trawl tows. (Bottom Left) Location of drifts, drifts were 8.6, 33 and 32 hrs length respectively. The drifter location at 22:30 hours each evening are shown by the crosses.

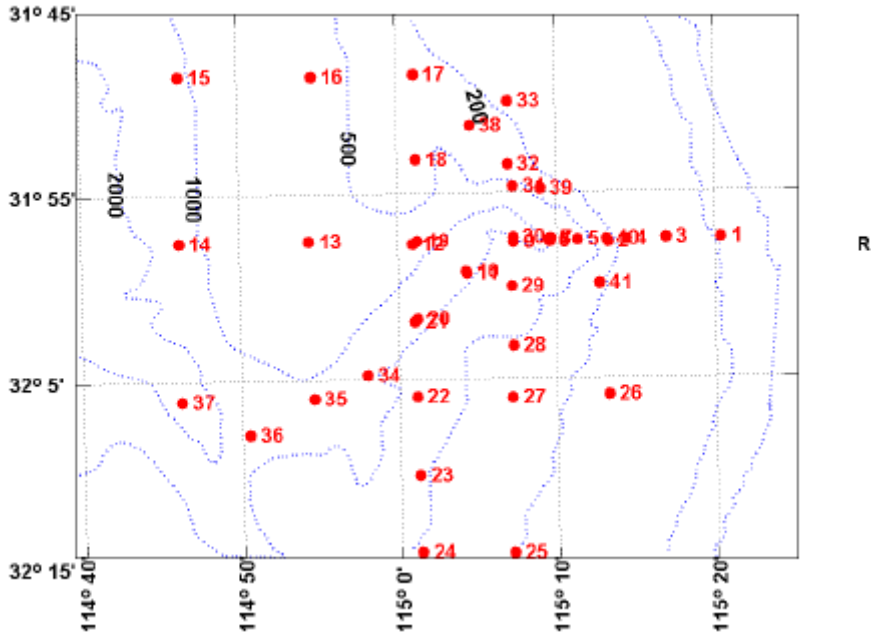


Figure 6: Location of CTD casts, numbered in the order they were taken.

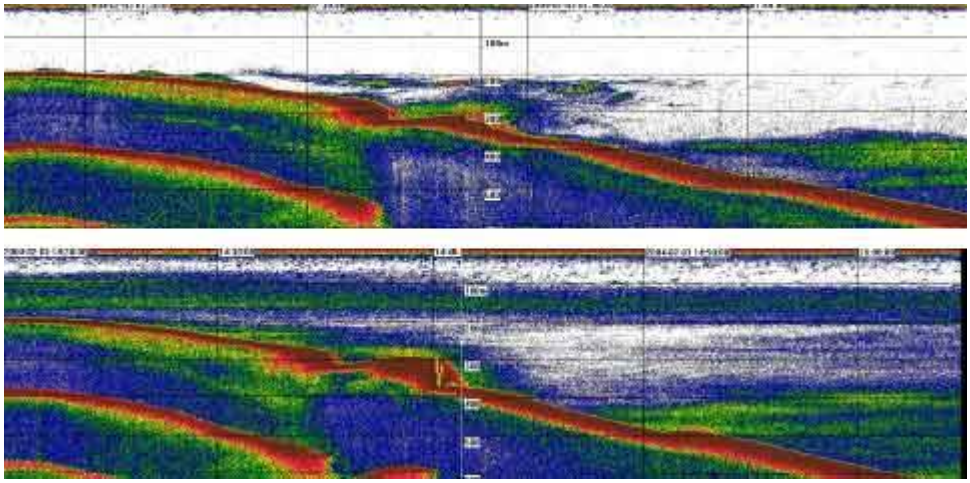


Figure 7: (top) Sounder records (12 kHz EA) for EZ tow 8 over 15:14 to 16:16, 3-Feb, and (bottom) for EZ tow 10 over the same transect over 22:18 to 23:04, 3-Feb.

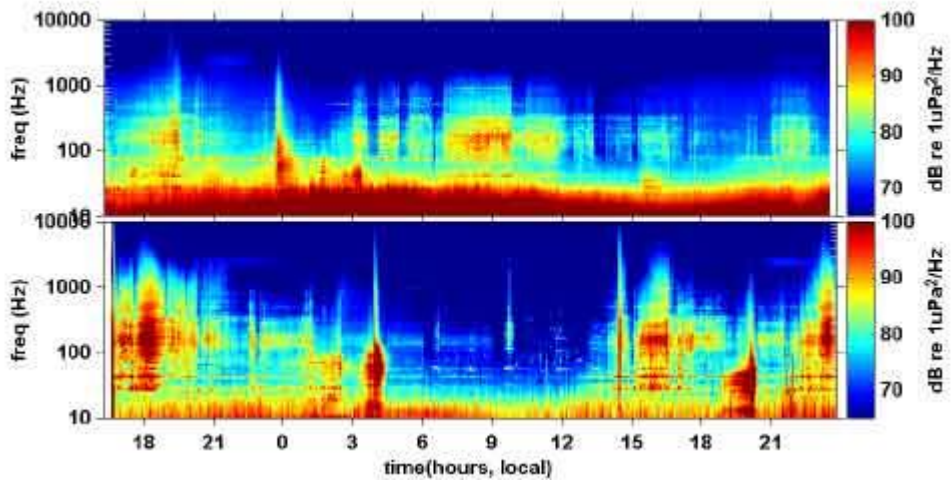
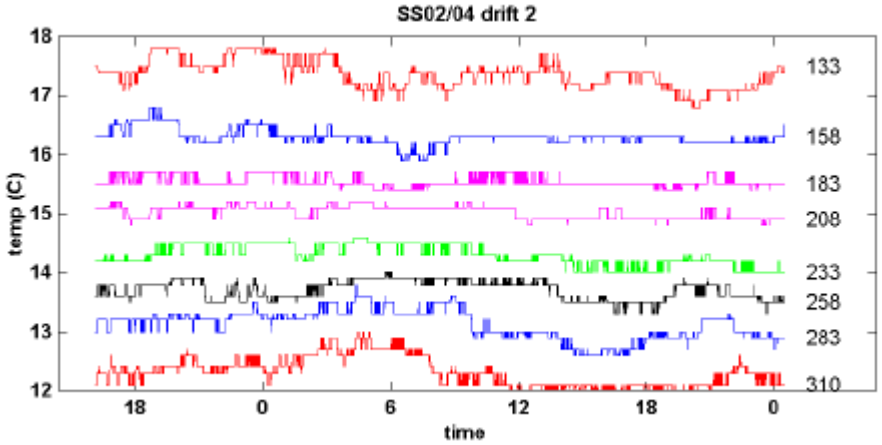


Figure 8: Sea noise from drifted loggers for deployments 2 (upper) and 3 (lower) (see Figure 5 for locations). The plots are shown as logarithmic frequency (y axis), time (x axis) and intensity (colour scale) with the intensity scale fixed to the range shown to enhance the fish choruses. The low frequency horizontal banding is vessel noise, Southern Surveyor (SS) mostly. Several close passages of the SS can be seen (ie. around 18:00 day 1 or 04:00 day 2 for drift 3 or lower plot). The presence of fish choruses can be seen from 21:00 — 24:00 hours each evening over the frequency band 2 — 3 kHz.



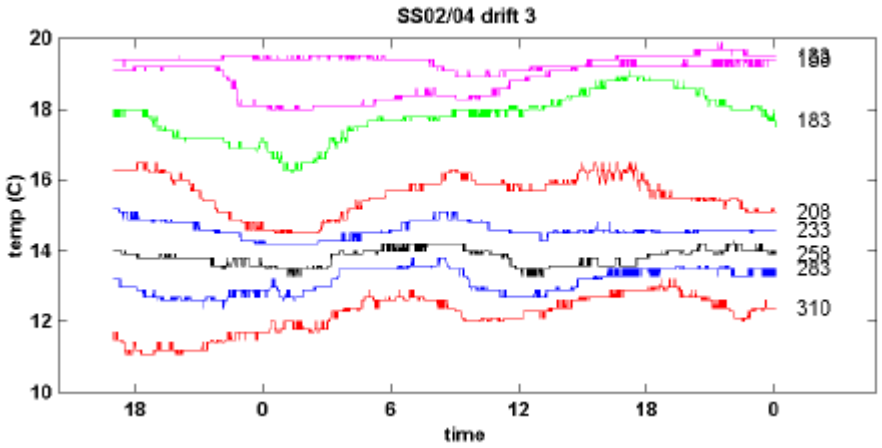


Figure 9: (top) Temperature from drifting set 2 (31-Jan 15:48 to 02-Feb 01:00) at the depths shown on right. (bottom) Temperature for drifting set 3 (02-Feb 17:00 to 04-Feb 00:10) at the depths shown.