

FRANKLIN

National Facility
Oceanographic Research Vessel

CRUISE SUMMARY

R.V. FRANKLIN

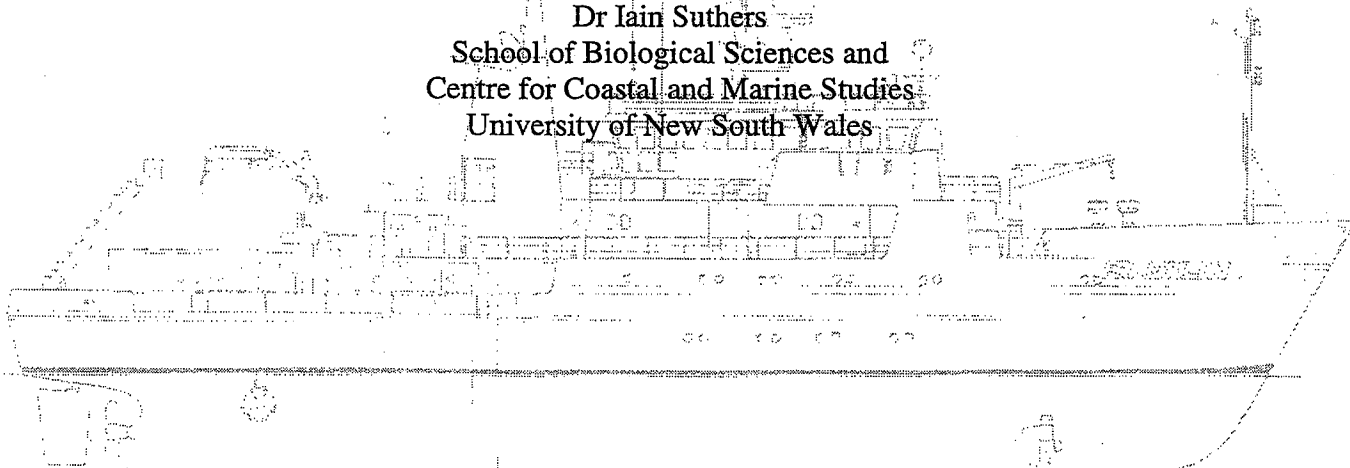
FR 14/98

Sail Sydney 1215 hrs, Saturday 14 November, 1998.
Arrive Sydney 0900 hrs, Friday 27 November, 1998.

Principal Investigators

Professor Jason Middleton
School of Mathematics and
Centre for Coastal and Marine Studies
University of New South Wales

Dr Iain Suthers
School of Biological Sciences and
Centre for Coastal and Marine Studies
University of New South Wales



For further information contact:

Operations Officer
CSIRO Marine Research
GPO Box 1538, Hobart, Tasmania 7001

Phone (03) 6232 5222
Fax (03) 6232 5028



FRANKLIN is owned and operated by CSIRO

Cruise Summary

R.V. Franklin

FR 14/98

Itinerary

Depart Sydney 1215 hrs, Saturday 14 November, 1998
Arrive Sydney 0900 hrs, Friday 27 November, 1998

Principal Investigators

Professor Jason H Middleton

School of Mathematics and Centre for Coastal and Marine Studies
University of New South Wales
Sydney, NSW 2052
Tel (02) 9385 7064
Fax (02) 9385 6637
Email j.middleton@unsw.edu.au

Dr Iain M Suthers

School of Biological Sciences and Centre for Coastal and Marine Studies
University of New South Wales
Sydney, NSW 2052
Tel (02) 9385 2065
Fax (02) 9385 1558
Email i.suthers@unsw.edu.au

Project Description

The overall objective is to measure upwelling processes caused by the East Australia Current (EAC) off the northern NSW coast, and to determine the effects of the nutrient supply on the phytoplankton, zooplankton and larval fish of the region. In particular, we plan to utilise CTD data, nutrient data, acoustic Doppler current profiler data, moored current meter data, samples of phytoplankton and zooplankton taken from nets and water samples, and larval fish from light traps and nets.

Results

The CTD (Conductivity–Temperature–Depth) sections offshore from Urunga showed substantial slope in the temperature (and density) contours, consistent with the observed strong East Australian Current flows at the shelf break. Currents were observed to rise from about 0.5kt inshore to over 3 kt offshore, with the Acoustic Doppler Current Profiler (ADCP) data broadly consistent with thermal wind estimates from the CTD data. Over the shelf proper in depths of 50-80m, colder waters had temperatures consistent with depths of 150m offshore, indicating that the strong current preconditions the shelf waters by uplifting colder (and presumably nutrient rich) waters from the deeper ocean. Fluorescence maxima were observed in shallower waters over the shelf (25-80m), consistent with primary production occurring as a result of the probable steady supply of nutrients in conjunction with available light.

At Smoky Cape the continental shelf narrows, and the observed currents were substantially stronger over the shelf proper, as expected. At Diamond Head currents were weaker toward the shore owing to the wider shelf, but there remained a consistently high level of fluorescence in the upper layers, consistent with a steady supply of nutrients. During the cruise strong southerly winds (to 40kt) created an ideal downwelling scenario, where in addition the surface mixed layer grew in depth, mixing physical properties and fluorescence through the upper water column.

Sea Surface Temperature images were obtained for 15 November and 21 November, and these clearly showed the EAC moving closer to the shore in the study area. Whether this was due to a normal EAC meander, or due to the strong winds which would provide a shoreward Ekman transport in the surface layers is unclear, although it appears that the currents strengthened over the continental slope at all measured depths.

Noctiluca scintillans were present in waters offshore from Cronulla, but were virtually absent from water samples at the Urunga section. Samples increased at the Diamond Head section off the northern NSW coast, but were greatest on return to Cronulla where they were seen to exist at substantial depth (50m). At this depth they are expected to be actively feeding at night, and laboratory analyses of the samples is predicted to prove this.

Drop net plankton composition at Cronulla was dominated by genus *Thalassiosira*, a diatom forming gelatinous colonies. The relative abundance of this taxon indicated that the spring/summer diatom successions had begun. At Urunga section, vertical haul nets indicated impressive concentrations of phytoplankton at all stations, with the exception of the deepest station (2000m). Preliminary examination revealed the dominance of the genus *Leptocylindrus* and to a lesser extent *Rhizosolenia*. Both of these diatom species are common in coastal waters. Large quantities of phytoplankton were obtained at the Smoky Cape, Point Plomer and Diamond Head sections, and it is believed these are actively utilising the upwelled nutrients.

Neuston nets comprised a 75cm square, 500um mesh net supporting a 20 cm diameter, 100um mesh inside. These nets deployed off the Urunga section caught small quantities of larval fish, but large amounts of zooplankton and Green Slime (a technical Suthers term for slimy green stuff) occurred.

Light traps caught few fish off Cronulla and off Urunga, probably as a result of both technical problems and the small numbers of larval fish present at the surface. By contrast the EZ net, deployed in the latter four nights of the cruise, obtained large quantities of larval fish, but these await analyses back in the laboratory.

Cruise Narrative

All times given in this narrative are Australian eastern summer time.

Saturday 14 November

Departed No 10 Darling Harbour at 1215 and transited to the beginning of the Port Hacking section. Began the section at 25m depth and took 6 good CTD stations through the afternoon, with water samples taken to search for plankton. With some rosette problems there were a number of test CTD's, and the good ones are numbered CTD1-3, CTD7-10, CTD13 and CTD15.

During the day, vertical haul net (37 um mesh, 50 cm diameter) samples were taken at CTD3, 7, and 13. These were initially examined for phytoplankton composition (and later on shore, for phytoplankton enumeration). Preliminary examination revealed the dominance of the genus *Thalassiosira*, a small diatom forming gelatinous colonies, in all casts. The relative abundance of this taxon indicated that the Spring/Summer diatom successions, characteristic of these waters at this time of year, had begun. During the night, while repairs to the CTD were being made, three trial MiniBAT deployments were made between the 50m and 125m stations. Weather was perfect.

Water samples from CTD1,2,3,7,8,9,10,13, and 15 and the underway flow were filtered onto a 100 um sieve, specifically for *Noctiluca scintillans*, a large heterotrophic, red-tide forming dinoflagellate. "Underway samples" were commenced 1700, sampling for approximately one hour on the hour. Fewer numbers of *Noctiluca* were found in the CTD due to the low volume (10-15 litres) sampled.

Sunday 15 November

Light traps were collected at between 0600-0740 Sunday local. Some traps had failed and only a few post-larval trevally and an unidentified larva were caught. The ship began the transit to the Urunga area at 30 30S. During this time underway collections of water samples were made at hourly intervals and filtered for *Noctiluca*. Relatively fewer cells of *Noctiluca* were found further north compared to Sydney.

Monday 16 November

The Urunga CTD section was begun with CTD stations 16 to 22 taken in water depths of 25, 50, 75, 100, 150, 200 and 300m. Each of these stations had nutrient samples drawn at 25m depth intervals. Fluorescence calibration samples were taken at CTD19 and 21, at depths corresponding to large CTD fluorescence peaks. The 300m station had no water samples as the rosette malfunctioned. The 500m station was not taken due to continued problems with the Rosette system, and CTD stations 23 and 24 were then taken at 1000m and 2000m in the East Australia Current with no water samples available for calibration or nutrients. CTD25 was a repeat of CTD24 with the fluorometer turned on!

A Sea Surface Temperature image for 15 November was downloaded, confirming the existence of a strong thermal front at 100m depth at the surface. The SST image was consistent with CTD observations of a temperature front with temperatures rising from 21C inshore to 24C offshore. Following the completion of the CTD work, the ship returned to the coast at Urunga, undertaking an Acoustic Doppler Current Profiler (ADCP) transect. Longshore currents varied from about 0.5m/s inshore to over 1.5 m/s offshore.

Fluorescence calibration samples were taken at CTD19 and 21, and on four occasions from the Wetstar underway fluorometer. Large fluorescence peaks were observed along this transect beyond the 50m station at approximately 40m depth.

Vertical haul net samples were made at CTD18, 19, 21, and 24), revealing impressive concentrations of phytoplankton at all stations, with the exception of CTD24 (1000m station). Preliminary examination revealed the dominance of the genus *Leptocylindrus* and to a lesser extent *Rhizosolenia*. Both these species are common diatom species found in these coastal waters. Water from CTD16 through to 21 was sampled and sieved through 100µm mesh sieve for collection of *Noctiluca*. No cells of *Noctiluca* were seen in these CTD samples nor in the underway samples.

Tuesday 17 November

On completion of the nighttime biosampling, the light traps were retrieved, and the ship headed south for the Smoky Cape section. This CTD section was begun with CTD stations 30 to 35 taken in water depths of 25, 50, 75, 100, 150 and 200m. CTD36 was a dud file, and the sequence continued with CTD37 at 300m and CTD38 at 500m. Each of these stations had nutrient samples drawn at depth intervals. CTD39 to 1000m was also used as a bottle leak test, with all bottles being fired at the bottom of the cast. Owing to technical problems occurring when the CTD was brought up to the block, the CTD wire was re-terminated. During the evening CTD stations were also taken at depths of 120m (CTD40), 50m (CTD41) and 100m (CTD42).

Continued underway and sample bottle sampling was undertaken for *Noctiluca*: also drop nets were taken at each station. MiniBAT tows were taken though areas where previous CTDs had indicated high fluorescence concentrations. Vertical haul net samples

were made at CTDs 32, 33 (x2), 35(x2) and 39 (1000m station). Preliminary inspection revealed the equally dominant genera *Thalassiosira* and *Leptocylindrus*. No *Noctiluca* was apparent. Fluorescence calibration samples were taken at CTD30 through to 34.

After the ADCP run back into the 50m station (while the CTD was being re-terminated), biological sampling began at 2200 with replicated Neuston net tows (with the 500 and 100um mesh) and a MiniBAT tow, out to 92m contour. We then steamed to the 100m station and repeated this sampling out to the 120m contour. A third Neuston tow was made simultaneously with the MiniBAT and OPC at 4m depth to compare the zooplankton abundance and size distribution by the two methods. CTD40 was then completed at 120m, and then we steamed back to the 50m station for CTD41, and further Neuston and MiniBAT tows. During the transit in we observed at around the 100m contour a 2 degree fluctuation in the thermosalinograph. We then returned to the 100m station for the final CTD42, Neuston and MiniBAT tow for the night, before steaming to Point Plomer.

Wednesday 18 November

After completion of night biosampling, the ship travelled south to the Point Plomer section. This was begun at 0620 with CTD43 at 25m depth. This was followed by CTD stations 44 to 50. By noon the wind had risen to 25kt, and the swell also. With 40kt wind gusts, the ship hove to at 1550, and this persisted through the day and into the evening. Along the Point Plomer section, vertical haul nets were made at CTD45, CTD46(x2), and CTD48. No night biosampling was conducted on Wednesday night due to high winds.

Thursday 19 November

Winds and gusts remained severe, with gusts occasionally at 50kt, and average winds from the south often exceeding 40kt, the ship remained hove to all day, and through the night.

Friday 20 November

At 0600 work was again begun on the Diamond Head section, beginning with CTD52 (25m) and ending at CTD57 (300m) when again conditions were too rough for CTD work. Temperature contours showed a distinct downward slope to the west, indicative of strong Ekman pumping toward the coast. Friday afternoon was spent building moorings and Friday night conducting net tows. Also at night CTD's were taken at, alternately, 50m and 100m depths, from CTD58 to CTD63.

Along the Diamond Head transect vertical hauls for phytoplankton were conducted at CTD53, 54(x2) and 56. At 1930 local, biological sampling commenced at the 50m station with CTD 58, a MiniBAT tow and Neuston tow. Similar sampling was conducted at the 100m station (CTD59), 50m (CTD60), 100m CTD61), 50m CTD62, and 100m station CTD63 at dawn. Large numbers of post larval fish were caught in the Neuston net, notably gonorrhynchids and pelagic juvenile tailor. There appeared to be a

greater biomass of zooplankton at this transect, compared to northern transects as expected. *Noctiluca* also appeared to occur at this station.

Saturday 21 November

Arrived at the 150m contour on the Diamond Head line and deployed Diamond Head mooring C 1235 at 31 46S, 153 05E in 150m of water. This mooring consisted of an Aanderaa RCM4 and an FSI-3D current meter. The ship then headed north and deployed mooring Smoky Cape C beginning at 1952 at the Smoky Cape 150m contour. Following this the ship moved to the Urunga section where light traps were deployed at 50m depth, and Neuston nets and MiniBAT tows were taken. CTD64 (50m), CTD65 (100m), CTD66 (50m) and CTD67 (100m) were also taken. Neuston and MiniBAT tows were conducted off Urunga at the 50m, 100m, 50m, and 100m stations during the night, before steaming back to Smoky Cape.

Sunday 22 November

Light traps were deployed at just the 50m station, and were retrieved at 0600. Three of the four traps functioned well, but only a few larval fish were caught. With light traps recovered the Franklin moved south to the Smoky Cape section and began a repeat standard CTD transect beginning with CTD68 at 25m, and ending with CTD76 at 880m. No nutrients were taken on this transect. Moorings were built through the day and deployed at 1930pm at Smoky B in 100m depth, and Smoky A at 2030pm in 50m depth. Vertical haul samples were conducted along the Smoky Cape CTD transect at CTD70 (75m), CTD71 (100m), CTD73 (200m), CTD76 (1000m).

The EZ net was connected, and after transit to the Urunga section, a number of EZ net tows were taken. No insurmountable problems were encountered in setting up, and we began the first tow at the 100m station at around 2330. Three 500um mesh nets were fitted (with a fourth for spare), which were towed for 10 min. at 2-3 knots at 80-50m depths, 50-30m and 30-10m. A 100um mesh net was inserted inside the top EZ net to sample for *Noctiluca*. Simultaneously we collected three Neuston net samples, the first being dedicated for liquid nitrogen collections (RNA-DNA analysis). Further EZ tows were conducted at the 50m station (at 40-30m, 30-20m, 20-10m), and again at 100m and 50m stations, finishing at dawn (0500). Larval yellowtail, anchovy and tailor were removed from the first Neuston tows at each station (and the fourth EZ net on the last tow), and frozen in liquid nitrogen for condition analysis. We then departed for Point Plomer. A beautiful SST image was received for 21 November showing textbook EAC activity, as it departed the coast at Point Plomer.

Monday 23 November

At 0530 the ship headed south toward the Point Plomer section, riding a 3kt East Australia Current. On arrival at the 500m depth contour, an ADCP run was made inshore to Point Plomer. Then a repeat Point Plomer CTD section was begun with CTD77 at 25m, and ending at CTD83 at 300m. The Franklin then returned to the 100m

contour and began EZ net tows through the night.

Along the Point Plomer CTD transect, vertical hauls for phytoplankton were made at CTD79 (75m), CTD80 (100m). An ADCP transect was conducted from the 500m station to inshore. After completing the 300m station, we conducted 5 EZ net/Neuston net tows off Point Plomer at the 50m, 100m, 50m, 100m, and 50m stations. A large number of yellow tail larvae (*Trachurus*) were taken from the Neuston and top EZ net tow and frozen.

Tuesday 24 November

At 0530 the ship headed further south, toward Diamond Head, beginning a repeat section starting with CTD84 in 25m, and ending with CTD91 in 300m. The ship then returned to the coast at about 1620 undertaking an ADCP run, and arriving about 1850. A mooring was then deployed at 1903 (Diamond AA in 25m depth), followed by mooring Diamond A at 1955 (in 50m depth), and Diamond B at 2045 (in 95m depth).

Along the Diamond Head CTD transect we conducted vertical hauls at CTD86 (75m), CTD87 (100m), CTD89 (200m). *Noctiluca* was found abundantly at the nearshore end of this transect. After laying moorings off Diamond Head, we completed EZ net/Neuston net tows at the 50m, 100m, 50m and 100m stations. Further samples of larval yellow tail were frozen. Rain squalls were encountered throughout the night but we completed the sampling and then began the transit to Port Hacking.

Wednesday 25 November

On completion of the night time biosampling the ship headed south to the Port Hacking transect, arriving at 1900. On arrival at Pt Hacking (1900) we conducted bottle casts using the uncalibrated CTD at the 100m, 50m, and 100m stations (CTD92, 93, and 94). *Noctiluca* were abundant in nearly all depths, down to at least 50m. As these dinoflagellates eat and divide during the early hours of the morning, these collections should determine if there are preferred prey species, and optimal depths for cell division. Each cast was followed by a Neuston tow.

At 2200, the bottle casts continued at the 50 and 100m stations (CTD95, 96, 97, 98) and were followed by four EZ net/surface Neuston net tows (during wind and rain, up to 25kt), finishing at 0500. During the night, swells caused some concern regarding cable tension, and the second last tow was not successful with the two bottom nets entrapped behind some bars.

Thursday 26 November

Two further CTD casts were made at the 50 and 100m stations (CTD99, 100), before commencing the Port Hacking transect at around 0630 (CTD101 at 66 m) to CTD107 (to 500m, finishing at 1430). Replicated 5 min Neuston tows were conducted after each CTD. An ADCP run back in commenced at 8 kt, and we then conducted CTD casts

(CTD108 – CTD115) and surface net tows from 1700 to 0400 Friday. Four MiniBAT tows were also conducted at the 50 and 100m stations during the night. A MiniBAT profile was conducted until 0600.

Friday 27 November

On completion of night biosampling, Franklin took on a pilot and docked at Darling Harbour at 0900.

Personnel

Scientists

Professor Jason Middleton	University of New South Wales (Chief Scientist)
Dr Iain Suthers	University of New South Wales
Jocelyn Delacruz	University of New South Wales
David Ghisolfi	University of New South Wales
Greg Nippard	University of New South Wales
Richard Piola	University of New South Wales
Moninya Roughan	University of New South Wales
Augy Syahailatua	University of New South Wales
Penny Ajani	Environment Protection Authority of NSW
Dave Terhell	CSIRO ORV (Cruise Manager, Hydrochemistry)
Bernadette Heaney	CSIRO ORV (Computing)
Alan Poole	CSIRO ORV (Electronics)

Crew

Neil Cheshire	Master
Arthur Staron	First Mate
John Lynch	Second Mate
David Mylius	Chief Engineer
Gordon Gore	First Engineer
Andrew McLagan	Electrical Engineer
Phil French	Greaser
Jannik Hansen	Bosun
Norm Marsh	AB
Travis Broadhurst	AB
Bill Hughes	AB
Gary Hall	Chief Cook
Tom Condon	Second Cook
Ron Culliney	Steward

Table 1. EZ net tows

File name	Area/bathymetry(m)	Date/time UTC
FR149802	Urunga/100	22 Nov./12:50
FR149803	Urunga/50	22 Nov./14:30
FR149804	Urunga/100	22 Nov./16:13
FR149805	Urunga/50	22 Nov./17:31
FR149806	Pt.Plomer/50	23 Nov./10:23
FR149807	Pt.Plomer/100	23 Nov./11:47
FR149808	Pt. Plomer/50	23 Nov./13:16
FR149809	Pt. Plomer/100	23 Nov./14:45
FR149810	Pt. Plomer/50	23 Nov./16:34
FR149811	Diamond Hd.(100)	24 Nov./10:53
FR149812	Diamond Hd.(50)	24 Nov./12:28
FR149813	Diamond Hd.(100)	24 Nov./14:18
FR149814	Diamond Hd.(50)	24 Nov./15:59
FR149815	Pt. Hacking (50)	25 Nov./11:18
FR149817	Pt. Hacking (100)	25 Nov./13:14
FR149818	Pt. Hacking (50)	25 Nov./15:05
FR149819	Pt. Hacking (100)	25 Nov./16:42

Table 2. CTD Log FR14/98

UNSW CTD LOG FR 14/98							
Cast #	Transect Name	Depth (m)	Date (UTC)	Time (UTC) start	Time (UTC) stop	Latitude	Longitude
1	Port Hacking	20	14 11 98	4:30	4:36	34 05 00	151 11 03
2	Port Hacking	45	14 11 98	5:24	5:32	34 35 49	151 11 48
3	Port Hacking	75	14 11 98	6:50	7:02	34 06.15	151 12 48
4	test						
5	test						
6	test					34 07.54	151 13.64
7	Port Hacking	105	14 11 98	13:00	13:17	34 07.04	151 13.00
8	Port Hacking	130	14 11 98	13:46	13:58	34 08.90	151 15.32
9	Port Hacking	140	14 11 98	14:27	14:30	34 10.88	151 17.76
10	Port Hacking	150	14 11 98	15:04	15:19	34 13.11	151 20.00
11	test	200	14 11 98	15:52	15:56	34 15.91	151 22.85
12	test	200	14 11 98	16:31	16:36	34 15.65	151 22.89
13	Port Hacking	198	14 11 98	16:56	17:12	34 15.44	151 22.90
14	dud!						
15	Port Hacking	105	14 11 98	18:38	18:46	34 07.02	151 13.06
16	Urunga	25	16 11 98	19:27	19:36	30 30.28	153 03.34
17	Urunga	50	16 11 98	20:21	20:34	30 31.53	153 08.97
18	Urunga	75	16 11 98	21:07	21:24	30 32.27	153 13.33
19	Urunga	100	16 11 98	21:55	22:11	30 32.56	153 15.39
20	Urunga	150	16 11 98	22:50	23:10	30 33.31	153 19.74
21	Urunga	200	16 11 98	23:45	0:00	30 33.33	153 20.63
22	Urunga	300	16 11 98	1:18	1:38	30 33.89	153 22.45
23	Urunga	1000	16 11 98	2:23	2:50	30 35.03	153.24.36
24	Urunga	2000	16 11 98	3:56	5:12	30 34.85	153 26.46
25	Urunga	2000	16 11 98	5:14	5:18	30 36.40	153 25.74
26	Urunga (night)	100	16 11 98	10:23	10:41	30 32.56	153 15.57
27	Urunga (night)	50	16 11 98	12:38	12:56	30 33.03	153 09.11
28	Urunga (night)	100	16 11 98	14:23	14:47	30 33.46	153 15.57
29	Urunga (night)	50	16 11 98	16:28	16:46	30 33.08	153 09.03
30	Smoky Cape	25	16 11 98	22:48	23:00	30 55.38	153 03.02
31	Smoky Cape	50	16 11 98	23:24	23:38	30 55.25	153 06.71
32	Smoky Cape	75	17 11 98	0:10	0:25	30 55.45	153 07.99
33	Smoky Cape	100	17 11 98	1:27	1:47	30 56.05	153 10.03
34	Smoky Cape	150	17 11 98	2:59	3:21	30 57.15	153 14.12
35	Smoky Cape	200	17 11 98	3:47	4:15	30 58.20	153 15.22
36	Smoky Cape	300	17 11 98	5:29	5:42	Dud cast	
37	Smoky Cape	300	17 11 98	5:43	6:15	30 58.15	153 16.72
38	Smoky Cape	500	17 11 98	6:53	7:27	30 58.08	153 19.60
39	Smoky Cape	1000	17 11 98	7:57	8:42	30 58.37	153 20.82
40	Smoky Cape N	120	17 11 98	13:13	13:44	30 56.83	153 12.51
41	Smoky Cape N	50	17 11 98	14:35	14:56	30 55.30	153 06.84
42	Smoky Cape N	100	17 11 98	16:10	16:29	30 55.85	153 10.13
43	Pt Plomer	25	17 11 98	20:00	20:13	31 18.99	152 59.54

44	Pt Plomer	50	17 11 98	20:36	20:51	31 19.31	153 01.09
45	Pt Plomer	75	17 11 98	21:33	21:54	31 19.74	153 03.79
46	Pt Plomer	99	17 11 98	22:27	22:46	31 19.83	153 05.65
47	Pt Plomer	150	17 11 98	23:48	0:13	31 21.42	153 10.21
48	Pt Plomer	200	18 11 98	1:02	1:26	31 22.03	153 11.12
49	Pt Plomer	300	18 11 98	2:36	3:08	31 23.64	153 14.26
50	Pt Plomer	500	18 11 98	4:11	4:37	31 24.90	153 17.08
51	Diamond Head	50	19 11 98	19:02	19:17	31 44.36	153 53.42
52	Diamond Head	25	19 11 98	19:57	20:11	31 43.53	152 49.80
53	Diamond Head	75	19 11 98	20:47	21:05	31 44.24	152 55.24
54	Diamond Head	100	19 11 98	22:02	22:21	31 44.95	153 00.84
55	Diamond Head	150	19 11 98	23:33	23:56	31 45.72	153 05.55
56	Diamond Head	200	20 11 98	0:30	0:51	31 45.84	153 07.23
57	Diamond Head	300	20 11 98	1:47	2:17	31 46.33	153 09.88
58	Diamond Head N	50	20 11 98	7:12	7:37	31 44.04	152 53.21
59	Diamond Head N	100	20 11 98	9:10	9:34	31 44.85	153 00.67
60	Diamond Head N	50	20 11 98	11:31	11:47	31 44.23	152 53.60
61	Diamond Head N	100					
62	Diamond Head N	50					
63	Diamond Head N	100	20 11 98	17:37	17:57	31 45.02	153 01.00
64	Urunga (night)	50	21 11 98	12:06	12:27	30 31.87	153 09.94
65	Urunga (night)	100	21 11 98	13:59	14:23	30 32.56	153 15.54
66	Urunga (night)	50	21 11 98	15:42	15:59	30 32.27	153 10.34
67	Urunga (night)	100	21 11 98	17:36	17:56	30 32.61	153 15.54
68	Smoky Cape	25	21 11 98	21:34	21:43	30 55.35	153 00.00
69	Smoky Cape	50	21 11 98	22:03	22:14	30 55.40	153 06.70
70	Smoky Cape	75	21 11 98	22:34	22:47	30 55.45	153 08.02
71	Smoky Cape	100	21 11 98	23:19	23:22	30 55.98	153 09.98
72	Smoky Cape	150	22 11 98	0:20	0:41	30 57.44	153 14.00
73	Smoky Cape	200	22 11 98				
74	Smoky Cape	300	22 11 98	2:40	3:07	30 58.85	153 16.56
75	Smoky Cape	500	22 11 98	3:56	4:31	30 57.85	153 19.62
76	Smoky Cape	1000	22 11 98	5:16	5:45	30 58.42	153 20.89
77	Point Plomer	25	23 11 98	1:07	1:09	31 19.01	152 59.45
78	Point Plomer	50	23 11 98	1:44	1:55	31 19.47	153 01.13
79	Point Plomer	75	23 11 98	2:30	2:44	31 19.58	153 03.90
80	Point Plomer	100	23 11 98	3:18	3:36	31 19.99	153 05.64
81	Point Plomer	150	23 11 98	4:41	5:04	31 21.26	153 10.00
82	Point Plomer	200	23 11 98	5:30	5:55	31 21.67	153 11.43
83	Point Plomer	300	23 11 98	7:47	8:21	31 22.34	153 14.47
84	Diamond Head	25	23 11 98	22:26	22:28	31 43.37	152 49.35
85	Diamond Head	50	23 11 98	23:06	23:17	31 43.99	152 53.27
86	Diamond Head	75	23 11 98	23:37	23:39	31 44.26	152 55.28
87	Diamond Head	100	24 11 98	0:39	0:41	31 45.04	153 00.61
88	Diamond Head	150	24 11 98	1:40	1:55	31 46.90	153 05.02
89	Diamond Head	200	24 11 98	2:29	2:47	31 47.53	153 06.67
90	Diamond Head	300	24 11 98	3:50	4:10	31 47.15	153 09.79
91	Diamond Head	500	24 11 98	4:56	5:22	31 47.7	153 13.96
92	Port Hacking N	100	25 11 98	7:55	8:06	34 06.88	151 12.91

93	Port Hacking N	50	25 11 98	8:49	9:02	34 05.46	151 11.51
94	Port Hacking N	100	25 11 98	9:42	10:01	34 06.96	151 12.89
95	Port Hacking N	50	25 11 98	10:43	10:57	34 05.53	151 11.69
96	Port Hacking N	100	25 11 98	12:46	13:02	34 06.96	151 12.84
97	Port Hacking N	50	25 11 98	14:32	14:51	34 05.68	151 11.52
98	Port Hacking N	100	25 11 98	16:15	16:29	34 06.87	151 12.79
99	Port Hacking N	50	25 11 98	18:02	18:14	34 05.82	151 11.81
100	Port Hacking N	100	25 11 98	19:01	19:16	34 06.87	151 12.83
101	Port Hacking	66	25 11 98	19:53	20:05	34 05.84	151 11.84
102	Port Hacking	75	25 11 98	20:32	20:34	34 05.97	151 11.98
103	Port Hacking	100	25 11 98	21:54	22:08	34 06.85	151 12.85
104	Port Hacking	150	25 11 98	23:49	0:04	34 13.99	151 20.96
105	Port Hacking	200	26 11 98	1:09	1:26	34 16.36	151 22.42
106	Port Hacking	300	26 11 98	2:14	2:34	34 17.58	151 23.98
107	Port Hacking	500	26 11 98	3:12	3:43	34 19.46	151 25.81
108	Port Hacking N	50	26 11 98	6:37	6:54	34 05.65	151 11.44
109	dud						
110	Port Hacking N	100	26 11 98	7:32	7:53	34 06.92	151 12.85
111	Port Hacking N	50	26 11 98	8:57	9:05	34 05.72	151 11.71
112	Port Hacking N	100	26 11 98	9:56	10:20	34 06.92	151 12.85
113	Port Hacking N	50	26 11 98	11:12	11:30	34 05.64	151 11.74
114	Port Hacking N	100	26 11 98	12:20	12:47	34 06.94	151 12.87
115	Port Hacking N	50	26 11 98	13:52	13:54	34 05.71	151 11.34
116	Port Hacking N	100	26 11 98	15:01	15:12	34 06.84	151 12.79

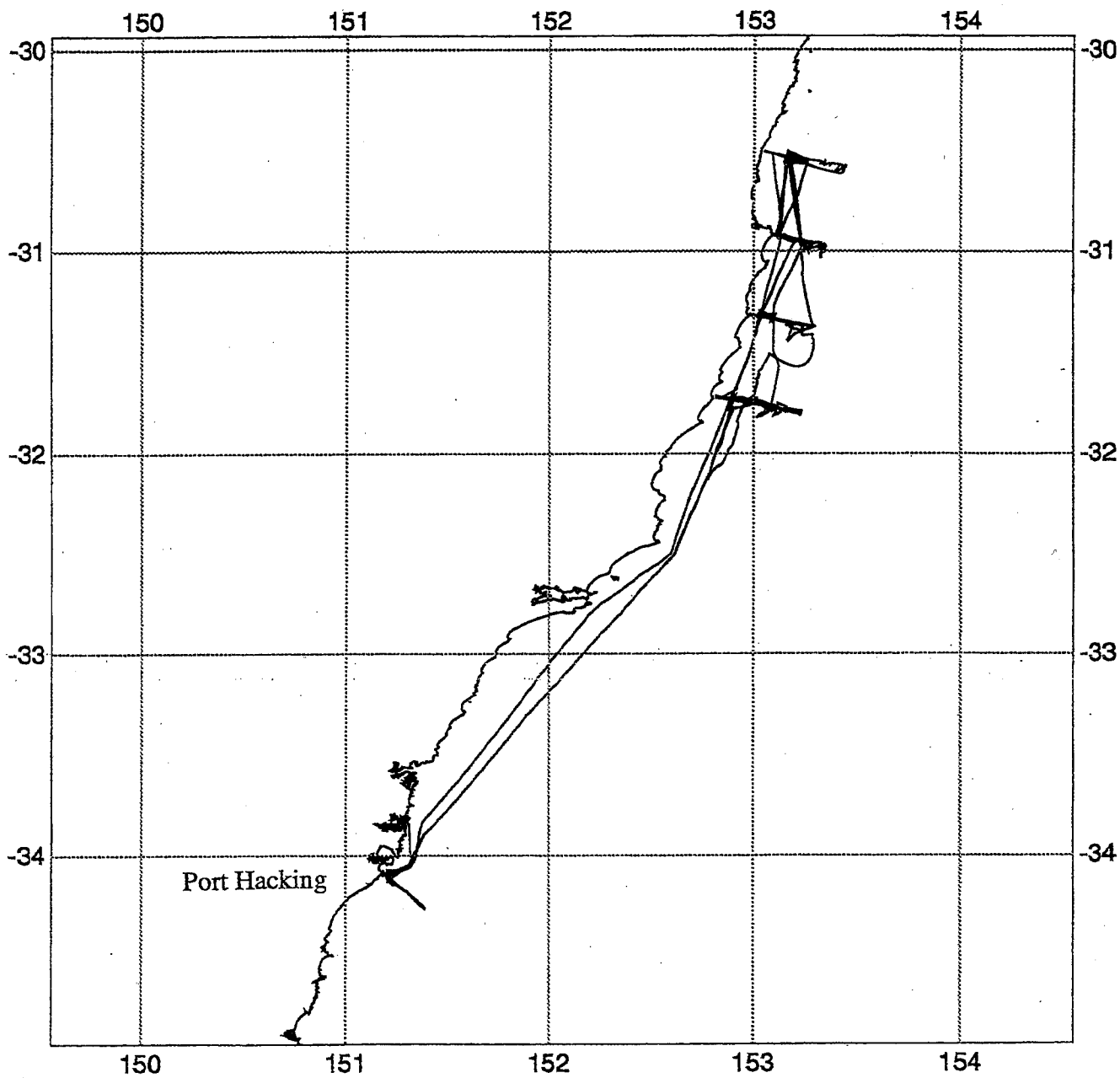


Figure 1. Cruise Track FR14/98