RESEARCH SUMMARY

CRUISE FR 8/92

Sailed	Brisbane	1400 hrs	Wdenesday 7 October 1992
Arrived	Townsville	1100 hrs	Tuesday 20 October 1992

Principal Investigators

Dr Iain Suthers
Associate Professor Jason Middleton
Centre for Marine Research
University of New South Wales

LARVAL FISH ASSOCIATED WITH FLOW DISTURBANCE ABOUT ISOLATED REEFS

November 1992

RESEARCH SUMMARY FR 8/92

1. Itinerary

Sailed from Brisbane: 1400 hrs, Wednesday 7 October 1992
Arrived at Townsville: 1100 hrs, Tuesday 20 October 1992

2. Scientific Program

The overall objectives were to examine the physical and biological oceanography around two isolated reefs in the Coral Sea: Cato Reef (23°S, 155°E) and Wreck Reef (22°S, 155°E). Currents in the region associated with the East Australian Current flow past these steep–sided reefs, creating a wake in the lee of the reefs which brings nutrients up into the euphotic zone and stimulates production of planktonic algae. This enhanced production is presumed to flow up the food chain to larval fish.

The objectives were thus:

2.1 To undertake physical measurements delineating the flow patterns in the region of the reefs, in order to determine the magnitude and extent of the wakes. These measurements were to include ADCP (Acoustic Doppler Current Profile) transects, CTD (Conductivity, Temperature and Depth) profiles and nutrient samples. In addition, current meter moorings were to be deployed in October near the crest of each of the reefs to monitor flow patterns until retrieved during the February cruise, FR2/93.

2.2 To determine phytoplankton abundance and productivity about each reef, and to relate these results to the physical measurements.

2.3 To obtain EZ net and surface samples in the wake of the reefs and in the free stream during both day and night, and to relate the health and abundance of larval fish to the physical environment and primary production.

3. Principal Investigators

Dr. Iain Suthers and Associate Professor Jason H. Middleton
Centre for Marine Science, University of New South Wales

4. Results

The physical component of the program essentially met all the original objectives. Strong currents of speed about 1 m/s were observed to impinge on both Cato and Wreck Reefs. In the case of Cato Reef, currents flowed from the east–northeast, resulting in extensive wakes to the southwest of the reefs. These wakes were evident firstly in the ADCP data, secondly in the CTD data, and lastly in the nutrient data.

Fluorescence profiles revealed subsurface maxima of phytoplankton biomass at various depths. Where a thermocline was present in the top 150 m the fluorescence maximum was associated with the thermocline. The contribution of net–, nano– and picoplankton to total phytoplankton biomass will be determined from acetone extractions of fractionated samples collected during the cruise. The rate of primary production will be determined from experiments run during the cruise using ^{14}C. The results for this component will have to wait until the samples are analysed using a scintillation counter in the laboratory, as racks were not available on *Franklin*.

The EZ net proved to have some initial installation–related electronic difficulties as a consequence of not having operated on *Franklin* for some time. These were overcome by Dave Edwards. In addition there were problems with the quality of the nets supplied since they were old and had numerous holes. Adroit work by Dave Wright rectified these problems. A third problem concerned

deployment in rough weather, as the vertical motion of the stern of the *Franklin* during recovery in mild to moderate weather resulted in the net being jerked rapidly through the water. This had the effect of ripping the nets and ripping off the cod–ends.

Plankton samples were dominated by myctophid fish and salps. A strong diel vertical migration was evident with zooplankton biomass greatest in the surface nets at night, and greatest in the bottom EZ net (105 m) by day. Any difference in zooplankton biomass and icthyoplankton abundance awaits analysis between samples from wake flow and clear stream flow.

5. Cruise Narrative

Wednesday, October 7, 1400: Sailed from No.2 Hamilton Wharf, Brisbane, tracking toward Cato Reef with light seas and 15 kt winds from the southeast.

Thursday, October 8, 1030: The lifeboat and safety briefing was given. At 1400 we began CTD Stations 1 and 2 to 1000 m to test the Niskin bottles and the CTD operation. All proved satisfactory. Arrived in the vicinity of Cato Reef at 2130 and began an ADCP survey to determine the wake structure behind Cato Reef. We found the incident current to be flowing toward the southwest, at between 30–50 cm/s. The survey continued through the night, delineating the width of the overall wake to about 20 nm downstream.

Friday, October 9, 0001: Continued the ADCP survey and prepared moorings to be deployed on the crest of Cato Reef. These were deployed in the following sequence. At 0724 we deployed mooring A in 22 m depth, range 2.0 nm, bearing 101°T to the northwest tip of Cato Island. Then followed CTD Station 3 just to the southwest of the Reef (in the wake). At 1008 we deployed mooring B in 33 m depth, range 2.18 nm, bearing 241°T to Cato Island. Both moorings A and B will remain until the February cruise. At 1115 mooring C was deployed in 55 m depth, range 5.35, bearing 228°T to Cato Island, followed at 1205 by mooring D in 55 m depth, range 3.85 nm, bearing 174°T to Cato Island, and at 1323 by mooring E in 58 m depth, range 4.86 nm, bearing 089°T to Cato Island. All moorings were deployed in a safe and expeditious manner with the help of scientists and crew. At 1708 we began CTD Station 4, the first of a line of stations planned to be across the wake and perpendicular to the mean flow. Some doming of isopycnals was evident, with stronger isopycnal slopes being consistent with the observed ADCP currents. The line of stations was completed just before midnight at CTD station 8. At this stage the wind had completely dropped and the sea had become so glassy we could see the surface tension ripples caused by the surface neuston feeding at the surface microlayer.

Saturday, October 10, 0016: We began a second line of CTD stations running from the southeast side of the wake toward the northwest. These stations were numbered from 9 to 15. Again, flow disturbance thought to be the wake of Cato Reef was noted in both the CTD temperature sections to 500 m, and the ADCP vectors at both 50 and 200 m depths. Stations 16 to 20 followed in the third line of CTDs, completing the survey in the lee of Cato Reef. At the completion of Station 20 at 1920 the ship headed toward the northeast to begin an ADCP and CTD section which would circumnavigate Cato Reef at a distance of about 10 nm from the 200 m contour. This proceeded through the night, with Stations 21 and 22 completed before midnight. A successful EZ net test was held at 2000, isolating minor electronic problems. Net repairs began on the holed nets. Currents remained strong to the southwest during this time, with seas still glassy and nil wind.

Sunday, October 11, 0016: Completed CTD Stations 23 to 26 through the night, circumnavigating Cato Reef. The ADCP data confirmed the incident flow to be coming from the east–northeast, with speeds approaching 100 cm/s (2 knots) in the free stream. Repositioning to the immediate vicinity of the southwest corner of Cato Reef (location the same as CTD Station 6) allowed the first primary productivity station (CTD Station 27) to be taken at 0745. At the same location (EZ location A) the first EZ net tow was undertaken at 0922 along with surface nets and drop nets.

EZ net deployments consisted of fine (333 micron) and coarse (1050 micron) mesh nets over depth intervals of 15–45 m, 45–75 m and 75–105 m. During the EZ net tows, fine and coarse surface nets tows were towed by the forward boom, and retrieved using a lazy line from the hydro–wire A–frame. This proved most satisfactory even in rough weather (25 kt winds). A 64 micron drop net was deployed at the end of each tow. Successive EZ net tows were undertaken at times of 1140, 1430 and 1630 at EZ locations B and C in the wake. Although some minor problems persisted with the net–trip indicators, all net tows occurred according to plan. CTD Station 28 was undertaken at 1900, following which the ship returned to EZ net location C (CTD Station 17) for EZ net tow 5. This was undertaken successfully at 2057 and was followed at 2300 with EZ net drop number 6 at location B. Conditions remained ideal with the swell dropping practically to zero, and winds remaining very light.

Monday, October 12, 0001: EZ net tows 7 (location A), 8 (A), 9 (E) and 10 (D) were completed at times of 0140, 0345, 0950 and 1220. At daybreak the wind started to rise and after the 0800 CTD for primary productivity (CTD 30) the EZ net operations proved more difficult. At noon, the EZ net was retrieved with a number of nets damaged and with several cod ends lost. Operations on the EZ net were then suspended. An XBT survey (beginning with XBT 1) and ADCP survey was begun, circumnavigating Cato Reef in a clockwise direction. This continued through the night. Results indicated a continued strong incident current, impinging on Cato from an east–northeast direction, although originating perhaps 10 degrees further to the east than before. The wake appeared to remain in the southwesterly quadrant from the Reef, and there was strong evidence of disturbed flow in the wake, with currents appearing to flow in a variety of directions and at speeds of less than 40 cm/s. Outside the wake, free stream currents appeared to have speeds approaching 100 cm/s as before.

Tuesday, October 13: The XBT and ADCP survey was completed at about 0900 with XBT 15 and a primary productivity CTD (CTD 30) and a regular CTD (31) were taken. Because of the marginal weather, it was decided to pick up the temporary moorings named C, D and E from the crest of Cato Reef. This was completed without incident by 1200. Preliminary results from the temporary moorings suggest that such moorings on the reef crest are a reasonable indicator of the overall incident flow. Then followed a number of replicated surface net tows at locations F, E and D, with CTD Station 32 taken at 1724.

Wednesday, October 14: The surface net tows continued through the night at EZ locations A, B and C and at 0700 a primary productivity CTD (Station 33) was undertaken at EZ site B. Following this the ship departed for Wreck Reef, with a short XBT section across the wake of Cato Reef being accomplished with XBT Stations 16–21. A CTD and ADCP survey was begun at 1400 with CTD Station 34. This continued through the night, circumnavigating Wreck Reef anticlockwise at a distance of about 15nm from the Reef. A surface chlorophyll patch was noted at CTD Stations 35, 36 and 37, these corresponding also to larger sub–surface maxima in the fluorescence profiles.

Thursday, October 15: The CTD and ADCP survey circumnavigating Wreck Reef was completed with CTD Station 47 at 0935. CTD Station 48 was taken at 1350 at EZ net location H, (the same location as CTD station 37) and the chlorophyll patch observed the previous day remained evident. Then followed EZ net tows at locations H (tow 11 at time 1438), at I (tow 12 at 1921) and at H (tow 13 at 2204). CTD Station 49 was taken at 1646.

Friday, October 16: In the early morning EZ nets were taken at EZ locations G (tow 14 at time 0045) and at H (tow 15 at 0255). The ship then turned to track west toward Bird Island on the eastern edge of Wreck Reef, and mooring F was deployed at 0637 in 60 m of water. This was followed by a primary production CTD Station (50) at 0830, and a suite of EZ net tows at location H (tow 16 at 1020), at location I (tow 17 at 1243), at location G (tow 18 at 1551). Evening EZ net tows were then conducted at location J (tow 19 at 1925), location K (tow 20 at 2133) and at location L (tow 21 at 2347).

Saturday, October 17: The day began with an early morning EZ net tow (tow 22) at 0207 at location *K* and CTD Station 51 was taken at the same location at 0340. The ship then steamed toward the western edge of Wreck Reef where a mooring was deployed at 0626. Following this a primary productivity CTD station (CTD No. 52) was taken at 0730. Then followed a sequence of EZ net tows at location *J* (tow 23 at 0900), location *K* (tow 24 at 1050), location *L* (tow 25 at 1310) and location *K* (tow 26 at 1517). The ship then steamed west to begin an ADCP survey circumnavigating the reef.

Sunday, October 18: The ship continued the ADCP survey, stopping for two short CTD stations at 1745 (CTD 53) and at 1000 (CTD 54) for primary productivity studies. The ADCP survey was completed and the ship set course for Townsville at 1100.

Monday, October 19: In transit to Townsville through the Capricorn Channel, inside the Great Barrier Reef.

Tuesday, October 20: Berthed at Townsville at 1100.

6. Summary

The circulation in the vicinity of Cato Reef was governed by a steady flow incident to the reef from the east–northeast at about 1 m/s. this created a large wake region to the southwest characterised by highly variable currents and doming of the isotherms by up to 50 m. Preliminary results from the nutrient analyses indicate that nutrient concentrations were below detectable limits in the surface waters although they rose significantly near the fluorescence maximum which varied between 45 and 100 m depth. A detailed description of the dependence of the nutrient fields on the structure of the water column and on the circulation awaits provision of the calibrated data.

Temporary current meter moorings deployed for 3 days in 30–60 m of water on the crest of Cato Reef also showed a strong southwesterly flowing current, with little tidal component. Two additional moorings were deployed on Cato reef, to be retrieved during the February cruise (FR2/93).

The circulation about Wreck Reef was less clear, despite this reef being circumnavigated three times. Observed currents were highly variable both in space and time. It is anticipated that remotely sensed sea–surface temperature data from the NOAA 11 radiometer will aid in the interpretation of this data. Two moorings were deployed on Wreck Reef for retrieval during the February cruise, one near Bird Island to the east and one near West Island to the west.

During the first 24 h a large surface chlorophyll patch was observed to the southwest, apparently associated with an increase in the mixed depth layer to the high fluorescence.

EZ net and surface net tows were conducted along 2 transects at each reef – a "wake" transect, and an "oceanic" transect. Each transect had 3 stations ranging from 2–15 nm from the reef. At each station, fine and coarse zooplankton was collected at the surface, 15–45 m, 45–75 m and 75–105 m deep during both day and night. In total 25 tows were made of the 48 planned tows – 10 at Cato and 15 at Wreck. Some stations were replicated during both day and night. Samples were dominated by myctophid fish and salps – it is unclear yet whether the wake stations had a greater biomass of zooplankton. Larval fish abundance may have been reduced by the full moon. Preliminary analysis will be made before the February cruise to determine the utility of day plankton tows, and the degree of variability of replicate tows. As expected, the day surface tows had very little zooplankton while the nutricline appears a focal area for phyto– and zooplankton biomass. During the February 1993 cruise we will concentrate on the wake/oceanic comparison and thermocline regions, to determine the influence of nutrient limitation on the health of larval fish and zooplankton. For this it is anticipated we will have new 333 micron mesh EZ nets and a line–haul winch for the drop net.

Thanks to Don Gordon and the ship's personnel for their support in undertaking a variety of tasks

in a professional and friendly manner. We wish Don good luck in his new ventures. Thanks also go to Dave Edwards, Jeff Dunn, Bob Griffiths and Dave Wright for their scientific and technical support, which was of the highest quality, enabling us to undertake tasks with equipment that at times needed some nursing, and also for their ever congenial company.

7(a) Scientific Personnel

Jason Middleton (University of New South Wales), (*Chief Scientist*)

Iain Suthers (University of New South Wales)

Greg Nippard (University of New South Wales)

Richard Manasseh (University of New South Wales)

Mike Lowry (University of New South Wales)

Anthony Macks (University of New South Wales)

Tom Trnski (Australian Museum)

Rick Royle (Monash University)

Dave Edwards (CSIRO), (*Cruise Manager*)

Jeff Dunn (CSIRO)

Dave Wright (CSIRO)

Bob Griffiths (CSIRO)

7(b) Crew

Don Gordon (*Master*)

Dick Dougal (*First Mate*)

Bryce Bathe (*Second Mate*)

Peter Noble (*Chief Engineer*)

Peter Harding (*Second Engineer*)

John Browne (*Electrician*)

Jannick Hansen (*Bosun*)

Bluey Hughes (*Able Seaman*)

Norm Marsh (*Able Seaman*)

Kris Hallen (*Able Seaman*)

Phil French (*Greaser*)

Garry Hall (*Chief Cook*)

Bob Clayton (*Second Cook*)

Steve Corridon (*Chief Steward*)

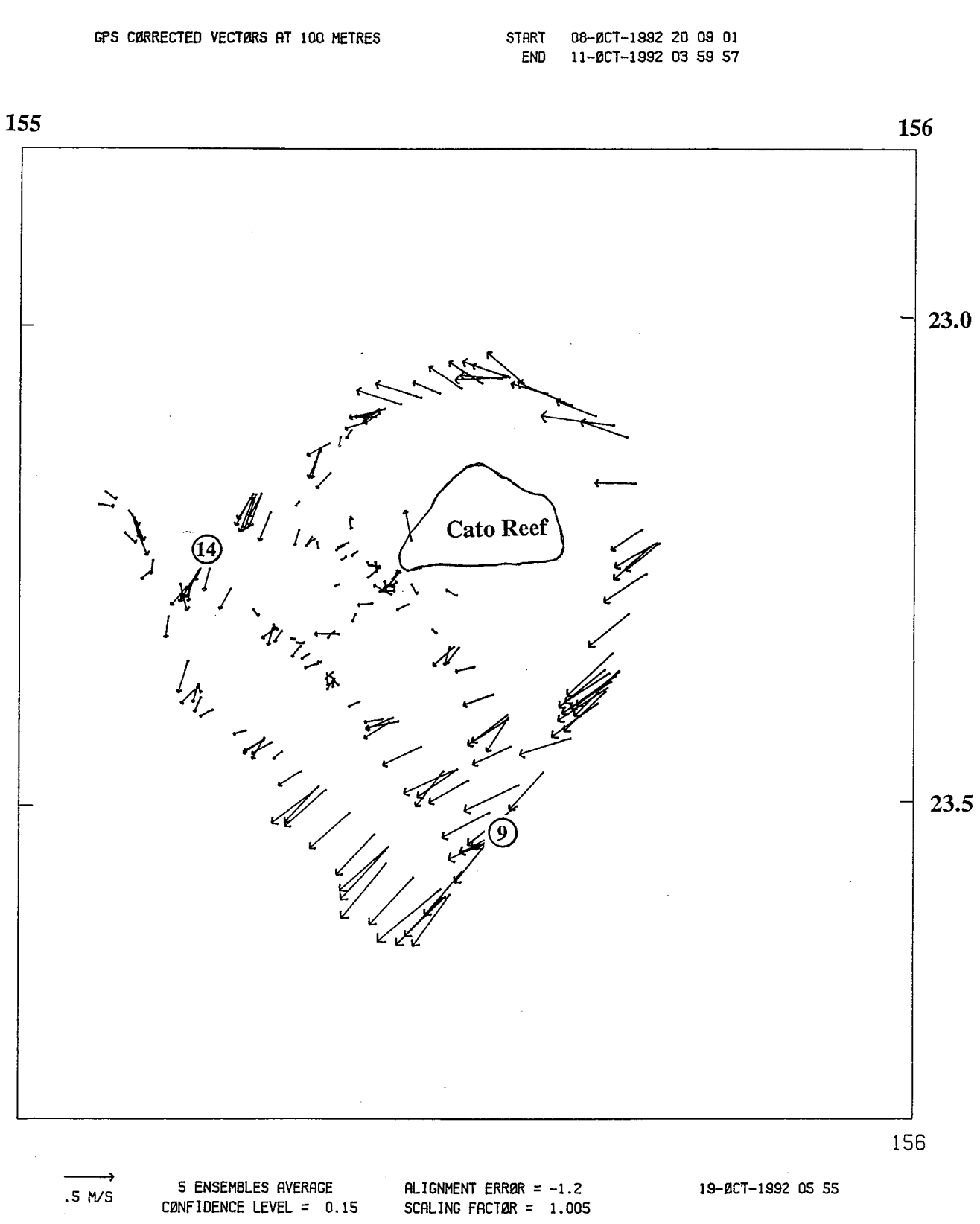

Figure 1. Current vectors around Cato Reef at 100 m depth acquired from the Acoustic Doppler Current Profiler, showing the average current incident from the east-northeast, and the confused wake to the southwest of the Reef. Also shown are the locations of CTD Stations 9 and 14, these lying at the ends of the temperature section shown in Figure 2.

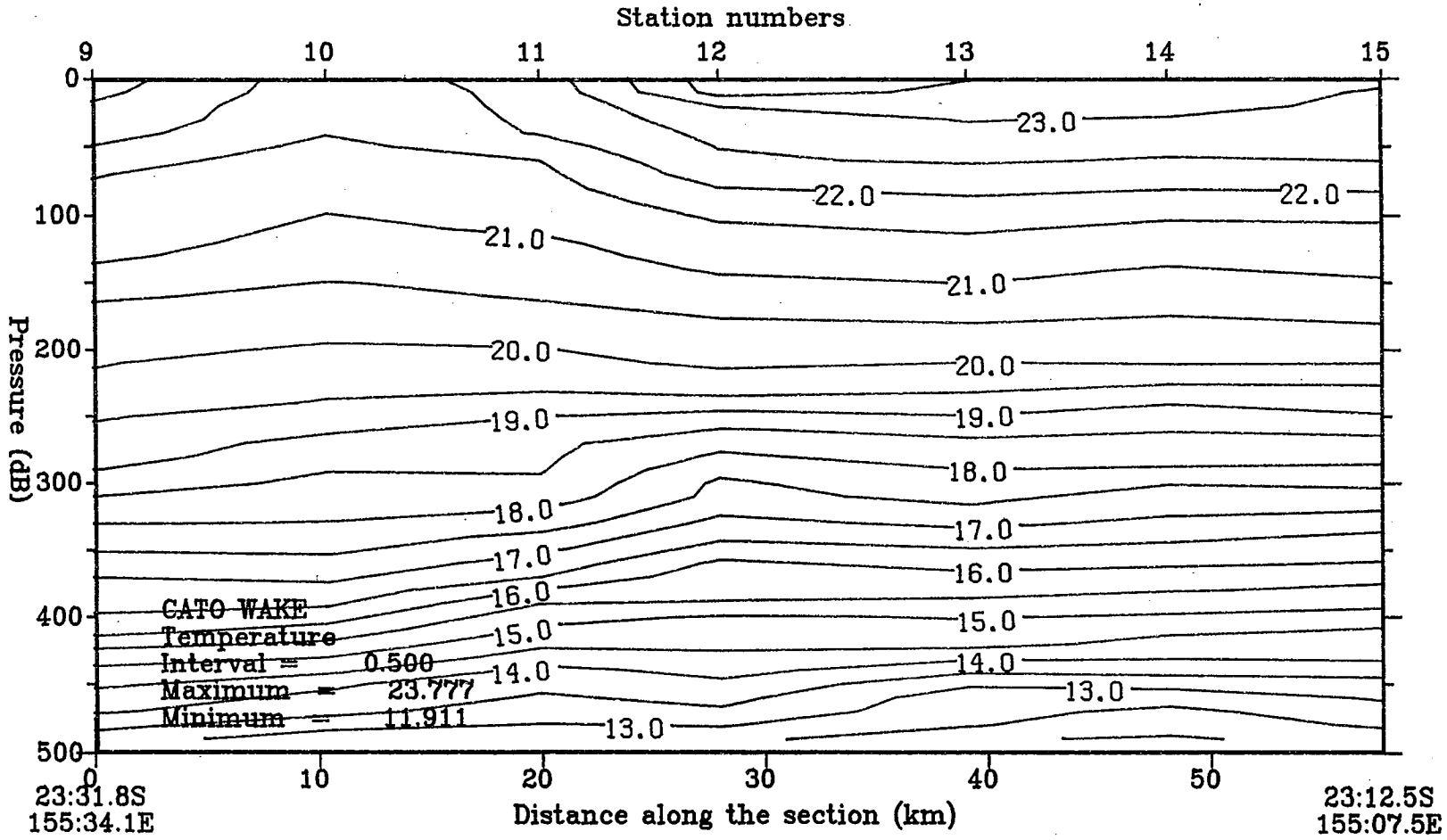

Figure 2. A temperature section taken across the Cato Reef wake, showing the strong uplift of isotherms between Stations 9 and 12.

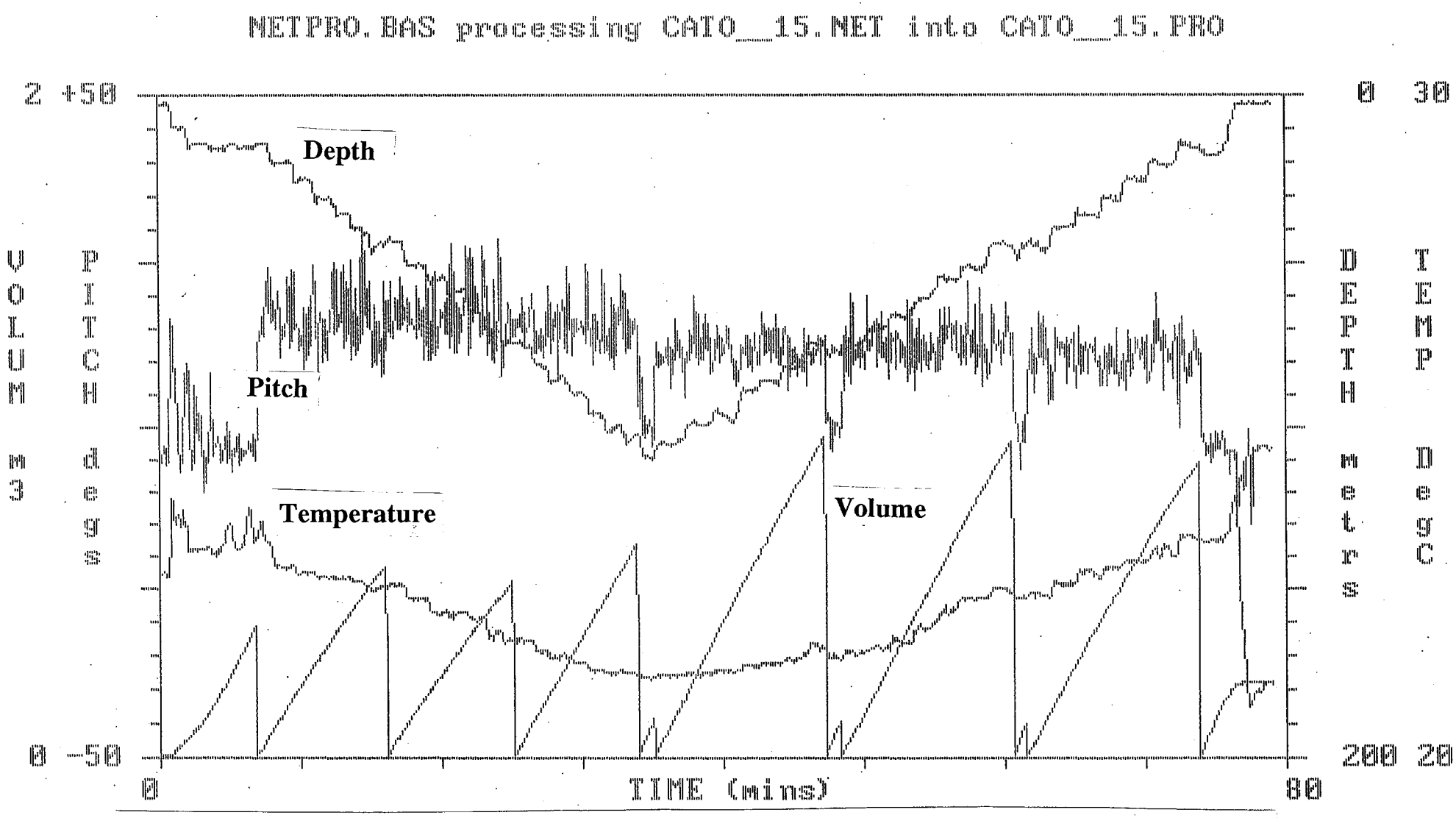

Figure 3. An example of the display trace accompanying an EZ net tow. The staircase plot is the depth of the net; the very noisy plot shows the net pitch; the sawtooth represents the volume filtered for each net, while the smoothest of the plots represents the temperature in degrees C.

CTD LOG

CTD Station	Lat.	Long	Time/Date (utc)	Time/Date (local)	Total Depth
1	24°15.72	155°17.96	0445/08 October	1445/08 October	4125
2	24°15.72	155°17.96	0510	0510	4125
3	23°17.36	155°24.94	2220	0820/09 October	1274
4	23°11.08	155°15.87	0708/09 October	1708	1991
5	23°13.92	155°19.67	0841	1841	1626
6 (A)	23°17.03	155°24.37	1005	2005	1280
7	23°20.73	155°29.01	1128	2128	1591
8	23°24.89	155°32.89	1247	2247	1567
9	23°31.84	155°34.17	1416/09 October	0016/10 October	1787
10	23°28.28	155°29.22	1540	0140	
11	23°25.07	155°25.06	1650	0250	
12 (B)	23°22.77	155°21.00	1840	0440	1715
13	23°18.58	155°16.28	2012	0612	2021
14	23°15.43	155°12.24	2140	0740	2506
15	23°12.51	155°07.51	0120/10 October	1120	2953
16	23°23.07	155°12.02	0300	1300	
17 (C)	23°26.50	155°16.25	0433	1433	1982
18	23°29.40	155°19.99	0611	1611/10 October	2063
19	23°33.01	155°24.89	0735	1735	2062
20	23°35.89	155°29.07	0859	1859	2200
21	23°22.15	155°40.43	1236	2236	1296
22	23°14.15	155°42.92	1440	0040/11 October	1338
23	23°07.01	155°40.93	1608	0208	1418
24	23°03.96	155°32.89	1727	0327	1315
25	23°05.95	155°24.04	1856	0456	1260
26	23°08.45	155°20.07	2015	0615	1757
27	23°16.96	155°24.23	2145	0745	1278
28	23°18.95	155°07.18	0858/11 October	1858	2910
29 (D)	23°17.07	155°36.84	2030	0630/12 October	917
30	23°19.94	155°42.84	2152	0752	1344
31	23°19.19	155°42.21	2240	0840	1340
32 (F)	23°23.18	155°48.68	0724/13 October	1724/13 October	1528
33	23°26.57	155°16.16	2149	0749/14 October	2157
34	22°24.89	155°19.98	0402/14 October	1402	3120
35	22°24.99	155°30.08	0542	1542	3070
36	22°22.09	155°36.84	0702	1702	2994
37 (H)	22°14.96	155°41.90	0831	1831	3062
38	22°07.02	155°42.08	0955	1955	3127
39	22°00.00	155°36.95	1122	2122	3155
40	21°55.03	155°29.95	1259	2259	3183
41	21°55.07	155°20.09	1436	0036/15 October	4364
42	21°55.07	155°09.99	1613	0213	2729
43	22°00.03	155°03.96	1738	0338	3244
44	22°06.91	155°00.00	1903	0503	3250
45	22°14.86	155°00.00	2034	0634	3266
46	22°21.98	155°04.00	2214	0814	3312
47	22°25.01	155°09.90	2335	0935	3261
48 (H)	22°14.51	155°41.70	0347/15 October	1347	3064
49 (I)	22°14.71	155°52.11	0646/15 October	1646	2252
50	22°14.52	155°41.90	2230/15 October	0830/16 October	3066
51 (K)	22°00.00	155°19.95	1737/16 October	0337/17 October	3221
52	22°06.23	155°15.73	2133/16 October	0733/17 October	1368

EZ NET LOG

EZ Drop No.	Time/Date (utc)	Time/Date (local)
1(A)	2322/10 October	0922/11 October
2(B)	0140/11 October	1140
3(C)	0430	1430
4(C)	0638	1638
5(C)	1057	2057
6(B)	1300	2300
7(A)	1540	0140/12 October
8(A)	1745	0345
9(E)	2350	0950
10(D)	0220/12 October	1220/12 October
11(H)	0438/15 October	1438/15 October
12(I)	0921	1921
13(H)	1204	2204
14(G)	1445	0045/16 October
15(H)	1655	0255
16(H)	0020/16 October	1020
17(I)	0243	1243
18(G)	0551	1551
19(J)	0925	1925
20(K)	1133	2133
21(L)	1347	2347
22(K)	1607	0207
23(J)	2300	0900/17 October
24(K)	0050/17 October	1050
25(L)	0310	1310
26(K)	0517	1517

EZ NET LOCATIONS

A	23°17.5	155°24E
B	23°23	155°21
C	23°26	155°16
D	23°17	155°37
E	23°20'	155°43
F	23°23	155°49
G	22°14.7	155°35
H	22°15.0	155°42
I	22°15.0	155°52
J	22°05	155°20
K	22°00	155°20
L	21°50	155°20

XBT LOG

XBT Station	Lat.	Long.	Time/Date (utc)	Time/Date (local)	Depth (m)
1	Aborted (Bad XBT) readjust lat, lon & graph axes				
2	no hard copy for station 1.				
3	23°01.25(S)	155°37.76(E)	0841/12 October	1841/12 October	1552
4	23°05.43	155°45.80	1006	2006	1471
5a	23°10.32	155°48.98	1143	2143	1630
5b	23°16.32	155°48.98	1143	2143	1630
6	23°24.93	155°47.49	1254	2254	1503
7	23°30.48	155°37.48	1359	2359	1594
8	23°30.10	155°26.15	1458	0058/13 October	1879
9	23°18.82	155°16.44	1617	0217	2038
10	23°11.90	155°16.10	1700	0300	1960
11	23°03.53	155°21.13	1801	0400	1942
12	22°59.00	155°29.31	1859/12th October	0459	1578
13	23°00.75	155°39.61	2006/12th October	0606	1548
14	23°08.23	155°43.99	2106 no hard	0706	1455
15	23°16.34	155°46.81	2203 copy	0803	1517
16	23°19.66	155°17.12	2307/13 October	0907	
17	23°15.16	155°17.45	2332/13 October	0932	1970
18	23°12.40	155°17.61	2347/13 October	0947	1822
19	23°06.24	155°17.73	0018/14 October	1018	2442
20	23°03.26	155°17.65	0033/14 October	1033	2205
21	22°57.21	155°17.38	0106/14 October	1106	2500