RESEARCH SUMMARY

CRUISE FR 9/93

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|---|---|---|---|---|
| Sailed | Sydney | 2000 | Thursday | 9 December 1993 |
| Arrived | Sydney | 2130 | Friday | 17 December 1993 |

# SYDNEY OUTFALLS INTERDISCIPLINARY STUDIES

**Principal Investigators**

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# DISTRIBUTION OF METALLIC AND ORGANIC CONTAMINANTS IN SHELFAL SEDIMENTS, CENTRAL NSW

**Principal Investigator**

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SYDNEY OUTFALLS INTERDISCIPLINARY STUDIES

**Scientific Objectives**

- Use chemical methods to "fingerprint" and trace sewage in coastal waters adjacent to Sydney.
- Undertake biodegradation experiments of sewage effluent material to determine the relative stability and persistence of specific marker compounds in the marine environment.
- Develop further indices using organic markers to accurately quantify and monitor sewage input in the marine environment. These data will be compared to data from techniques currently used for monitoring sewage outfalls (faecal coliform and other viral and bacterial viral sewage microorganisms).
- To determine the physical oceanographic features in coastal waters off Sydney through the measurement of vertical and horizontal profiles of S, T, currents, transmissivity and fluorescence.
- Assess re suspension of marker compounds and faecal microorganisms (viral, protozoa and bacteria) from sediments off Malabar and at a reference site near south of the Sydney region.
- Determine the prevalence of heavy metal- and antibiotic resistant bacteria in marine sediments.
- Collect zoo plankton and determine, by major group, their heavy metal content.
- To map the distribution, fate and impact of Sydney's sewage effluent using the combined chemical, micro biological, biological and physical oceanographic data.

**Cruise objectives**

- Conduct regular CTD stations and underway ADCP measurements along the cruise track.
- Deploy and recover chemistry moorings; one at site of DOOM and one at DOOB.
- Collect water, sediments and plankton at stations along the NSW coast, including in the Sydney region.
- Collect underway surface water temperature, salinity, and fluorescence data.
- Conduct underway ADCP transects to the 1000 m contour in addition to the continuous ADCP measurements routinely performed. Transects will be perpendicular to the coast.
- Provide appropriate sample collection and preparation facilities for external organisations (AWT-Science and Environment, Sydney Water Board and University of Sydney) undertaking collaborative studies with the Division of Oceanography.

DISTRIBUTION OF METALLIC AND ORGANIC CONTAMINANTS IN SHELFAL SEDIMENTS, CENTRAL NSW, AUSTRALIA

## Scientific Objectives

- To delineate the nature, concentration and provenance of organic and metallic contaminants in surficial shelf sediments located adjacent to the urban and industrial centres of Wollongong, Sydney and Newcastle.
- To establish present baseline and historical background data sets and construct a contaminant stratigraphy for the midshelf sediments.
- To study the nature and mechanisms of fixation and release of contaminants from marine sediments.
- To use assemblages of contaminants to identify sources and dispersal pathways for suspended sediments on the open shelf.
- To provide a regional framework for other, more restricted environmental studies.
- To map contemporary sediments on the shelf and determine sedimentological and hydrologic controls of sediment/contaminant dispersal.

## Cruise objective

- Collect sediments at stations along the NSW coast in the Wollongong, Sydney and Newcastle regions.

## Cruise Summary

The commencement of the cruise was delayed due to problems with the ships bow thruster. During dockside testing of the bow thruster after the dry dock work period, further new problems were encountered with the electric motor of the bow thruster. As it would not have been possible to complete repairs to the bow thruster motor within a reasonable period, the cruise was commenced without the use of the bow thruster. The cruise finally commenced at 2000 December 9, (original scheduled, departure 2200 December 7).

The planned deployment of the chemistry moorings near the deep ocean outfalls was not conducted, as their recovery may not have been possible without the ships bow thruster. Apart from the loss of this minor component of the scientific schedule, the cruise proceeded largely as according to the original cruise plan. No further loss of planned activities from the scientific program occurred, due largely to the skill of the master and officers of *Franklin*.

On departing Sydney harbour, we steamed south to commence section T1 off Kiama. Twenty four sections were then occupied perpendicular to the coast between Kiama in the south and Broken Bay in the north. Sections T1-T19 were occupied from south to north. Upon

completion of section T19, we steamed north to section T25 and conducted sections T25 to T20 from north to south.

A total of 155 stations were occupied with surface sediment collected at all sites. Complete details on station locations and sampling details [CTD, chemistry (chemical biomarkers, metals, toxicants), microbiology, zoo plankton] are provided in Table 1 (see also Figure 1). Note that the station number differs from the CTD number as CTD profiles were only performed at approximately half the stations (Table 1). In addition, acquisition of ADCP data was performed for the entire cruise.

Station sampling generally proceeded as follows:
(i) CTD profile and water (hydrology, microbiology and other chemistry) sampling (not all stations),
(ii) sediment grab (all stations),
(iii) zoo plankton tow (sections T1, T2, T3, T10, T12, T14, T16, T23, T24, T25; 0.5, 5 and 20 nm),
(iv) sediment coring (stations #5, #43 and #116 only, multiple cores were taken at these sites).

CTD profiling was conducted and water column sampling (hydrology, chemistry, microbiology) was performed for 13 of the twenty four sections (sections T1, T6, T8, T9, T10, T11, T12, T13, T15, T18, T19, T23 and T25). Representative CTD profiles of temperature, fluorescence, salinity and transmission for station #78 (CTD#47, adjacent to Malabar deep ocean outfall) are shown in Figure 2. A strong transmissometer signal was observed at 35-50 m at station #78. The change in transmissometer signal was not accompanied by an increase in fluorescence, indicating that the signal was not due to increased algal biomass. This signal can be attributed to the rising plume from the deep ocean outfall (see also Figure 3), as it is also accompanied by a decrease in salinity associated with the input the sewage plume.

A decrease in the CTD transmissometer signal was observed in bottom waters at many inner shelf stations, indicating that under the current conditions present during the cruise that sedimentary material is being mobilised in bottom waters. This feature is illustrated in Figure 3 which shows a plot of transmission versus water depth for transect T12 (Malabar transect). Visual examination of particulate matter obtained by filtering bottom waters where there was a decrease in transmission showed a higher density of fine particles present. These observations are consistent with the mobilisation of sedimentary material under the sea conditions experienced during the cruise.

Data are available on sediment transport in the Sydney region. For example, a seabed flux model for the inner shelf region off Sydney has been developed (Gordon and Hoffman 1985). Those authors reported that whilst the dominant steady current is to the south (East Australian Current), seabed shear induced during these southerly events is seldom sufficient to entrain sediment. Rather, transport occurs during short-lived periods of northerly currents resulting from the strong wind gradient produced by intense weather systems in the Tasman Sea.

The observation of sedimentary material (predominately fine particles) in bottom waters in the prevailing weather conditions (mainly fine, wind speeds less than 20 knots) and sea conditions

encountered during December 1993 indicates that transport, at least of fine particles, also occurs during periods of less intensity than suggested by Gordon and Hoffman (1985). As flux measurements were not made during this cruise aboard *Franklin*, the importance of this type of sediment transport relative to that encountered under more extreme conditions cannot be estimated. Particle size measurements of material present in bottom waters during both intense and milder weather conditions would provide further information on sediment transport in the region.

For the CTD sampling, water was collected at 3-5 depths for stations up to 100 m water depth (0, 25, 50, 75, bottom). At stations between 100-1000 m water depth, additional sampling was performed at 200, 500, 750 and 1000 m. Sampling depth was modified based on observation of the transmissivity and fluorescence signals.

Sediment cores (both gravity and box) were collected at three sites (section T1, station #5, section T8, station #43; section T18, station #116). The gravity corer used during the cruise had been recently purchased by *Franklin*. Around 10 cores of up to 1.5 m in length were obtained and the corer is certainly suitable for the type of near-shore, shallow water (up to 100 m) coring performed during this cruise. Extra weight (100 lb)was added to the corer to maximise penetration into the sediment. It is recommended that extra weight be purchased.

To distinguish sources of input to the coastal zone, the isotopic composition of methane within sea water is to be determined from samples collected during the cruise. Samples were collected in two ways; firstly, using a gas extractor (AGSO developed) connected to the *Franklin* thermosalinograph sea water line, and secondly, sea water was collected from Niskin bottles fired just below the surface during CTD casts. Gas samples collected by the two methods were obtained at two locations (stations #34 and #111) for comparative purposes. Station #34 was selected as a site remote from the Sydney region and was located in approximately 700 m water depth. Station #111 was an inshore site (section T17, mouth of Sydney Harbour) in 60 m water that may be impacted by anthropogenic inputs.

Sediment samples were collected from muddy sites (stations #5, #43 #118) using a Soutar type box corer. Sub-cores were obtained from the box cores using 8 cm diameter acrylic tubes. The sampling protocol is shown in Figure 4. Additionally one sub-core was collected at each site, sectioned under nitrogen, the pore waters extracted by centrifugation, and the supernatant and sediment was frozen for the analysis of metals. Laboratory flux measurements of nutrients (nitrogen and phosphorous) and oxygen were conducted on sub-cores from stations #5 and #43 aboard *Franklin*. The flux experiments were undertaken in a laboratory incubator, generally over a12 hour period on three consecutive days. Oxygen consumption rates at station #5 and #43, were 280 $mg/m^2/day$; these results are within the range of data previously observed for sediments in the Sydney region. Following the nutrient flux experiments, cores were sectioned under nitrogen and centrifuged to separate the pore waters. The pore water and solid phase were frozen for subsequent analyses (nutrients, organic carbon, total nitrogen and total phosphate).

Oxygen micro-profiles for sediments (e.g. Figure 5) showed that oxygen is depleted within the top 3 mm at stations #5 and #118, whereas sediment from station #43 is depleted of oxygen by 6

mm. These results are within the range of other results for the Sydney region. In addition to the box core sampling, gravity cores were collected to ascertain sedimentation rates and particle mixing rates within these fine grain sediments. Down-core dating will be conducted using $^{14}C$ and $^{210}Pb$. To compliment these data, samples from the box core will be dated to examine the bioturbation zone (to depths of approximately 25 cm).

Sites additional to those in the original cruise plan were sampled as part of a research contract performed by the Division of Oceanography for the Sutherland Shire Council: Providential Head sites: #45, 46, 47; Cape Banks sites: #57, 58, 66 (circles at mouth of Botany Bay and second innermost site on section from northern headland of entrance to Botany Bay). These sites were within the boundaries of the proposed sand mining zones in these two regions.

Zoo plankton were collected at 30 sites during the cruise. Collection details were as follows: ship speed 2-2.5 knots, wind on starboard side, towing time 10-15 minutes, towing used the ships bow boom and was generally done at night. To accommodate this requirement, location of zoo plankton stations was changed during the cruise, and slight detours between sections were required, particularly in the Sydney region. Many of the zoo plankton samples collected contained large numbers of salps; the reasons for this observation await further data analysis.

Bacteriology on water and sediment samples was undertaken on board *Franklin*. In addition, 100 L samples were concentrated to 1 L and preserved together with 10 L parasite samples at 4 $^{o}C$ on board. The container laboratory was most satisfactory for the level of microbiology performed.

Franklin docked at the CSR wharf in White Bay at 2130 December 17. Visitors from the Sydney Water Board, Sutherland Shire Council and others were provided with brief tours of the vessel.

**General Comment**

The temperature and salinity data from the CTD casts and the current data from the ADCP have been examined in a preliminary manner. The oceanographic features that the data revealed indicated that over the 9 days that *Franklin* was in the Sydney region, currents were extremely variable; currents ranged from 1 knot southward, to weaker on-shore currents, then turned to northward at up to 0.7 knots during the final days of the cruise (Figure 6). The precise implications of these observations with respect to sediment transport on the inner shelf are beyond the scope of this report.

It will be some time before all the data and samples collected during the cruise are analysed in detail. Together the data from this multidisciplinary study will provide a wealth of information on the complex interaction of physics, chemistry and biology (including microbiology) in Sydney's coastal waters. The results will be of use in future management strategies and decisions to be made on the disposal of Sydney's sewerage effluent.

**Scientific Personnel**

| | | |
|---|---|---|
| Peter Nichols | CSIRO Oceanography | Chief Scientist |
| Rhys Leeming | " | |
| Val Latham | " | |
| Jan Peterson | " | |
| Ron Plascke | CSIRO ORV | |
| Dave Edwards | CSIRO ORV | |
| Jeff Dunn | CSIRO ORV | |
| Nick Ashbolt | AWT-Science and Environment, Sydney Water Board | |
| Philip Gibbs | AWT-Science and Environment, Sydney Water Board | |
| Louise Backhouse | AWT-Science and Environment, Sydney Water Board | |
| Gary Bickford | AWT-Science and Environment, Sydney Water Board/AGSO | |
| Penjai Sompongchaiyakul | University of Sydney | |

**Ships Crew**

| | |
|---|---|
| Dick Dougal | Master |
| Ian Menzies | |
| Bryce Bathe | |
| Max Cameron | |
| Ian Hayward-Bryant | |
| Don Roberts | |
| Janick Hansen | |
| Kris Hallen | |
| Bluey Hughes | |
| Norm Marsh | |
| Phil French | |
| Reg Purcell | |
| Garry Hall | |
| Bob Clayton | |

**Acknowledgement**

We extend our sincere thanks to the master and crew of *Franklin* and to our fellow CSIRO colleagues and external collaborators for their cooperation and assistance before and throughout the cruise and during preparation of the cruise summary. Val Latham, Dave Vaudrey, Gary Bickford and Jan Peterson kindly assisted with the preparation of Figures. The Division of Oceanography workshop manufactured the Smith-MacIntyre grab that enabled surface sediment to be collected during the cruise.

Peter D Nichols Rhys Leeming George Cresswell

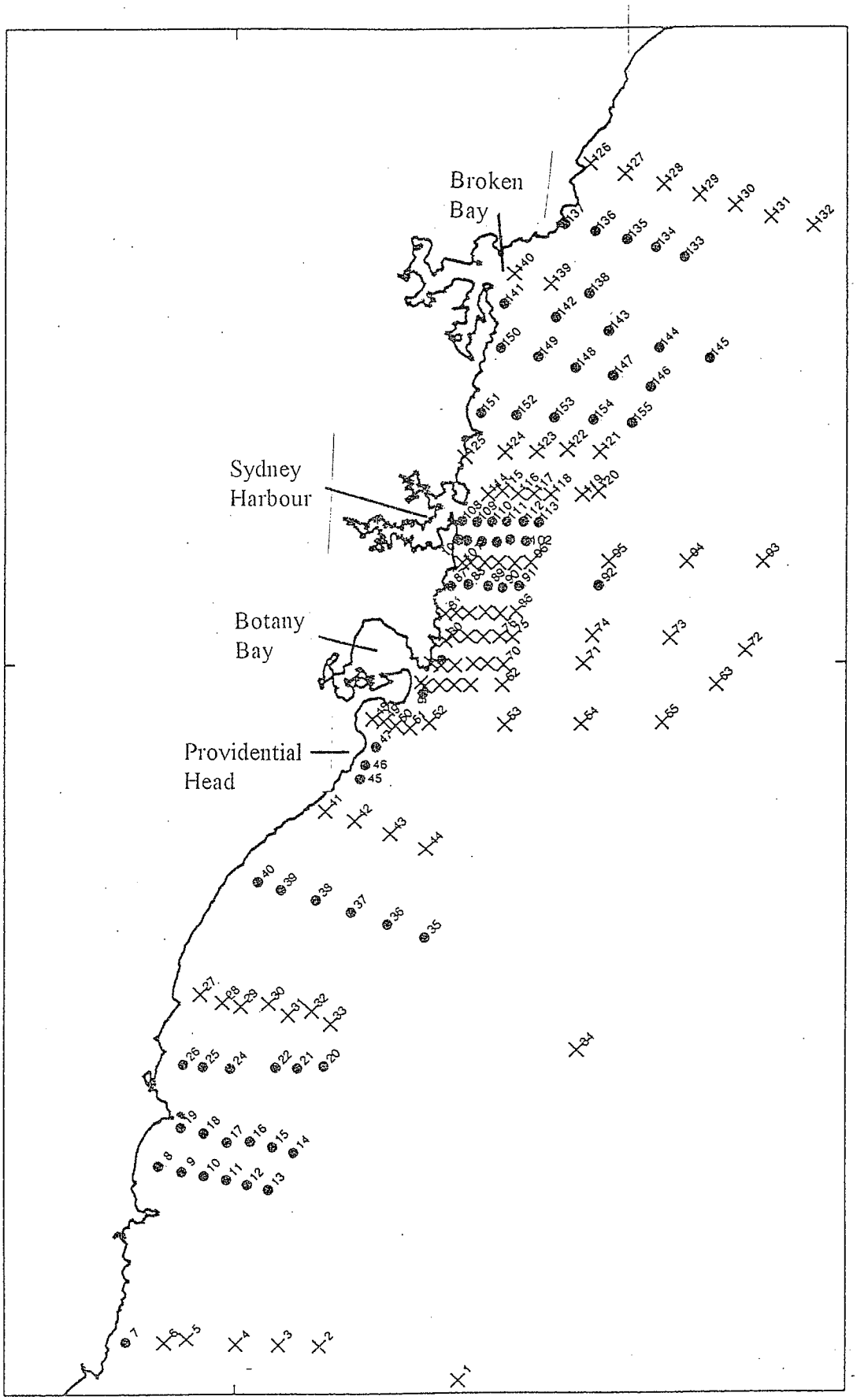




Figure 1. Station locations for *RV Franklin* cruise FR9/93. Station numbers for start and end of sections are indicated. See also Table 1. Crosses denote CTD profiles and sediment collection; circles indicate sediment collection only. Sites additional to those in the original cruise plan were sampled as part of a research contract performed by the Division of Oceanography for the Sutherland Shire Council: Providential Head sites: #45, 46, 47; Cape Banks sites: #57, 58, 66 (circles at mouth of Botany Bay and second innermost site on section from northern headland of entrance to Botany Bay).

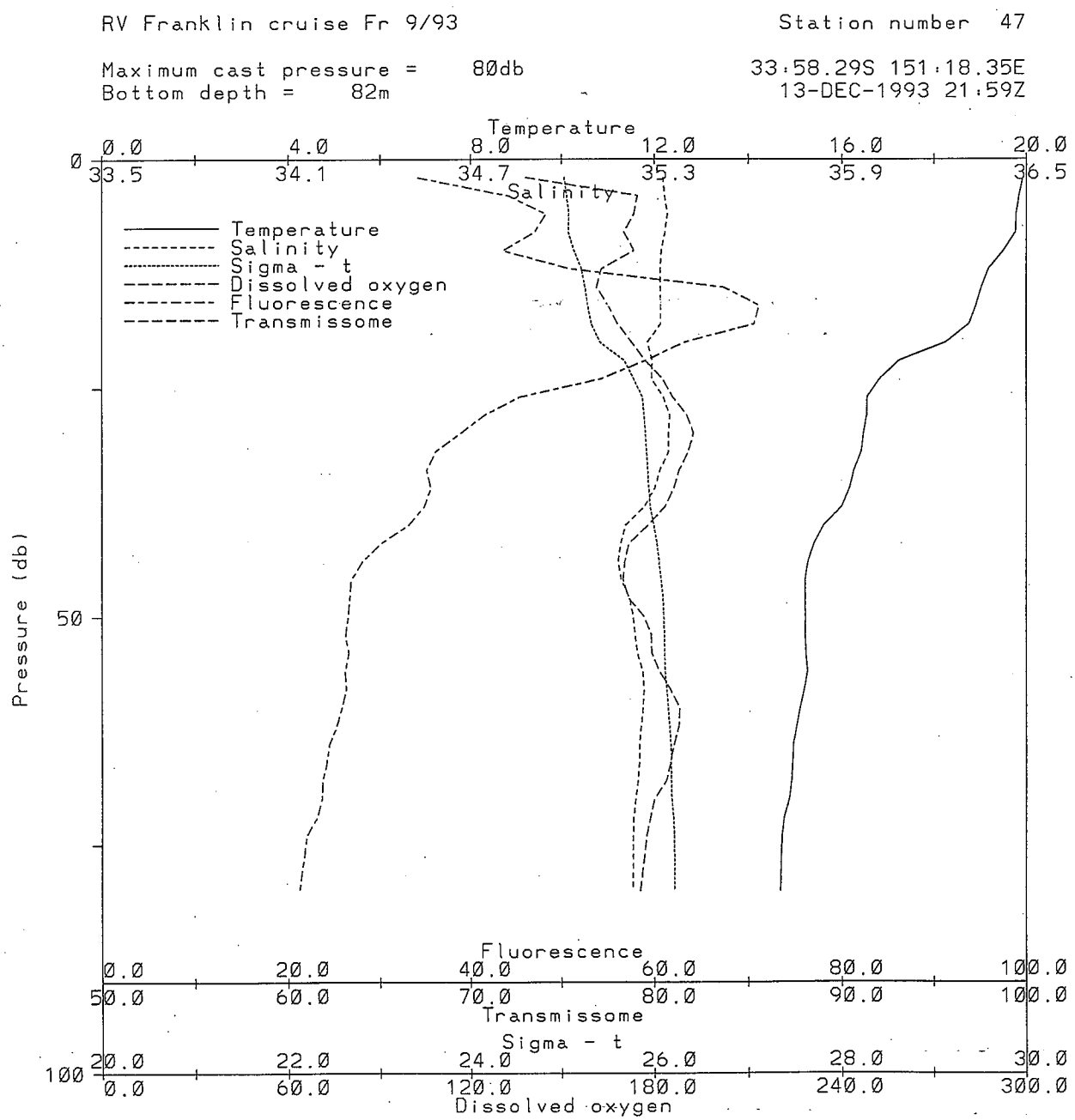


Figure 2. CTD profiles of temperature, fluorescence, salinity and transmission for station #78 (CTD #47).

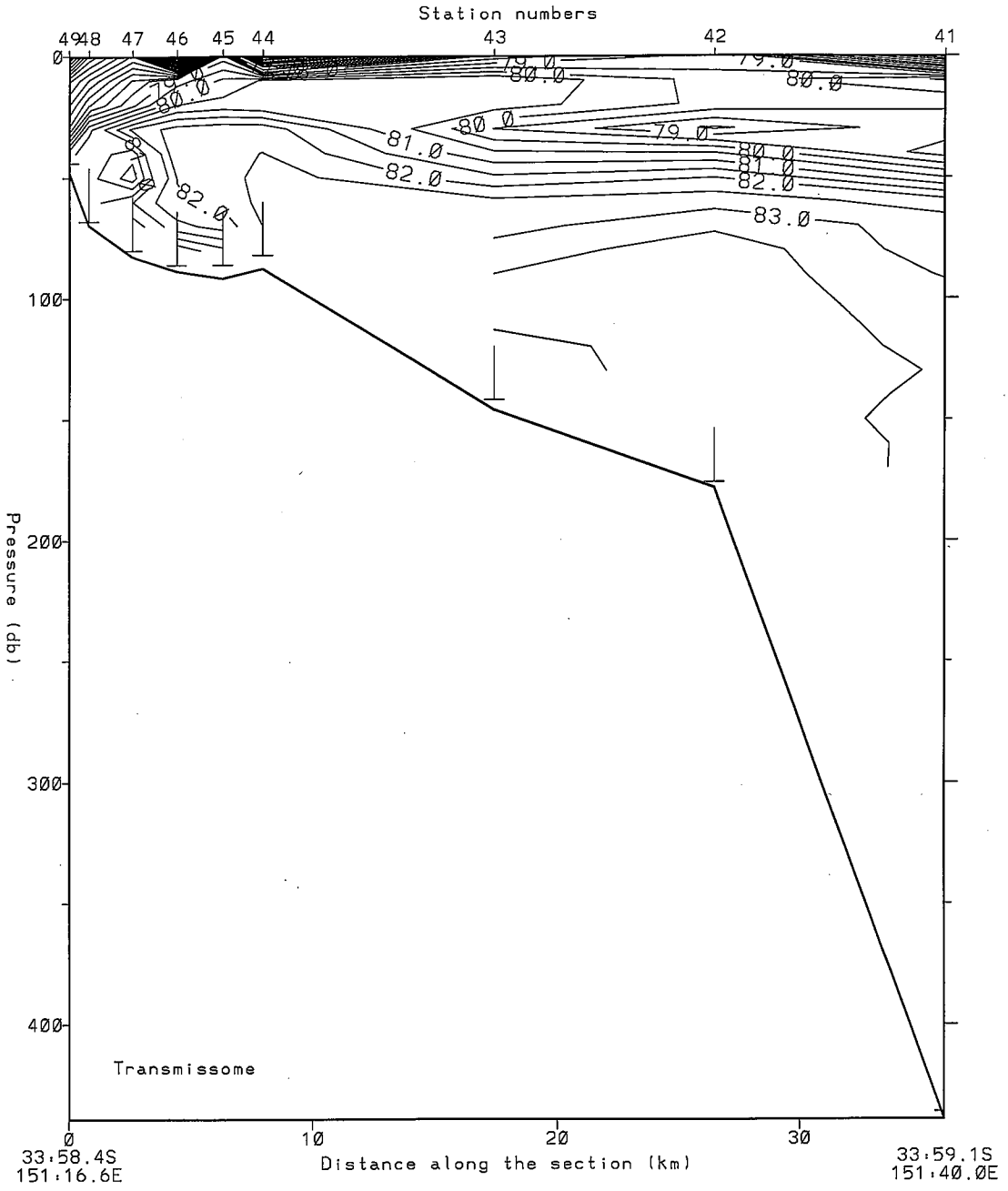


Figure 3. Section T12 off Malabar. Plot of transmissometer signal versus water depth.

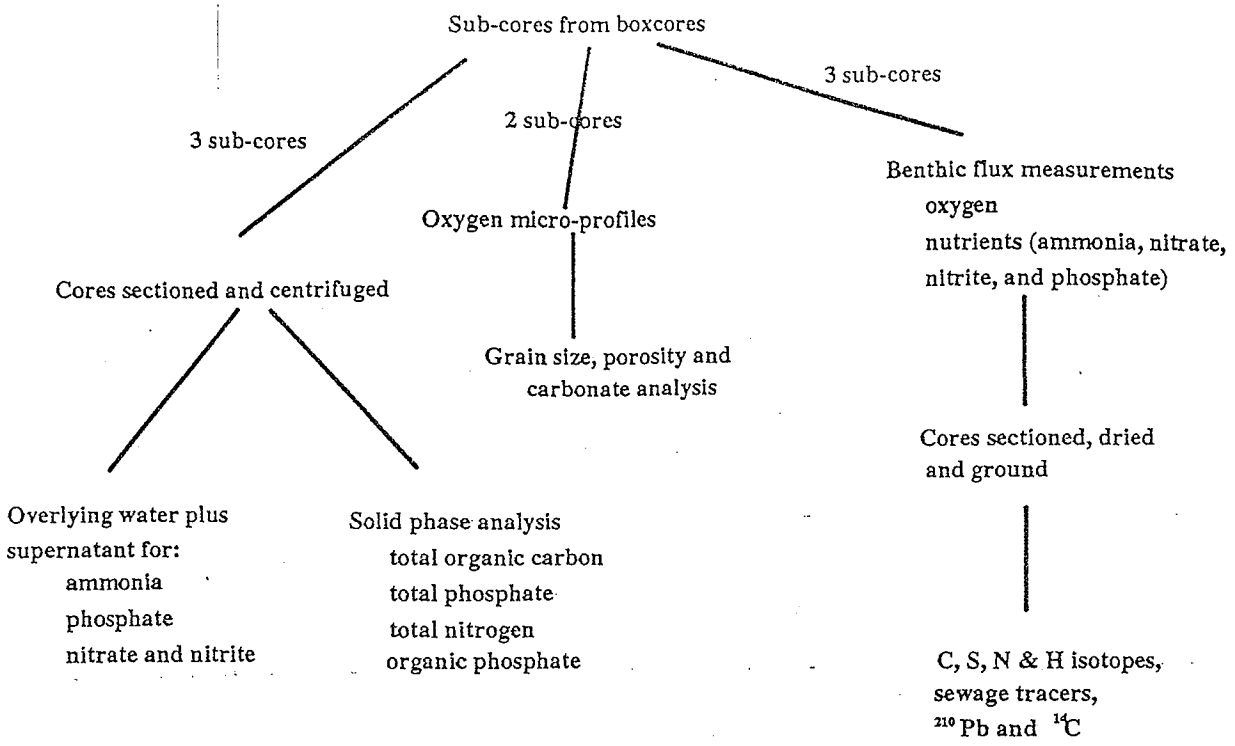


Figure 4. Sampling protocol for subcores collected from box cores. (AGSO).

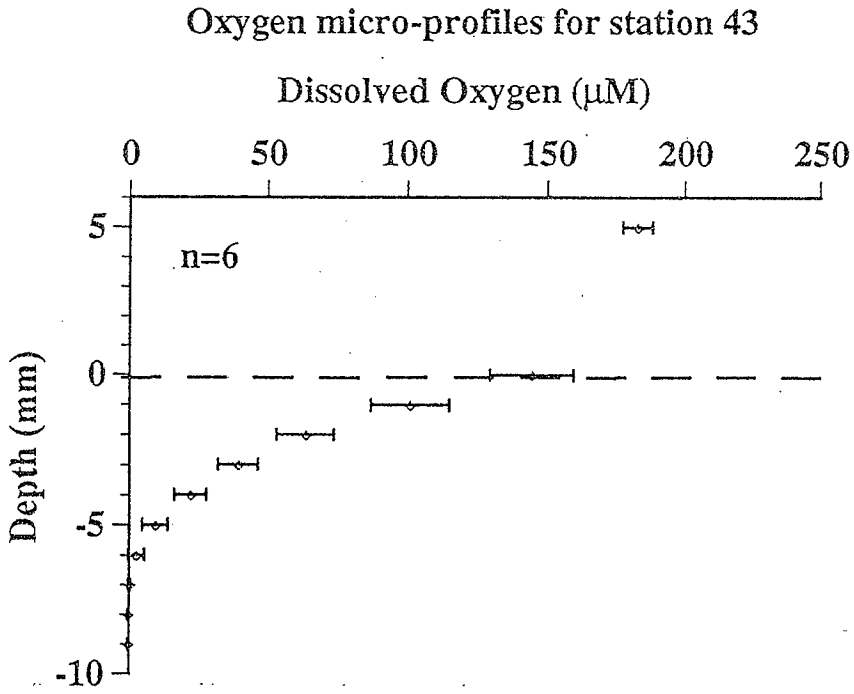


Figure 5. Oxygen micro-profile for sediment at station #43.

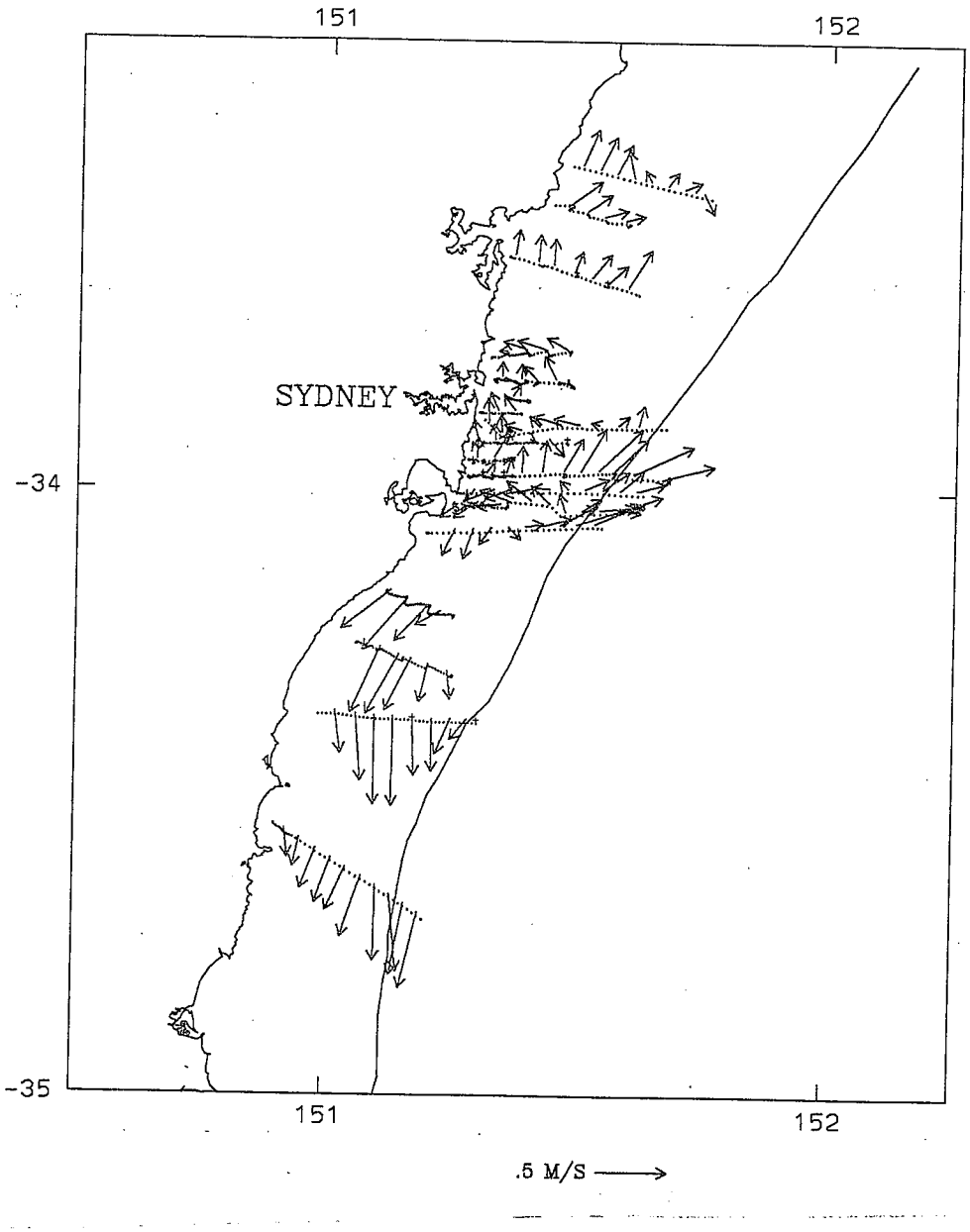


Figure 6. Near-surface current vectors for 18 of the 24 sections completed during RV Franklin cruise FR9/93.

Table 1: FR9/93 station locations and sampling details

| Station No | CTD No | Latitude | Longitude | Date UTC | Time UTC | Water Depth | Hydrology sampling | Sampling Depths | Lipids Water | Sediment | Zoology Plankton net tow | Microbiology Bacto | Virus | Parasite | Total | Box coring | Gravity coring |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Section T1** | | | | | | | | | | | | | | | | | |
| 1 | 1 | 34 47.13S | 151 17.60 | 9/12/93 | 14:22 | 1205 | X | 25, 1202 | X | X | | | | | | | |
| 2 | 2 | 34 44.82S | 151 06.66 | 9/12/93 | 18:46 | 188 | X | 50, 179 | X | X | | | | | | | |
| 3 | 3 | 34 44.74S | 151 03.41 | 9/12/93 | 20:09 | 137 | X | 25, 133 | X | X | | | | | | | |
| 4 | 4 | 34 44.69S | 151 00.04 | 9/12/93 | 21:36 | 124 | X | 50, 121 | X | X | | | | | | | |
| 5 | 5 | 34 44.34S | 150 56.19 | 10/12/93 | 1:18 | 90 | X | 25, 85 | X | X | X | | | | | 2 | |
| 6 | | 34 44.60S | 150 54.41 | 10/12/93 | 3:05 | 68 | | | | X | | | | | | | |
| 7 | 6 | 34 44.56S | 150 51.39 | 10/12/93 | 3:33 | 35 | X | 15, 33 | X | X | X | X | X | X | X | | |
| **Section T2** | | | | | | | | | | | | | | | | | |
| 8 | | 34 33.00S | 150 54.00 | 10/12/93 | 9:00 | 39 | | | | X | X | X | | | X | | |
| 9 | | 34 33.37S | 150 55.80 | 10/12/93 | 9:51 | 59 | | | | X | | | | | | | |
| 10 | | 34 33.64S | 150 57.56 | 10/12/93 | 10:31 | 79 | | | | X | | | | | | | |
| 11 | | 34 33.91S | 150 59.33 | 10/12/93 | 11:08 | 104 | | | | X | | | | | | | |
| 12 | | 34 34.23S | 151 00.94 | 10/12/93 | 11:39 | 120 | | | | X | | | | | | | |
| 13 | | 34 34.55S | 151 02.62 | 10/12/93 | 12:17 | 128 | | | | X | | X | | | X | | |
| **Section T3** | | | | | | | | | | | | | | | | | |
| 14 | | 34 32.13S | 151 04.68 | 10/12/93 | 14:00 | 132 | | | | X | | X | | | X | | |
| 15 | | 34 31.75S | 151 02.99 | 10/12/93 | 14:54 | 128 | | | | X | | | | | | | |
| 16 | | 34 31.40S | 151 01.20 | 10/12/93 | 15:24 | 110 | | | | X | | | | | | | |
| 17 | | 34 31.43S | 150 59.38 | 10/12/93 | 15:52 | 77 | | | | X | | | | | | | |
| 18 | | 34 30.89S | 150 57.56 | 10/12/93 | 16:24 | 55 | | | | X | | | | | | | |
| 19 | | 34 30.49S | 150 55.77 | 10/12/93 | 16:54 | 40 | | | | X | | X | | | X | | |
| **Section T5** | | | | | | | | | | | | | | | | | |
| 20 | | 34 26.55S | 151 07.06 | 10/12/93 | 18:24 | 134 | | | | X | | X | | | X | | |
| 21 | | 34 26.64S | 151 04.97 | 10/12/93 | 19:11 | 117 | | | | X | | | | | | | |
| 22 | | 34 26.56S | 151 03.23 | 10/12/93 | 19:36 | 91 | | | | X | | | | | | | |
| 23 | | 30 26.56S | 151 01.35 | 10/12/93 | 19:57 | 75 | | | | X | | | | | | | |
| 24 | | 34 26.61S | 150 59.67 | 10/12/93 | 20:45 | 48 | | | | X | | | | | | | |
| 25 | | 34 26.55S | 150 57.51 | 10/12/93 | 21:09 | 45 | | | | X | | | | | | | |
| 26 | | 34 26.34S | 150 55.97 | 10/12/93 | 21:32 | 34 | | | | X | | X | | | X | | |
| **Section T6** | | | | | | | | | | | | | | | | | |
| 27 | 7 | 34 21.77S | 150 57.27 | 10/12/93 | 22:41 | 35 | X | 0, 31 | X | X | | | | | | | |
| 28 | 8 | 34 22.33S | 150 59.04 | 10/12/93 | 23:35 | 45 | X | 25, 44 | X | X | | | | | | | |
| 29 | 9 | 34 22.57S | 151 00.48 | 11/12/93 | 0:34 | 51 | X | 25, 51 | X | X | | | | | | | |
| 30 | 10 | 34 22.40S | 151 02.65 | 11/12/93 | 1:34 | 70 | X | 25, 70 | X | X | | | | | | | |
| 31 | 11 | 34 23.17S | 151 04.23 | 11/12/93 | 2:32 | 92 | X | 27, 89 | X | X | | | | | | | |
| 32 | 12 | 34 22.90S | 151 06.11 | 11/12/93 | 3:30 | 114 | X | 37, 110 | X | X | | | | | | | |
| 33 | 13 | 34 23.76S | 151 07.60 | 11/12/93 | 4:32 | 126 | X | 46, 118 | X | X | | | | | | | |
| 34 | 14 | 34 25.48S | 151 26.85 | 11/12/93 | 7:33 | 851 | X | 48, 840 | X | X | | | | | X | | |
| **Section T7** | | | | | | | | | | | | | | | | | |
| 35 | | 34 18.08S | 151 14.99 | 11/12/93 | 16:51 | 143 | | | | X | | X | | | X | | |
| 36 | | 34 17.22S | 151 12.07 | 11/12/93 | 17:25 | 134 | | | | X | | | | | | | |
| 37 | | 34 16.43S | 151 09.17 | 11/12/93 | 18:03 | 121 | | | | X | | | | | | | |
| 38 | | 34 15.61S | 151 06.42 | 11/12/93 | 18:46 | 79 | | | | X | | | | | | | |
| 39 | | 34 14.92S | 151 03.58 | 11/12/93 | 19:15 | 55 | | | | X | | | | | | | |
| 40 | | 34 14.39S | 151 01.76 | 11/12/93 | 20:17 | 43 | | | | X | | X | | | X | | |

Table 1 (continued)

| Station No | CTD No | Latitude | Longitude | Date UTC | Time UTC | Water Depth | Hydrology sampling | Sampling Depths | Lipids Water | Sediment | Zoology Plankton net tow | Bacto | Microbiology Virus | Parasite | Total | Box coring | Gravity coring |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Section T8** | | | | | | | | | | | | | | | | | |
| 41 | 15 | 34 09.73S | 151 07.16 | 11/12/93 | 21:13 | 46 | X | 0, 25, 44 | X | X | | X | | | X | | |
| 42 | 16 | 34 10.40S | 151 09.50 | 11/12/93 | 22:18 | 92 | X | 0, 50, 90 | X | X | | | | | | | |
| 43 | 17 | 34 11.26S | 151 12.27 | 11/12/93 | 23:32 | 118 | X | 0, 25, 115 | X | X | | | | | | 3 | 4 |
| 44 | 18 | 34 12.24S | 151 15.09 | 12/12/93 | 1:02 | 132 | X | 0, 25, 130 | X | X | | X | | | X | | |
| **Metromix** | | | | | | | | | | | | | | | | | |
| 45 | | 34 07.63S | 151 09.89 | 12/12/93 | 4:38 | 48 | | | | X | | | | | | | |
| 46 | | 34 06.71S | 151 10.33 | 12/12/93 | 4:57 | 34 | | | | X | | | | | | | |
| 47 | | 34 05.53S | 151 11.14 | 12/12/93 | 5:24 | 33 | | | | X | | | | | | | |
| **Section T9** | | | | | | | | | | | | | | | | | |
| 48 | 19 | 34 03.68S | 151 10.90 | 12/12/93 | 6:08 | 23 | X | 0, 18 | X | X | | X | X | X | X | | |
| 49 | 20 | 34 03.84S | 151 11.75 | 12/12/93 | 7:05 | 32 | X | 10, 25 | X | X | | | | | | | |
| 50 | 21 | 34 04.10S | 151 12.72 | 12/12/93 | 8:01 | 56 | X | 15, 30, 51 | X | X | | X | X | X | X | | |
| 51 | 22 | 34 04.24S | 151 13.83 | 12/12/93 | 8:59 | 81 | X | 0, 10, 75 | X | X | | | | | | | |
| 52 | 23 | 34 03.93S | 151 15.36 | 12/12/93 | 10:00 | 104 | X | 0, 30, 95 | X | X | | | | | | | |
| 53 | 24 | 34 04.04S | 151 21.24 | 12/12/93 | 11:13 | 138 | X | 0, 31, 130 | X | X | | X | | | X | | |
| 54 | 25 | 34 04.01S | 151 27.14 | 12/12/93 | 12:35 | 148 | X | 0, 43, 140 | X | X | | X | | | X | | |
| 55 | 26 | 34 03.92S | 151 33.31 | 12/12/93 | 14:08 | 300 | X | 0, 25, 295 | X | X | | X | | | X | | |
| **Section T10** | | | | | | | | | | | | | | | | | |
| 56 | 27 | 34 01.22S | 151 14.72 | 12/12/93 | 19:04 | 55 | X | 0, 25, 50 | X | X | X | X | X | X | X | | |
| 57 (Metromix) | 28 | 34 01.50S | 151 14.97 | 12/12/93 | 20:05 | 51 | X | 0, 25, 50 | X | X | X | | | | | | |
| 58 (Metromix) | | 34 01.95S | 151 14.83 | 12/12/93 | 21:19 | 51 | | | | X | | | | | | | |
| 59 | 29 | 34 01.40S | 151 16.16 | 12/12/93 | 21:45 | 81 | X | 0, 25, 77 | X | X | | X | X | X | X | | |
| 60 | 30 | 34 01.42S | 151 17.30 | 12/12/93 | 23:00 | 95 | X | 0, 25, 90 | X | X | | | | | | | |
| 61 | 31 | 34 01.39S | 151 18.58 | 13/12/93 | 0:03 | 105 | X | 0, 25, 103 | X | X | | X | | | X | | |
| 62 | 32 | 34 01.42S | 151 21.08 | 13/12/93 | 1:16 | 137 | X | 0, 25, 130 | X | X | | X | | | X | | |
| 63 | 33 | 34 01.41S | 151 37.66 | 13/12/93 | 3:22 | 400 | X | 0, 35, 391 | X | X | X | X | | | X | | |
| **Section T11** | | | | | | | | | | | | | | | | | |
| 64 | 34 | 33 59.99S | 151 15.54 | 13/12/93 | 6:36 | 40 | X | 30, 38 | X | X | | X | X | X | X | | |
| 65 | 35 | 34 00.09S | 151 16.27 | 13/12/93 | 7:40 | 56 | X | 0, 30, 45 | X | X | | | | | | | |
| 66 (Metromix) | | 33 59.75S | 151 16.30 | 13/12/93 | 8:12 | 55 | | | | | | X | | | X | | |
| 67 | 36 | 34 00.11S | 151 17.38 | 13/12/93 | 8:37 | 85 | X | 0, 35, 77 | X | X | | X | | | X | | |
| 68 | 37 | 34 00.01S | 151 18.77 | 13/12/93 | 9:47 | 92 | X | 0, 35, 85 | X | X | | | | | | | |
| 69 | 38 | 33 59.99S | 151 19.90 | 13/12/93 | 10:33 | 102 | X | 0, 35, 92 | X | X | | | | | | | |
| 70 | 39 | 34 00.05S | 151 21.16 | 13/12/93 | 11:23 | 111 | X | 0, 35, 100 | X | X | | X | X | X | X | | |
| 71 | 40 | 33 59.99S | 151 27.32 | 13/12/93 | 12:48 | 139 | X | 30, 130 | X | X | | X | | | X | | |
| **Section T12** | | | | | | | | | | | | | | | | | |
| 72 | 41 | 33 59.16S | 151 40.00 | 13/12/93 | 14:59 | 434 | X | 0, 50, 440 | X | X | X | X | | | X | | |
| 73 | 42 | 33 58.32S | 151 33.92 | 13/12/93 | 16:35 | 179 | X | 0, 30, 175 | X | X | | X | | | X | | |
| 74 | 43 | 33 58.18S | 151 27.98 | 13/12/93 | 17:54 | 145 | X | 0, 30, 142 | X | X | | X | | | X | | |
| 75 | 44 | 33 58.25S | 151 21.84 | 13/12/93 | 19:00 | 80 | X | 0, 25, 80 | X | X | | | | | | | |
| 76 | 45 | 33 58.20S | 151 20.85 | 13/12/93 | 19:54 | 91 | X | 0, 25, 88 | X | X | | | | | | | |
| 77 | 46 | 33 58.21S | 151 19.55 | 13/12/93 | 21:00 | 88 | X | 0, 15, 86 | X | X | | X | | | X | | |
| 78 | 47 | 33 58.20S | 151 18.33 | 13/12/93 | 22:00 | 82 | X | 0, 46, 82 | X | X | | X | X | X | X | | |
| 79 | 48 | 33 58.18S | 151 17.18 | 13/12/93 | 23:03 | 68 | X | 0, 25, 65 | X | X | | | | | | | |
| 80 | 49 | 33 58.42S | 151 16.61 | 13/12/93 | 23:57 | 48 | X | 0, 25, 45 | X | X | | X | X | X | X | | |

Table 1 (continued)

| Station No | CTD No | Latitude | Longitude | Date UTC | Time UTC | Water Depth | Hydrology sampling | Sampling Depths | Lipids Water | Sediment | Zoology Plankton net tow | Bacto | Microbiology Virus | Parasite | Total | Box coring | Gravity coring |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Section T13** | | | | | | | | | | | | | | | | | |
| 81 | 50 | 33 56.70S | 151 16.61 | 14/12/93 | 2:17 | 37 | X | 10, 35 | X | X | | X | X | X | X | | |
| 82 | 51 | 33 56.66S | 151 17.42 | 14/12/93 | 3:31 | 64 | X | 0, 30, 60 | X | X | | X | | | X | | |
| 83 | 52 | 33 56.69S | 151 18.45 | 14/12/93 | 4:30 | 70 | X | 0, 30, 65 | X | X | | X | X | X | X | | |
| 84 | 53 | 33 56.62S | 151 19.74 | 14/12/93 | 5:34 | 75 | X | 0, 30, 70 | X | X | | X | | | X | | |
| 85 | 54 | 33 56.73S | 151 20.91 | 14/12/93 | 6:45 | 84 | X | 0, 36, 75 | X | X | | | | | | | |
| 86 | 55 | 33 56.56S | 151 22.10 | 14/12/93 | 7:39 | 93 | X | 0, 40, 86 | X | X | X | X | | | X | | |
| **Section T14** | | | | | | | | | | | | | | | | | |
| 87 | | 33 54.92S | 51 16.99E | 14/12/93 | 9:10 | 38 | | | | X | X | X | | | X | | |
| 88 | | 33 54.82S | 51 18.37E | 14/12/93 | 9:44 | 67 | | | | X | | X | | | X | | |
| 89 | | 33 54.90S | 51 19.94E | 14/12/93 | 10:21 | 74 | | | | X | | X | | | X | | |
| 90 | | 33 55.01S | 51 21.06E | 14/12/93 | 10:50 | 83 | | | | X | | | | | | | |
| 91 | | 33 54.90S | 51 22.31E | 14/12/93 | 11:09 | 91 | | | | X | | | | | | | |
| 92 | | 33 54.92S | 51 28.45E | 14/12/93 | 11:58 | 126 | | | | X | | X | | | X | | |
| **Section T15** | | | | | | | | | | | | | | | | | |
| 93 | 56 | 33 53.34S | 51 41.38E | 14/12/93 | 13:28 | 300 | X | 0, 40, 292 | X | X | X | X | | | X | | |
| 94 | 57 | 33 53.30S | 51 35.24E | 14/12/93 | 15:30 | 151 | X | 0, 40, 145 | X | X | | X | | | X | | |
| 95 | 58 | 33 53.32S | 51 29.22E | 14/12/93 | 16:44 | 130 | X | 0, 40, 130 | X | X | | X | | | X | | |
| 96 | 59 | 33 53.35S | 51 23.25E | 14/12/93 | 17:48 | 105 | X | 0, 25, 103 | X | X | | X | | | X | | |
| 97 | 60 | 33 53.41S | 51 22.01E | 14/12/93 | 18:48 | 82 | X | 0, 25, 80 | X | X | | X | | | X | | |
| 98 | 61 | 33 53.38S | 51 20.76E | 14/12/93 | 19:30 | 75 | X | 0, 25, 72 | X | X | | X | | | X | | |
| 99 | 62 | 33 53.35S | 51 19.67E | 14/12/93 | 20:44 | 71 | X | 0, 20, 68 | X | X | X | X | | | X | | |
| 100 | 63 | 33 53.38S | 51 18.52E | 14/12/93 | 22:18 | 67 | X | 0, 15, 63 | X | X | | X | X | X | X | | |
| 101 | 64 | 33 53.38S | 51 17.92E | 14/12/93 | 23:16 | 52 | X | 0, 15, 52 | X | X | | X | X | X | X | | |
| **Section T16** | | | | | | | | | | | | | | | | | |
| 102 | | 33 52.00S | 151 22.85 | 15/12/93 | 3:44 | 92 | | | | X | | X | | | X | | |
| 103 | | 33 51.91S | 151 21.63 | 15/12/93 | 4:01 | 74 | | | | X | | | | | | | |
| 104 | | 33 52.07S | 151 20.59 | 15/12/93 | 4:17 | 72 | | | | X | | | | | | | |
| 105 | | 33 52.00S | 151 19.42 | 15/12/93 | 4:41 | 66 | | | | X | | | | | | | |
| 106 | | 33 51.96S | 151 18.23 | 15/12/93 | 4:58 | 52 | | | | X | | X | | | X | | |
| 107 | | 33 51.86S | 151 17.65 | 15/12/93 | 5:25 | 38 | | | | X | | X | | | X | | |
| **Section T17** | | | | | | | | | | | | | | | | | |
| 108 | | 33 50.66S | 151 17.85 | 15/12/93 | 5:49 | 35 | | | | X | | X | | | X | | |
| 109 | | 33 50.68S | 151 19.00 | 15/12/93 | 6:38 | 50 | | | | X | | X | | | X | | |
| 110 | | 33 50.70S | 151 20.20 | 15/12/93 | 7:12 | 58 | | | | X | | | | | | | |
| 111 | | 33 50.69S | 151 21.37 | 15/12/93 | 7:29 | 70 | | | | X | | | | | | | |
| 112 | | 33 50.69S | 151 22.68 | 15/12/93 | 8:37 | 79 | | | | X | | | | | | | |
| 113 | | 33 50.76S | 151 23.83 | 15/12/93 | 8:59 | 103 | | | | X | | | | | | | |
| **Section T18** | | | | | | | | | | | | | | | | | |
| 114 | 65 | 33 48.88S | 151 19.88 | 15/12/93 | 9:51 | 54 | X | 0, 44 | X | X | X | X | X | X | X | | |
| 115 | 66 | 33 48.67S | 151 21.02 | 15/12/93 | 11:00 | 67 | X | 0, 25, 56 | X | X | X | X | X | X | X | | |
| 116 | 67 | 33 48.86S | 151 22.24 | 15/12/93 | 12:03 | 67 | X | 0, 25, 59 | X | X | | X | | | X | | |
| 117 | 68 | 33 48.86S | 151 23.45 | 15/12/93 | 13:12 | 83 | X | 0, 32, 76 | X | X | | | | | | | |
| 118 | 69 | 33 48.92S | 151 24.77 | 15/12/93 | 14:20 | 106 | X | 0, 28, 105 | X | X | | | | | | 3 | 6 |
| 119 | 70 | 33 48.95S | 151 27.18 | 15/12/93 | 18:26 | 118 | X | 0, 30, 118 | X | X | | X | | | X | | |
| 120 | 71 | 33 48.72S | 151 28.40 | 15/12/93 | 19:14 | 125 | X | 0, 35, 122 | X | X | X | | | | | | |

Table 1 (continued)

| Station No | CTD No | Latitude | Longitude | Date UTC | Time UTC | Water Depth | Hydrology sampling | Sampling Depths | Lipids Water | Sediment | Zoology Plankton net tow | Zoology Bacto | Microbiology Virus | Microbiology Parasite | Total | Box coring | Gravity coring |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Section T19** | | | | | | | | | | | | | | | | | |
| 121 | 72 | 33 46.13S | 151 28.51 | 15/12/93 | 20:49 | 120 | X | 0, 30, 120 | X | X | | | | | | | |
| 122 | 73 | 33 45.98S | 151 25.99 | 15/12/93 | 21:45 | 109 | X | 0, 35, 108 | X | X | | | | | | | |
| 123 | 74 | 33 46.10S | 151 23.65 | 15/12/93 | 22:32 | 75 | X | 0, 35, 73 | X | X | | X | | | X | | |
| 124 | 75 | 33 46.12S | 151 21.18 | 16/12/93 | 0:05 | 43 | X | 0, 25, 43 | X | X | | X | | | X | | |
| 125 | 76 | 33 46.39S | 151 18.08 | 16/12/93 | 1:14 | 35 | X | 0, 25, 33 | X | X | | X | | | X | | |
| **Section T25** | | | | | | | | | | | | | | | | | |
| 126 | 77 | 33 27.00S | 151 27.73 | 16/12/93 | 3:26 | 34 | X | 0, 26 | X | X | X | X | | | X | | |
| 127 | 78 | 33 27.66S | 151 30.34 | 16/12/93 | 4:21 | 49 | X | 0, 34, 41 | X | X | X | X | | | X | | |
| 128 | 79 | 33 28.38S | 151 33.33 | 16/12/93 | 5:17 | 68 | X | 0, 35, 60 | X | X | | | | | | | |
| 129 | 80 | 33 29.09S | 151 36.17 | 16/12/93 | 6:06 | 86 | X | 0, 43, 82 | X | X | | | | | | | |
| 130 | 81 | 33 29.78S | 151 39.07 | 16/12/93 | 6:57 | 118 | X | 0, 45, 110 | X | X | | | | | | | |
| 131 | 82 | 33 30.57S | 151 41.96 | 16/12/93 | 7:56 | 126 | X | 0, 45, 117 | X | X | | X | | | X | | |
| 132 | 83 | 33 31.17S | 151 45.35 | 16/12/93 | 9:43 | 140 | X | 0, 44, 135 | X | X | X | X | | | X | | |
| **Section T24** | | | | | | | | | | | | | | | | | |
| 133 | | 33 33.24S | 151 35.01 | 16/12/93 | 13:33 | 104 | | | | X | | | | | | | |
| 134 | | 33 32.60S | 151 32.70 | 16/12/93 | 14:18 | 81 | | | | X | | | | | | | |
| 135 | | 33 32.02S | 151 30.53 | 16/12/93 | 14:42 | 63 | | | | X | | | | | | | |
| 136 | | 33 31.48S | 151 28.12 | 16/12/93 | 15:05 | 52 | | | | X | X | X | | | X | | |
| 137 | | 33 31.03S | 151 25.78 | 16/12/93 | 15:48 | 35 | | | | X | | X | | | X | | |
| **Section T23** | | | | | | | | | | | | | | | | | |
| 138 | | 33 35.59S | 151 27.66 | 16/12/93 | 16:48 | 60 | | | | X | | | | | | | |
| 139 | 84 | 33 34.97S | 151 24.74 | 16/12/93 | 17:38 | 47 | X | 0, 35, 44 | X | X | X | X | X | X | X | | |
| 140 | 85 | 33 34.26S | 151 21.90 | 16/12/93 | 18:50 | 33 | X | 0, 30 | X | X | X | X | X | X | X | 1 | |
| **Section T22** | | | | | | | | | | | | | | | | | |
| 141 | | 33 36.24S | 151 21.09 | 16/12/93 | 20:06 | 32 | | | | X | | | | | | | |
| 142 | | 33 37.17S | 151 25.11 | 16/12/93 | 20:35 | 54 | | | | X | | | | | | | |
| 143 | | 33 38.13S | 151 29.13 | 16/12/93 | 21:06 | 83 | | | | X | | | | | | | |
| 144 | | 33 39.23S | 151 32.97 | 16/12/93 | 21:37 | 123 | | | | X | | | | | | | |
| 145 | | 33 39.95S | 151 37.02 | 16/12/93 | 22:11 | 130 | | | | X | | | | | | | |
| **Section T21** | | | | | | | | | | | | | | | | | |
| 146 | | 33 41.82S | 151 32.35 | 16/12/93 | 22:59 | 125 | | | | X | | | | | | | |
| 147 | | 33 41.07S | 151 29.45 | 16/12/93 | 23:30 | 114 | | | | X | | | | | | | |
| 148 | | 33 40.52S | 151 26.64 | 16/12/93 | 23:50 | 82 | | | | X | | | | | | | |
| 149 | | 33 39.77S | 151 23.74 | 17/12/93 | 0:16 | 57 | | | | X | | X | | | X | | |
| 150 | | 33 39.20S | 151 20.83 | 17/12/93 | 1:04 | 39 | | | | X | | X | | | X | | |
| **Section T20** | | | | | | | | | | | | | | | | | |
| 151 | | 33 43.52S | 151 19.28 | 17/12/93 | 1:39 | 30 | | | | X | | | | | | | |
| 152 | | 33 43.68S | 151 22.10 | 17/12/93 | 2:06 | 56 | | | | X | | | | | | 1 | |
| 153 | | 33 43.84S | 151 24.98 | 17/12/93 | 2:42 | 87 | | | | X | | | | | | | |
| 154 | | 33 44.02S | 151 28.01 | 17/12/93 | 3:10 | 120 | | | | X | | | | | | | |
| 155 | | 33 44.22S | 151 30.92 | 17/12/93 | 3:38 | 121 | | | | X | | | | | | | |