FRANKLIN

National Facility
Oceanographic Research Vessel

AIMS Exmouth Hydrocarbon Transect

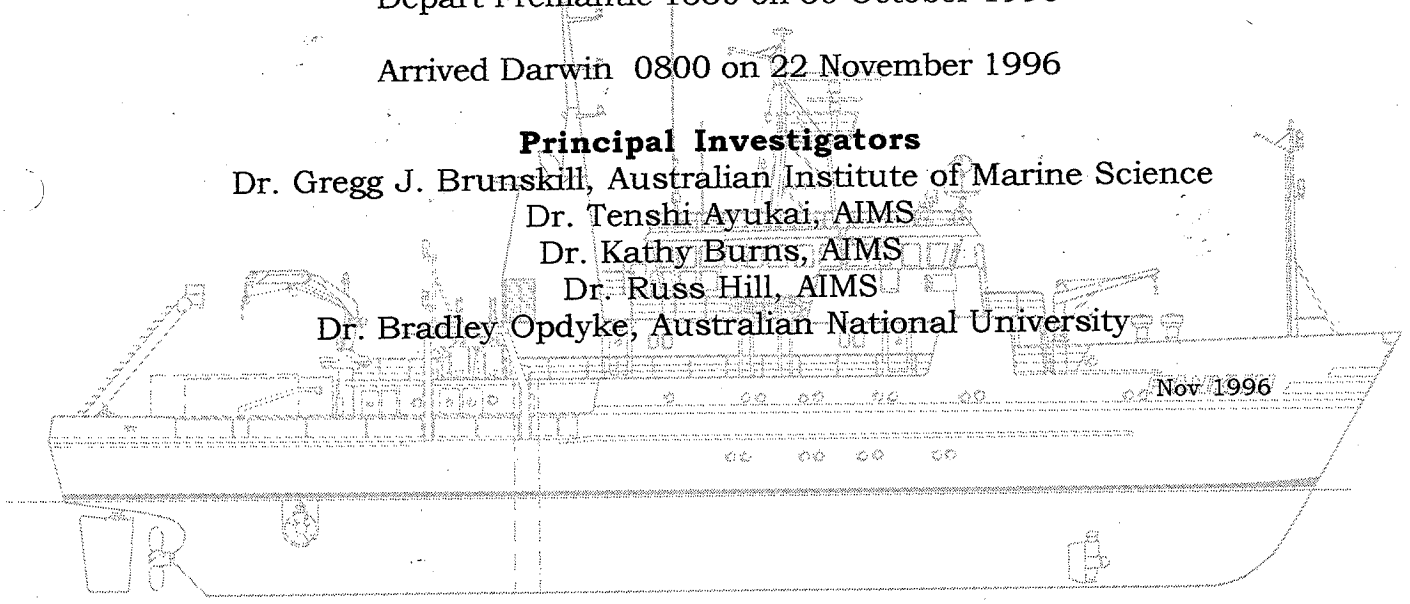
Cruise Summary

Fr9/96

Depart Fremantle 1330 on 30 October 1996

Arrived Darwin 0800 on 22 November 1996

Principal Investigators
Dr. Gregg J. Brunskill, Australian Institute of Marine Science
Dr. Tenshi Ayukai, AIMS
Dr. Kathy Burns, AIMS
Dr. Russ Hill, AIMS
Dr. Bradley Opdyke, Australian National University



Nov 1996

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RESEARCH SUMMARY

R/V Franklin Cruise FR 09/96

AIMS EXMOUTH HYDROCARBON TRANSECT

PRINCIPLE INVESTIGATORS:

Dr. Gregg J. Brunskill, Australian Institute of Marine Science
Dr. Tenshi Ayukai, AIMS
Dr. Kathy Burns, AIMS
Dr. Russ Hill, AIMS
Dr. Bradley Opdyke, Australian National University

ITINERARY:

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RESEARCH OBJECTIVES:

1. In the region of Exmouth Gulf, shelf, slope, and Exmouth Plateau, to estimate the rates of synthesis of organic matter in the surface layer, and to estimate the flux of organic matter from the surface layer into deep waters and surface sediments, using sediment traps and sediment cores.

2. In this region of petroleum industry development, to determine the concentrations and fluxes of natural and petroleum industry hydrocarbons in the water column and sediments.

3. In this sediment-starved coastal region, to determine the locations of fine sediment (& organic matter) accumulation (& erosion), and to produce a geochemical map of surface sediments.

CRUISE NARRATIVE

29-30 October 96: Loaded 2 containers of equipment from Fremantle wharf to the Franklin. Depart Fremantle 1330 on 30 October.

31 October-1 November: Assembled two sediment traps, Kasten corer, core slicing table, mooring string for sediment traps and current meters. Considerable use of the hydraulic crane was

required to move traps from storage to assembly areas, and then to deployment position.

2 November: Arrive Station 1 (Fig. 1) off Exmouth in Exmouth Gulf. CTD, primary production profiles, Smith-MacIntyre Grab and Kasten core successful. Pumped 400 L for radiochemical sample. Picked up Dr. Opdyke from Learmouth Dive Shop zodiac at 1230. Steam for Station 7, with equidistant CTD profiles along the way.

Seven out of 18 hydrocarbon extraction columns burst due to freezing in the fridge in the hold.

3 November: Arrive Station 7 at 0730. Sediment trap arrays and current meters were deployed at 300 and 1200 meters at 1430 m water depth at 0950. Steamed to Station 6, where we deployed 4 SeaStar filtration/extraction rigs at 80 m, near the top of the fluorescence (chlorophyll) peak and at the maximum of the primary production profile, drogued with a weighted Great Southern Dingo Flour Bucket. CTD, primary production profiles, a sediment grab sample, and a Kasten sediment core (1.86 m) were obtained in the afternoon. This ship followed the SeaStar buoy all night and the next day, and it moved very little.

4 November: The ship followed the SeaStar buoy all day, and it was retrieved after 30 hours pumping time at 1715. During this time, we obtained large volume radiochemical samples (0.5 to 1 cubic meter) from 5 and 70 m depth, 3 CTD and primary productivity profiles, and made preparations for the next pair of sediment trap arrays and moorings. The ship steamed to Station 5 during the night.

5 November (Melbourne Cup Day): At Station 5 we deployed 2 sediment trap arrays at 300 and 600 m in 700 m water depth. The 4 Seastar pumping systems were deployed attached to the surface buoy of the sediment trap mooring. While steaming to Station 4, the next mooring and sediment trap was assembled. At Station 4, a CTD and primary production profile was obtained, as well as a sediment grab sample. Two attempts at Kasten coring failed, due to hard bottom. A single sediment trap and current meter array was deployed at 300 m at Station 4 (400 m) in the late afternoon. During the night, grab samples were taken on a grid pattern.

6 November: Large volume water sampling for radiochemistry was done at Station 3. Grab and Kasten Cores were obtained, and profiles of primary production and CTD were obtained. During this time, another sediment trap and mooring string was prepared for deployment. We steamed back to Station 5 to

recover the SeaStars at 1600. Sediment grab samples were taken on a grid pattern all night.

7 November: A single sediment trap and current meter array, and 4 SeaStar rigs, were deployed at Station 3. We steamed to Station 2 for radiochemistry sample pumping (2 cubic meters), CTD and primary production profiles, a grab sample, and two attempts to Kasten core (both failed, due to hard sandy bottom). Sediment grab samples were taken on a grid pattern all night, in rough weather (40 kt wind).

8 November: At Station 5, we pumped surface water for 4 hours for radiochemical samples, tried another 2 Kasten cores (both failed), and did another two CTD and primary production profiles. A Niskin was lost off the rosette on one of these profiles. We steamed to Station 4 for more CTD and primary production profiles, and then top Station 3 for afternoon primary production profiles, suspended sediment concentrations samples (50 L), and recovered the SeaStar rigs at 1600. After tea, we got a good Kasten core. Sediment grab samples were taken on a grid pattern all night.

9 November: Having obtained SeaStar large volume samples for hydrocarbons at the major stations, we were now free to concentrate on transects of primary productivity and nutrients across the shelf, slope, and plateau. Early morning was used for coring in shallow regions west of Barrow Island (one successful core obtained). The rest of the day was for primary production and nutrient transects (80 to 420 m depths) across the shelf and slope. Another attempt at Kasten coring failed. Grab samples were taken all night.

10 November: Early morning sediment grabs and successful Kasten coring was done in 500 m depth west of Montebello Island. Mid-day was used for another CTD, nutrient, and primary production transect off the shelf and slope NW of Montebello Island. A good Kasten core was obtained from Station 8 at 1100 m NW of Montebello Island in the evening. Grab samples were taken on a grid pattern all night.

11 November: At Station 8, the primary production probe was suspended at 20 m depth on a buoy during 1000-1400 to measure the variation in the light field and the primary production response. Replicate large volume samples were taken for suspended sediments, and repeated CTD and nutrient samples. In the evening, two attempts at Kasten Coring at 450 and 630 m

failed, due to hard sandy bottom. Grab samples were taken on a grid pattern all night.

12 November: We had planned to begin retrieval of the Station 3 sediment trap array, but the acoustic release deck box electronics failed and could not be repaired on the ship. We phoned AIMS to have another deck box air freighted to us in Exmouth. From 1000 to 1500 hrs, another CTD, nutrient, and primary production transect was done north of the mouth of Exmouth Gulf. Two Kasten core attempts were made in this region, with no success. Sediment grab samples were taken on a grid pattern all night.

13 November: Radiochemical sample pumping began at first light at Station 5, to obtain over 1400 L of sample. We steamed to Point Muriat to meet Malcolm Toole of the Exmouth Diving Centre, who delivered the acoustic release deck box from AIMS. We steamed back NE into the "mud patch" to the west of Barrow Island and attempted Kasten coring, with no luck. Sediment grab samples taken all night on a grid pattern.

14 November: At Station 3, at first light (0515) the sediment trap mooring string was released, and by 0630 the trap and current meter were on board safely. The filtration crew began their work on the samples, as the trap was cleaned and capped and moved to storage on the upper deck with the crane. We steamed to Station 4, and had the trap array on deck by 0930. Samples were recovered, the trap washed down, capped, and craned to storage. After lunch, we recovered the two trap string at Station 5 by 1400, and washed, capped, and stored by 1600. En route to Station 7 we attempted 2 Kasten cores in rough weather, and both failed. Grab samples were taken throughout the night.

15 November: By 0915 we had the 300 m trap from Station 7 on deck, with the current meter somewhat damaged by a wrap of the mooring wire. The flotation assembly for the 1200 m trap was tangled with the current meter (which should have been below the trap) when raised. Four floats were cut off the string by the wire when we tried to winch in the bottom floats near the acoustic release (these were recovered by the zodiac), and four floats were crushed in the tangle. The bottom acoustic release wire snapped during winching, but we had a "wire stopper" on the wire above the floats and trap. The sediment trap array came up upside down. It appears likely that the acoustic release had one too many floats above it, and it rose faster than the sediment trap, encircling it at least once. The trap array frame was not damaged, and only the tops of 4 trap tubes were bent. There was no useful sample in the bottles.

The ship steamed for Dampier, with sediment grab samples being taken along the way. It became too rough to work later in the night, and the bridge sounder was not working, making it difficult to select sampling sites by depth. Sediment trap filtration continued into the night, but one set of trap bottles were stored in the mess cooler overnight, for processing the next day.

16 November: We entered Mermaid Strait, near Dampier at 0630, to meet a Woodside Petroleum boat to offload Dr. Ayukai and Mr. McLean, and to take on Dr. Russell Hill and Ms Jo Johnston. A sick Franklin crew man was exchanged for a new person via commercial boat. At 0745 we steamed for Rowley Shoals (Mermaid Reef).

17 November: We reached the Mermaid Reef mooring site at 0900, did a CTD profile, tried to raise the mooring, but discovered that the hydrophone was faulty. A second hydrophone worked well, and the mooring string was on deck by 1015. After cleaning up the rig, and installing new instrumentation (temperature, pressure), the mooring was deployed at 1135 in 398 m depth at 17deg 05.01min S and 119deg 41.11min E. A series of sediment grab samples from 420 to 1100 m depth were taken for microbiological studies. We steamed for Scott Reef at 2030 hrs.

18 November: We arrived at the Scott Reef mooring site at 1130, did a CTD profile to calibrate the mooring thermistor, and tried to release the mooring. No floats appeared, so we did a sonar sweep of the 350-400 m depth position, and found a signal at 70-100 m that was exactly at the mooring site (14deg 5.34min S, 121deg 43.1min E). We phoned AIMS to consult with the users of this mooring, and decided to leave it for AIMS to recover by other methods. A series of grab samples for micobiological study was done from 1500 to 2200 m to the WNW of Scott Reef, and a 3 m Kasten core was obtained in a small trough to the West of Scott Reef. At midnight we steamed for another mooring landward of Scott Reef.

19 November: Our initial attempt at raising the mooring anchored at 200 m depth failed, but a check of the R/V Lady Basten ship log indicated we were off the position by about 17 miles of longitude. The mooring came up willingly at the beckoning of the hydrophone, the string was recovered and on deck by 0845, and the rest of the day was spent painting the rig with anti-foulant, checking clocks and instrumentation. This current meter mooring was deployed again at 1555 at 14deg 38.298min S, 122deg 20.429min E at 180 m depth. A second mooring for a temperature/pressure sensor was deployed at 1745

in 180 m of depth at 14deg 38.22min S, 122deg 20.93min E. We steamed for Pee Shoals at 1810.

20 November: We arrived at the Pee Shoals region at 1400, where two grab samples were taken for microbiological studies. These mounds are thought to be related to hydrocarbon seeps. We steamed for Penguin Deeps at 1600, and noted the high sea surface temperature (31.9deg C) en route.

21 November: At 0330, we obtained a grab, Kasten core, and CTD profile from the 136 m depression inside Holothuria Banks. We steamed for Darwin at 0415 with sheet lightning and piddling rain. All the heavy gear on the aft deck was taken apart and made ready for offloading. Lab gear was packed in nallybins.

22 November: Arrive Darwin Harbour (Fort Hill Wharf) at 0800. Unload gear to Wharf and 2 containers.

RESULTS

Dr. Ayukai's new primary production & PAR probe worked very well, and will be related to the CTD fluorescence estimation of chlorophyll/biomass, and water sample filters for chlorophyll measurement. Same-day production, CTD, and nutrient transects from shallow shelf to slope and plateau revealed apparent nutrient enrichment of the euphotic zone over the slope, with productivity and water column biomass declining landward and seaward (Fig. 2). Forty-two CTD profiles were completed, with 167 lab measurements of salinity, and 149 measurements of nitrate, silicate, and phosphate.

Samples were collected to estimate particle removal rate from the water column. Suspended material concentrations were made on 10-50 L filtrations, sometimes with replication. Concentrations of dissolved and particulate hydrocarbons and short-lived particle reactive radionuclides will be estimated from 300-2200 L pumped samples. Particulate organic and carbonate carbon, nitrogen, phosphorus, and sulfur concentrations will be estimated from smaller volume filtrations. The downward flux of these elements will be estimated from sediment trap collections over 10-11 days. Trap material was abundant, due to the large size of the tubes, and some of the trap material from deep water appears to be aeolian or resuspended shelf sediment. Five out of 6 trap arrays worked well, with the saline solution in the trap bottle remaining greater than ambient seawater. The sixth trap was damaged upon retrieval, but can be easily repaired. (These traps will be used in TROPICS operations in the Gulf of Papua and perhaps the north coast of PNG). From this combination of water

column concentrations and trap fluxes, we can estimate particle and chemical compound residence times in the water column

The weighted Smith-MacIntyre Grab sampler worked extremely well for sampling surficial sediments for physical properties, hydrocarbons, inorganic chemistry, and microbiological samples. We took 107 grab samples, and nearly all of the fine sediment grabs had the surface 1-2 cm oxidized layer intact. A variety of physical, chemical, and isotopic measurements on these samples will allow the construction of sedimentary contour maps of the Exmouth/Barrow Island region. We attempted 27 Kasten cores, with 12 of them being successful. In hindsight, a large box corer with a 50 cm deep box would have been more appropriate for this work. From this work, we think that the Holocene sediments on the shelf are only 20-40 cm thick, with perhaps a little more at the base of the slope. We speculate that a large proportion of the fine fraction of the shelf, slope, and plateau sediments is transported by the SE Trade Winds from Western Australia. Sediment accumulation rates are extremely low (20-40 cm/10,000 years), and sediment distribution appears to be completely controlled by currents, tides, waves, and not by sediment supply from the land. Fine silty-clays appear to be focused on the outer shelf west of Barrow Island, perhaps due to an eddy spinning off Montebello and Barrow Island during SW flow along this coast. ADCP plots (Fig. 3) appear to support this speculation, although this data requires expert interpretation.

Surface sediment sampling for microbiological experiments with different growth substrates was done. Six agar plate enrichments (including petroleum products) were used to test growth and substrate assimilation by actinomycetes in surface sediments.

Moorings of equipment installed in June 96 from AIMS ships were retrieved, tuned up, and redeployed successfully, with the exception of the Scott Reef mooring.

SUGGESTIONS & COMMENTS:

We were pushing the limits of the Franklin aft deck space and ship storage space on this cruise. With most multidisiplinary research, some operations are interfere with others. The Kasten coring rail system on the aft deck caused problems with the deployment of the sediment trap arrays, and we will try to re-design the Kasten rail system to allow partial removal during mooring operations. The deployment and recovery of the sediment trap and current meter arrays went very well, almost

too fast for the processing of the trap samples. The integration of CTD, nutrient samples, and primary production with the fluorescence probe worked well, and allowed 1000-1500 hrs transects across the shelf and slope that would not be possible with standard C-14 incubations. The efforts of the ship crew to keep the aft deck clean during trap preparations and core slicing was greatly appreciated.

The refridgerator in the hold should either be fixed or thrown away, as it froze and broke 7 extraction columns intended for SeaStar deployments. Early Kasten coring deck operations resulted in breaking the welded rails off the deck, due to the difficulty in communications between the winch operator, the A frame operator, and the scientist in charge. This problem was corrected, and the system worked flawlessly after the 3rd day of coring. Although we are not physical oceanographers, we had anticipated using the ADCP data to interpret the source of water masses delivering particles to the sediment traps, and the likely advective path of high productivity water masses. The ADCP was not working properly during the early part of the cruise, due to hardware/software problems. The lack of a standard oceanographic 3.5 kHz sonar/sounder on the ship made sediment coring operations a blind business, and many cores were attempted where little sediment thickness exists.

ACKNOWLEDGEMENTS:

We thank Master Neil Cheshire and his bridge staff for careful attention and advice through the difficult parts of this cruise. Engineers Terry Carruthers, Lindsay Cale, and Don Roberts fixed equipment that was damaged during our work. Jannik Hansen and Norm Marsh helped our mooring, sediment grab and coring crew. Ron Plashke did some extra work on nutrient determinations and data summaries. Phil Adams tried to get the ADCP working for us, and David Vaudrey was kind, considerate, and helpful before and during the cruise.

SCIENTIFIC PARTY:

Gregg Brunskill, AIMS, Chief Scientist
Tenshi Ayukai, AIMS (Fremantle-Dampier Leg)
Russell Hill, AIMS (Dampier-Darwin Leg)
Bradley Opdyke, ANU
Irena Zagorskis, AIMS
Sue Codi, AIMS
John Pfitzner, AIMS
John Soles, AIMS
Cary McLean, AIMS (Fremantle-Dampier Leg)
Jo-Anne Cavanagh, AIMS
Jo Johnston, AIMS (Dampier-Darwin Leg)
Dave Vaudrey, CSIRO
Phil Adams, CSIRO
Ron Plaschke, CSIRO

SHIP CREW:

Neil Cheshire, Master
Ian Menzies, First Officer
Doug Henderson, Second Officer
Terry Carruthers, Chief Engineer
Lindsay Cale, First Engineer
Don Roberts, Electrical Engineer
Jannick Hansen, Bosun
Ray Issel, Able Seaman
Wayne Browning, Able Seaman
Norm Marsh, Able Seaman
Les Clark, GRSR (Fremantle-Dampier Leg)
Phil French, GRSR (Dampier-Darwin Leg)
Gary Hall, Chief Cook
Peter Dux, 2nd Cook
John Tilley, CH Stewart

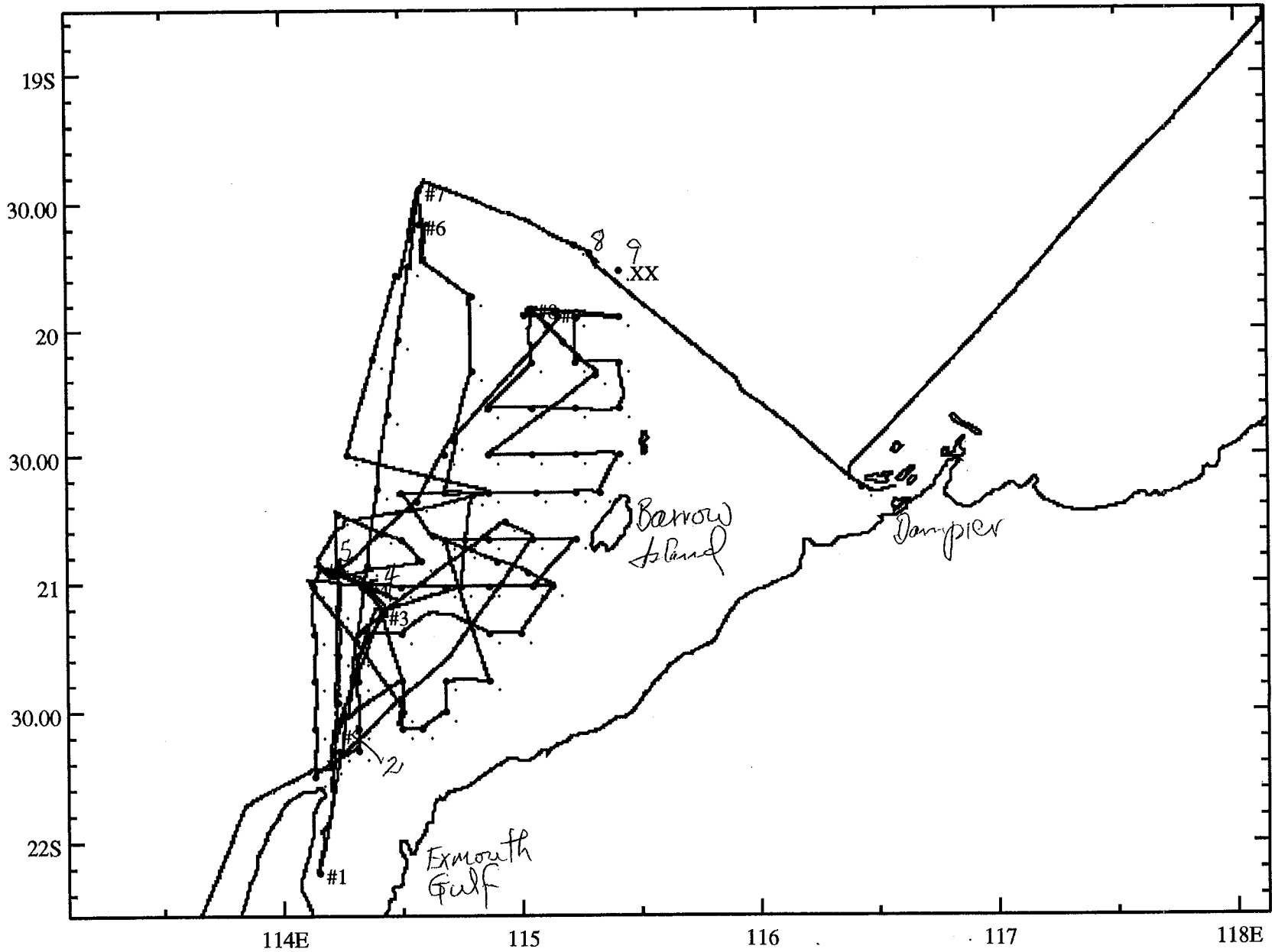
FIGURES:

Figure 1a. Simplified ship track for the Exmouth Shelf portion of FR-09/96.

Figure 1b. Ship track for the 16-22 November portion of FR-09/96.

Figure 2. Primary production (in relative units) for a transect from inside Exmouth Gulf to the shelf and slope northward. This estimation is derived from light and photosynthetic chloroplast fluorescence emission profiles. The vertical axis is water depth, and the horizontal axis shows Station locations indicated in Fig. 1.

Figure 3. Acoustic doppler current profiler results for a period during FR-09/96. The arrows indicate vectors of flow velocity at 15 m water depth.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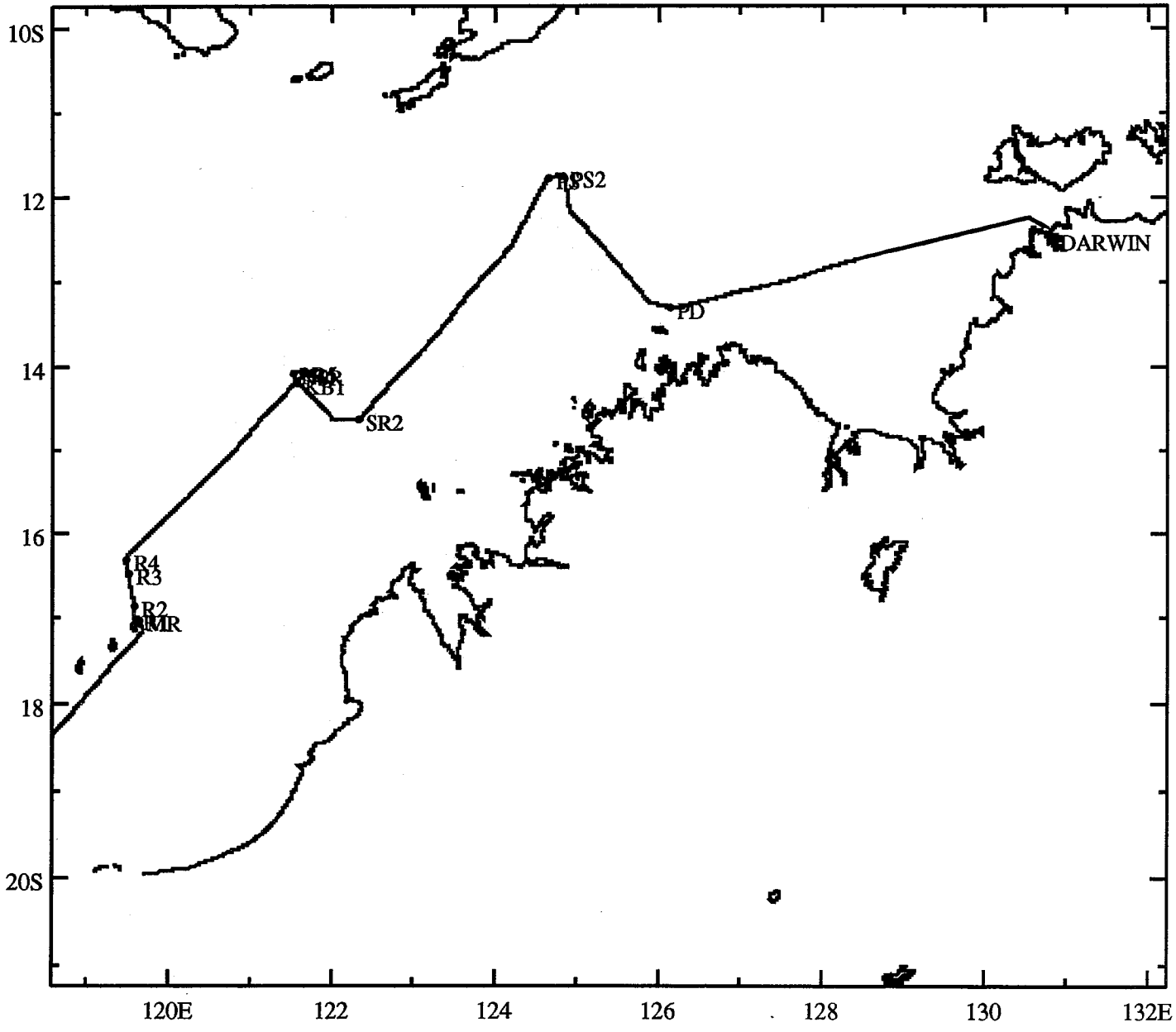
20
30.00
21
30.00
22S
114E
115
116
117
118E
#1
#2
#3
#4
#5
#6
#7
#8
#9
XX
Barrow Island
Dampier
Exmouth Gulf

Fig. 1a

Fig. 15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12
14
16
18
20S
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128
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DARWIN
PD
SR2
R4
R3
R2

Fig. 16

Exmouth

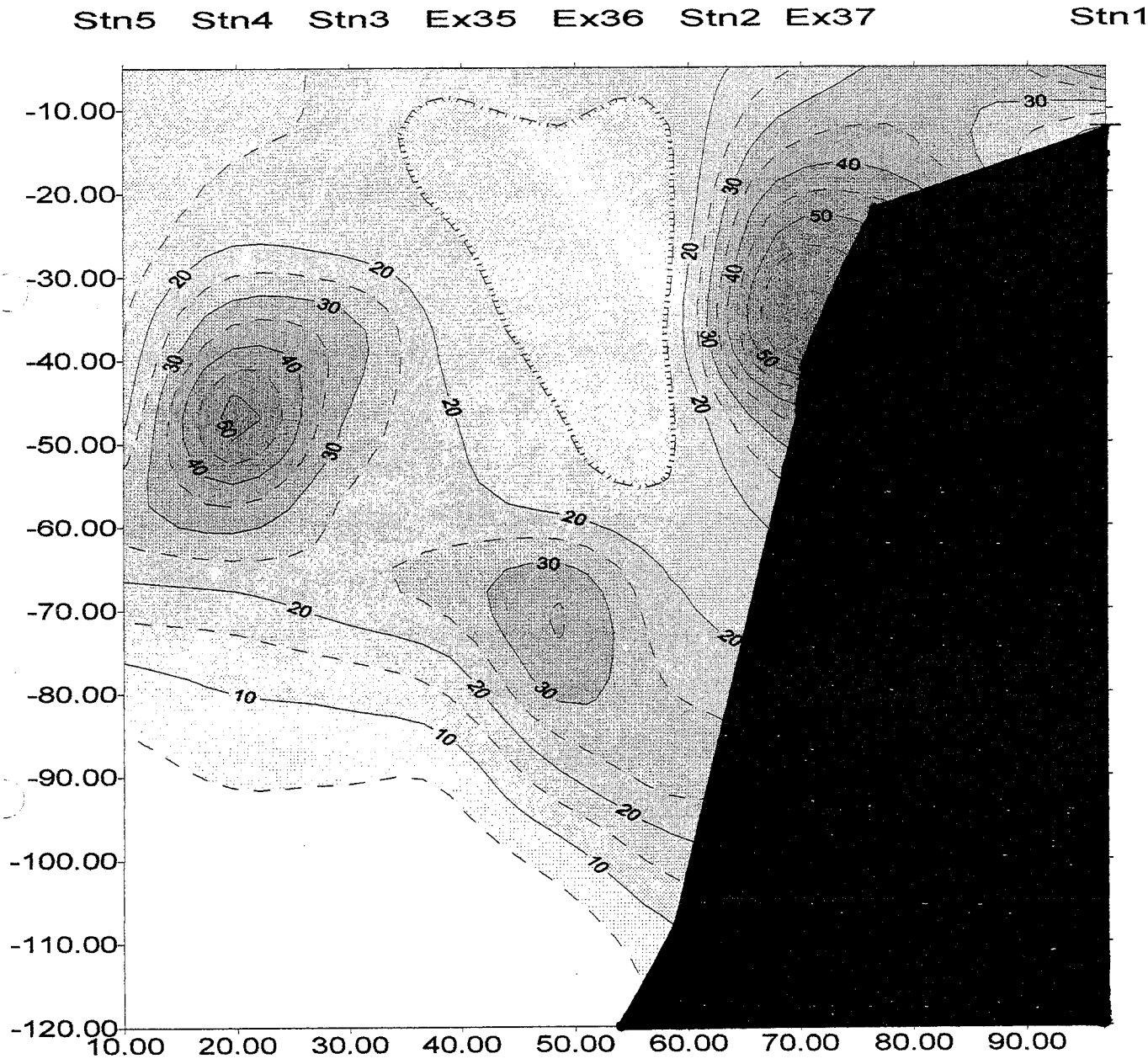

Fig. 2

Corrected Currents [bdp] at 15m

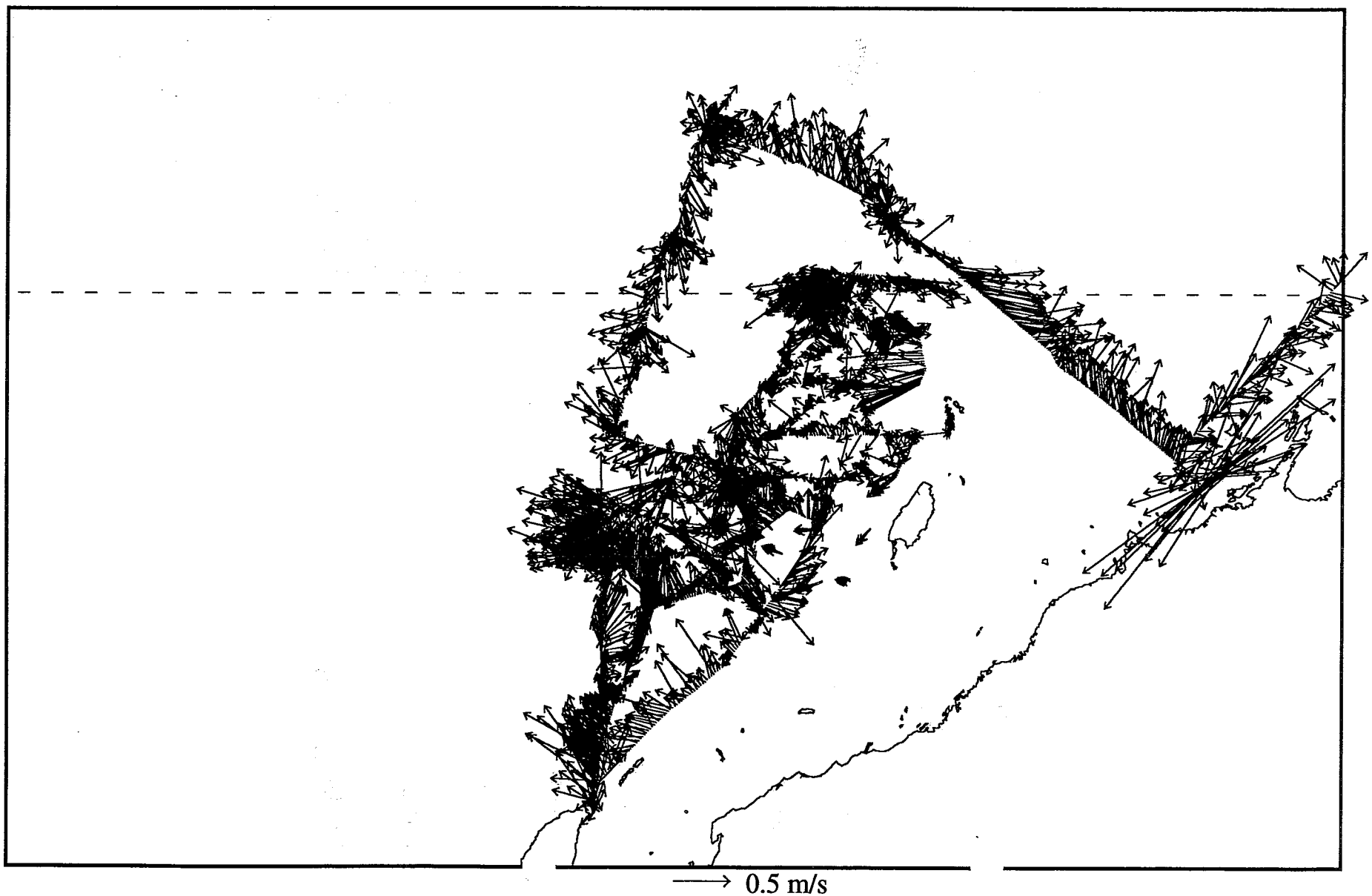

Fig. 3