MARINE RESERVE MONITORING PROGRAMME: NINGALOO MARINE PARK AND ADJACENT WATERS

CALM MARINE CONSERVATION BRANCH AND EXMOUTH DISTRICT

CROSS-SHELF SALINITY-TEMPERATURE SURVEYS BETWEEN NINGALOO MARINE PARK AND ADJACENT WATERS: 20-23 JANUARY 1997

Field Programme Report: MRMP/NMP - 1/97

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CONTENTS

SUMMARY

This report describes a proposed oceanographic field programme to investigate the potential for upwelling in the oceanic waters off Ningaloo Marine Park, Western Australia, under sustained south-southwesterly winds during summer. Vertical salinity-temperature-density profiles will be collected daily along cross-shelf transects off Tantabiddi during 20-23 January 1997.

The study aims to improve the understanding of the ecology of the whale shark, *Rhincodon typus*, by investigating physical factors that may influence their behavioural patterns. Whale sharks aggregate in substantial numbers during autumn off Ningaloo Marine Park and their presence forms the basis of an important tourist industry involving both sightseeing and closer interactions by way of tourists swimming in close proximity to the animals. The Department of Conservation and Land Management (CALM) manages the industry and this study aims to improve the technical basis for the management of human interaction with whale sharks.

The study will investigate the hypothesis that strong south-southwesterly winds during summer lead to upwelling of deeper nutrient-rich waters thereby leading to a seasonal pulse of increased primary productivity (phytoplankton) which may result in an increased abundance of zooplankton. It is proposed that this may influence the aggregation of whale sharks in the region during the autumn months.

This proposed study is part of CALM's Marine Reserve Monitoring Programme and is being coordinated by the Marine Conservation Branch and conducted in collaboration with CALM's Exmouth District.

ACKNOWLEDGMENTS

Direction

- Keiran McNamara - Director, Nature Conservation Division, CALM.
- Dr Chris Simpson - Manager, Marine Conservation Branch (MCB),CALM.
- Doug Myers - Manager, Exmouth District, CALM

Logistics and field work

- Caroline Williams, Andy Darbyshire - Exmouth District, CALM

Data

- *Meteorological data* - Perth Bureau of Meteorology
- *Satellite data* - Mike Steber, Department of Land Administration
- *Salinity-temperature data (7 April 1994)* - Jennie Cary, Tim Daly, Doug Coughran, Sue Osborne, CALM

Preparation

- *Gilles Monty (CALM volunteer, Marine Conservation Branch)*

1 INTRODUCTION

1.1 Aim

The primary aim of the study is to determine the potential for upwelling and any associated relationships this may have on the presence of the whale shark, *Rhincodon typus*, off the Ningaloo reef tract during autumn.

A secondary aim of the exercise is to improve the general understanding of the oceanography of the waters within and adjacent to the Ningaloo Marine Park, consistent with the importance placed on this issue in relation to management in the Ningaloo Marine Park (State Waters) Management Plan 1989-1999 (CALM, 1989).

1.2 Background

1.2.1 General

Human interactions with the whale shark, *Rhincodon typus*, in the waters off the Ningaloo Marine Park is an issue that requires careful management (Colman, 1996). CALM monitors and regulates commercially based tourism operations that exploit the presence of whale sharks off Ningaloo reef in the form of whale watching and diving tours. Over the last four years the predictable occurrence of the whale sharks off Ningaloo reef has led to the development of a small but expanding industry, focussing on human-whale shark interactions. From 1993 onwards, commercial whale shark tourism has been managed by CALM through a system of controls, including licensing a limited number of operators for whale shark interaction tours within the Marine Park. The demand for more whale shark interaction licenses is increasing. It is unclear whether increased tourism pressure is presently generating any short or long-term detrimental impacts on individual sharks or the group as a whole. The behavioural characteristics of the whale shark are poorly understood at present (see the review by Colman, 1996) and, in order to improve the general understanding of the ecology of whale sharks, CALM is actively involved in scientific research on their behavioural patterns and in particular their response to human interactions. As a contribution to this research the present study aims to investigate physical factors that may influence natural behavioural patterns of whale sharks in the region. This is required in order to help discern whether changes in whale shark behaviour are human or naturally induced.

The physical factors influencing the migratory patterns of whales are poorly understood. The hypothesis being investigated in this study is that the whale sharks may aggregate in the waters off Ningaloo Marine Park during autumn in response to a seasonal increase in productivity during the preceding summer months triggered by nutrient-rich upwellings of relatively deep waters driven by sustained south-southwesterly winds in summer. The presence of the Leeuwin Current down the Western Australian coastal zone is generally believed to suppress coastal upwelling that would otherwise occur as a result of south-southwesterly winds (see Pearce, 1996). However, localised upwelling may still occur where the shelf is narrow or when upwelling favourable winds are particularly strong. It is possible that the concurrence of both these factors off Ningaloo Reef during summer may in fact cause upwelling of deeper colder waters adjacent to the shelf. If this is the case this then it is also possible that upwelling may bring with it nutrients which in turn may stimulate a seasonal pulse of phytoplankton and zooplankton growth in the region. This potential increase in primary productivity may be one important influence in attracting whale sharks to the region.

It appears that to date no systematic field investigation of the potential for upwelling off Ningaloo Reef has been conducted.

1.2.2 Past data: cross-shelf salinity-temperature survey of 7 April 1994

A cross-shelf salinity-temperature survey was conducted along a 20 km transect off Tantabiddi on 7 April 1994 (0900-1220 hrs) by Nick D'Adamo, Jennie Cary and Tim Daly from the CALM vessel *Psuedorca*. Doug Coughran and Dr Sue Osborne (CALM) assisted with the logistics for the survey. The data were collected with a profiling Hamon salinity-temperature bridge (Yeokal Model 602) and calibrated against a standard scientific thermometer and seawater samples which were analysed at the CSIRO Marmion Laboratories, Marmion, Western Australia (Ref: Mr Bob Griffiths). Figure 2 presents the resulting cross-shelf vertical contour plots of salinity and temperature structure. During the 24 hours preceding the survey winds ranged from southeasterly to southwesterly with speeds of about 15 to 18 km h^{-1} and on 4/5 April a relatively strong south-southwesterly wind event (20-30 km h^{-1}) occurred (see Appendix 1). As shown, there was significant vertical and horizontal salinity and temperature stratification between the lagoonal waters and the adjacent oceanic zone out to about 20 km offshore. There is a prominent zone of relatively low temperature between stations NR400 and NR700 in the shape of a convex bulge, with the slope of the isotherms on either side of this feature being of the order of 10 m vertically in 2 km horizontally. The salinity contours also exhibit depth between stations NR500 and NR600. These data are inconclusive in terms of the prevailing dynamics at the time of the survey, however they show the presence of significant stratification in salinity and temperature. It is not possible to comment on the forcings responsible for the observed structure however dynamical instabilities associated with the Leeuwin Current (Pearce, 1991; Mills, D'Adamo, Wyllie and Pearce, 1996), as observed in NOAA-AVHRR imagery from 7 April 1994 (Ref: Department of Land Administration), preceding northward wind stress (Appendix 1) and internal waves are possibilities that may have contributed to the formation of the observed structure.

An important parameter associated with processes related to the earth's rotational forces is the Inertial Period, defined as $2\pi/f$ seconds, where f is the Coriolis parameter (equal to $1.46 \times 10^{-4}\sin\theta$, where θ is the latitude). This parameter indicates the time it takes before the earth's rotational force begins to signficantly deviate a current (counterclockwise in the southern hemisphere). For the latitude of the study region (approximately 22^{o}) the inertial period is calculated to be of order 30 hours. For times that scale with the inertial period a geostrophic balance will occur in long-shore Ekman transport, with northward near-surface flows (such as generated by a shore-parallel wind stress) rotated away from the coast. An upwelling, in the form of an upward flow of deeper colder water towards the shelf will replace the loss of coastal water. The magnitude of this mechanism will depend on the strength and direction of the wind and on the ambient strength of the vertical stratification of density (caused by salinity and/or temperature stratification). Csanady (1982) presents a detailed discussion of these mechanisms. In this coastal region the presence of significant vertical stratification (eg as occurred on 7 April 1994) indicates that isotherm displacements could be useful indicators of water movements.

2 SURVEY GRID AND METHODS

2.1 Site details

A detailed bathymetric map of the study region, data transect path and salinity-temperature monitoring sites, is presented in Figure 3. As shown, there are 11 sites in all. Table 1 lists the latitude and longitude of each site.

Table 1. Coordinates of salinity-temperature monitoring sites .

SITE	LATITUDE (^{o}S)	LONGITUDE (^{o}E)
NR5	21^{o} 53.2'	113^{o} 59.0'
NR10	21^{o} 53.2'	113^{o} 58.1'
NR15	21^{o} 53.2'	113^{o} 57.2'
NR20	21^{o} 53.2'	113^{o} 56.6'
NR25	21^{o} 53.2'	113^{o} 55.2'
NR30	21^{o} 53.2'	113^{o} 53.0'
NR35	21^{o} 53.2'	113^{o} 50.0'
NR40	21^{o} 53.2'	113^{o} 46.0'
NR45	21^{o} 53.2'	113^{o} 41.0'
NR50	21^{o} 53.2'	113^{o} 36.0'
NR55	21^{o} 53.2'	113^{o} 30.0'

2.2 Methods

At each site the vessel will be positioned at the coordinates specified and a vertical salinity-temperature (ST) cast will be performed. A CSIRO/YEOKAL SDL MODEL 606 probe will be used. These probes measure salinity, temperature and depth at resolutions of 0.1 pss, 0.1 ^{o}C, and 0.1 m, respectively. Three SDL probes have been provided for the survey: one from Murdoch University, Marine and Freshwater Research Laboratory, and two (as backups) from Mr Jack Robbins.

The SDL probe will be lowered manually to the bottom (or a maximum depth of 200 m) at a speed of about 0.5 m per second in the upper 50 m and then about 1 m per second below 50 m depth. This will result in ST data at approximately 1.5 m depth intervals for the upper 50 m and then 3 m depth intervals below 50 m depth (the sampling rate is to be set at 20 samples per minute).

Upon completion of each vertical ST cast the data are to be checked and stored electronically by the process of downloading the vertical profile data via the communications cap/cable to the laptop computer provided. Each data file is to be backed up to floppy disk between sites.

During each day surface salinity samples of seawater (3 per transect: first site, middle site and end site) are to be collected from a clean bucket and placed in a clean salinity sample bottle (washed with seawater from the site). These samples will be accurately analysed for salinity after the survey thereby providing salinity calibration information from which to check and adjust, if necessary, raw salinity records. In addition, water temperature spot checks (3 per transect first site, middle site and end site) are to be performed with the scientific thermometer to record any variations between SDL probe temperature readings and true temperature. This will provide temperature calibration data from which to check and adjust, if necessary, raw temperature records.

In addition, water samples can be collected with the NISKIN water sample collector. The NISKIN bottle has been equipped with a rope of 160 m length. The sampling regime for water sampling will be decided upon during the survey.

Four DATAFLOW temperature loggers are available for deployment. These loggers measure temperature at a resolution of 0.1 ^{o}C. These will be individually placed in dive sample bags which will be attached to rope/weight/buoy strings at the following sites:

Site NR5: one logger at mid-depth.
Site NR10: one logger at near-surface and one logger at near-bottom.
Site NR15: one logger at mid-depth.

The temperature loggers will be pre-set to start recording continuously at 5 minute intervals from 0600 hours, Monday 20 January.

During the survey all relevant notes and observations (e.g., weather, sea conditions, logger deployments and retrievals, malfunctions) are to be recorded in a field log book.

Water level data will be obtained from the Department of Transport.

Meteorological data will be obtained from the Bureau of Meteorology, Perth.

NOAA-AVHRR satellite overpass times will be obtained from the Department of Land Administration, Remote Sensing Applications Centre. Sea-surface temperature data data collected during the surface with the SDL loggers will be forwarded to Mr Alan Pearce, CSIRO Division of Oceanography, for NOAA-AVHRR sea-surface temperature image groundtruthing and interpretation.

2.3 Contingency for adverse weather conditions

In the event of adverse weather, such as severe coastal breezes or storm frontal activity, the vessel's skipper will have the responsibility to judge on safety issues and reserves the right to cancel offshore work on the basis of safety considerations. If offshore work is not possible a restructured monitoring programme for the inner lagoonal waters will be formulated by the Project Leader, Nick D'Adamo, during the survey period.

3 FIELD PROGRAMME

The field work is planned to span a total of 4 days during 20-23 January 1977. Table 2 presents the field itinerary for the programme. This may be altered during the survey according to weather conditions, scientific considerations or other logistical factors.

4 SAFETY

All safety procedures relating to navigation and associated onboard procedures will be the responsibility of the skipper of the vessel.

Alterations to field procedures based on safety aspects related to weather conditions are the primary responsibility of the skipper. Decisions to modify the field programme will be made in consultation between Nick D'Adamo and the skipper.

The Project Leader, Nick D'Adamo, is responsible for ensuring that all field work undertaken by CALM staff, including volunteers, is conducted according to CALM's departmental safety procedures and protocols.

Table 2 Field itinerary

Date	Activity
Sunday 19-1-97	N D'Adamo departs for Learmonth from Perth Domestic Airport at 4.00 PM, on Flight AN6579. Arrive Learmonth at 6.40 PM. To be met at Learmonth by Doug Myers, Manager, CALM Exmouth District. **Contacts while in Exmouth** **CALM Exmouth District office: Ph 099-491676, Fax 099-491580** **Exmouth Diving Centre: Ph 099-491201, Fax 099-491680.** **Shore to Ship communications** **HF radio: channel 2182 or 4125.** **Alternatively, via Exmouth Sea Rescue who will relay on VHF radio (commander of Sea Rescue is John Sanderson, Ph 099-491591).**
Monday 20-1-97	0500 hrs - N D'Adamo and C Williams (possibly plus A Darbyshire) travel to Tantabiddi ramp (CALM Landcruiser). 0545 hrs - load monitoring gear onto Concord. 0615 deploy loggers at NR5, NR10 and NR15 en-route to first ST profiling site NR55. Then proceed along transect, performing ST profiles at all sites back to NR5..
Tuesday 21-1-97	0545 hrs - Depart Tantabiddi and proceed to first ST profiling site NR55. Then proceed along transect, performing ST profiles at all sites back to NR5.
Wednesday 22-1-97	0545 hrs - Depart Tantabiddi and proceed to first ST profiling site NR55. Then proceed along transect, performing ST profiles at all sites back to NR5.
Thursday 23-1-97	0545 hrs - Depart Tantabiddi and proceed to first ST profiling site NR55. Then proceed along transect, performing ST profiles at all sites back to NR5. Retrieve temperature loggers at sites NR15, NR10 and NR5 as part of ST transect.
Friday 24 24-1-97	N D'Adamo travels back to Perth on AN6579. Depart 12.20 PM from Learmonth Airport for Perth via Carnarvon. Arrive Perth Domestic Airport at 3.40 PM.

5 COMMUNICATIONS

Contacts while in Exmouth
CALM Exmouth District office: Ph 099-491676, Fax 099-491580
Exmouth Diving Centre: Ph 099-491201, Fax 099-491680.

Shore to Ship communications
HF radio: channel 2182 or 4125.
Alternatively, via Exmouth Sea Rescue who will relay on VHF radio (commander of Sea Rescue is John Sanderson, Ph 099-491591).

Perth contact: CALM, Marine Conservation Branch, Ph: 09-4325100, Fx: 09-4305408.

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Pearce A F (1991). Eastern boundary currents of the southern hemisphere. In: 'The Leeuwin Current: an influence on the coastal climate and marine life of Western Australia' (eds. A F Pearce and D I Walker). *J. Roy. Soc. of W. Aust.* **74**: 35-45.

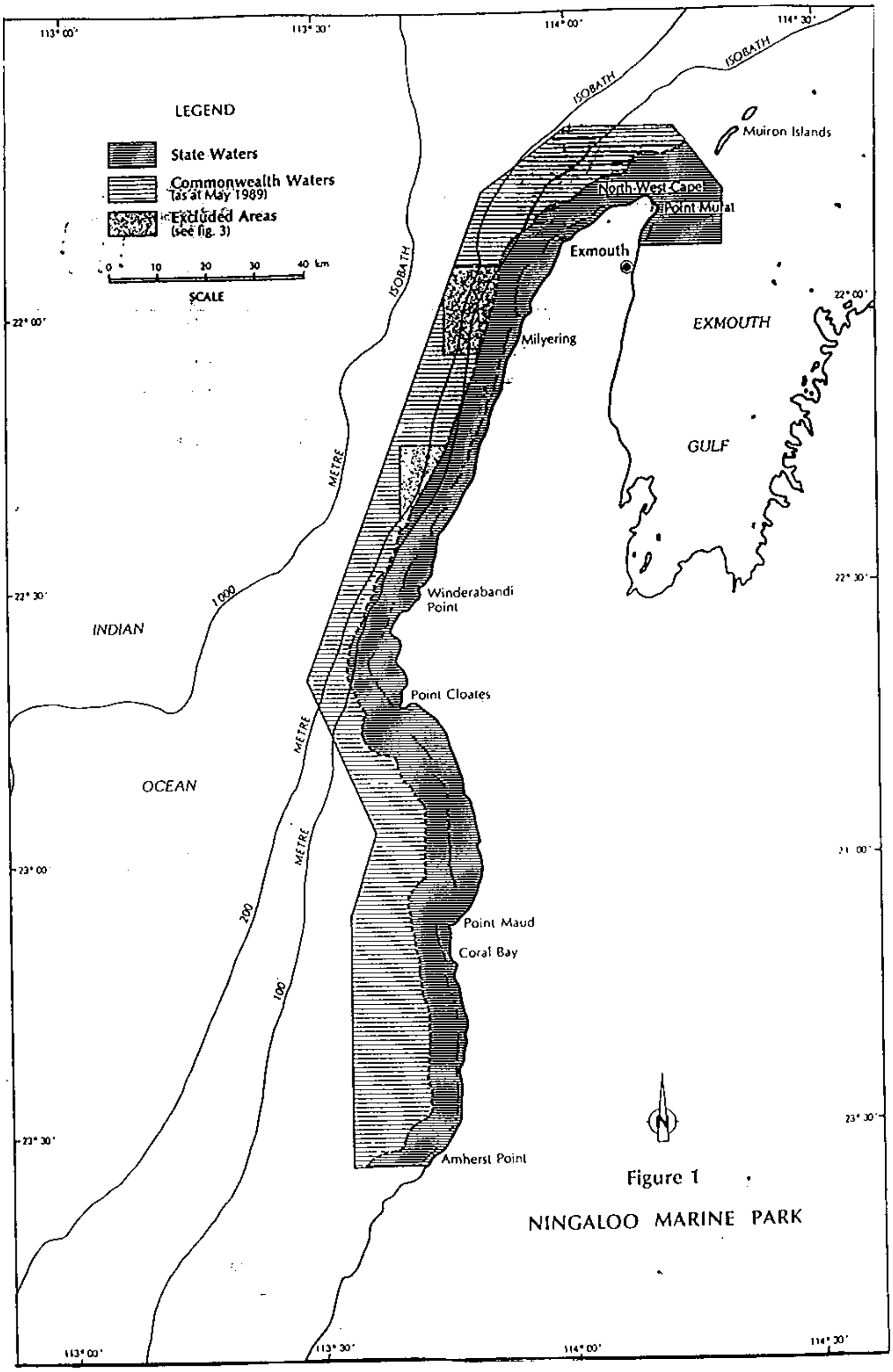

Figure 1 Locality diagram, showing Ningaloo Marine Park region (State and Commonwealth waters).

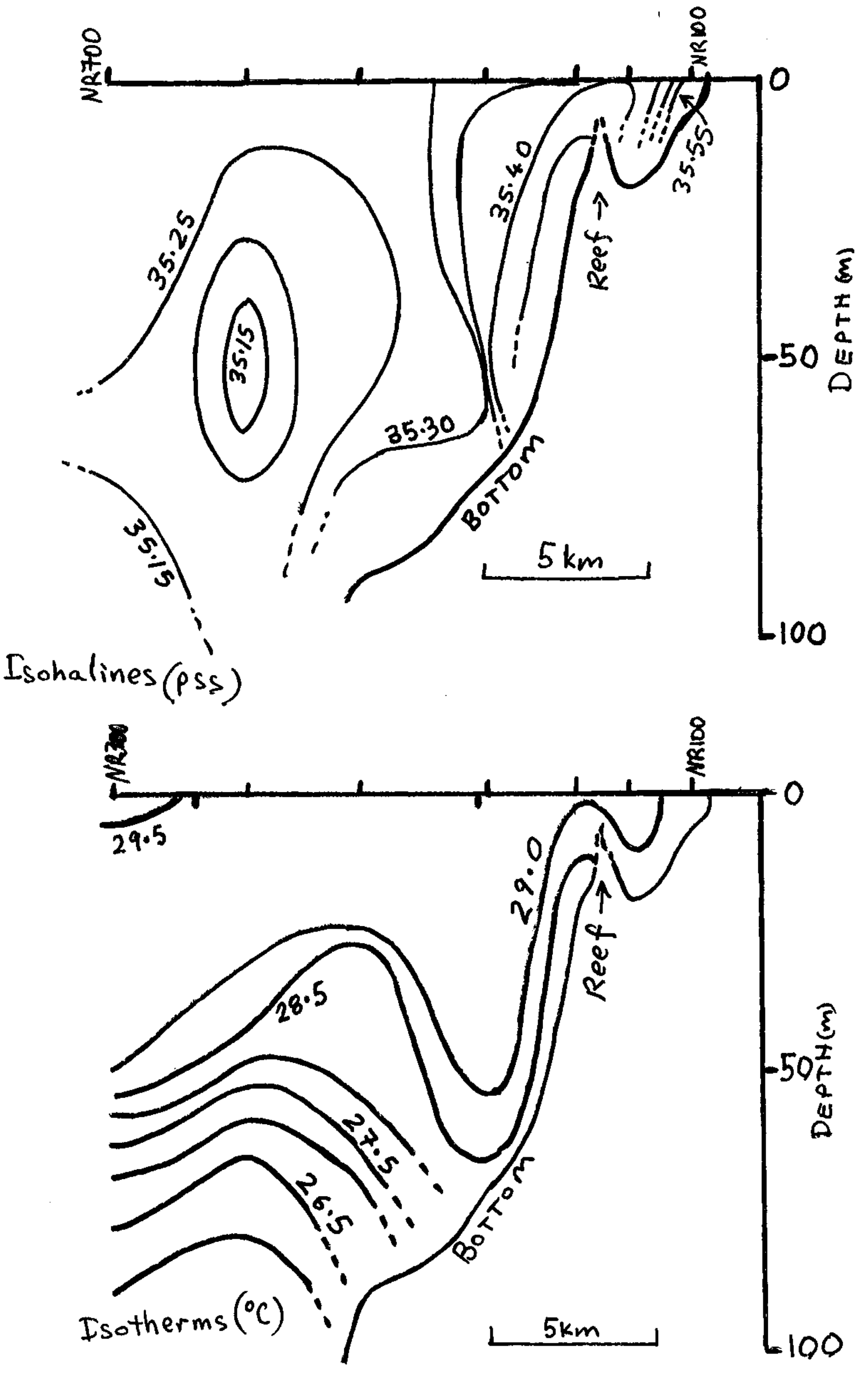

Figure 2 **Cross-shelf salinity-temperature contour plots off Tantabiddi from 7 April 1994.**

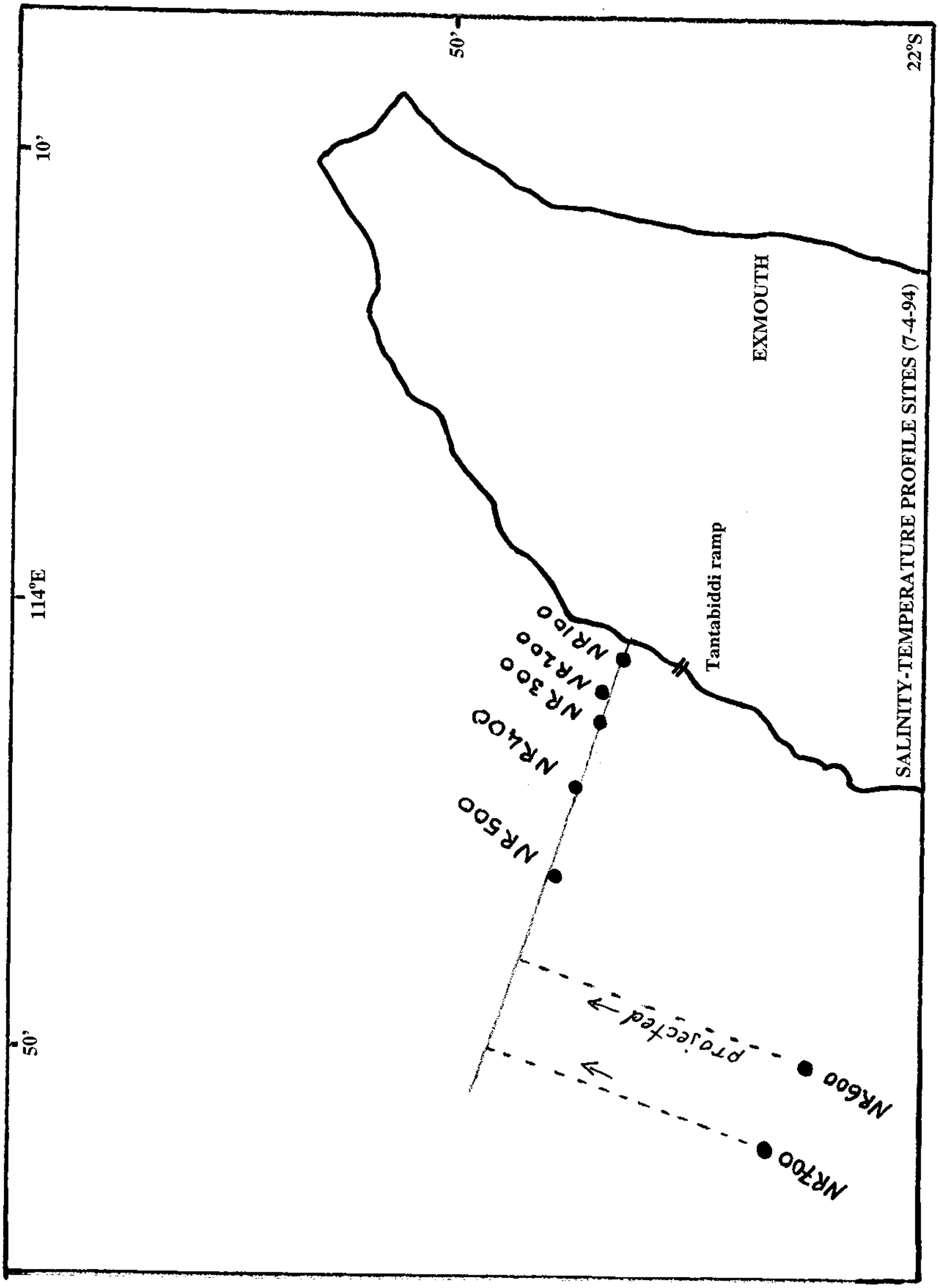

Figure 2 (cont.) Location of ST profile sites from 7 April 1994, showing projection of sites onto horizontal contour axis.

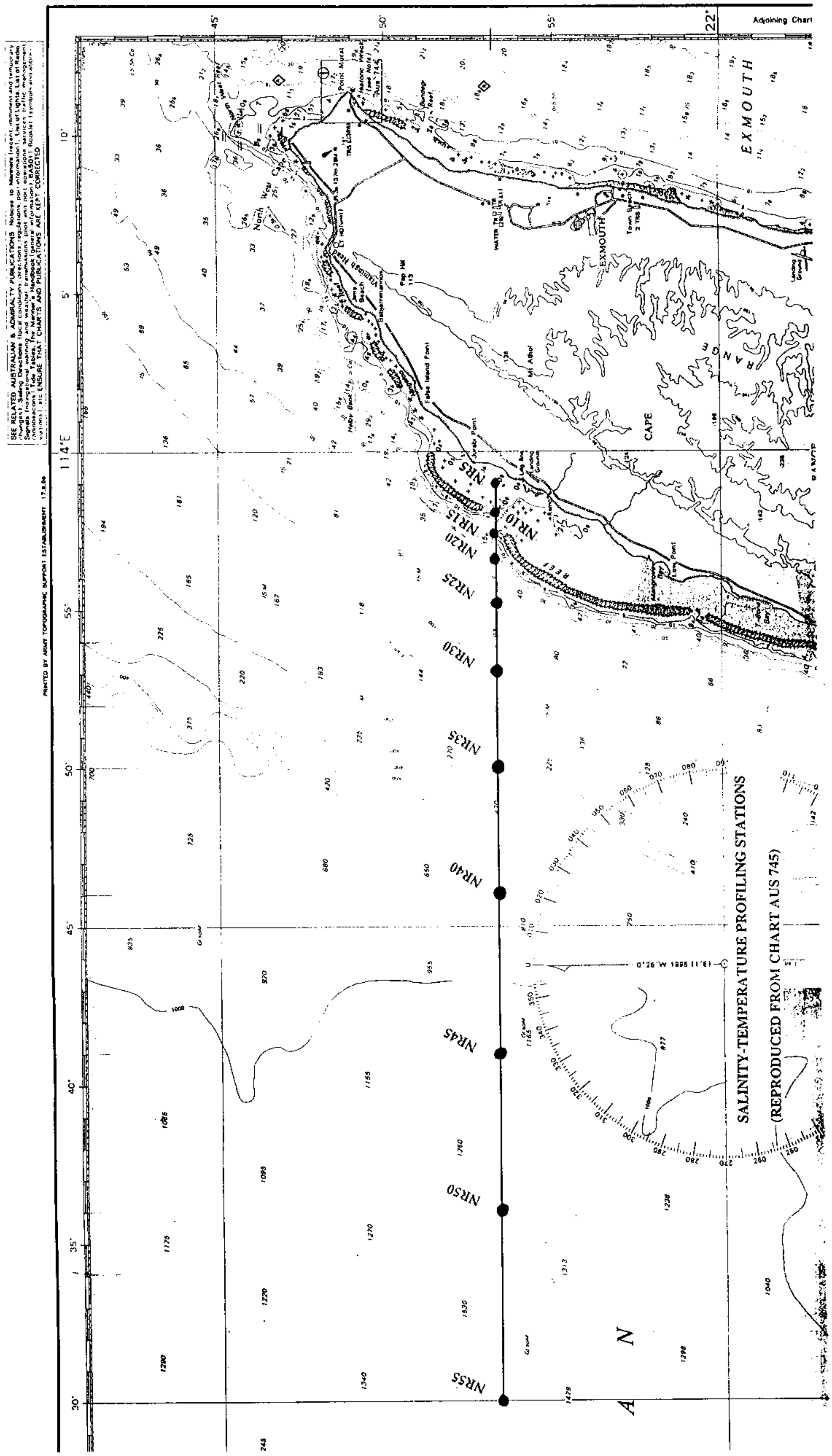

Figure 3 Bathymetry of the study region and salinity-temperature monitoring transect showing site locations (Tantabiddi to offshore).

APPENDIX 1 Meteorological data collected at Learmonth Airport during 1-8 April 1994 (from the Perth Bureau of Meteorology).

Hourly climate data for LEARMONTH (A.M.O.)

stn no	Date	Time	TEMP	WETB	RH	PRES	MSL	DIR	KMH	RAIN
005007	01/04/94	0000	24.5	17.2	46	1015.1	1015.7	203	30	
005007	01/04/94	0300	22.5	16.1	48	1014.6	1015.2	203	15	
005007	01/04/94	0600	22.2	15.9	49	1015.3	1015.9	225	15	
005007	01/04/94	0900	30.0	19.5	33	1016.0	1016.6	158	18	
005007	01/04/94	1200	36.3	22.3	25	1014.5	1015.1	135	22	
005007	01/04/94	1500	38.0	23.0	24	1012.4	1013.0	045	5	
005007	01/04/94	1800	34.1	22.1	32	1013.1	1013.7	293	33	
005007	01/04/94	2100	29.1	23.0	58	1014.6	1015.2	270	4	
005007	02/04/94	0000	26.6	21.5	63	1014.3	1014.9	180	4	
005007	02/04/94	0300	25.4	19.3	56	1013.3	1013.9	203	9	
005007	02/04/94	0600	25.2	18.3	47	1013.7	1014.3	203	5	
005007	02/04/94	0900	29.7	21.4	44	1015.2	1015.8	090	9	
005007	02/04/94	1200	32.3	22.1	38	1013.8	1014.4	023	5	
005007	02/04/94	1500	35.6	22.6	29	1011.9	1012.5	360	18	
005007	02/04/94	1800	32.1	24.1	49	1011.8	1012.4	360	15	
005007	02/04/94	2100	27.8	24.1	75	1013.9	1014.5	203	13	
005007	03/04/94	0000	26.5	20.4	56	1013.3	1013.9	225	11	
005007	03/04/94	0300	26.0	22.1	70	1011.9	1012.5	225	15	
005007	03/04/94	0600	22.1	20.3	83	1012.0	1012.6	225	5	
005007	03/04/94	0900	27.8	20.7	52	1013.4	1014.0	158	8	
005007	03/04/94	1200	30.8	21.8	44	1011.9	1012.5	045	11	
005007	03/04/94	1500	31.1	24.5	55	1010.0	1010.6	023	22	
005007	03/04/94	1800	31.9	20.3	32	1010.8	1011.4	248	13	
005007	03/04/94	2100	25.5	21.4	67	1013.0	1013.6	225	24	
005007	04/04/94	0000	23.4	20.5	76	1012.8	1013.4	203	17	
005007	04/04/94	0300	21.7	19.8	85	1012.0	1012.6	203	21	
005007	04/04/94	0600	20.6	19.7	91	1012.9	1013.5	203	17	
005007	04/04/94	0900	25.0	20.6	65	1013.8	1014.4	203	26	
005007	04/04/94	1200	32.1	21.1	33	1012.4	1013.0	203	26	
005007	04/04/94	1500	33.1	21.6	32	1011.0	1011.6	203	24	
005007	04/04/94	1800	28.5	20.7	47	1011.8	1012.4	203	32	
005007	04/04/94	2100	24.9	20.5	66	1013.3	1013.9	225	21	
005007	05/04/94	0000	22.4	19.1	72	1013.3	1013.9	180	30	
005007	05/04/94	0300	19.9	18.1	83	1012.9	1013.5	203	22	
005007	05/04/94	0600	17.9	16.9	89	1013.3	1013.9	203	11	
005007	05/04/94	0900	24.0	18.2	54	1013.9	1014.5	180	24	
005007	05/04/94	1200	30.7	19.1	28	1012.5	1013.1	158	22	
005007	05/04/94	1500	35.1	19.6	18	1010.2	1010.8	090	5	
005007	05/04/94	1800	33.2	21.2	29	1009.9	1010.5	203	11	
005007	05/04/94	2100	25.7	19.5	52	1012.2	1012.8	225	5	
005007	06/04/94	0000	24.5	18.8	55	1011.9	1012.5	203	11	
005007	06/04/94	0300	21.6	16.6	58	1010.9	1011.5	203	15	
005007	06/04/94	0600	21.3	15.3	52	1011.3	1011.9	225	5	
005007	06/04/94	0900	28.0	17.4	30	1012.8	1013.4	180	11	
005007	06/04/94	1200	34.6	18.6	17	1011.5	1012.1	135	11	
005007	06/04/94	1500	37.6	20.1	15	1008.8	1009.4	135	4	
005007	06/04/94	1800	33.7	19.2	21	1009.1	1009.7	248	18	
005007	06/04/94	2100	28.5	21.1	50	1010.5	1011.1	225	15	
005007	07/04/94	0000	25.6	18.1	46	1010.4	1011.0	203	15	
005007	07/04/94	0300	24.2	15.4	33	1009.9	1010.5	203	18	
005007	07/04/94	0600	24.0	14.8	31	1009.8	1010.4	225	17	
005007	07/04/94	0900	31.2	19.2	27	1011.8	1012.4	135	8	

Untitled

005007	07/04/94	1200	33.0	21.0	30	1011.4	1012.0	045	13
005007	07/04/94	1500	33.0	24.5	46	1009.9	1010.5	360	26
005007	07/04/94	1800	32.5	22.5	42	1010.3	1010.9	360	15
005007	07/04/94	2100	29.7	23.4	56	1013.7	1014.3	000	0
005007	08/04/94	0000	28.2	21.6	54	1012.7	1013.3	180	11
005007	08/04/94	0300	28.4	20.3	44	1011.5	1012.1	180	13
005007	08/04/94	0600	24.6	17.1	42	1012.4	1013.0	225	4
005007	08/04/94	0900	30.0	18.2	27	1014.5	1015.1	180	5
005007	08/04/94	1200	36.3	19.8	15	1013.7	1014.3	113	13
005007	08/04/94	1500	37.0	21.0	20	1011.4	1012.0	000	0
005007	08/04/94	1800	33.6	21.1	31	1011.4	1012.0	203	32
005007	09/04/94	0000	25.0	18.5	50	1013.5	1014.1	203	22

not spooling currently

APPENDIX 2 NOAA-AVHRR satellite overpass times (from DLA, RSAC)

Sat	Orbit	Date (WST)	Equator Cross Time	Equator Cross Long	Start Time	Azim	Lat	Long	Max Elev	Min
12	29507	18/ 1/1997	1806	127.730	1932	175.26	-56.66	119.53	52	15
12	29514	19/ 1/1997	555	310.460	648	1.46	-5.70	116.54	54	15
12	29521	19/ 1/1997	1744	133.250	1910	168.32	-56.14	124.76	87	15
12	29528	20/ 1/1997	533	315.990	626	13.72	-6.22	121.95	81	16
12	29578	23/ 1/1997	1757	130.030	1922	171.92	-58.40	122.89	62	15
12	29585	24/ 1/1997	546	312.760	639	6.14	-7.36	118.47	66	15
12	29592	24/ 1/1997	1735	135.550	1900	165.85	-57.88	128.09	72	16

Sat	Orbit	Date (WST)	Equator Cross Time	Equator Cross Long	Start Time	Azim	Lat	Long	Max Elev	Min
14	10557	17/ 1/1997	054	318.040	147	17.71	-4.79	124.17	79	16
14	10621	21/ 1/1997	1346	125.090	1512	176.79	-58.63	118.68	42	15
14	10635	22/ 1/1997	1335	127.870	1501	173.72	-58.37	121.29	54	16
14	10642	23/ 1/1997	130	309.240	223	358.07	-6.15	115.05	47	15
14	10649	23/ 1/1997	1324	130.660	1450	170.62	-58.12	123.90	66	16
14	10656	24/ 1/1997	119	312.020	212	4.35	-6.41	117.78	61	15
14	10663	24/ 1/1997	1313	133.450	1439	167.53	-57.86	126.52	77	16

DISTRIBUTION LIST

Marine Reserve Monitoring Programme. Cross-shelf salinity-temperature surveys between Ningaloo Marine Park and adjacent waters: 20-23 January 1997 Field Programme Report MRMP/NMP-01/97.

Keiran McNamara, Director, Nature Conservation Division, CALM
Chris Simpson, Manager, Marine Conservation Branch, CALM
Doug Myers, Manager, Exmouth District, CALM
Caroline Williams, Conservation Officer, Exmouth District, CALM
Andrew Darbyshire, Marine Operations Officer, Exmouth District, CALM
Gilles Monty, CALM volunteer, Marine Conservation Branch
Mal Toole, Exmouth Diving Centre

BUDGET (FOR INTERNAL MARINE CONSERVATION BRANCH USE)

Item	**Cost ($)**
Staff Mike Lapwood (2 days @ $154/day)	 308
Accomodation (c/- D Myers) (nominal)	250
Air travel (1 person @ $560)	560*
Meals 1 person x 6 days @ $30/day)	 180*
Vessel costs (4 days @ 1050/day)	4200*
SDL meter (4 days @ $200/day)	800*
Backup SDL meters	1000*
Marine charts	50*
Temperature loggers (4 x 4 days @ $10/day)	160
Vehicle costs Toyota landcruiser (nominal)	 $100
Consumables (rope, shackles, buoys etc)	100*
Contingency (10%)	689*
Sub-total (funds from MCB) **Sub-total (in-kind contribution from MCB ands/or Exmouth District)** **Total**	**7529** **818** **$8348**
Staff resources Preperation N D'Adamo M Lapwood G Monty Field trip N D'Adamo Data report N D'Adamo T Daly **Total** (not including M Lapwood's time, see above)	**days** 4 2 1 6 3 3 **17 days**