MARINE RESERVE IMPLEMENTATION PROGRAMME: JURIEN BAY AND ADJACENT WATERS

CALM MARINE CONSERVATION BRANCH

OCEANOGRAPHIC FIELD PROGRAMME FOR JURIEN BAY AND ADJACENT WATERS: 28 JANUARY TO 7 FEBRUARY 1997

Field Programme Report: MRIP/JB - 1/97

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CONTENTS

SUMMARY

This report describes a proposed oceanographic field programme for the measurement of circulation and salinity-temperature-density characteristics of the coastal waters between Sandy Point and Cervantes during the period 28 January to 7 February 1997. The study region, which is focussed around Jurien Bay, was recommended as worthy of marine reservation in the "Wilson Report" (*A Representative Marine Reserve System for Western Australia - Report of the Marine Parks and Reserves Selection Working Group, June 1994).* The Jurien area is part of Australia's longest continuous temperate limestone reef system, which extends for 300 km from Dongara to Hillarys, and is ecologically notable for its rich biological overlap of tropical and temperate marine life.

This proposed field programme is part of CALM's Marine Reserve Implementation Programme and is being coordinated by the Marine Conservation Branch (MCB) of the Department of Conservation and Land Management (CALM).

The primary aims of the study are to obtain direct measurements of currents in Jurien Bay and adjacent waters in order to provide validation data for the assessment of predicted currents from the HAMSOM numerical hydrodynamic model. This model has recently been applied to the study region to simulate the circulation during typical summer meteorological conditions by the Department of Environmental Engineering, University of Western Australia. A secondary aim of the exercise is to measure the characteristics of vertical and horizontal salinity, temperature and density stratification during typical summer conditions in order to assess the potential for density gradients to influence transport and mixing.

The main techniques to be employed in the survey are drogue tracking, salinity-temperature monitoring and fixed point temperature logging. A GPS (with differential capability) will be used for position fixing. The CALM Marine Conservation Branch marine research vessel, *Bidthangara,* will be used for the field survey.

ACKNOWLEDGMENTS

Direction

- Keiran McNamara **-** Director, Nature Conservation Division, CALM.
- Dr Chris Simpson **-** Manager, Marine Conservation Branch (MCB), Nature Conservation Division, CALM.

Modelling

- Dr Charitha Pattiaratchi and Mr Donald Pang, Department of Environmental Engineering, University of Western Australia

Data

- *Water level* **-** Mr Don Wallace, Department of Transport
- *Meteorological data* **-** Perth Bureau of Meteorology
- *Satellite data* **-** Mr Mike Steber, Department of Land Administration

CALM volunteers

- Heidi Oswald
- Gilles Monty

1 INTRODUCTION

1.1 Aim

The primary aims of the study are to (i) develop a better understanding of the wind-driven hydrodynamics of the coastal waters off Jurien Bay between Sandy Point and Cervantes and (ii) to provide validation data from which to assess the performance of a barotropic numerical hydrodynamic model (HAMSOM) which has been applied to the Jurien coastal region for typical summer meteorological conditions.

A secondary aim of the exercise is to measure the vertical and horizontal salinity, temperature and density stratification under typical summer meteorological conditions in order to assess the potential for density gradients to influence the transport and mixing characteristics of these waters.

1.2 Background

1.2.1 General

The study region was recommended in the *Report of The Marine Parks And Reserves Selection Working Group* titled *A Representative Marine Reserve System for Western Australia* (CALM, 1994; commonly known as the "Wilson Report") as worthy of consideration for marine reservation (Figure 1).

The CALM Act allows for the establishment of multiple-use marine reserves for the purposes of conservation of marine flora and fauna and public recreation. Commercial activities, such as fishing, aquaculture and petroleum exploration and production, are also acceptable within specific zones of multiple-use marine reserves. Commercial and recreational fisheries in marine reserves are managed by the Fisheries Department.

The CALM Act specifies the statutory process for the reservation of marine reserves, including a public planning process for the development of management zoning schemes that allow for the spatial separation of incompatible activities in a marine park. In anticipation of this process the broadscale hydrodynamics of the area is being investigated to provide information on the transport and mixing of water. This information can then be used to predict the transport and mixing of substances of biological interest that may be contained in the water (eg nutrients, larvae, contaminants). The inter-inter-connectivity within the area and the throughflow (flushing) of water are important factors to be considered in assessing the likely impacts of various activities, particularly in view of the multiple-uses that will be allowed for in marine reserves. The selection of appropriate locations for sanctuary zones, the transport of biological material and the adequate assessment of concentration fields from introduced contaminants are issues that depend critically upon an adequate understanding and predictability of the hydrodynamics.

The oceanographic field survey outlined here is part of CALM's Marine Reserve Implementation Programme and is being coordinated by the Marine Conservation Branch of CALM. Nick D'Adamo is the Project Leader and Tim Daly is the Field Team Leader.

A habitat ground-truthing study for the coastal region from Cervantes to Cliff Head is currently underway and is being conducted by the Marine Conservation Branch of CALM as part of the Marine Reserve Implementation Programme (see Burt, 1997).

1.2.2 Past hydrodynamic studies

A literature search revealed that there has been little work published on the hydrodynamics of Jurien Bay and adjacent waters. A Masters research study on the hydrodynamics of the region is currently underway at the University of Western Australia, Department of Environmental Engineering (student: Mr Donald Pang; supervisor: Dr Charitha Pattiaratchi). This study has resulted in time series data of currents in the area between Island Point and Essex Rocks, limited salinity-temperature data, meteorological data and barotropic numerical model simulations of the flow fields south of Jurien under constant winds. The HAMSOM numerical hydrodynamic model (Pattiaratchi and Knock, 1995) was applied in barotropic mode for that study.

Pang and Pattiaratchi's HAMSOM model domain was extended to produce flow fields for the region between Sandy Point and Cervantes for constant winds from the SW, SE, NE and NW. This modelling was carried out by Mr Pang under a contract funded by the Marine Conservation Branch, CALM, and the results are presented in Figure 2. Although the model runs have yet to be compared to field measurements they are nevertheless useful as preliminary indicators of probable flow patterns under moderate to strong wind forcings (> 7.5 m s^{-1}). Earlier current meter recordings of the general flow fields under strong sea-breeze conditions indicate that the speeds predicted by the model are reasonably similar to measured flows. The HAMSOM model has also previously been applied to lagoonal regions near Perth under similar wind forcings (Pattiaratchi and Knock, 1995). The barotropic model results for the Jurien region (Figure 2) suggest that the broad-scale flow fields are likely to be dominated by wind stress, but with the bathymetry strongly influencing the finer details of the circulation patterns. For example, comparing the 1, 5 and 15 m level model results for all four wind forcings indicates that the relatively deep partially enclosed lagoonal sub-regions display the propensity for recirculation and overturning due to bathymetric constraints. Hence, these sub-regions could be areas of relatively long residence times during periods of weak winds and/or strong vertical stratification. These results are important in providing guidance to the selection of sites for flow measurements, salinity-temperature profiling and temperature logging.

2 SURVEY GRID, METHODS AND EQUIPMENT

2.1 Site and grid details

A detailed bathymetric map of the study region is presented in Figure 3. As shown, there are a series of major reef lines aligned approximately shore parallel, with spits and tombolas that connect the shore with some of the reef structures. These bathymetric features result in a number of partially enclosed lagoonal sub-regions, such as the northern and southeast areas of Jurien Bay and the zone between Essex Rocks and Jurien. The model results (Figure 2) have indicated that these sub-regions could experience re-circulating flows. Furthermore, the high recreational and commercial (eg aquaculture and fishing) importance of some of these areas suggest that an appropriate level of understanding of the flushing and internal mixing characteristics is required in order to adequately assess potential environmental threats and to effectively manage such regions for multiple usage. Hence, the field grid has been chosen not only to provide calibration data for the broad-scale modelling but to also place particular emphasis in areas most susceptible to relatively poor flushing.

The field grid is presented in Figure 4. Drogue release points JB1-JB7 have been chosen to monitor currents likely to be directly wind-driven with minimal steering due to adjacent reefs. Drogue release points JB8-JB13 have been chosen to monitor currents likely to be significantly influenced by recirculating patterns due the presence of nearby banks or reef lines.

Transects T1-T4 are paths along which vertical salinity-temperature profiling will be conducted. Transects T1, T2 and T3 have been aligned so that salinity-temperature-density differences between the shelf zone and the inner reef region can be measured. Transect T4 has been aligned to provide information on the along-shore variation in salinity, temperature and density.

Temperature loggers will be deployed at sites JB8, JB11, JB12 and JB13. Sites JB11, JB12 and JB13 have been chosen to lie within the semi-enclosed lagoonal areas of the study region. Site JB8 has been positioned in a relatively exposed area of the study region west of the major reefs and the data will be compared to data from the lagoonal sites to discern any differences caused by differential exposure to meteorological forcings of relatively protected and exposed areas around the study site. Loggers will be attached to a vertically buoyed rope at various depths throughout the water column and will record the temporal variation of vertical temperature structure at 10 minute intervals.

The Project Leader may add new sites or make alterations to the position of sites during the survey.

2.2 Methods

Drogue tracking

At each site both a near-surface and a near bottom 2x2 m^2 drogue will be released and tracked with GPS. The accuracy of the GPS will be regularly checked (at least hourly) by switching on the DGPS and noting the respective readings of the DGPS and the standard GPS. Other than for these spot checks the standard GPS will be used. It is unlikely that the DGPS will be needed for continuous tracking as the positioning error due to standard GPS is likely to be less than about 50 m which will be small compared to the likely distances (~1 km) travelled by a drogue in one hour.

Recordings of the positions of drogues are to be taken at least once every 30 minutes and recorded on EXCEL spreadsheets during tracking. Each data point will comprise a drogue number, time of position fixing, latitude and longitude in spherical coordinates (deg, min, sec), latitude and longitude in grid coordinates (metres), and any relevant comments such as weather, unusual drogue trajectories, or influence of the seabed (such as the drogues getting snagged on a reef or coming to rest on the seabed).

In shallow regions it may be necessary to deploy smaller drogues and a number of 1x1 m^2 drogues will be provided for this purpose. These drogues are likely to be significantly influenced by wind drag on their above surface components and hence the resulting recorded speeds may be useful only as qualitative indicators of current velocity.

Salinity-temperature profiling

At each site the ST meter is to be used to record salinity and temperature recorded every metre. A bottle of seawater (for calibration purposes) is to be collected from the surface every 2-3 hours and the meter reading of salinity at the surface is to be recorded to the field log sheet. The ST data are to be recorded on the data sheets and transferred to pre-formatted data files on the portable PC immediately after profiling.

The objective of the ST profiling is to determine whether circulation patterns indicated by drogue trajectories are influenced by salinity-temperature (and therefore density) stratification. Salinity-temperature profiles are to be collected adjacent to a drogue during every second fix. This should ensure an ST profile is collected adjacent to a particular drogue at least every 2 hours. In addition, regular profiling at temperature logging sites is to be conducted.

In addition, ST transects starting near the shore and running out to the shelf zone west of the reefs will be performed with the ST meter as determined during the field survey. Notional transect paths for ST profiling are presented in Figure 4.

Temperature logging

Four DATAFLOW temperature loggers will be deployed throughout the survey at sites shown in Figure 4. The loggers measure to an accuracy of +/- 0.1 ^{o}C and will be set to measure every 10 minutes. At each site the loggers will be distributed along buoyed ropes at equal spacings from near-bottom to near-surface. This will yield a time series of vertical temperature structure and provide quantitative information on the formation and breakdown of vertical temperature structure throughout diurnal cycles within a typical summer synoptic cycle. Complementary salinity profiles will be collected at the temperature logging site thereby allowing density profiles to be calculated. The logger depths and deployment/retrieval times for each logger are to be recorded in the field log notes.

2.3 Equipment

2.3.1 Current measurements

Drogues: Eight 2 m^2 X 2 m^2, if available. Alternatively, 1 m^2 X 1 m^2.drogues can be used.

Position fixing: standard GPS, with Differential GPS used (DPGS) at selected times.

2.3.2 Salinity-temperature monitoring

ST profiling: CALM’s Yeokal Hamon ST bridge (serial No. ST384).

CTD profiling: Optional, using the Centre for Water Research CTD probe, equipped with flourometer and turbidity sensor.

Temperature logging: CALM’s DATAFLOW temperature loggers (four will be deployed).

2.3.3 Water level

Water level data will be obtained from the Department of Transport for Geraldton and Jurien Bay.

2.3.4 Meteorological data

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

2.3.5 Satellite data

NOAA-AVHRR satellite overpass times will be obtained from the Department of Land Administration, Remote Sensing Applications Centre.

2.4 Contingency for adverse weather conditions

In the event of adverse weather, such as severe coastal breezes or storm frontal activity, the field programme will revert to detailed drogue tracking and salinity-temperature monitoring in the inner lagoon regions of Jurien Bay. However, in all cases the vessel's skipper will have the responsibility to judge safety issues and reserves the right to cancel field operations on the basis of safety considerations.

3 FIELD PROGRAMME

The field work is planned to span a total of 11 days from 28 January to 7 February 1997 with the objective of capturing the hydrodynamic behaviour during a period of typical summer winds (~ 5-10 m s^{-1}). Table 1 presents the field itinerary for the data collection. This may be altered during the survey according to weather conditions, scientific considerations or other logistical factors.

Date	Activity
Tue 28-1-97	N D'Adamo, T Daly and G Monty depart at 0800 for Jurien with Landcruiser. Arrive approximately 1000 hrs. Contact: Jurien Bay Hotel (Ph: 096 521022, Fax: 096 521425). Set up vessel (Bidthangara stationed at Jurien Bay Marina). Deploy temperature loggers and perform ST profiling at logger sites.
Wed 29-1-97	Drogue deployments JB1, JB2, JB3 and ST transects T3 and T4.
Thu 30-1-97	Drogue deployments JB1, JB2, JB3 and ST transects T3 and T4.
Fri 31-1-97	Drogue deployments JB4, JB5 and ST transects T2and T4.
Sat 1-2-97	Drogue deployments JB6, JB13 and ST transects T2 and T4. Saturday evening (1700 hrs) field team return to Perth in Landcruiser.
Sun 2-2-97	Free day. Sunday evening (1700 hrs) field crew (N D'Adamo, T Daly and H Oswald) travel to Jurien.
Mon 3-2-97	Drogue deployments JB8, JB9, JB10 and ST transects T1 and T4.
Tue 4-2-97	Drogue deployments JB7, JB9 and ST transects T1 and T4.
Wed 5-2-97	Drogue deployments JB11, JB12 and ST transects T1 and T4.
Thu 6-2-97	Drogue deployments JB11, JB12 and ST transects T1 and T4. Retrieve temperature loggers and perform ST profiling at logger sites.
Fri 7-2-97	Weather permitting, depart Jurien for Perth (T Daly and N D'Adamo, onboard Bidthangara) at approximately 0500 hrs. Approximate travel time 10 hours. H Oswald to drive Landcruiser back to Perth.

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 (Field Team Leader) and the skipper, Tim Daly.

The Field Team Leader 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.

5 COMMUNICATIONS

While at sea, members of the field team can usually be contacted during the day as follows.

Marine HF - channel 2182, 4620. These channels will establish contact with:
VIP Perth radio (Ph 09-3020104), VIC Carnarvon Radio
Dept of Transport, Jurien Bay Marina (Ph: 096-521323)

Marine VHF: channel 16 (any station)

CALM VHF: channel 16 Jurien Bay

Jurien Sea Rescue: Ph 096-521290, Fax 096-521337

On land, members of the field team will be staying at the Jurien Bay Hotel, Ph: 096-521022, Fx: 096-521425.

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

Local field contact: CALM Cervantes, Ph: 096-527043, Fx: 096-527340.

6 DATA PROCESSING AND REPORTING

The following sequence outlines the minimum level of processing, analysis and reporting that will follow the field survey.

- A data report containing all edited data.

- A report detailing the current patterns and speeds measured under the various wind regimes. The report will make a comparison between measured currents and predicted currents from earlier numerical simulations conducted by the Department of Environmental Engineering, University of Western Australia.

7 FUTURE WORK

7.1 Field surveys

Depending on the range of meteorological and hydrodynamic conditions encountered, further field studies may be required to complement the results of this study. For example, it may be required that a specific hydrodynamic study be conducted during characteristic autumn conditions to investigate the transport and mixing characteristics of the area under weak wind conditions. During such conditions there may significant vertical and horizontal density structure which could have an important influence on the hydrodynamics. For example, the creation of relatively dense layers within a basin can lead to a degree of trapping and hence poor flushing.

7.2 Modelling

Although numerical modelling of the hydrodynamics is not within the scope of this proposal it is recommended that the results of the field exercise be considered for use in further numerical modelling of the hydrodynamic behaviour of these waters under a wide range of oceanographic and meteorological conditions. It remains to be seen how important density effects are relative to wind and tidal effects in the hydrodynamics of these waters. Future field studies will help to resolve this issue.

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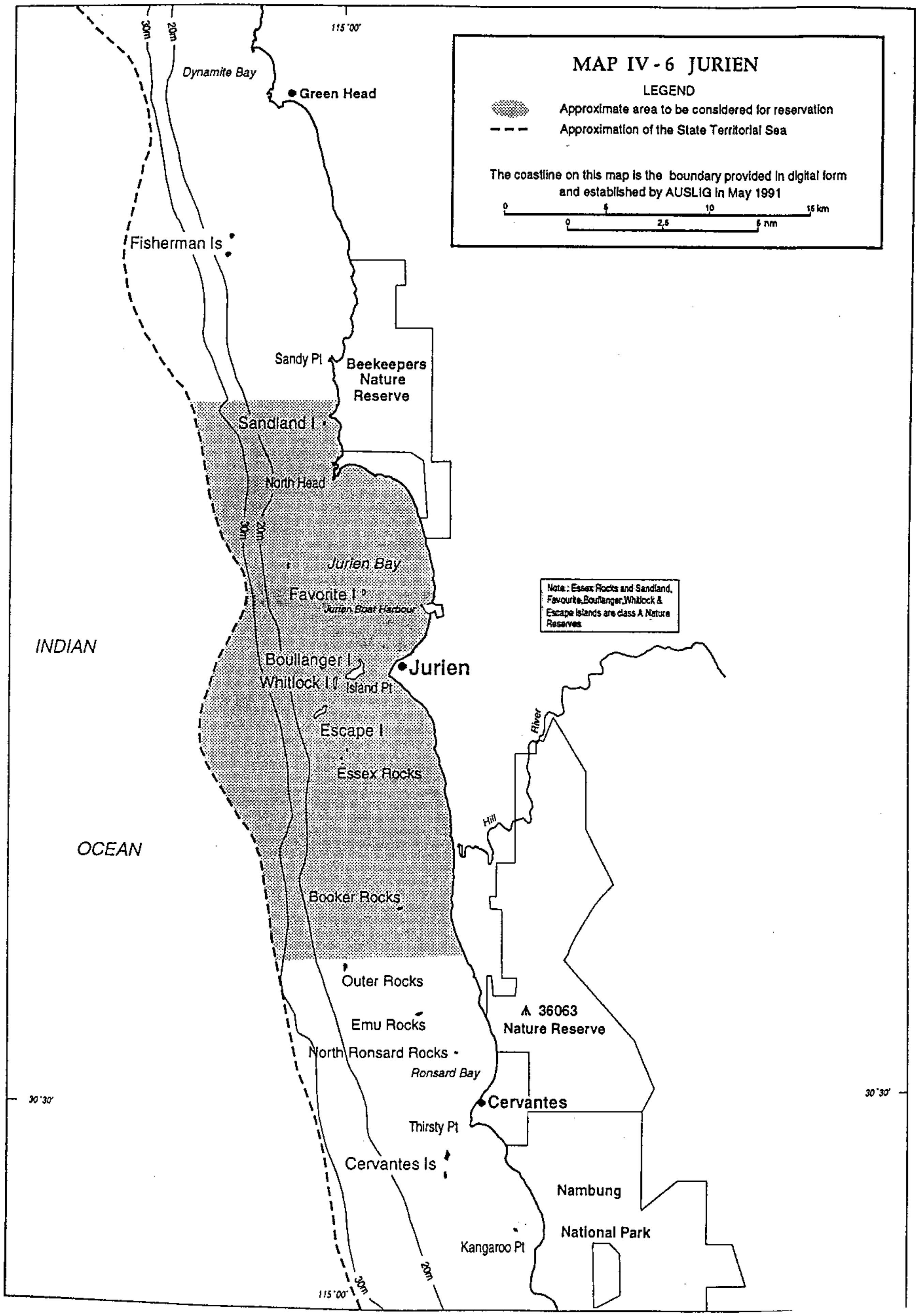


Figure 1 Locality diagram, showing "Wilson Report" recommendation for a marine reserve in the Jurien region (from CALM, 1994).

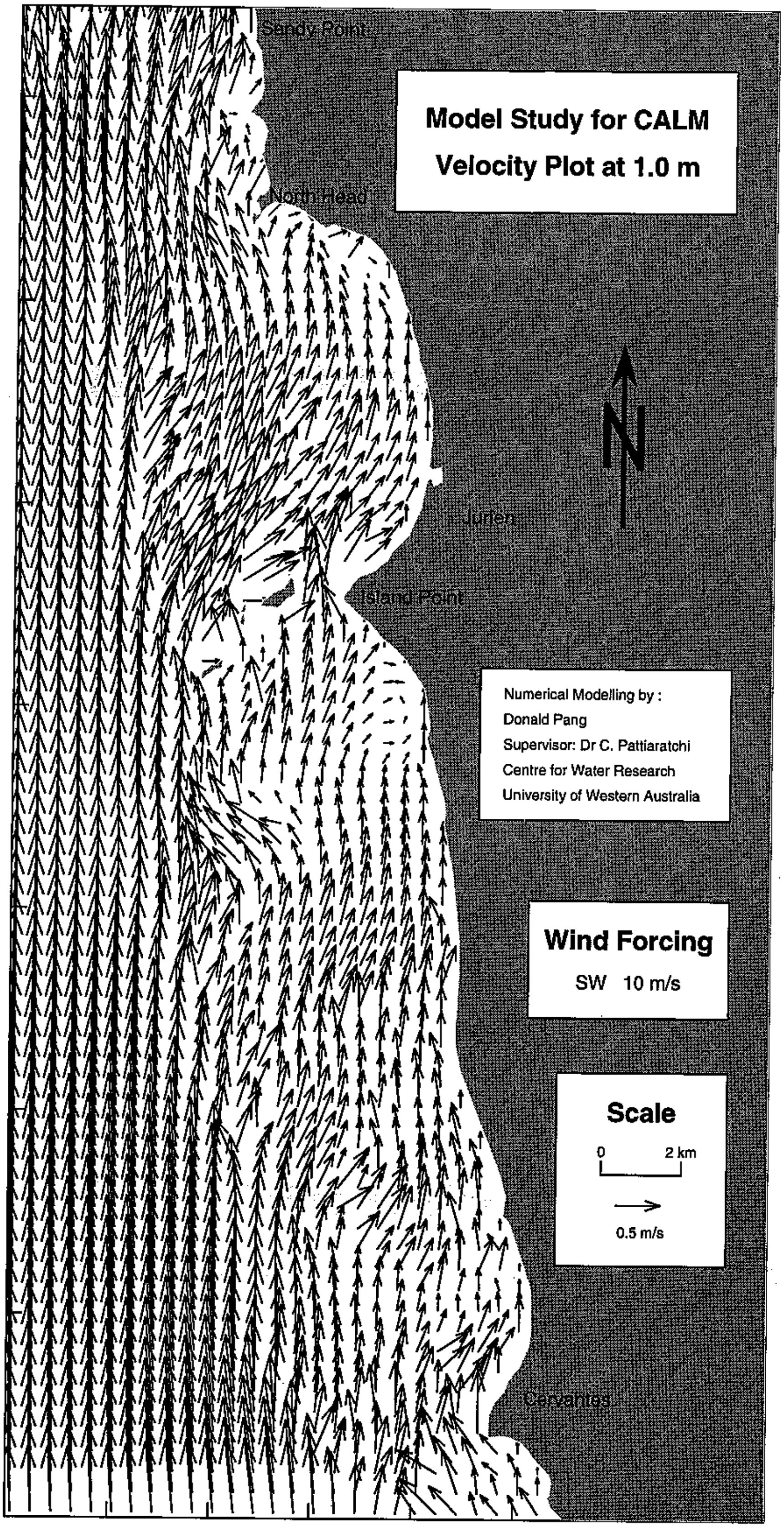
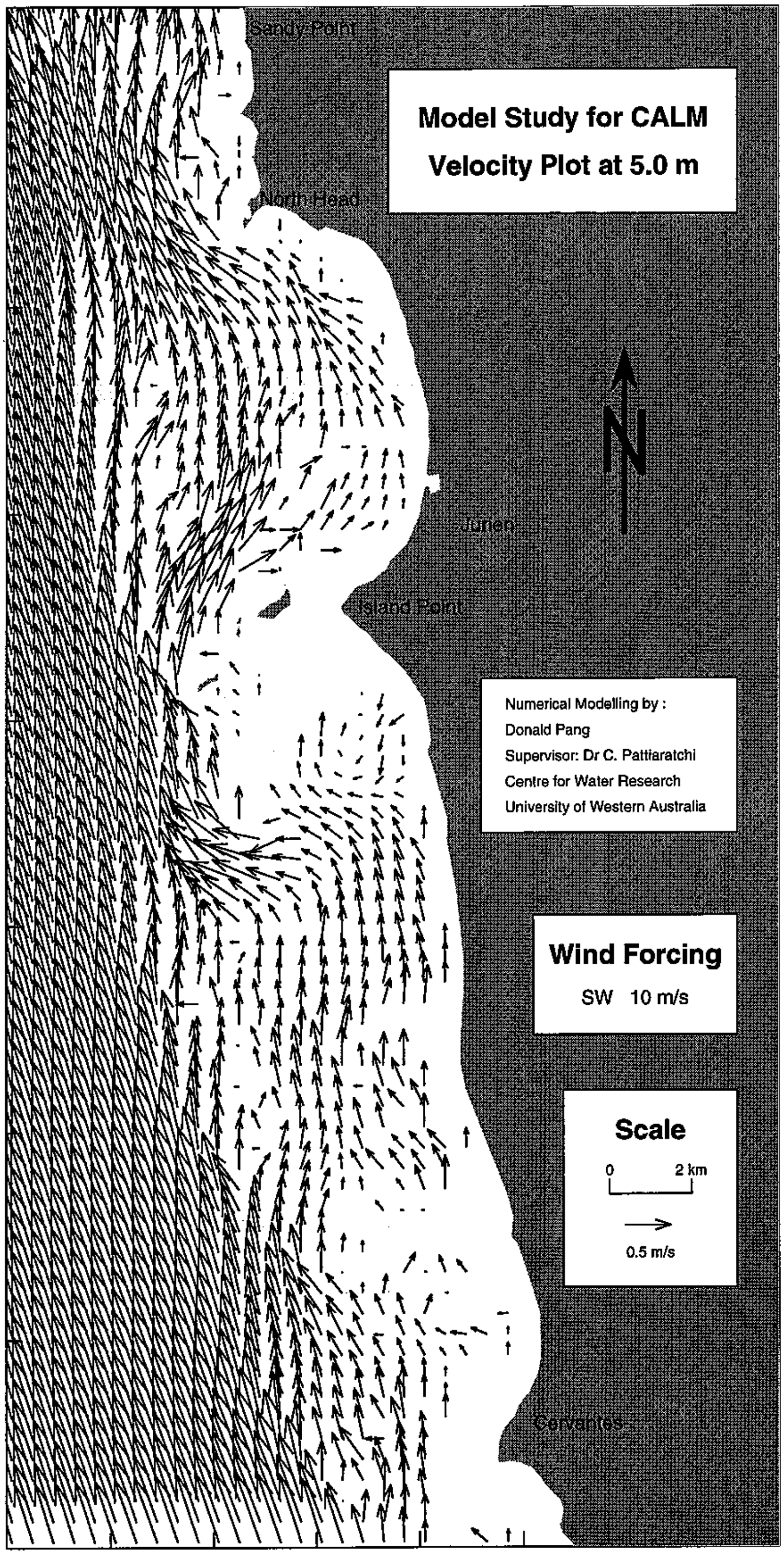


Figure 2 Hydrodynamic numerical model results of barotropic wind-driven circulation at 1m, 5m and 15 m depths in the region from Sandy Point to Cervantes under (a) SW wind at 10 m s^{-1}, (b) SE wind at 7.5 m s^{-1}, (c) NE wind at 10 m s^{-1} and (d) NW wind at 10 m s^{-1}. Simulations were performed with the HAMSOM model (Pattiaratchi and Knock, 1995) by Mr Donald Pang and Dr Charitha Pattiaratchi of the Department of Environmental Engineering, University of Western Australia for CALM's marine reserve implementation programme.



Sandy Point
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Model Study for CALM
Velocity Plot at 5.0 m
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Donald Pang
Supervisor: Dr C. Pattiaratchi
Centre for Water Research
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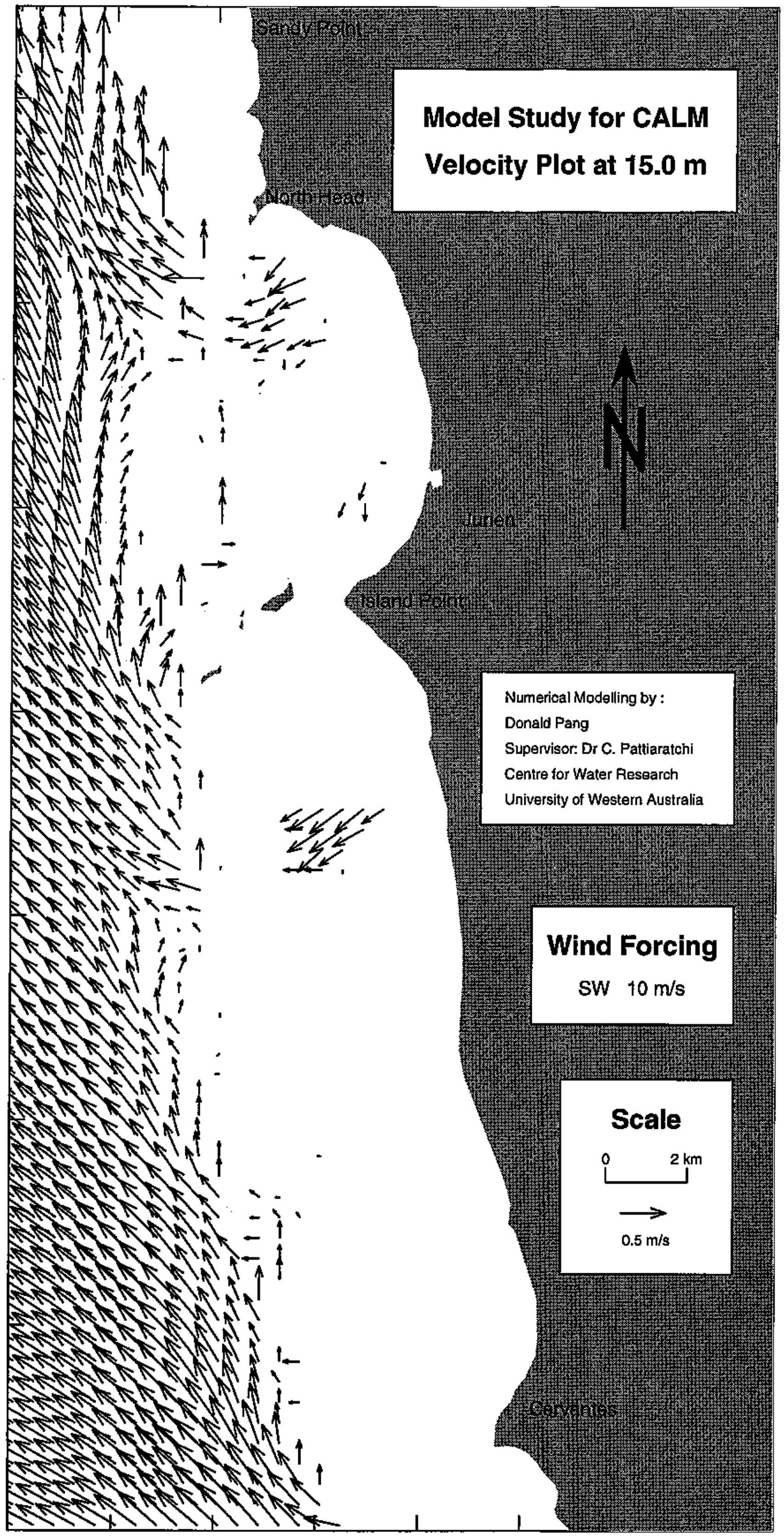
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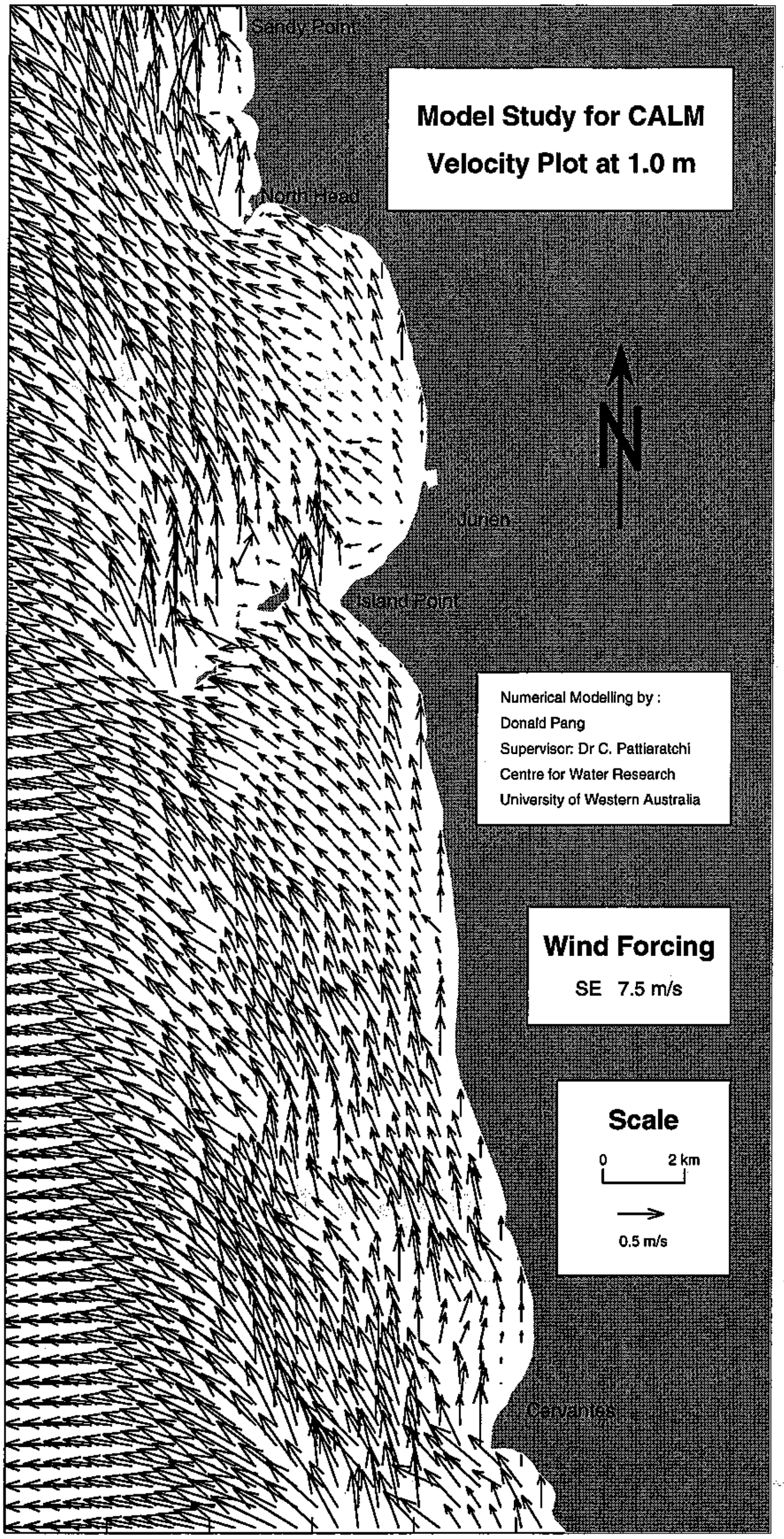

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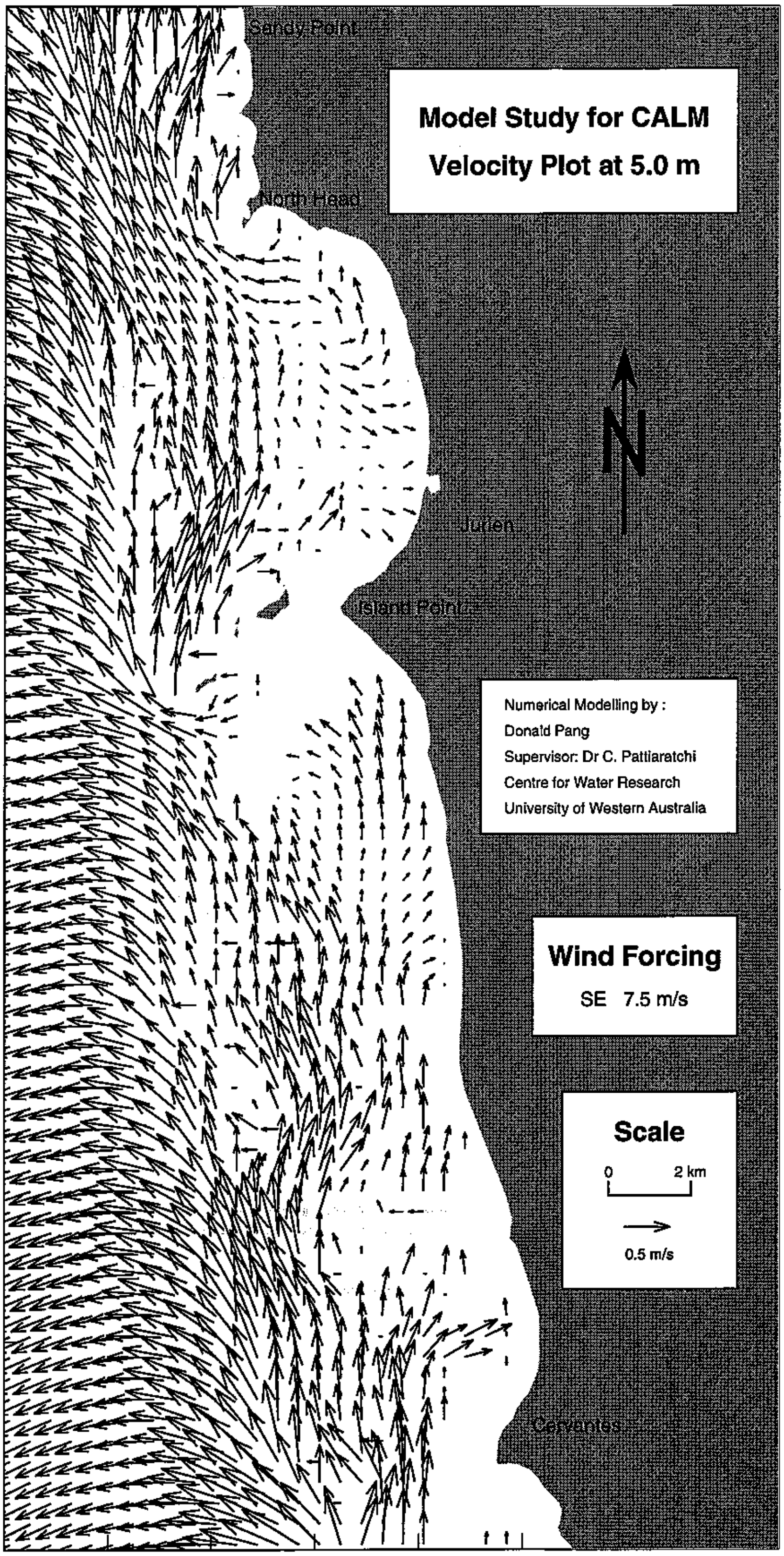
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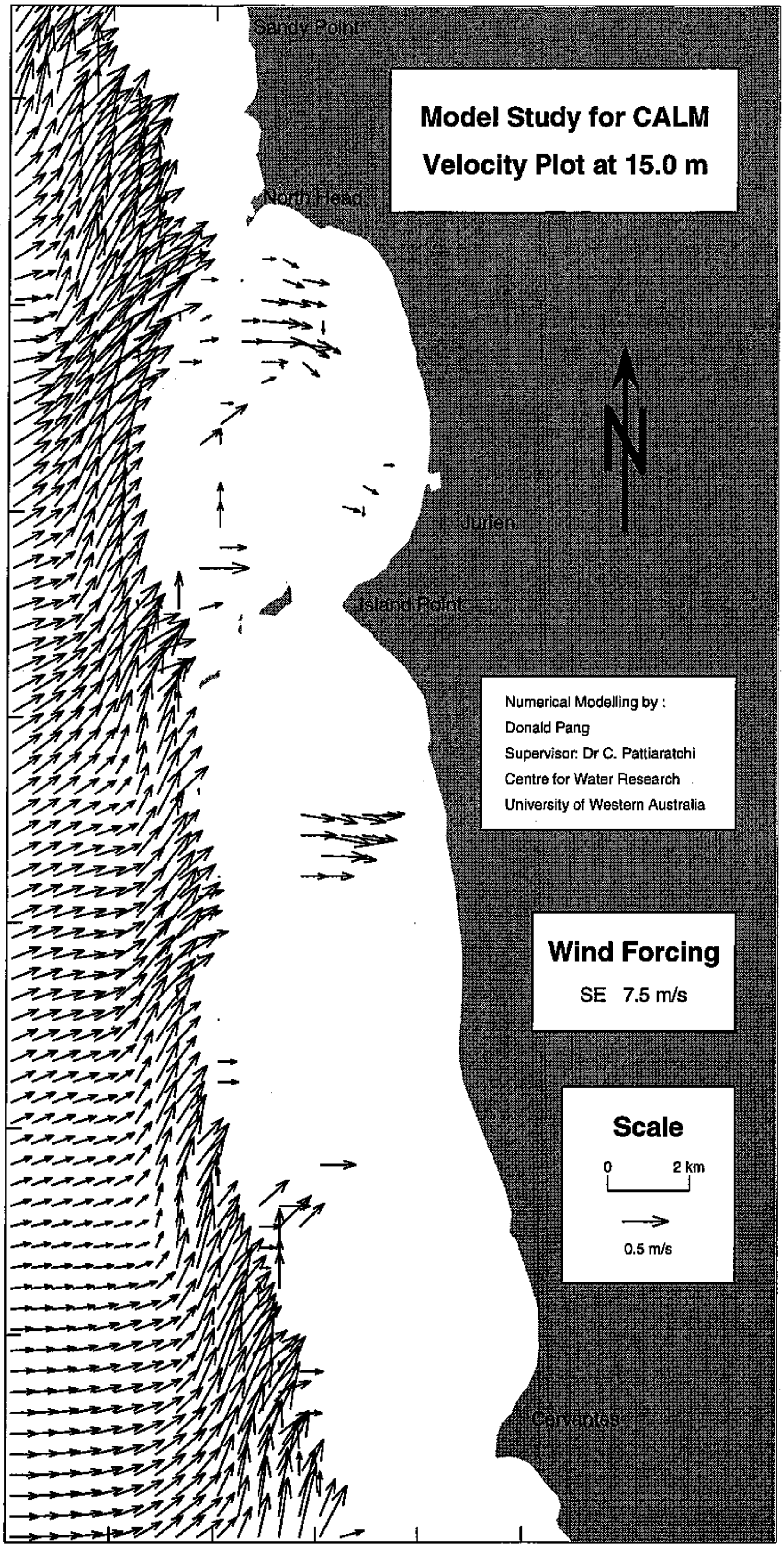

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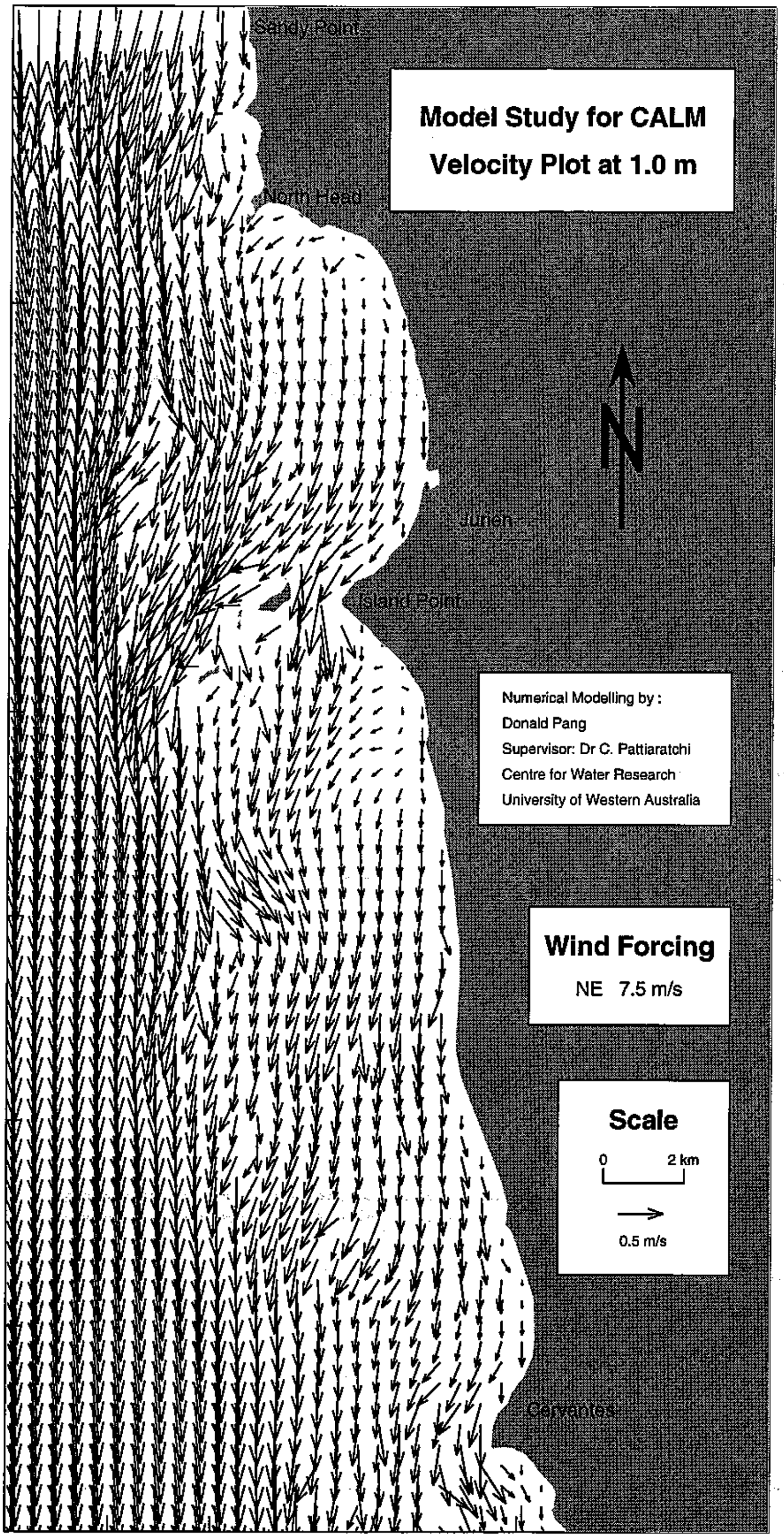
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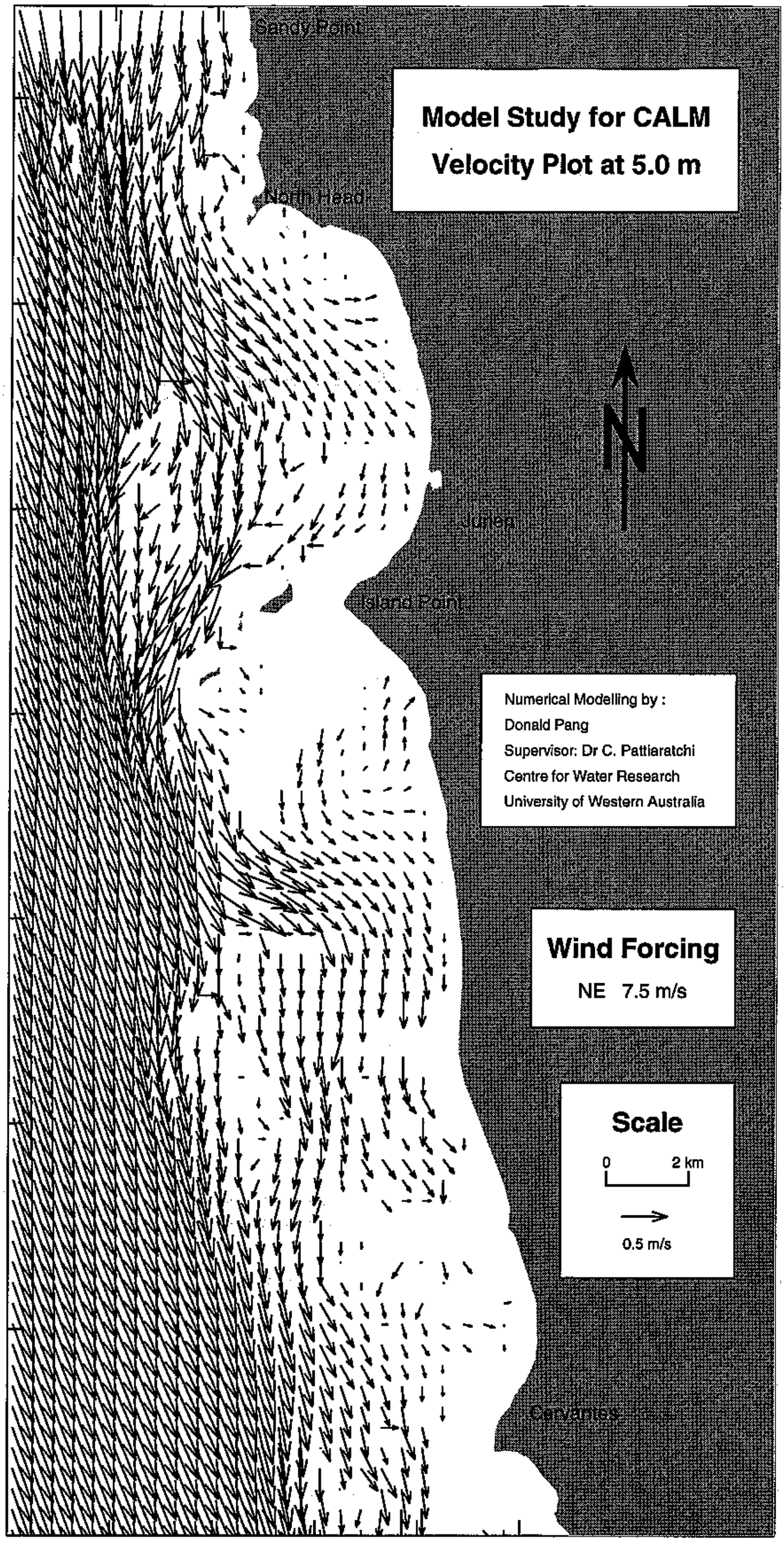

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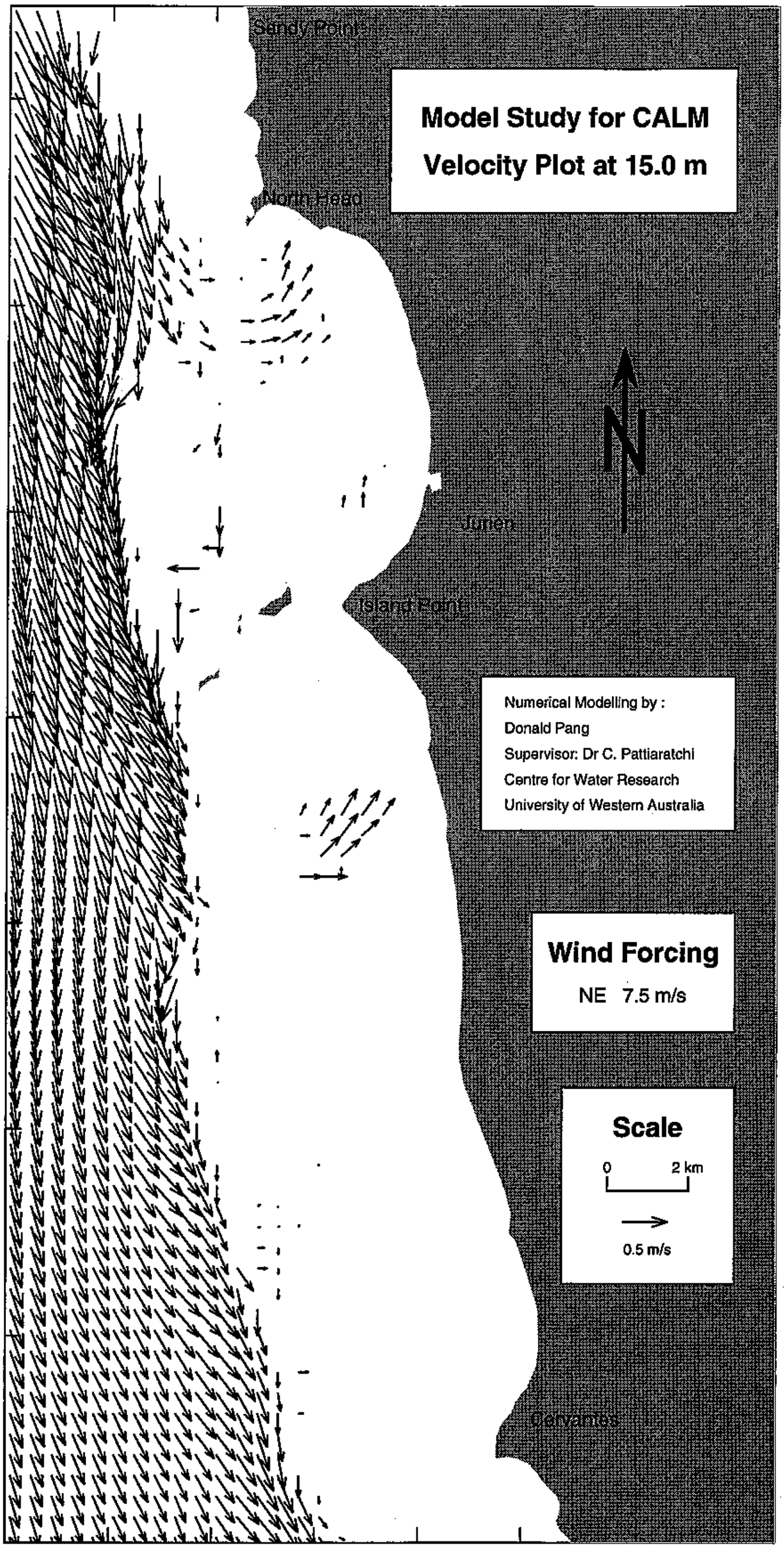

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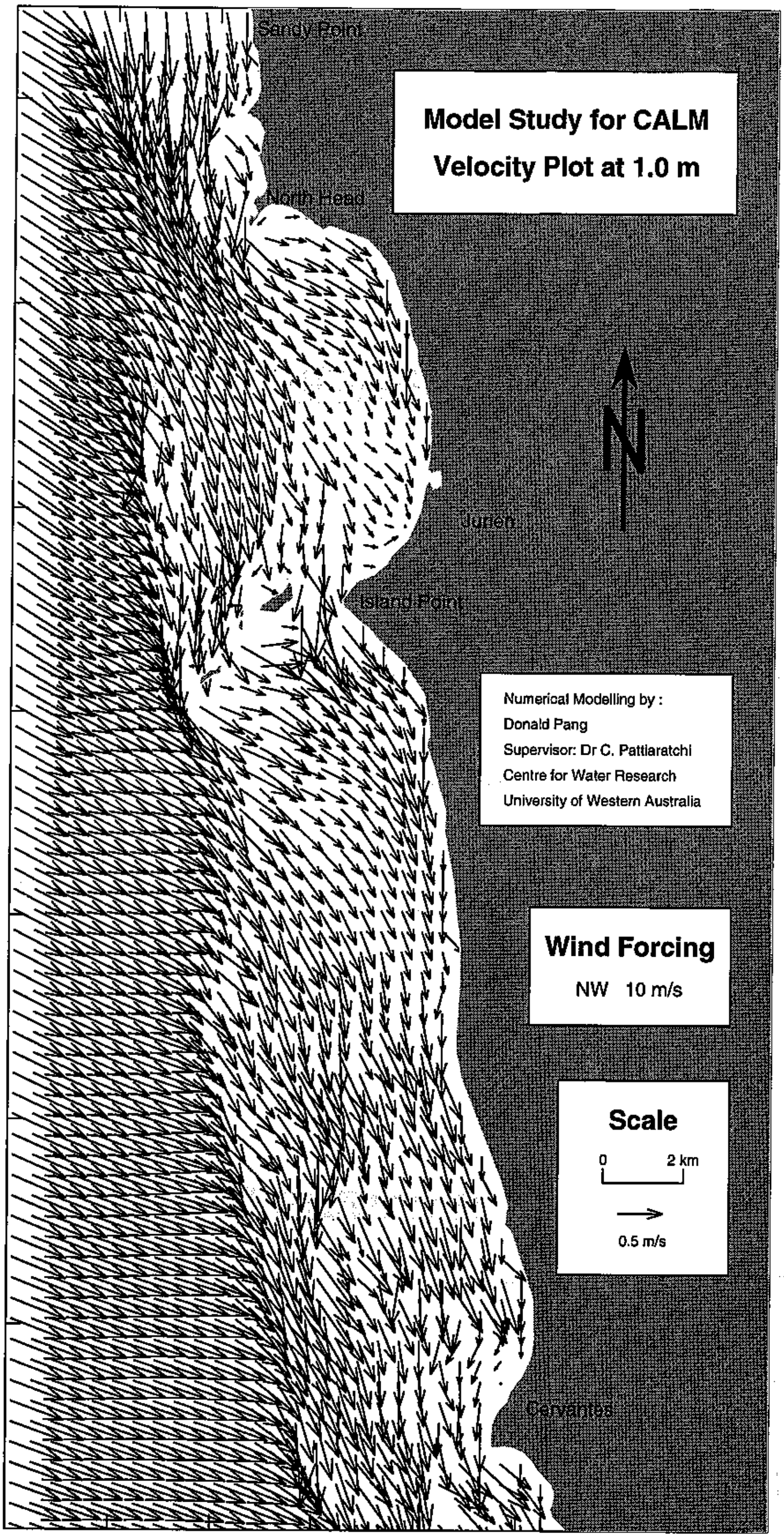

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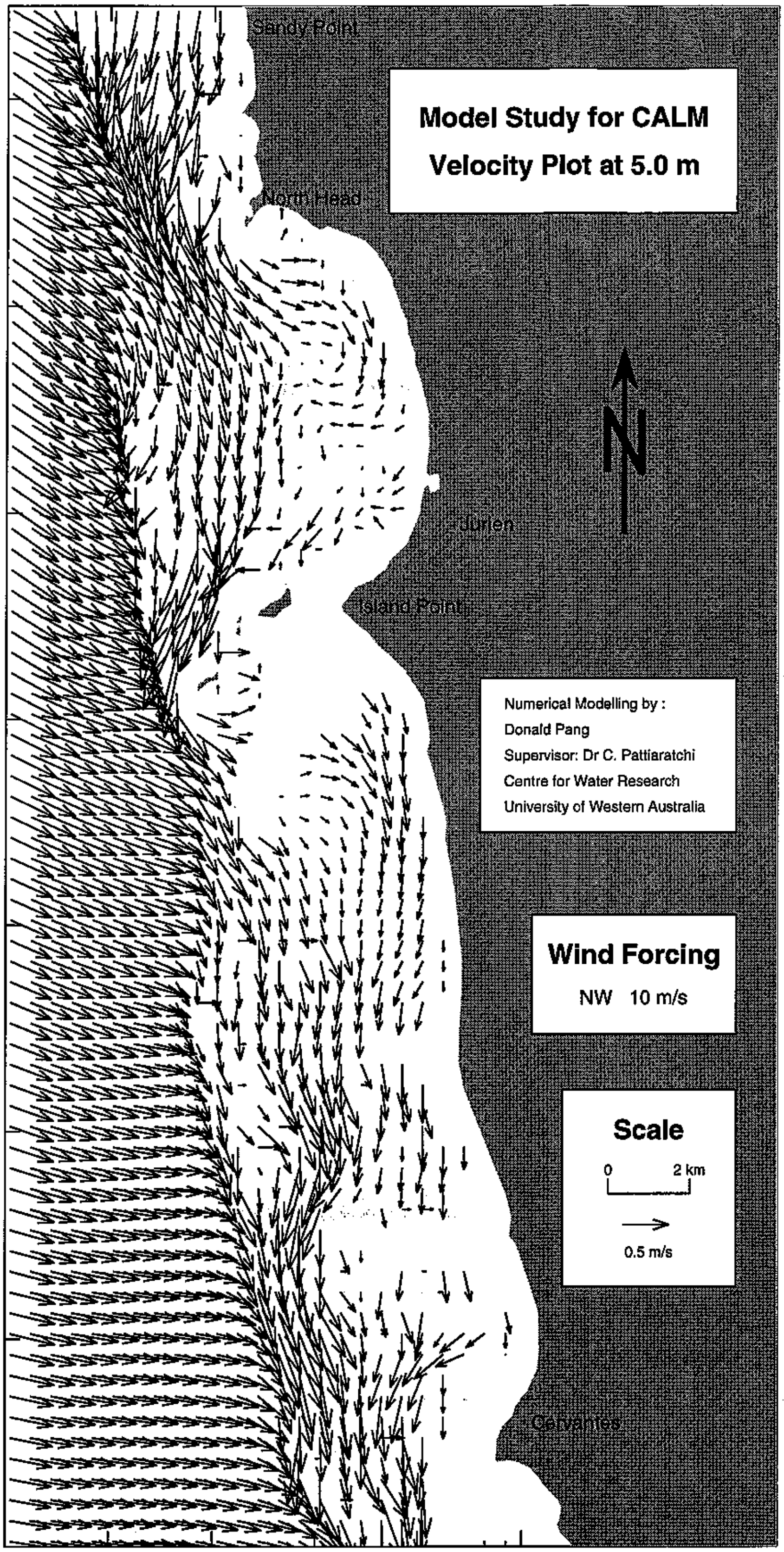

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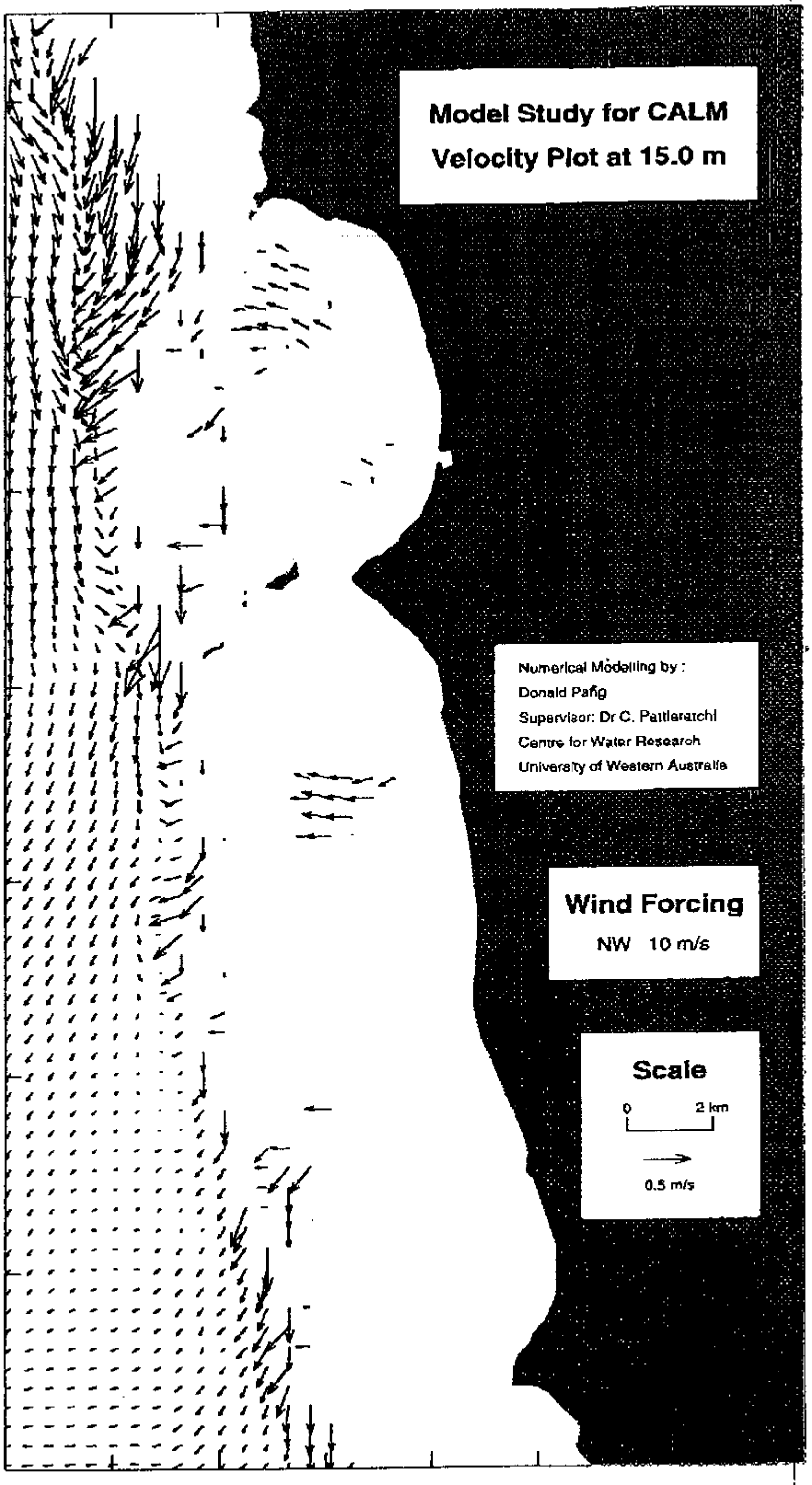
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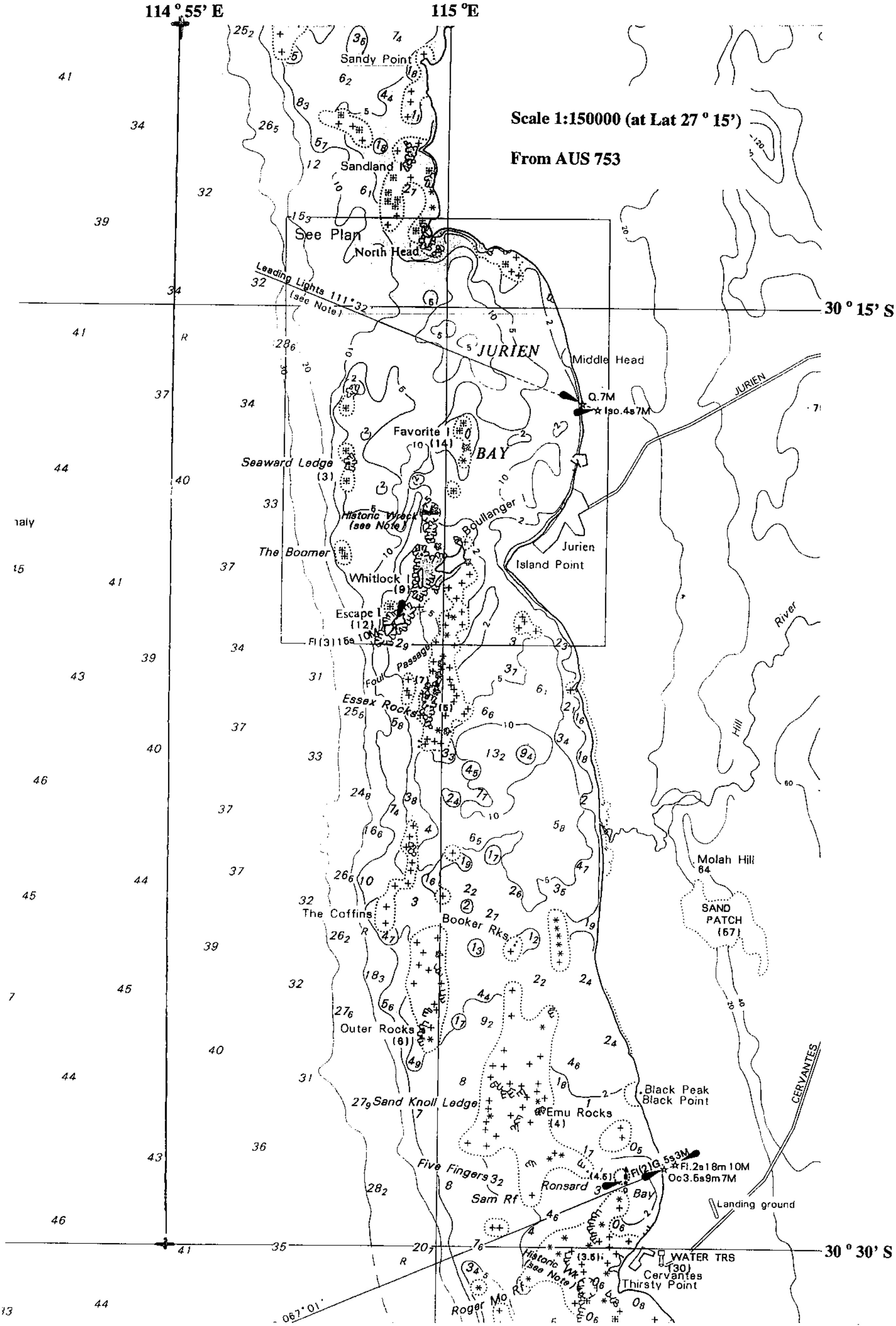

Figure 3 Bathymetry of the study region from Sandy Point to Cervantes.

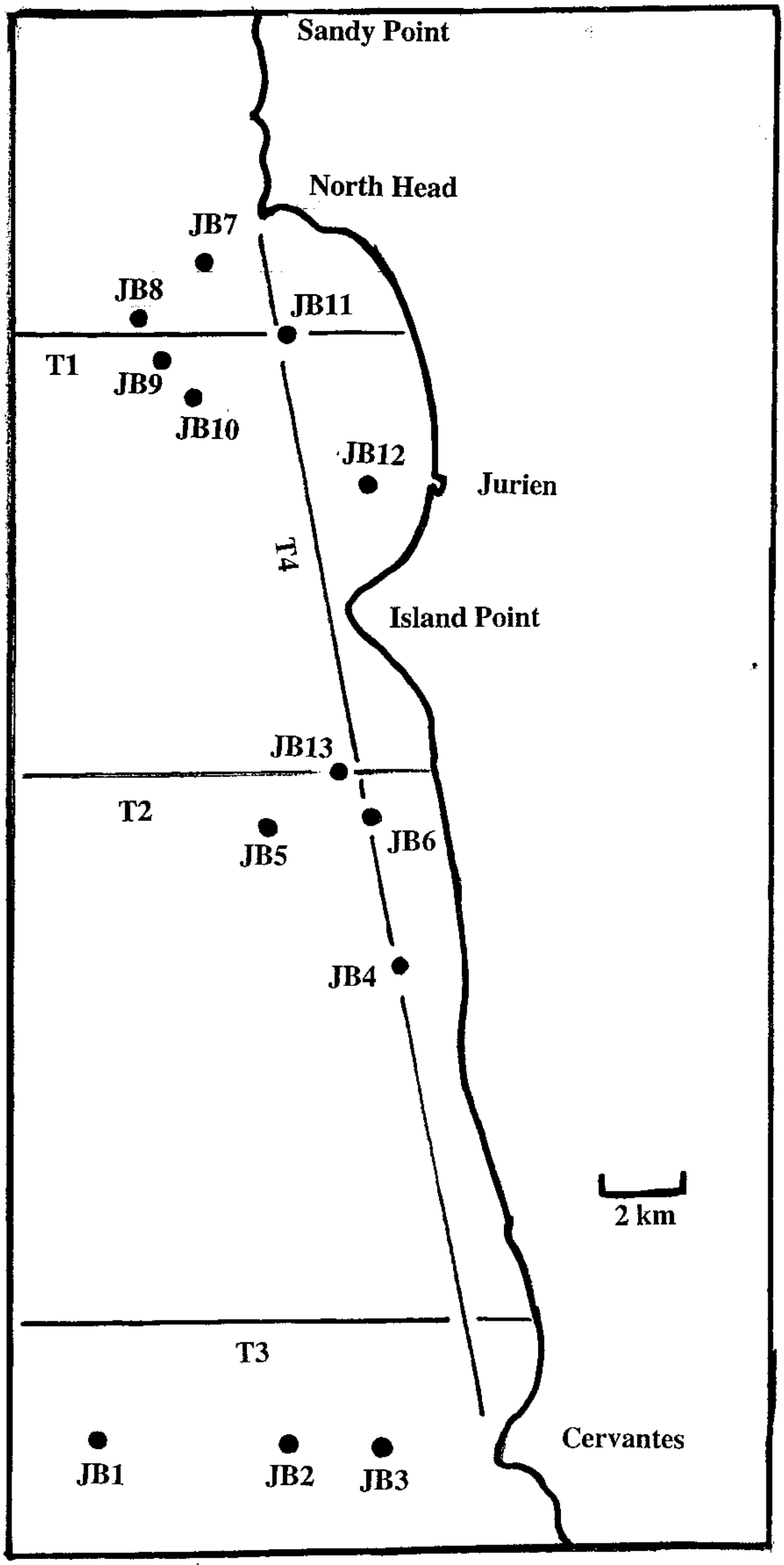

Figure 4 Field survey grid. T1 etc are transect paths for salinity-temperature profiling. JB1 etc are sites for drogue and temperature logger deployments, and salinity-temperature profiling.

APPENDIX 1 NOAA-AVHRR satellite overpass times (from DLA, RSAC)

Fax sent by : REMOTE SENSING A4->A4 15/01/97 13:53 Pg: 2/2

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 Implementation Programme. Oceanographic field programme for Jurien Bay and adjacent waters: 28 January to 7 February 1997. Field Programme Report MRIP/JB-01/97.

Gary Snook, Chairman, Central Coast Regional Planning Committee
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Greg Leaman, Manager, Midwest region, CALM
David Rose, Manager, Moora District, CALM
Ron Shephard, Program Leader, Nature Conservation, Midwest Region, CALM
Tim Daly, Technical Officer, Marine Conservation Branch, CALM

BUDGET (FOR INTERNAL MARINE CONSERVATION BRANCH USE)

Item	**Cost ($)**
Staff Tim daly (15 days @ $154/day)	 2310
Accomodation and meals 3 persons x 10 days @ $50/day)	 1500*
Vessel costs (11 days @ $400/day)	4400
Vessel fuel (includes Jurien - Perth)	2280*
ST meter (10 days @ $50/day)	500
Drogues (10 X 10 days @ $5/day/drogue)	500
Marine charts	100*
Temperature loggers (4 x 11 days @ $10/day)	440
GPS (includes Differential GPS satellite time) (8 days @ $50/day)	400*
Vehicle costs Toyota landcruiser (12 days @ $10/day) Fuel	 120 400*
Numerical modelling contract (UWA)	1500*
Consumables (rope, shackles, buoys etc)	250*
Contingency (10%)	643*
***Sub-total (funds from MCB)** **Sub-total (in-kind contribution from MCB)** **Total**	**7073** **8270** **$15343**
Staff resources <u>Preperation</u> N D'Adamo T Daly <u>Field trip</u> N D'Adamo T Daly MCB Volunteers (G Monty, H Oswald) <u>Data report</u> N D'Adamo T Daly MCB Volunteer (G Monty) **Total** (not including T Daly's time, see above) Note: staff rate for Principle Investigator (N D'Adamo) @ $248/day This figure to be multiplied by 2.7 to determine true cost to CALM	**days** 7 3 11 12 12 10 5 40 **80 days**