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MARINE BIODIVERSITY RESEARCH
Prediction and Management of Australia's Marine Biodiversity

# Mapping and characterising soft-sediment habitats, and evaluating physical variables as surrogates of biodiversity in Jervis Bay, NSW

*Anderson, T., Brooke, B., Radke, L., McArthur, M., and Hughes, M.*

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APPLYING GEOSCIENCE TO AUSTRALIA'S MOST IMPORTANT CHALLENGES

GEOSCIENCE AUSTRALIA SURVEYS GA303, GA305, GA312 AND GA309

# Mapping and characterising soft-sediment habitats, and evaluating physical variables as surrogates of biodiversity in Jervis Bay, NSW

## Jervis Bay Post-Survey Report

**DECEMBER 2007 – NOVEMBER 2008 (SURVEYS: GA303, GA305, GA312, GA309)**

GEOSCIENCE AUSTRALIA
RECORD 2009/10

by

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# Contents

# Figure List

# Table List

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# Executive Summary

A series of short field surveys in Jervis Bay, New South Wales, were undertaken by GA staff as part of the Surrogates Program in the Commonwealth Environmental Research Facilities (CERF) Marine Biodiversity Hub. The aim of the Jervis Bay field work was to collect accurately co-located physical and biological data to enable research into the utility of physical parameters as surrogates for patterns of benthic biodiversity in shallow soft-sediment habitats. In this report the survey design and sampling methods are described; selected field datasets are mapped and discussed; initial results of the laboratory analysis of seabed samples are presented; and there is a brief description of the upcoming analysis of covariance of the physical and biological datasets.

The major outputs of the survey work to date are:

1. High-resolution multibeam acoustic datasets for priority areas along the open coast of Jervis Bay (Beecroft Head to Drum and Drumsticks), within the Jervis Bay National Park; and within the southern bay around Darling Road, and in the bay entrance.
2. High quality underwater video footage of benthic habitats in the Darling Road study area acquired with GA's shallow-water towed-video system. The video was used to characterise benthic habitat types, relief/bedform types, and biota occurrence. Characterisations were collected in real-time along bi-directional (six offshore and four alongshore) towed video transects, and were subsequently processed and mapped into three ArcGIS map layers.
3. A set of broad-scale (bay-wide) widely-spaced, co-located sediment and biotic (infauna) seabed samples from the bay's soft-sediment habitats (polychaete mounds, drift algal beds, sand flats, and sand ripple and wave habitats);
4. Sediment samples for geochemical, biogeochemical and sedimentological analyses.
5. A new acoustic doppler current profiler was successfully trialed, and is now being used to collect seabed current data in the Darling Road study area.
6. A progress report on the survey work was presented at the annual CERF Marine Biodiversity Hub's Annual Science Workshop in October 2008.

# 1. INTRODUCTION

High-frequency multibeam sonar systems can now map the shelf with a vertical accuracy of centimetres and differentiate seabed textures based on the characteristics of the return (backscatter) signal (Wille, 2005). These advances in marine acoustics have also greatly enhanced our ability to map biologically important habitats over broader scales that are useful for marine environmental management (e.g. Kostylev et al., 2001; Anderson and Yoklavich, 2007; *papers in* Todd and Greene, 2008). High-resolution multibeam systems, for example, are now prominent in mapping and delineating rocky and sandy habitats that support a diversity of marine organisms (Todd and Greene, 2008).

Resource management and marine conservation of both coastal and offshore systems, however, often require an understanding of the many different types of habitats present in an area and the number and type of marine organisms that these habitats support. While high-resolution multibeam systems are indispensable for mapping complex habitats such as rocky reefs, these systems may be less useful in mapping soft-sediment habitats, sandy and muddy seabeds, that often exhibit little variation in bathymetry or acoustic reflectivity. This is an important issue as most estuaries and coastal waterways have large expanses of these types of seabed. While soft-sediment seabed is extensive, it should not simply be considered as encompassing homogeneous benthic habitats. On the contrary, many soft-sediment systems are spatially complex, can encompass a large suite of habitat types (e.g. sand waves, rippled beds, bioturbated sediments, polychaete-tube fields), and may support very high levels of biodiversity (Gray 2002; Snelgrove, 1999). Consequently, to evaluate habitat representativeness, and the comparative importance of habitat types to patterns of biodiversity, it is critical that all habitats types are adequately characterised and mapped.

The management of marine ecosystems has historically been hindered by the paucity of biological data and species information over the extent and physical complexity of the system. In contrast to biological data, physical variables can often be collected more rapidly and over much larger spatial extents (e.g. National Marine Bioregionalisation of Australia: DEH, 2005). Consequently, where strong bio-physical relationships exist, physical variables may be valuable surrogates in predicting biodiversity patterns over relatively broad scales that are useful for environmental management. However bio-physical relationships may often be complex. Within soft-sediment systems a range of processes operating at different scales can generate and maintain seabed heterogeneity. The physical variables that shape habitat heterogeneity are also likely to have an important influence on the association between organisms and their habitat. Physical processes such as tidal currents, wave exposure, temperature, water depth, light attenuation, and salinity may generate spatial gradients and patchiness in assemblage distributions as either a result of internal physiological constraints by organisms to these abiotic factors (Turner et al., 1999) or as an indirect effect of changes to the physical structure of the seabed, such as sediment type (Morrisey et al., 1993). In addition, rather than any one simple relationship, measured associations may in fact be the result of the integration of multiple physical and habitat-specific variables (Livingston, 1984; Legendre and Fortin, 1989; Post, 2008).

In this study we examine the potential of physical variables as surrogates in predicting fine-scale patterns of biodiversity and assemblage distributions - a key objective of the Marine Biodiversity Hub's Surrogates Program. In doing so, we also assess the relative strengths of acoustic, video, and grab sampling approaches in mapping and characterising a shallow-water, heterogeneous soft-sediment environment. To examine bio-physical relationships, high quality co-located physical and biological data were acquired across a 3 x 5 km survey grid adjacent to Darling Road, in the southern area of Jervis Bay (here on referred to as the Darling Road grid). This area was chosen as it encompassed several distinct benthic habitat types that were also representative of the broader benthic environment within Jervis Bay (CSIRO, 1993; Jacoby et al., 1995). Multibeam and towed-video surveys were undertaken to examine the relative capabilities of each method to map, delineate, and characterise the different habitat types and their associated patterns of biodiversity and assemblage structure.

### 1.1. SPECIFIC SURVEY OBJECTIVES

Four short surveys were undertaken in Jervis Bay, often as a 'piggy-back' to field trials of GA marine survey equipment. The main objectives of the surveys are:

- Acoustically map two areas within southern Jervis Bay: i) The Darling Road grid, to examine whether bathymetry and/or backscatter can be used to identify and delineate different soft-sediment communities; and ii) The Entrance grid (4 x 4 km) to experimentally examine how different roughness parameters can be used to classify soft, mixed, and hard substratum habitats.
- Map and delineate abiotic and biotic patterns in soft-sediments using towed-video in the Darling Road grid.
- Collect co-located biological and physical samples from stations across Jervis Bay (broad-scale sampling), using a spatially explicit sampling approach, to examine the bio-physical relationships between infauna and the geomorphology and geochemistry of the sediments.
- Collect co-located biological and physical samples from stations within the Darling Road grid (fine-scale sampling) to examine the bio-physical relationships between infauna and the geomorphology and geochemistry of the sediments.
- Examine the relationship between the physical structure and biological character of seabed habitats within the Darling Road grid and the hydrodynamic processes occurring within the bay.

### 1.2. REGIONAL SETTING – JERVIS BAY

Jervis Bay is a large (115 km$^2$, 100 km coastline) coastal embayment situated 200 km south of Sydney on the south coast of New South Wales (latitude 35º 07' S and longitude 150º 42' E). The embayment is semi-enclosed, with a 3.5 km wide entrance at its southern end that links the embayment to the Tasman Sea (CSIRO, 1993). Most of the bay is less than 20 m deep, with large areas of shallow (<15 m) and relatively flat seabed in the northern bay, while the deepest area (~40 m) is at the entrance between Point Perpendicular and Bowen Island (Marine Parks Authority, 2008).

The bay has a relatively small catchment of around 376 km$^2$ and the major streams, Moona Moona Creek, Currumbene Creek and Carama Inlet, input very little sediment (Bowyer, 1992). The bay was classified as a 'largely unmodified coastal waterway' during the initial assessment of the National Land and Water Resources audit of 2001 (NLWRA; 2001). However, the major catchment impact was urban development, which has considerably expanded since the Audit.

#### 1.2.1. Geological setting

Jervis Bay lies near the southern margin of the Permo-Triassic (298-205 Ma) Sydney Basin. Rocks in and around the bay are predominantly well-bedded siltstone and sandstone units of marine origin that were deposited in the early Permian (Snapper Point Formation, ~290 Ma). In a few places these rocks have been intruded by dolerite of Late Permian age (e.g. Green Point; Abell and Jones, 1993; Perry and Dickins, 1952). The bay mostly lies in a broad depression (syncline) in the Permian rocks, the axis of which is orientated approximately NNE-SSW through the middle of the bay. The rocks dip upwards to the east of the syncline and form the 100m high cliffs and plateau of Bherwerre and Beecroft Peninsulas, while to the west they rise above and inland of the bay. During long periods when sea level was lower than present, streams that today flow into the bay eroded the sandstone and cut the entrance of the bay. Marine erosion, over many periods of high sea level in the Quaternary and possibly Tertiary, has produced sea cliffs on the open coast (Bowyer, 1992).

Much of the seabed within Jervis Bay is covered in fine-medium quartz and minor carbonate sand of marine origin (Taylor, 1972), with a flood tide delta between Bowen Island and Governor Head. Muddier sand occurs in the more quiescent sections of the bay and tidal inlets. The shoreline of the bay is dominantly sandy (60%), with extensive beaches and dunes in the northern and western bay (Short, 2007). Rocky reef extends into the bay from sections of bedrock shoreline in the west near Vincentia and Huskisson, in the north around Hare Bay and near the entrance around Long Nose Point, Point Perpendicular, Governor Head and Bowen Island (Figure 1.1; Marine Parks Authority, 2008).

### 1.2.2. Biological Setting

Coastal habitats around the circumference of Jervis Bay comprise intertidal flats (0.62 $km^2$) and patchy distributions of mangroves (1.25 $km^2$) (Underwood and Atkinson, 1995; Millar, 1995). Benthic marine habitats along the subtidal perimeters of the bay are characterised by either soft-sediment seagrass beds (~8.9 $km^2$ aerial coverage comprised mostly of *Zostera* and *Posidonia*; Kirkman et al., 1995) or rocky outcrops supporting attached macroalgae (3.56 $km^2$; Underwood and Atkinson, 1995; Millar, 1995), while deeper regions within the centre of the bay comprise unconsolidated sandy habitats (~73 $km^2$; Figure 1.1). Coastal and marine zones within the region are managed by NSW State (Jervis Bay Marine Park; JBMP) or Commonwealth (Boodereee National Park) Government agencies, and include no take marine sanctuaries and habitat protection zones.

In 1990-91 CSIRO undertook a bay-wide towed-video survey to examine the types of seabed habitats within the expansive sandy regions of Jervis Bay (CSIRO, 1993). Several soft-sediment habitats were identified within the bay, including areas of drift algae, polychaete hummocks, rippled and bioturbated sands, bivalve clumps, and heart urchin (*Echinocardium cordatum*) areas (Jacoby et al., 1995). The results of these surveys were then extrapolated to create a bay-wide seabed habitat map (Jervis Bay Marine Parks unpublished maps, Figure 1.2).

### 1.2.3. Oceanographic Setting

Fresh water input to the bay is limited to minor creeks, the largest being Currambene Creek, which enters the bay at Huskisson. The general shallowness of the bay means that the water column is often well-mixed in the vertical, however, differential cooling of the shallow regions of the bay in winter leads to thermal stratification (Wang and Symonds, 1999). Circulation from this differential cooling serves to flush the bay on a time scale of a week or so, according to model calculations and measurements (Holloway et al, 1992). Current speeds in the bottom water exiting the bay reach 0.1-0.2 $m\ s^{-1}$ in model simulations (Wang and Symonds, 1999).

Tidal currents inside the bay are weak, with maximum recorded speeds of only 0.07 $m\ s^{-1}$ near the bay entrance and <0.01 $m\ s^{-1}$ in the interior of the bay (Holloway et al., 1991). Locally generated wind waves in the bay are fetch-limited, with the longest fetch distance being 6 km. The bay is exposed to offshore sea and swell, however, particularly from the SE direction. The offshore wave conditions have been described as a highly variable wind-wave climate superimposed on a persistent, high energy southerly and southeasterly swell (Thom et al., 1973). The modal wave height is 1.5 m with a 10 s period, and the 1 % exceedence height is about 6 m (Lawson and Abernathy, 1975). Most of this offshore wave energy reaches the coastline due to minimal frictional dissipation over the narrow shelf (Wright, 1976). Wave energy density within the bay will be reduced through shallow-water refraction, diffraction and frictional attenuation.

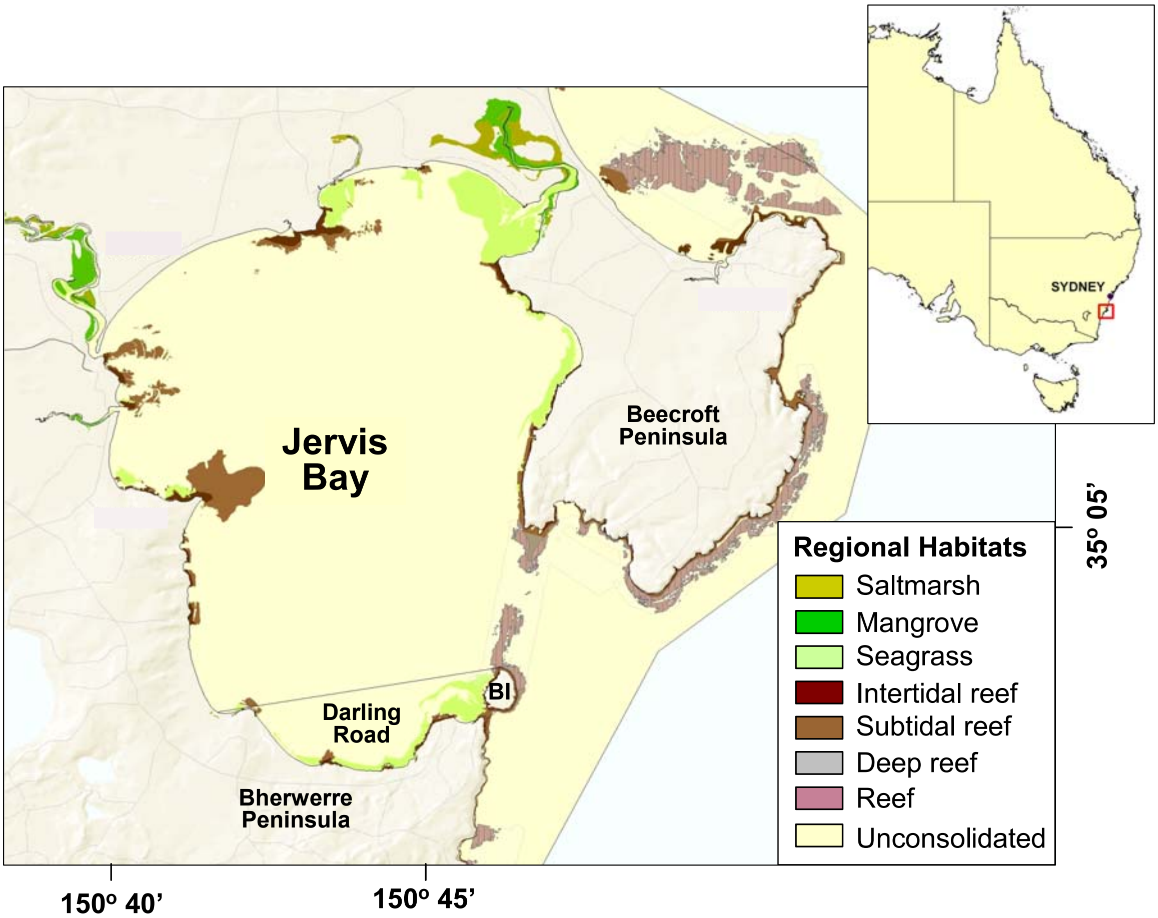


***Figure 1.1:*** *Jervis Bay National Park map depicting regional habitats. Insert top right: location of Jervis Bay 200 km south of Sydney, NSW. Grey line from Bowen Island (BI) to shore indicates the Boodereee National Park marine boundary, inshore from this line is Darling Road (cf Darling Roadstead/anchorage) and Commonwealth Territory. Base image from Jervis Bay National Parks.*

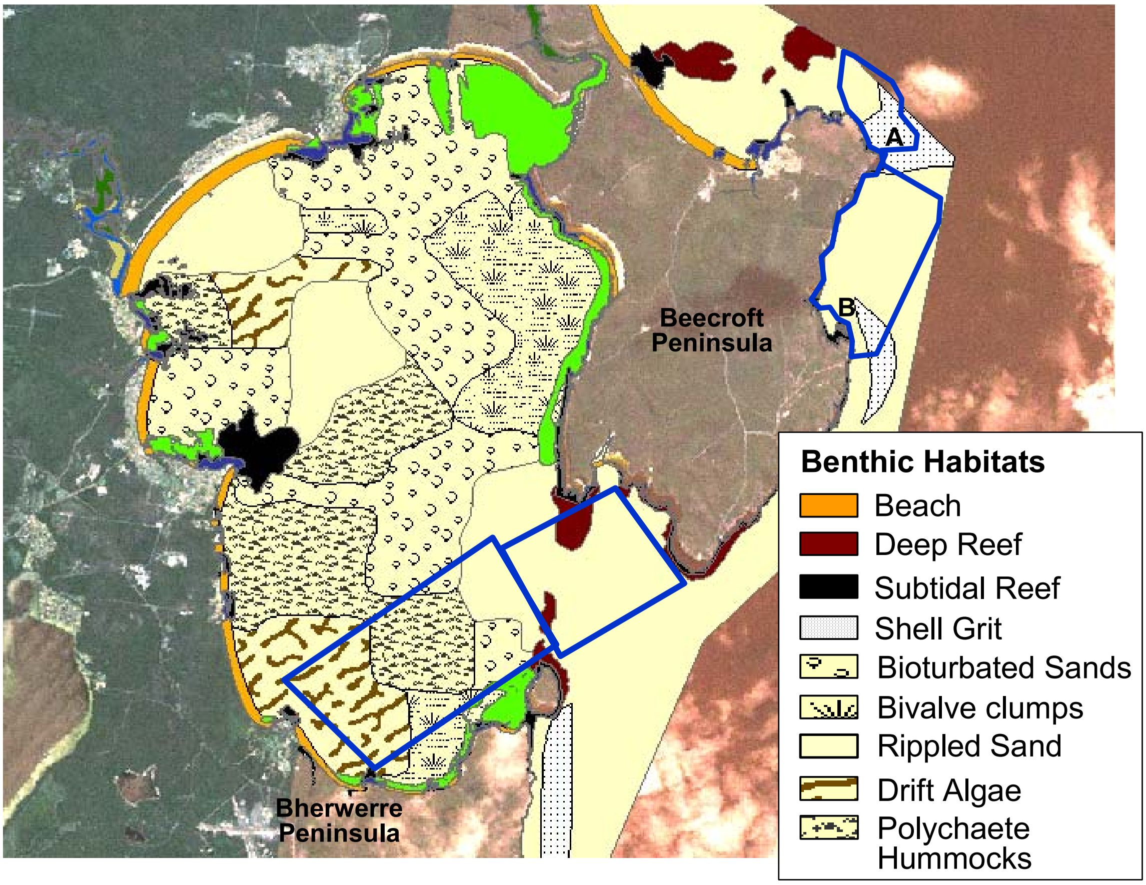


***Figure 1. 2:*** *Jervis Bay National Parks map depicting benthic marine habitats identified during the 1991 CSIRO towed-video survey (CSIRO, 1993; Jacoby et al., 1995). Blue boxes inside Jervis Bay depict the locations of the two GA/CERF survey grids: Darling Road grid (left) and the Entrance grid (right); while the blue polygons east of Beecroft Peninsula depict the areas adjacent to Beecroft Head (A) to Drum and Drumsticks (B) that were surveyed by multibeam. Base image from Jervis Bay National Parks.*

# 2. METHODS AND OUTPUTS

## 2.1. SURVEY AREA

An area 3 x 5 km off Darling Road in the southern reaches of Jervis Bay ('Darling Road grid') was selected for the main focus of this study as it encompasses a variety of benthic habitat types (Figure 1.2), that support diverse fauna and flora, that are also present throughout the bay (CSIRO, 1993; Langtry and Jacoby, 1996). Several habitats were predicted to occur within the Darling Road grid based on the historical CSIRO video surveys and were subsequently verified by towed-video footage; these included extensive drift algal areas (dominated by two red algal species: *Gracilaria edulis* and *Acrosorium venulosum*); rippled and bioturbated sands; polychaete mounds (formed by dense aggregations of the chaetopterid worm *Mesochaetopterus minutus*); and flat sediments with bivalve mounds, although now the bivalve mounds only occur sparsely (Figure 2; CSIRO, 1993; Langtry and Jacoby, 1996).


***Figure 2.1:*** *The MV Kimbla, HMAS Cresswell's 18 m research vessel.*

## 2.2. SAMPLING OVERVIEW

Within the Darling Road grid we undertook a series of mapping and bio-physical sampling surveys using the MV Kimbla - HMAS Cresswell's 18 m research vessel (Table 2.1; Figure 2.1). First, we mapped the 3 x 5 km Darling Road grid using a high-resolution multibeam acoustic system (Simrad EM3002D) to determine what soft-sediment habitat types could be identified and delineated using multibeam data. We then undertook a towed-video survey to characterise and map the types and spatial extents of benthic habitats present within the grid. Upon verifying that multiple habitat types were present within the Darling Road grid, we then undertook a spatially explicit grab sampling survey to collect co-located infaunal, sedimentology and geochemistry samples. To provide a broader scale bay-wide framework of the Jervis Bay system, we also collected co-located infauna and geochemistry samples and seabed morphology data from equidistant stations across the entire bay.

To examine the role of hydrodynamic processes in structuring the bio-physical composition and spatial configuration of the seabed within the grid, an oceanographic mooring will be deployed, with attached ADP and ADV sensors, to measure current strength and direction, and bed stress for a period of 6 weeks within each of the habitat types, starting in November 2008.

**Table 2.1**. Surveys conducted in Jervis Bay between Dec 2007 and Nov 2008.

| MONTH/SEASON | SURVEY | SAMPLING TYPE | LOCATIONS SURVEYED |
|---|---|---|---|
| Early summer, Dec. 2007 | GA303 | EM3002 multibeam | Darling Rd and entrance grids |
| * Late autumn, May 2008 | GA305 | EM3002 multibeam | Darling Rd grid, coastal areas |
| Early winter, Jun. 2008 | GA312 | Towed-video and Grab Sampling surveys | Darling Rd grid and large bay region |
| Late winter, Aug. 2008 | GA309 | Towed-video, Grab Sampling surveys; and Oceanographic mooring trial | Darling Rd grid; Entrance to HMAS Creswell |

## 2.3. EM3002 MULTIBEAM SURVEYS

Several locations within or adjacent to Jervis Bay were mapped during acceptance tests of Geoscience Australia's new multibeam sonar system. The EM3002D is a 300 kHz system produced by Kongsberg Maritime, Norway. It is an advanced multibeam sonar, with high resolution and dynamically focused beams. The system is designed to operate with either one (single head) or two transducers (dual head). In dual-head mode it forms 508 beams along the swath, 254 beams per transducer. Maximum swath width coverage is 200° in dual head mode and 130° with a single head. Its depth range is from 1 m up to typically 130 m in the open sea. A major feature of the system is its electronic pitch compensation system and roll stabilised beams that enable it to acquire high-quality data in relatively rough sea conditions when matched with an effective motion sensing unit and precise GPS, such as the Aplannix motion reference system couple with a high-precision C-Nav GPS system used by GA. All received beams in the EM3002 are dynamically focused and beams can be set in an equidistant or equiangular spacing to optimise the system performance and resolution.

During the initial acceptance test of the EM3002 dual-transducer system, 10-15th December 2007 (GA Survey No. GA303), at several locations within or adjacent to Jervis Bay were mapped. Bathymetric data collected within the 3 x 5 km Darling Road area were gridded at 70 cm (Figure 2.2). During the initial trails, a fine-scale multipath interference was recorded in the multibeam data at greater than >38° off nadir. This artefact made the collected data unusable at greater than 38° from nadir. At the time of writing this report the dual-transducer configuration problem had not been resolved but is actively being addressed by the manufacturer.

In June of 2008, a second successful trial (GA Survey No. GA305) was conducted using the EM3002 in a single-transducer arrangement (Tables 2.1 and 2.2). During this trial high-quality high-resolution multibeam data were collected from areas within Jervis Bay (central section of the Darling Road grid), and along the outer coastal regions (Beecroft Head to Drum and Drumsticks - Grey-nurse nursery ground) of the Jervis Bay National Park (JBNP) (Figure 1.2 and Appendix 6.4). However, due to Naval exercises and time constraints the Darling Road grid could not be fully remapped. In order to correctly identify if EM3002 bathymetry and/or backscatter data can be used to map and delineate biologically-important soft-sediment habitats, the entire Darling Road grid will be remapped to the highest possible quality and resolution in December 2008. These data alone will be used for comparative analyses.

**Table 2.2:** Survey participants for the EM3002 Multibeam acceptance-trials conducted in Jervis Bay on the RV Kimbla. Trial 1 (GA Survey No. GA303) was conducted on the 10-15th Dec 2007 unsuccessfully using the 45º dual-transducer installation; Trial 2 (GA Survey No. GA305) was successfully conducted on the 29 May – 1 Jun 2008 using a single transducer.

| STAFF/ORGANISATION | ROLE |
|---|---|
| Ian Atkinson (Trial 1 and 2) | Snr. Electronics technician, GA |
| Cameron Buchanan (Trial 1 and 2) | Multibeam technician, GA |
| Craig Wintle (Trial 2 only) | Mechanical technician, GA |
| Michelle Spinoccia (Trial 1 only) | Multibeam technician, GA |
| James Daniell (Trial 1 only) | Multibeam scientist, GA |
| Tara Anderson (Trial 1 only) | Biologist, project leader, GA |
| Johnathon Griffith (Trial 1 only) | Graduate student, GA |

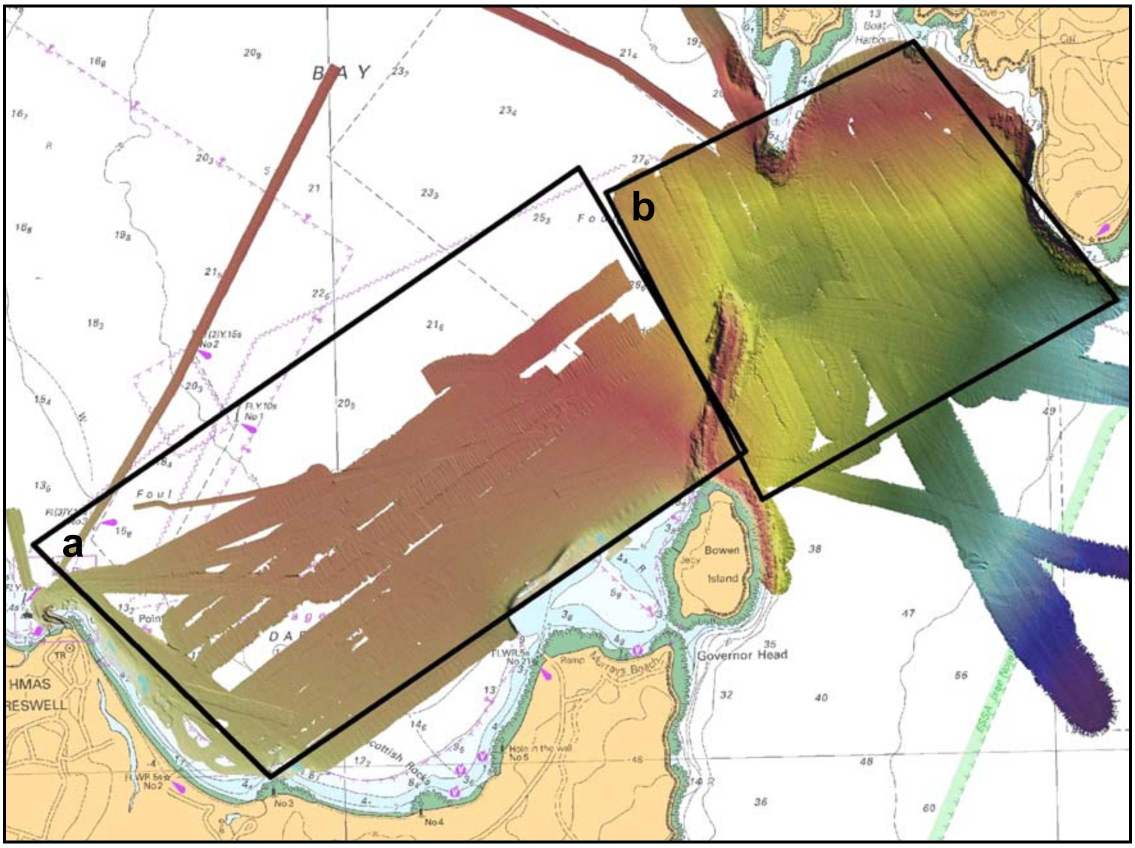


*Figure 2.2: EM3002 multibeam bathymetry for Jervis Bay, collected in acceptance trial Dec 2007. a) Darling Road grid; b) entrance grid. This preliminary data contains several artefacts.*

### 2.4. TOWED-VIDEO CAMERA

To map and characterise the composition and spatial structure of bio-physical habitats within the Darling Road grid, we collected high-resolution video footage from bi-directional towed-video transects (4 parallel and 6 perpendicular to the depth gradient) using the GA shallow-water Raytech towed-video system (Figure 2.3, Table 2.3). The initial survey was undertaken during the 17-20th, June 2008 (early Australian winter) as part of the acceptance test of the new towed-video system (GA Survey No. GA312: Tables 2.3 and 2.4). During this time we successfully collected 6 offshore transects and 1 of the 4 alongshore transects. A follow-up survey two months later on 25-26th August 2008 completed the remaining 3 alongshore transects (GA Survey No. GA309: Tables 2.3 and 2.5).

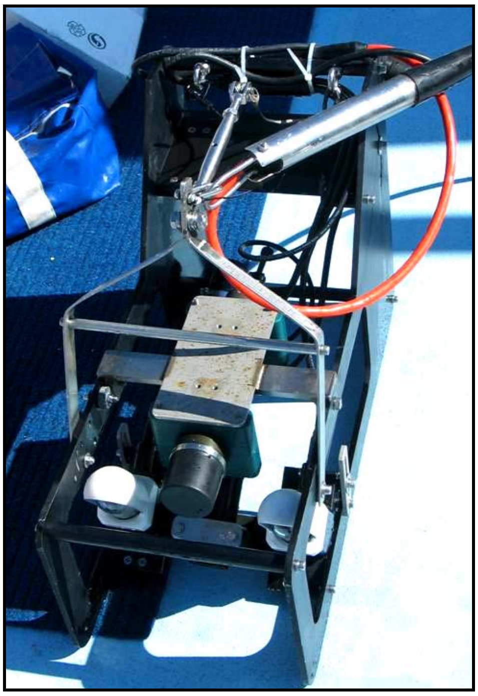

***Figure 2.3:*** *Raytech towed-video system. Dimensions 30 x 50 cm. The system is fitted with a high-definition low-light video camera, and 2 (250 w) lights.*

**Table 2.3**: Towed-video transect lines conducted in Jervis Bay, 17-20th June 2008 (GA Survey No. GA312) and 25-26th August 2008 (GA Survey No. GA309), on board the RV Kimbla.

| SURVEY NO. | VIDEO TRANSECT | UTC DATE AND TIME (START) | START LATITUDE | START LONGITUDE | END LATITUDE | END LONGITUDE | DURATION OF VIDEO |
|---|---|---|---|---|---|---|---|
| GA312 | JBcam_tx01 | 18/06/2008 04:05:14 | -35.11158 | 150.70778 | -35.13263 | 150.72740 | 00:52:24 |
| GA312 | JBcam_tx02 | 18/06/2008 05:10:30 | -35.13330 | 150.73798 | -35.10750 | 150.71730 | 01:14:06 |
| GA312 | JBcam_tx03 | 18/06/2008 23:47:24 | -35.10132 | 150.72597 | -35.12627 | 150.74373 | 01:24:18 |
| GA312 | JBcam_tx04 | 19/06/2008 01:38:06 | -35.12005 | 150.74908 | -35.09977 | 150.73346 | 01:09:58 |
| GA312 | JBcam_tx05 | 19/06/2008 03:56:02 | -35.09559 | 150.74123 | -35.11683 | 150.75761 | 01:15:28 |
| GA312 | JBcam_tx06 | 19/06/2008 05:38:06 | -35.11118 | 150.76596 | -35.09034 | 150.74933 | 01:07:52 |
| GA312 | JBcam_tx07a | 19/06/2008 07:13:38 | -35.09426 | 150.76057 | -35.10620 | 150.74004 | 01:02:22 |
| GA312 | JBcam_tx07b | 19/06/2008 23:04:04 | -35.12199 | 150.71094 | -35.10609 | 150.74025 | 01:34:26 |
| GA312 | JBcam_tx08 | 20/06/2008 01:05:18 | -35.12796 | 150.71834 | -35.12166 | 150.72977 | 01:31:28 |
| GA309 | JBcam_tx09a | 25/08/2008 01:49:40 | -35.11800 | 150.70232 | -35.10279 | 150.73257 | 01:32:00 |
| GA309 | JBcam_tx09b | 26/08/2008 03:19:50 | -35.08900 | 150.75667 | -35.10570 | 150.72638 | 01:26:48 |
| GA309 | JBcam_tx10a | 25/08/2008 04:18:10 | -35.11271 | 150.74615 | -35.12436 | 150.72408 | 01:13:00 |
| GA309 | JBcam_tx10b | 26/08/2008 01:17:28 | -35.10298 | 150.76422 | -35.11427 | 150.74254 | 00:52:22 |
| GA309 | JBcam_tx11 | 25/08/2008 22:56:46 | -35.13319 | 150.72357 | -35.10827 | 150.77098 | 01:00:14 |

**Table 2.4:** Survey participants for the GA Raytech towed-video acceptance trial conducted in Jervis Bay, 17-20th June 2008 (GA survey No. GA312) on the RV Kimbla.

| STAFF/ORGANISATION | ROLE |
|---|---|
| Tara Anderson | Biologist, project leader, GA |
| Steve Hodgkins | Electronics technician, GA |
| Stan Hancock | Field technician, GA |
| Maggie Tran | Researcher, GA |

**Table 2.5:** Survey participants for the follow-up towed-video survey and oceanographic mooring trial conducted in Jervis Bay, 25-26th August 2008 (GA survey No. GA309), on the RV Kimbla.

| STAFF/ORGANISATION | ROLE |
|---|---|
| Tara Anderson | Biologist, project leader, GA |
| Matthew Carey | Field technician, GA |
| Stan Hancock | Field technician, GA |
| Michael Hughes | Oceanographer, GA |
| Anna Potter | Researcher, GA |
| Joe Nielson* | Researcher, Dept. of the Environment |

* = Only on board for the 26th August 2008

### 2.4.1. Real-time video characterisations

Seabed characterisations were recorded in real-time every 30 seconds, or more frequently across transition zones, along each video-transect using the 3-tiered characterisation scheme of substratum composition, bedform-relief, and biota presence described in Anderson et al. (2008). A 15-second period (i.e. 5 seconds prior to and 10 seconds following the GPS fix) was evaluated to characterise the seabed. Seabed characterisations were entered in 'GNav Real-time GIS Tracker' software (© Gerry Hatcher, 2002) using a 142 key Cherry programmable keyboard (© Cherry, 2008). For each data entry location, the GPS captured ship's navigation (UTC date, time, latitude, and longitude). Data entry took between 3-12 seconds, and required a two-person team (i.e. observer and data-enterer).

Substrata composition (i.e. rock, boulders (>25.5cm), cobbles (6.5-25.5 cm), sand, and mud) was categorised by primary (>50% cover) and secondary (>20% cover) percent-cover following the earlier protocol of Stein et al. (1992) and Yoklavich et al (2000). For example, if the seabed was comprised of >50% sand and >20% mud the substratum composition was classified as 'sand-mud' (SM); alternatively >70% sand was classified as 'sand-sand (SS). Bedform-relief was defined as either soft-sediment 'bedform' such as hummocky, sediment ripples, or sediment waves, or by the vertical 'relief' of consolidated sediments: relief classes ranged from flat (0 m), low (<1 m), moderate (1-3 m), to high relief (>3 m), or rock walls (high-relief with >80° incline). Biota composition was described by recording the presence of benthic macro-organisms identified to groups (e.g. starfish and brittlestar), class (e.g. featherstars and anemones), or broad ecological categories (e.g. fish) (see Anderson et al., 2008 for more detailed methods).

### 2.4.2. Video processing and mapping

Video data were processed using a SAS macro-program (Statistic Analysis System, SAS Institute Inc., 2001) that parsed the variable-length text file, checked and cleaned syntax, removed duplicate entries, formatted errors, transposed the data, and populated the data tables with zeros where no occurrence for an organism was recorded. The formatted data table was then exported as a MS-Access database file (JervisBay_video.mdb), and as a ArcGIS data file. A shapefile was then created in ArcMap and plotted in ArcGIS to display the three spatial data layers: substrata (e.g. Figure 2.4a), bedform/relief (e.g. Figure 2.4b), and biota occurrences (e.g. Figure 2.5a,b).

### 2.4.3. Preliminary video results

Several primary habitat types were identified from video observation, and were spatially delineated across the grid (Figure 2.4a). Sandy habitats were the most dominant habitat type recorded (59% of all locations), and were recorded throughout the survey grid. Drift algal habitats were also common but were characteristic of the southern region of the grid (24% of all locations). Polychaete worms (cf: chaetopterid worm *Mesochaetopterus minutus*) were the next most abundant habitat type (11% of all locations) found within the grid. Dense aggregations of these worms however were restricted to the central region of the grid. Other more minor habitats were algae (4% of locations) located throughout the region, seagrass (1.19%) located in the nearshore, and rocks and boulders (0.88% and 0.25% respectively) located in the north-eastern corner of the grid covering the edge of 'middle ground' – a large rock outcrop immediately north of Bowen Island in the entrance to Jervis Bay.

Seabed relief and bedform also varied across the grid (Figure 2.4b). Four major relief/bedform types were identified. Sand wave and sand ripple habitats were the most common habitat (17% and 29% of all locations respectively) and together were located in the north-western section of the grid, which characterised the high-energy region closest to the entrance of Jervis Bay. Hummocky habitats were present in two regions of the grid, firstly a central area correlated with the occurrence of the tube-building polychaete worms (chaetopterid worm *Mesochaetopterus minutus*) termed 'polychaete hummocks', while a second smaller inshore area correlated with the occurrence of nearshore seagrass beds. Next, a flat relief habitat (15% of all locations) was present on the shoreward side of the polychaete hummocks, while in the south-eastern section of the grid the relief of the seabed was unknown (22%) as it lay hidden beneath a thick layer of drift algae. On the rare occasion when the seabed could be seen we recorded sand wave bedforms. Frequently, algal mats were also observed in lines parallel to the sand waves suggesting that drift algae might accumulate in the troughs of these bedform waves.

The combination of substratum type, relief and bedform type delineated four major habitat types and several minor habitats. The four major habitats were i) sand wave and ripple habitats located in the north-west section of the grid; ii) Polychaete hummocks in the centre of the grid; iii) sand flats shoreward of the polychaete mounds containing sparse occurrence of bivalve clumps; iv) drift algal mats covering much of the seabed in the south-east section of the grid. Minor habitats consisted of nearshore seagrass meadows; rock and boulder habitats comprising the nearshore edge of middle ground in the very north-east corner of the grid; and finally discrete patches of *Caulerpa* and Polychaete trees (Eunicid polychaete worms: *Eunice australis*) at various locations within the central regions of the grid.

Fifty nine biological taxa were recorded during the video survey of Darling Road video. Each taxa could subsequently be plotted in ArcGIS to examine their spatial distribution across the grid and relative to substratum type, relief/bedform, and other taxa. For example the small crinoid, *Antedon incommoda*, was recorded at only 7% of all locations, but exhibited a clumped central distribution and occurred where the seabed was stabilised by other organisms, such as polychaete tubeworms and algae (Figure 2.5a). Similarly, polychaete trees (eunicid polychaete worms: *Eunice australis*) were present in 15% of all locations, however their distribution was clumped around the south-eastern section of the grid (Figure 2.5b), where they may be associated with the presence of drift algae – which they rely on as a food source.

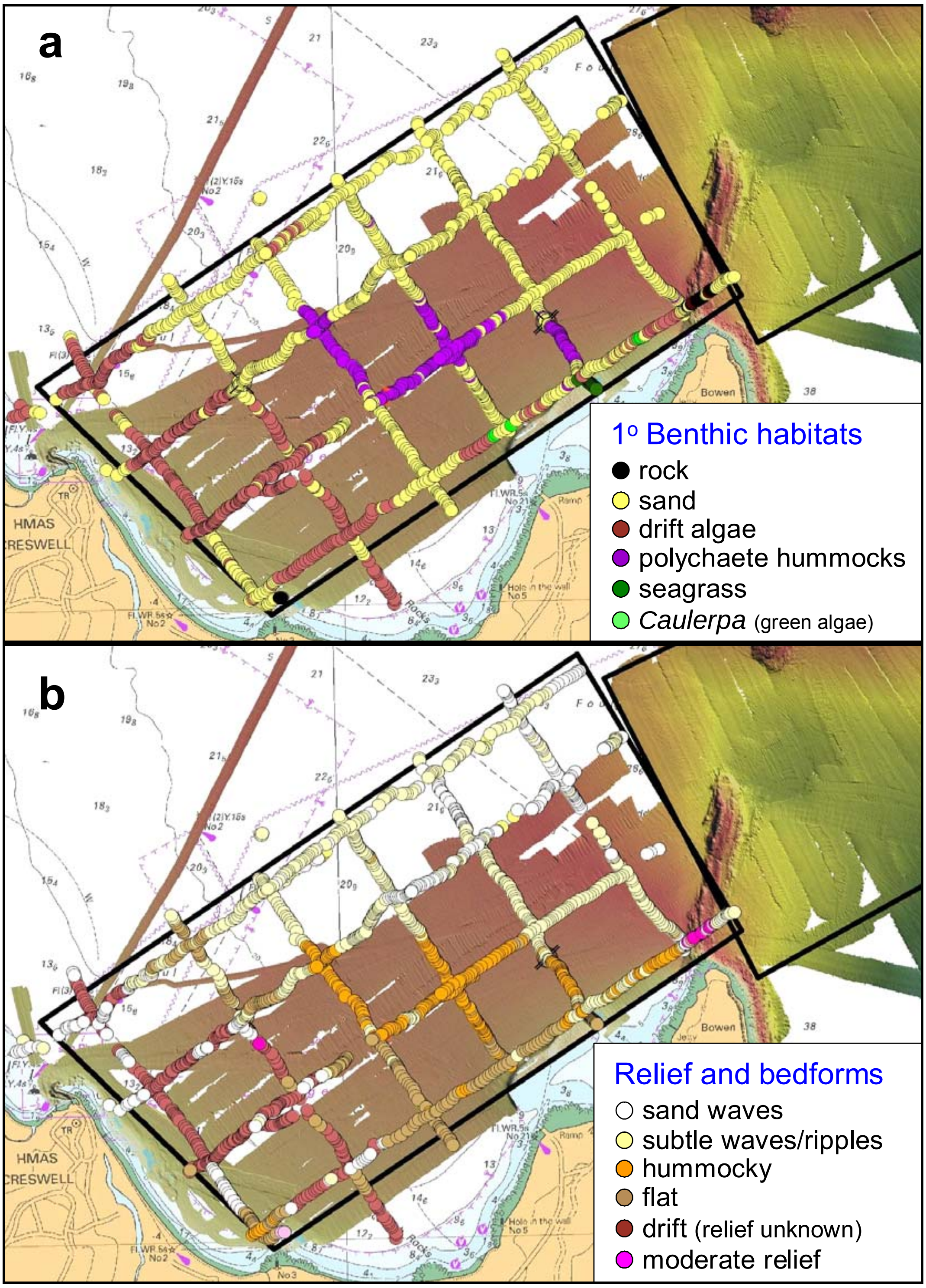


***Figure 2. 4:*** *Seabed characterisations from bi-directional towed-video transects surveyed within Darling Road grid, Jervis Bay. a) Primary substratum type, b) relief and bedform types across the grid.*

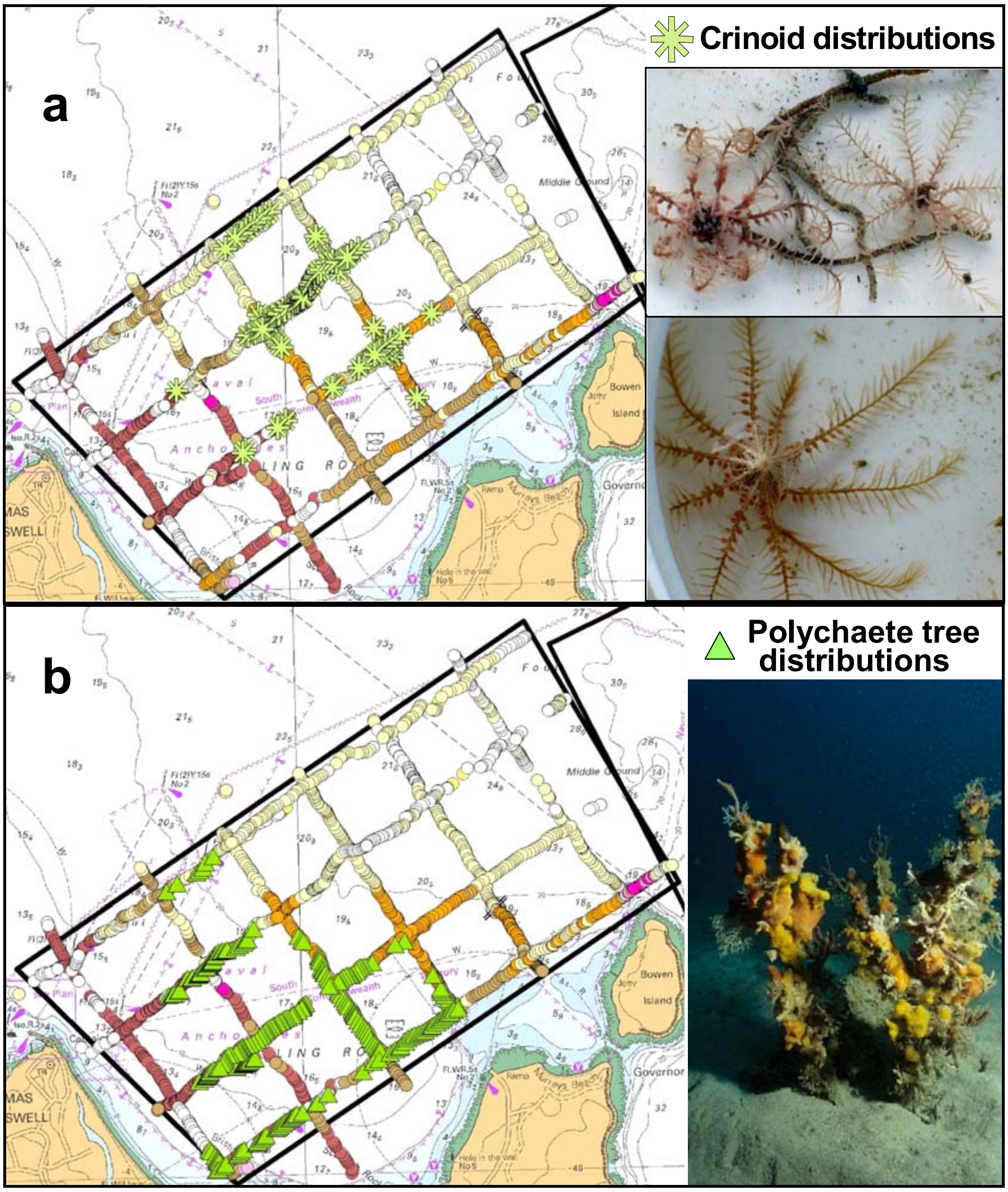


***Figure 2.5:*** *Examples of Biota distributions overlaid on the bedform/relief layer of the bi-directional towed-video transects surveyed within Darling Road grid, Jervis Bay. a) spatial distribution of the crinoid,* Antedon incommoda*, across the grid; and b) spatial distribution of polychaete trees (Eunicid polychaete worms:* Eunice australis*) across the grid (Photos a. Tara Anderson, Geoscience Australia, b. NSW Parks).*

## 2.5. GRAB SAMPLING

Co-located physical and biological samples were collected from broad-scale (bay-wide survey), and fine-scale (Darling Road grid) sampling stations to: (1) examine the correlation of infauna distribution and abundance and biodiversity patterns with physical variables such as sediment grain size and geochemical variables; (2) determine if bio-physical patterns reflected the spatial configuration of the habitat types identified in the towed-video survey; and (3) explore the potential of physical variables as surrogates of biodiversity and assemblage patterns within a soft-sediment system.

### 2.5.1. Sampling overview

In the broad-scale survey, 19 sampling stations were allocated to a systematic grid across the bay (Figure 2.6; Tables 2.6 and 2.7, Appendix 6.6). In the fine-scale survey, 60 grab sampling stations (30 stations, 2 time periods) were allocated across the extent of the Darling Road grid using a spatially-explicit stratified-random sampling design (Figure 2.7, Tables 2.6 and 2.7, Appendix 6.6). Thirty stations were allocated to the two time periods concurrent with the two tow-video surveys: early winter (24-28th June 2008 – although only 28 stations could be sampled), and late winter (27-29th August 2008 – where 32 stations were sampled, 30 + the 2 missed in June) (Tables 2.8 and 2.9 respectively). To ensure sampling interspersion over the grid per time period, we used a navigational chart to divide the area into 30 equal blocks; we then assigned 2 stations randomly within each block (1 station, per time, per grid), with stations constrained to be a minimum of 30 m apart to avoid re-sampling a station where infauna and sediments had already been removed. Sampling at each time was conducted over three-to-four consecutive days, from the 27-29th June and the 24-28th September, between the hours of 08:00 am and 17:00 pm.

Two types of sediment grab samples were collected at each station; a small Van Veen grab was used to collect infauna, while a small 'Shipek' type grab was used to collect sediments for the geomorphology and geochemistry (Figure 2.8). Surface and benthic water column characteristics (water temperature, salinity, dissolved oxygen concentration and degree of saturation and irradiance) were also measured at each station to provide background environmental data.

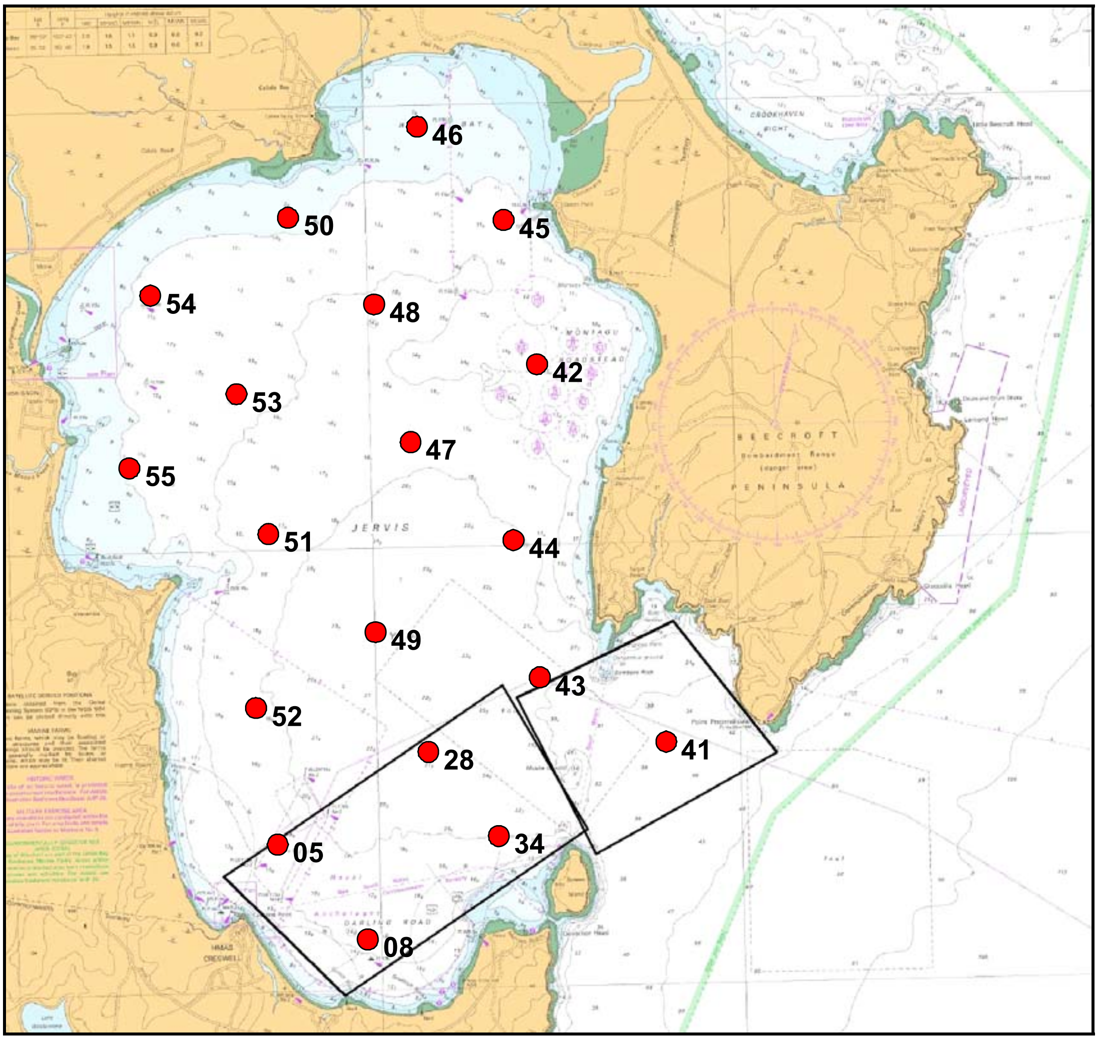


***Figure 2.6:*** *Broad-scale (bay-wide) grab sampling stations in Jervis Bay. Nineteen stations were sampled in June 2008 (red circles). Black boxes depict the locations of the survey grids: Darling Road grid (left) and the Entrance grid (right).*

**Table 2.6.** Survey participants for the grab sampling survey conducted in Jervis Bay, 24-28th June 2008, on board the RV Kimbla (GA survey No. GA312).

| STAFF/ORGANISATION | ROLE |
|---|---|
| Dr Tara Anderson | Biologist, project leader, GA |
| Dr Lynda Radke | Geochemist, GA |
| Dr Rachel Przeslawski | Biologist, GA |
| Matt Carey | Field technician, GA |
| Jodie Smith | Geochemist, GA |

**Table 2.7.** Survey participants for the grab sampling survey conducted in Jervis Bay, 27-29th August 2008, on board the RV Kimbla (GA survey No. GA309)

| STAFF/ORGANISATION | ROLE |
|---|---|
| Dr Tara Anderson | Biologist, project leader, GA |
| Dr Lynda Radke | Geochemist, GA |
| Dr Michael Hughes | Oceanographer, GA |
| Matt Carey | Field technician, GA |
| Stan Hancock * | Field technician, GA |
| Anna Potter | Reseacher, GA |

* only on board for the 27th August 2008

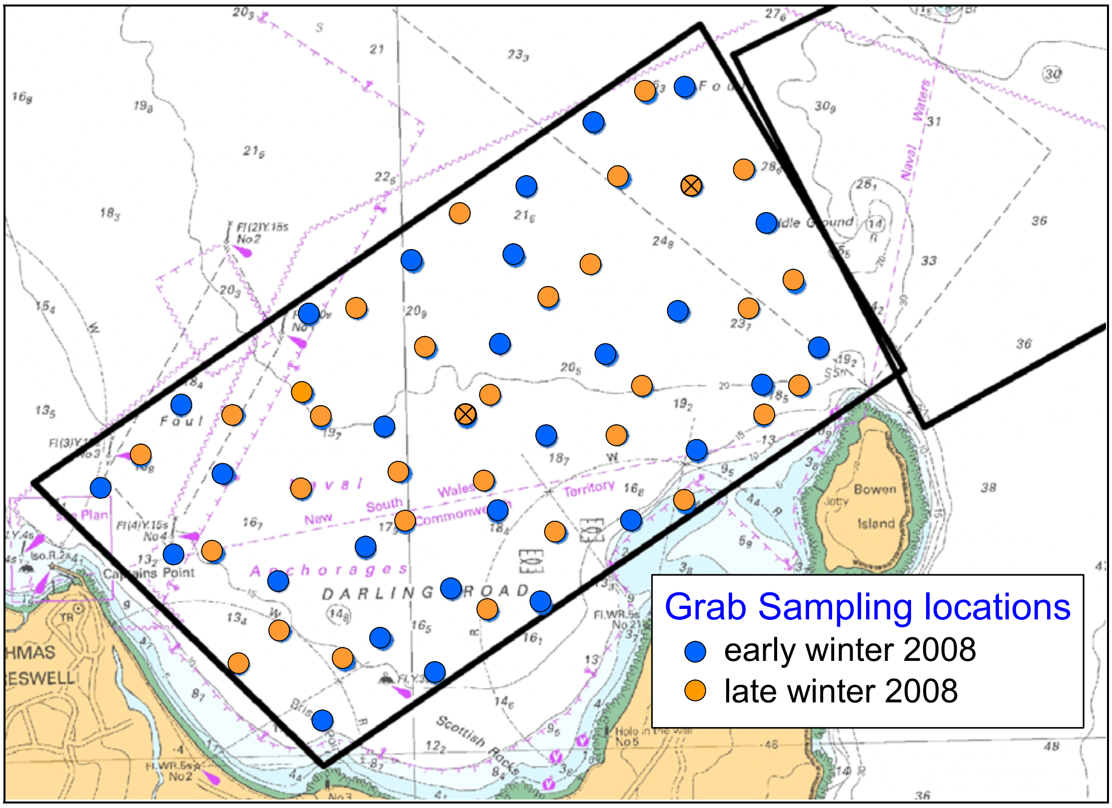


***Figure 2.7:*** *Fine-scale grab sampling stations within the Darling Road Grid, in southern Jervis Bay. Sixty sampling stations were sampled: Twenty-eight stations were sampled in June 2008 (blue circles), while 32 stations (orange circles) were sampled in August 2008. The two crossed orange circles represent stations missed in June 08, but subsequently collected in August 08.*

**Table 2.8.** Grab survey sampling stations conducted in Jervis Bay, 17-20th June 2008, on board the RV Kimbla (GA survey No. GA312). Grid = Darling Road Grid sampling survey; Bay = Bay-wide sampling survey. Grid/Bay = Four stations were collected to be included in both surveys. Refer to appendix 6.6 for a description of the sample types collected at each station.

| STATION | LOCATION | DATE | UTC TIME | LATITUDE | LONGITUDE |
|---|---|---|---|---|---|
| 01 | Grid | 27/06/2008 | 14:30 | -35.11583 | 150.70874 |
| 02 | Grid | 27/06/2008 | 09:05 | -35.12047 | 150.71567 |
| 04 | Grid | 25/06/2008 | 13:57 | -35.13092 | 150.72543 |
| 05 | Grid/Bay | 23/06/2008 | 16:46 | -35.11134 | 150.71513 |
| 06 | Grid | 25/06/2008 | 13:27 | -35.11550 | 150.71921 |
| 07 | Grid | 27/06/2008 | 14:30 | -35.12232 | 150.72328 |
| 08 | Grid/Bay | 24/06/2008 | 16:34 | -35.12562 | 150.73033 |
| 10 | Grid | 27/06/2008 | 09:29 | -35.12062 | 150.72949 |
| 11 | Grid | 27/06/2008 | 09:56 | -35.12803 | 150.73445 |
| 14 | Grid | 27/06/2008 | 14:08 | -35.12270 | 150.73651 |
| 15 | Grid | 27/06/2008 | 12:06 | -35.10583 | 150.72646 |
| 16 | Grid | 25/06/2008 | 15:44 | -35.11189 | 150.73105 |
| 17 | Grid | 25/06/2008 | 14:16 | -35.12342 | 150.74345 |
| 20 | Grid | 27/06/2008 | 13:53 | -35.11806 | 150.74022 |
| 21 | Grid | 25/06/2008 | 12:15 | -35.10235 | 150.73418 |
| 22 | Grid | 27/06/2008 | 13:30 | -35.10740 | 150.74121 |
| 23 | Grid | 25/06/2008 | 14:47 | -35.11353 | 150.74443 |
| 24 | Grid | 27/06/2008 | 10:12 | -35.11909 | 150.75078 |
| 25 | Grid | 27/06/2008 | 13:01 | -35.10215 | 150.74171 |
| 26 | Grid | 27/06/2008 | 13:16 | -35.10902 | 150.74918 |
| 28 | Grid/Bay | 23/06/2008 | 14:44 | -35.09777 | 150.74260 |
| 30 | Grid | 27/06/2008 | 10:31 | -35.11530 | 150.75504 |
| 31 | Grid | 25/06/2008 | 11:59 | -35.09324 | 150.74806 |
| 33 | Grid | 25/06/2008 | 15:28 | -35.10527 | 150.75404 |
| 34 | Grid | 23/06/2008 | 15:57 | -35.11129 | 150.76097 |
| 36 | Grid | 27/06/2008 | 11:43 | -35.09215 | 150.75548 |
| 38 | Grid | 27/06/2008 | 10:59 | -35.10044 | 150.76143 |
| 40 | Grid | 27/06/2008 | 10:48 | -35.10839 | 150.76534 |
| 41 | Bay | 24/06/2008 | 15:58 | -35.09692 | 150.78659 |
| 42 | Bay | 25/06/2008 | 11:02 | -35.04042 | 150.76425 |
| 43 | Bay | 24/06/2008 | 15:28 | -35.08755 | 150.76337 |
| 44 | Bay | 25/06/2008 | 11:30 | -35.06592 | 150.75774 |
| 45 | Bay | 24/06/2008 | 10:25 | -35.01839 | 150.75874 |
| 46 | Bay | 24/06/2008 | 10:59 | -35.00483 | 150.74445 |
| 47 | Bay | 25/06/2008 | 10:01 | -35.05051 | 150.74080 |
| 48 | Bay | 25/06/2008 | 10:32 | -35.03019 | 150.73355 |
| 49 | Bay | 24/06/2008 | 14:54 | -35.08046 | 150.73347 |
| 50 | Bay | 24/06/2008 | 11:28 | -35.01757 | 150.71933 |
| 51 | Bay | 24/06/2008 | 13:59 | -35.06486 | 150.71449 |
| 52 | Bay | 24/06/2008 | 13:27 | -35.09058 | 150.71165 |
| 53 | Bay | 24/06/2008 | 12:20 | -35.04370 | 150.70955 |
| 54 | Bay | 24/06/2008 | 11:56 | -35.02855 | 150.69429 |
| 55 | Bay | 24/06/2008 | 14:25 | -35.05480 | 150.68848 |
| 56 | Grid/Bay | 23/06/2008 | 16:27 | -35.11102 | 150.75519 |

**Table 2.9**. Grab survey sampling stations conducted in Jervis Bay, 25-26th August 2008, on board the RV Kimbla (GA survey No. GA309). Grid = Darling Road Grid sampling survey. Refer to appendix 6.6 for a description of the sample types collected at each station.

| STATION | LOCATION | DATE | UTC TIME | LATITUDE | LONGITUDE |
|---|---|---|---|---|---|
| 03 | Grid | 27/08/2008 | 01:55 | -35.1277 | 150.7189 |
| 09 | Grid | 27/08/2008 | 12:20 | -35.1166 | 150.7257 |
| 12 | Grid | 28/08/2008 | 12:34 | -35.1111 | 150.7256 |
| 13 | Grid | 28/08/2008 | 12:10 | -35.1157 | 150.7329 |
| 18 | Grid | 29/08/2008 | 11:34 | -35.1077 | 150.7351 |
| 19 | Grid | 28/08/2008 | 09:28 | -35.1127 | 150.7385 |
| 27 | Grid | 28/08/2008 | 09:50 | -35.1141 | 150.7331 |
| 29 | Grid | 29/08/2008 | 10:40 | -35.1032 | 150.7481 |
| 32 | Grid | 28/08/2008 | 03:16 | -35.0974 | 150.7506 |
| 35 | Grid | 28/08/2008 | 10:14 | -35.1126 | 150.7610 |
| 37 | Grid | 29/08/2008 | 08:44 | -35.0985 | 150.7562 |
| 39 | Grid | 29/08/2008 | 09:17 | -35.1061 | 150.7600 |
| 61 | Grid | 27/08/2008 | 02:16 | -35.1271 | 150.7283 |
| 62 | Grid | 27/08/2008 | 02.47 | -35.1243 | 150.7395 |
| 63 | Grid | 27/08/2008 | 03.14 | -35.1196 | 150.7454 |
| 64 | Grid | 28/08/2008 | 04:39 | -35.1181 | 150.7548 |
| 65 | Grid | 28/08/2008 | 10:40 | -35.1107 | 150.7633 |
| 66 | Grid | 29/08/2008 | 09:38 | -35.1035 | 150.7635 |
| 67 | Grid | 29/08/2008 | 10:07 | -35.1107 | 150.7514 |
| 68 | Grid | 28/08/2008 | 01:32 | -35.1159 | 150.7394 |
| 69 | Grid | 27/08/2008 | 03.36 | -35.1192 | 150.7331 |
| 70 | Grid | 27/08/2008 | 01:34 | -35.1249 | 150.7236 |
| 71 | Grid | 29/08/2008 | 01:45 | -35.1204 | 150.7185 |
| 72 | Grid | 29/08/2008 | 12:11 | -35.1120 | 150.7268 |
| 73 | Grid | 29/08/2008 | 11.07 | -35.1108 | 150.7404 |
| 74 | Grid | 28/08/2008 | 02:30 | -35.1058 | 150.7444 |
| 75 | Grid | 28/08/2008 | 04:00 | -35.0973 | 150.7603 |
| 76 | Grid | 28/08/2008 | 03:32 | -35.0920 | 150.7523 |
| 77 | Grid | 28/08/2008 | 02:52 | -35.0992 | 150.7372 |
| 78 | Grid | 28/08/2008 | 12:59 | -35.1053 | 150.7300 |
| 79 | Grid | 27/08/2008 | 11:00 | -35.1117 | 150.7207 |
| 80 | Grid | 27/08/2008 | 11:41 | -35.1144 | 150.7126 |

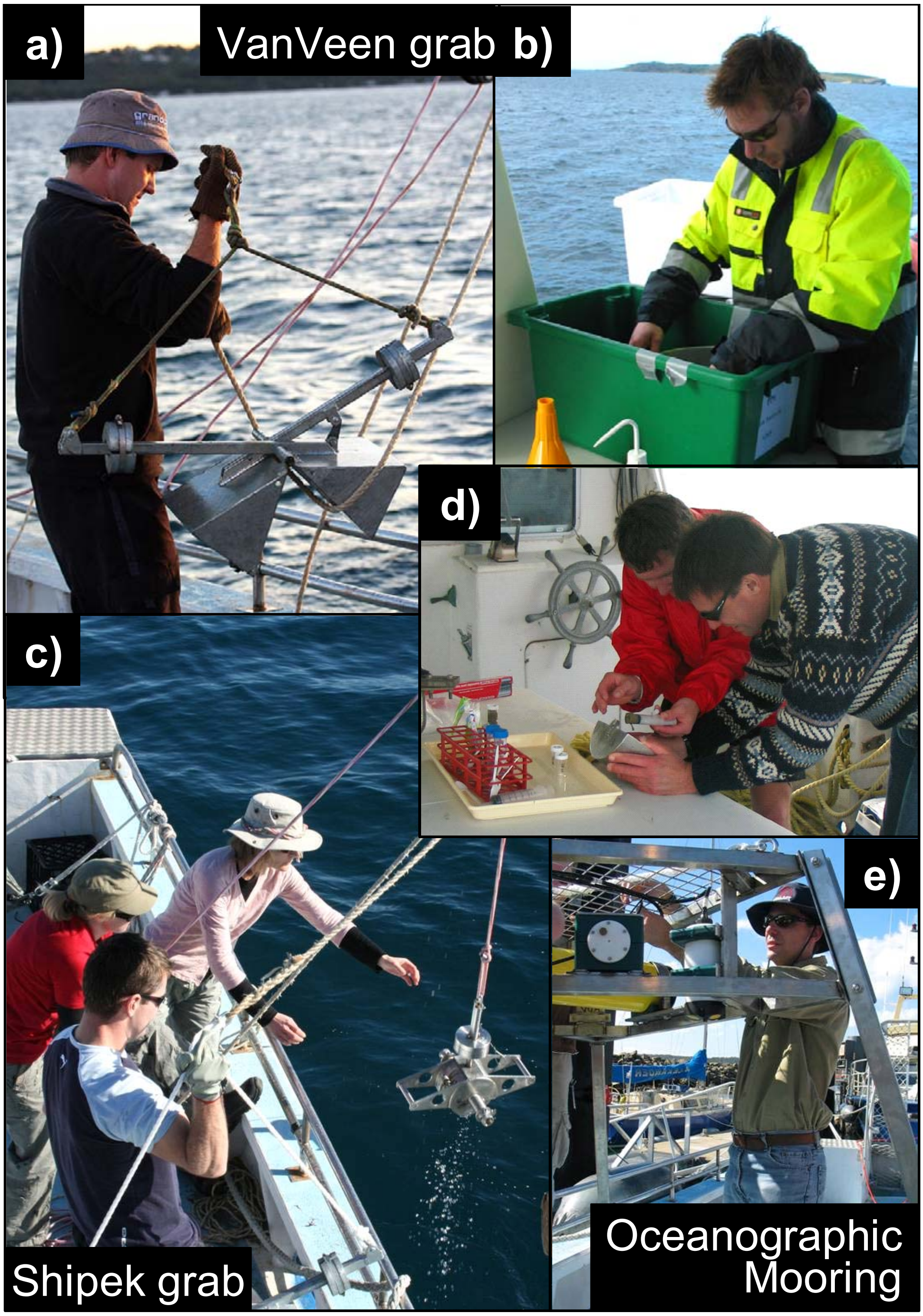


***Figure 2.8:*** *Field Sampling in Jervis Bay. a) Van Veen grab deployed to sample infauna; b) sieving fauna and flora collected from the Van Veen grab; c) Shipek grab deployed to collect sediments for grain size and geochemistry analyses; d) collected sediments being processed for geochemistry analyses; e) oceanographic mooring with ADP and ADT instruments for measuring bed stress and current direction and strength. (Photos: Tara Anderson, Anna Potter, and Rachel Przselawski, Geoscience Australia).*

### 2.5.2. Infaunal sampling

Infauna were quantitatively sampled using a small Van Veen grab (Figure 2.8a) whereby collected sediments were released into a 30 L Nally bin. Sample amount was recorded as the mean of four sediment depth measures within the Nally bin. The sediment sample was then elutriated using a modified 10 L elutriating bucket, and sieved through a 500 µm sieve (Figure 2.8b). The fauna and material in the sieve were photographed (e.g. Figures 2.9a; 2.10a, c); large visible taxa were then carefully removed and individually photographed (Figures 2.9b, c, d; 2.10b).

Taxonomically similar groups (e.g. bivalves together, heart-urchins together, etc.) were then placed together in an appropriate sized jar with a unique barcode and preserved following GA protocols – 4% buffered formalin (e.g. worms, algae, and ascidians) or 99% ethanol (all other specimens). The residual sieved material (a collection of sediments and small/microscopic fauna > 500 µm in size) was removed and preserved in a container with a unique barcode for further sorting by microscope in the laboratory. At the time of writing this report, infaunal samples had been stored at GA for processing, and some samples had been completed.

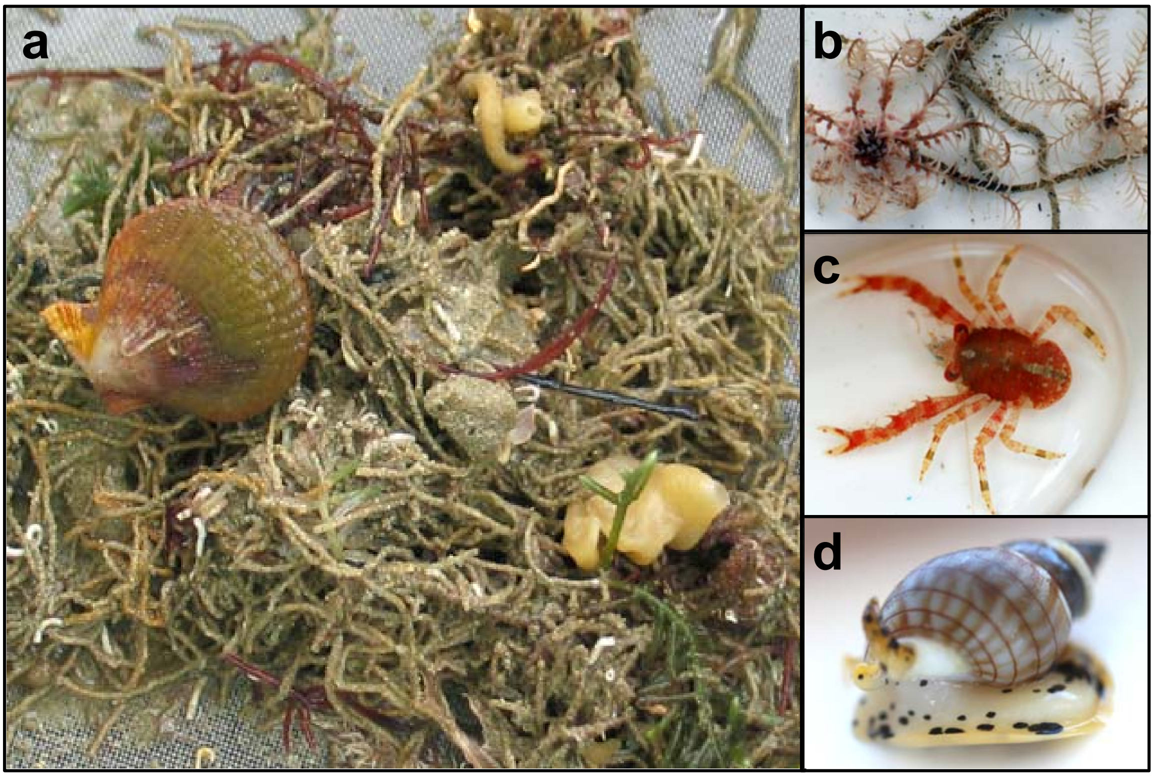


***Figure 2.9:*** *Fauna and flora collected from Jervis Bay sampling. a) mixed sample of chaetopterid worms (*Mesochaetopterus minutus*), with sponges,* Calerpa, *ascidians and doughboy scallop (*Mimachlamys asperrima*); b) crinoids (*Antedon incommoda*); c) Squat lobster (*Galathea australiensis*); and d) gastropod (*Nassarius particeps*) (Photos by Tara Anderson and Rachel Przeslawski, Geoscience Australia).*

### 2.5.3. Infaunal observations

Although infaunal grab samples are at present being processed, some basic observations were made during field collections. Samples collected from the major habitat types appeared to have distinct faunal assemblages. For example, samples taken from sand rippled and sand wave habitats contained small heart urchins (*Echinocardium cordatum*) (Figure 2.10a), with coarser-grained sediments near the entrance to the bay having fewer urchins. Eunicid polychaete worms, although rarely captured in the small Van Veen grab, were collected from sites near HMAS Creswell where drift algae covered the seabed (Figure 2.10b). Sediment samples collected from polychaete hummock habitats contained high densities of chaetopterid worms (Figure 2.10c) and supported a diverse assortment of epifaunal taxa (e.g. Figure 2.9 and 2.10c).

High infaunal biomass and species richness have been recorded from the grab samples sorted to date. The infauna of sandy habitats was dominated by corophiid amphipods and deposit feeding polychaete worms. Polychaete hummocks, that supported higher epifaunal richness, supported lower species richness of infauna than sandy habitats, but higher biomass dominated by the suspension feeding chaetopertid polychaete, *Mesochaetopterus minutes* - the species that forms the mucous/sand tubes that characterise and consolidate the mounds. The red algae, *Acrosorium venulosum*, retained in grab samples was home to hundreds of recently recruited *Electroma geogiana* bivalves.

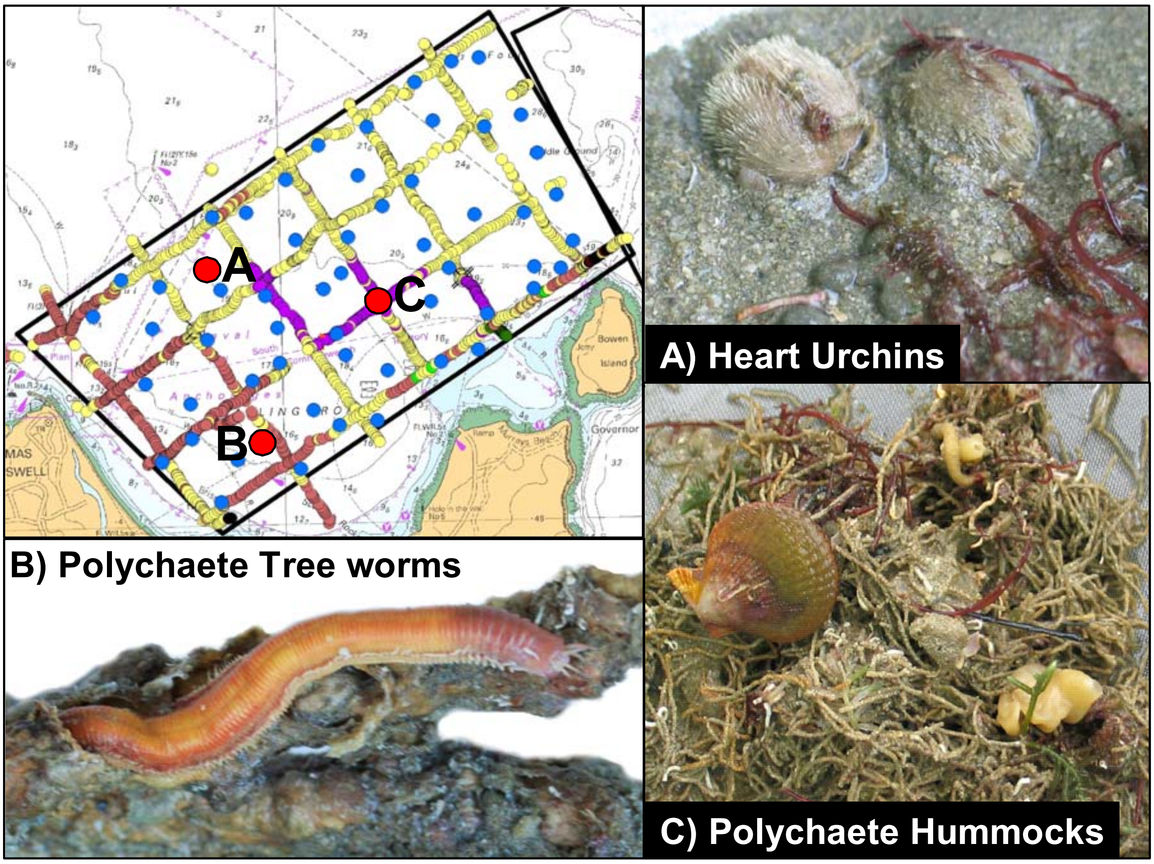


***Figure 2.10:*** *Examples of assemblage types collected from different habitats within Jervis Bay. A) heart urchin areas (*Echinocardium cordatum*), B) polychaete trees (eunicid polychaete worms:* Eunice australis*) (reported as E. impex in Jacoby et al. 1995), C) Polychaete mound species, including chaetopterid worms (*Mesochaetopterus minutus*), with sponges,* Caulerpa *spp, ascidians and* Mimachlamys*. Photos by Tara Anderson and Matthew McArthur, Geoscience Australia.*

### 2.5.4. Sedimentology and geochemistry samples

These samples were collected using a small 'Shipek' type grab sampler (Figure 2.8c). Samples were collected either synchronous with biological sampling (if conditions were conducive to safe operations), or immediately before/after the biological sampling at a given location. The sampler collects a sediment sample in its spring-loaded scoop that is triggered by the release of a sliding weight on the top of the sampler as it makes contact with the seabed. This device can collect an intact sample of sediment up to 5 cm by 12 cm in area and 5 cm thick. Upon triggering, the grab immediately covers the sample, which prevents wash-out of fine sediment during retrieval to the surface.

Immediately after the grab sampler was back aboard, the sample container was removed from the grab. The top 2 cm of the sediment (wet) was then sub-sampled into six separate containers (Figure 2.8d) to separately measure: (i) grain size/carbonate; (ii) porosity and bulk density (10 cc volumetric bottles); (iii) potentially bio-available trace elements (10 cc volumetric bottles which were acid washed prior to use); and (iv) chlorophyll a levels (10 cc volumetric bottles wrapped in aluminium foil). In addition, two 58 ml falcon vials were filled with sediment for the measurement of $TCO_2$ pools and production rates (on the pore waters) and major element oxide composition, sediment surface area, carbon and nutrient contents and isotopic composition and major element oxide composition (on the solid phase).

The porosity and chlorophyll a samples were frozen immediately after collection. The falcon vials were wrapped in aluminium foil and placed in a container in which seawater was held at near in situ water temperatures. No later than 5 hours after collection, the pore waters of one of the two falcon vials (labelled time = zero) were extracted by centrifugation (8890 rpm; 5 minutes) and placed in 3 ml exetainers that had been pre-charged with 0.025 ml of mercuric chloride (to poison the samples). Approximately 24 hours later, the second of the two falcon vials from each site (labelled time = 1) were sampled by the same methods. These extracts were then stored in the refrigerator prior to analysis for dissolved inorganic carbon (DIC) at GA.

To date, DIC, porosity, sediment grain size, surface area, chlorophyll *a* and XRF analyses have been undertaken in the laboratories at GA, and are now complete. Samples for sediment nutrients (and isotopes) and HCL extractable (bio-available) elements have been sent to external laboratories and are still pending analysis.

### 2.5.5. Initial geomorphology and geochemical findings

Sediments within the grid were dominated by sand, which comprised 56 -100% of all samples (Fig. 2.11). Mud was a minor component of many samples and was highest in the southern end of the grid but decreased towards the entrance of the bay (inversely sand content increased towards the entrance). Mud was a significant component (12 – 44%) of most samples inshore of around the 20 m isobath (Fig. 2.11), possibly reflecting the more quiescent depositional setting close to shore where the surrounding hills provide protection from the prevailing southeasterly wind. Also, discharge from small creeks in the area likely provides some fine sediment to the inshore. In contrast, sediments collected deeper than 20 m were comprised of sand (>98% sand). These deeper areas appear to be part of the bay's flood tide delta, with sand transported into the bay by tidal currents.

The spatial distribution of physical habitat features (relief, bedforms) across the grid also appears to match the bathymetry pattern, with the large area of sand dunes beyond the 20 m isobath, most of the hummocky seabed siting in around 20m water depth, and flat and drift covered seabed in the inshore zone (Fig. 2.12).

The $TCO_2$ flux rates also varied over the grid (Fig. 2.13). The $TCO_2$ flux is used as an indicator of the amount of labile organic matter in the sediment. It is a measure the amount of $CO_2$ that is liberated during the breakdown of organic matter over a specified period of ~24 hours. Interestingly, the highest fluxes (> 0.8 umol $cm^{-3}$ $d^{-1}$) observed during August survey were found in the vicinity of the 20m depth contour, in benthic habitat dominated by polychaete hummocks (Fig. 2.12).

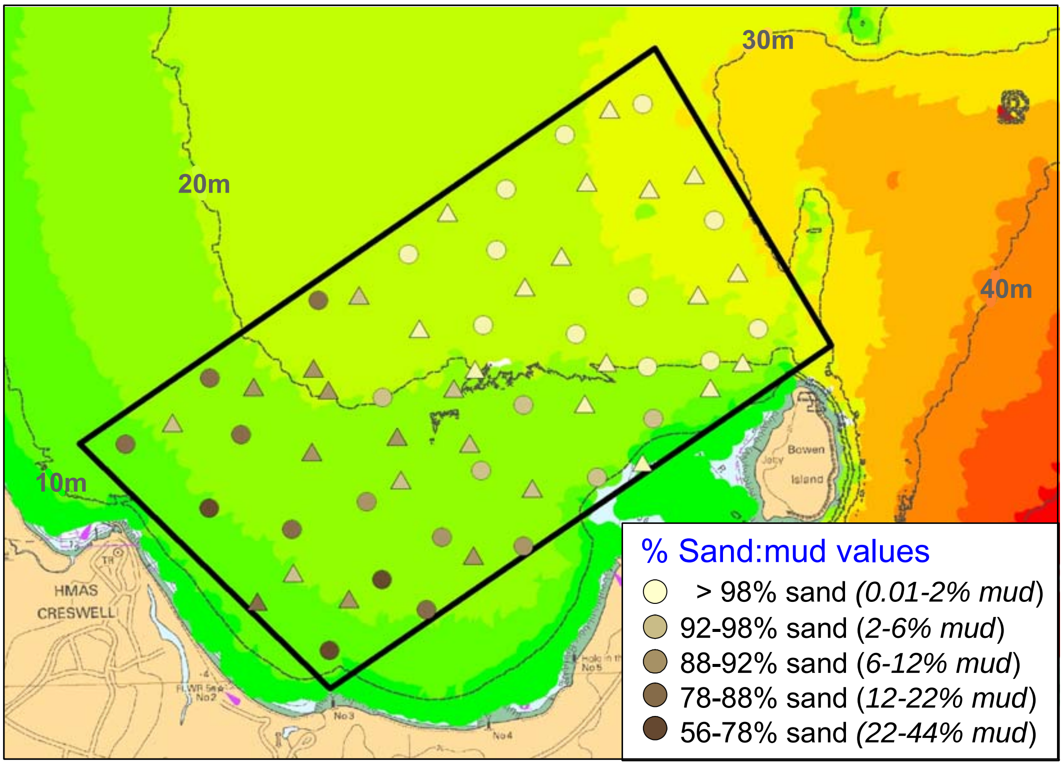


***Figure 2.11:*** *Sediment grainsize values collected from the Darling Road Grid, Jervis Bay in late June (circles) and late August (triangles) 2008. Graduated symbol colours are presented using natural breaks in the data, overlaying single-beam bathymetric data.*

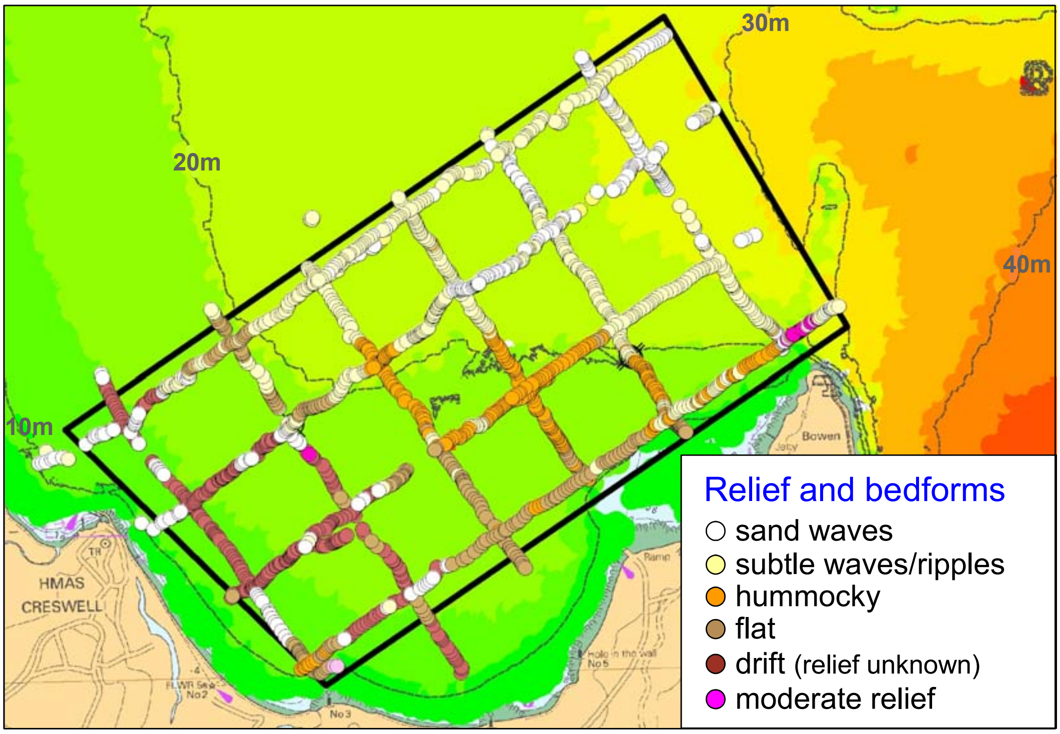


***Figure 2.12:*** *Seabed relief and bedform characterisations recorded from towed-video transects within Darling Road grid, Jervis Bay, overlaying single-beam bathymetric data.*

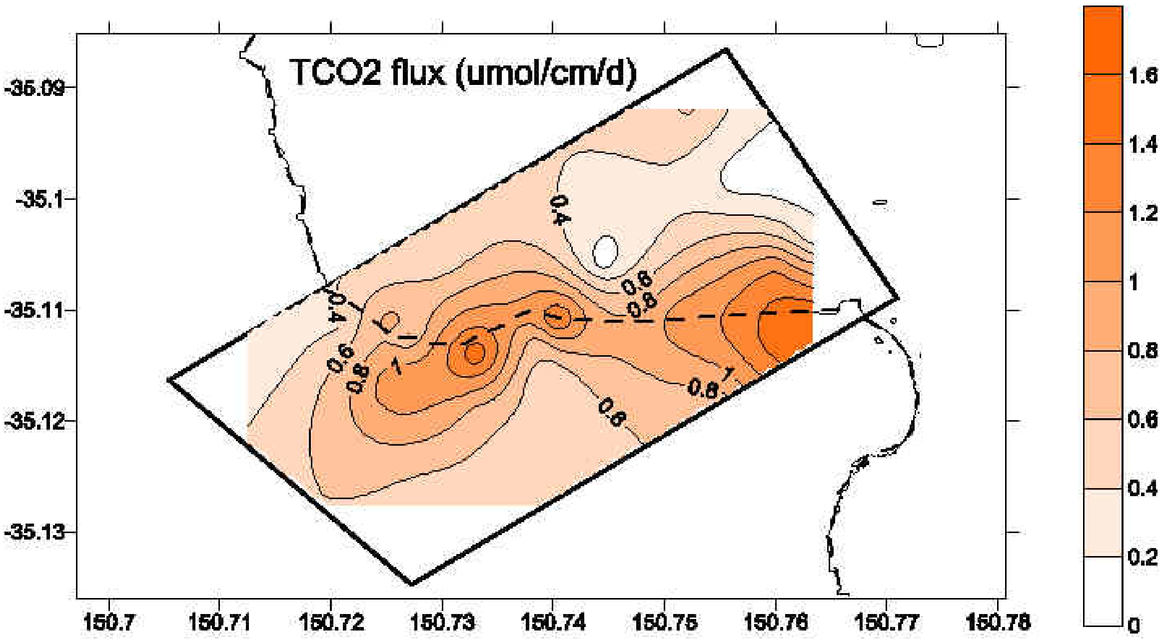


***Figure 2.13:*** *Contour map of $TCO_2$ fluxes (umol $cm^{-3}$ $d^{-1}$) measured in the Darling Road Grid, Jervis Bay in August 2008 based on vial incubation experiments. The hashed line through the diagram marks the position of the 20m isobath.*

## 2.6. OCEANOGRAPHIC MOORING (3-DAY DEPLOYMENT TRIAL)

Four major habitat types (i.e. outer sand wave/rippled habitats, central polychaete hummocks, nearshore drift algae, and inner sediment flats) were discriminated within the Darling Road grid from video. The physical structure of these habitats appears to vary along an exposure gradient from distance to the entrance, and might reflect variability in bed shear stress due to waves and/or currents. An oceanographic mooring, with an acoustic Doppler profiler (ADP) attached (Figure 2.8e), was deployed to determine its suitability for future extended deployments to measure combined waves and currents, bed shear stress, and turbulence. These physical variables could be used to partly explain the bio-physical structure of the seabed both within the grid, and potentially across the larger bay-wide area. On the 25th of August 2008, concurrent with the follow-up video and grab sampling surveys, the mooring was successfully deployed off HMAS Creswell in Jervis Bay (lat: -35.12112, lon: 150.70331), retrieving it on the 29th of August 2008. An example of some of the data collected is shown here as a directional wave energy spectrum (Figure 2.14). The next phase will be to deploy the oceanographic mooring within the Darling Road grid for a period of 4 weeks within each of the 4 major habitat types, starting in March through to July 2009. These data will be used to inform and verify numerical models of the main process drivers, an example of which is shown in Figure 2.15. The high-resolution bathymetry that will be obtained in the next phase of the project will enable modelling of bed shear stresses with a spatial scale commensurate with the biological gradients that have been observed to date (ca. 10 m).

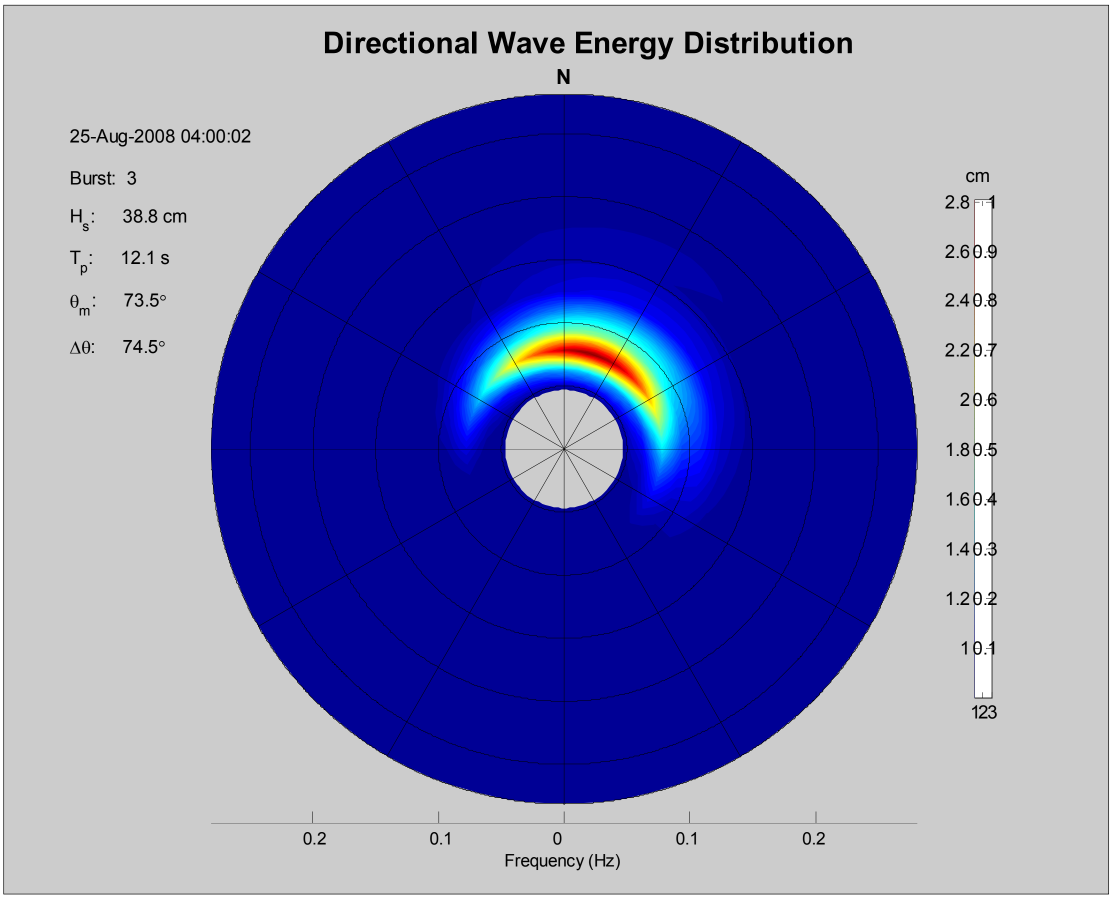


***Figure 2.14:*** *Example of a directional wave energy spectrum measured on the 25 August at 0400 hrs.*

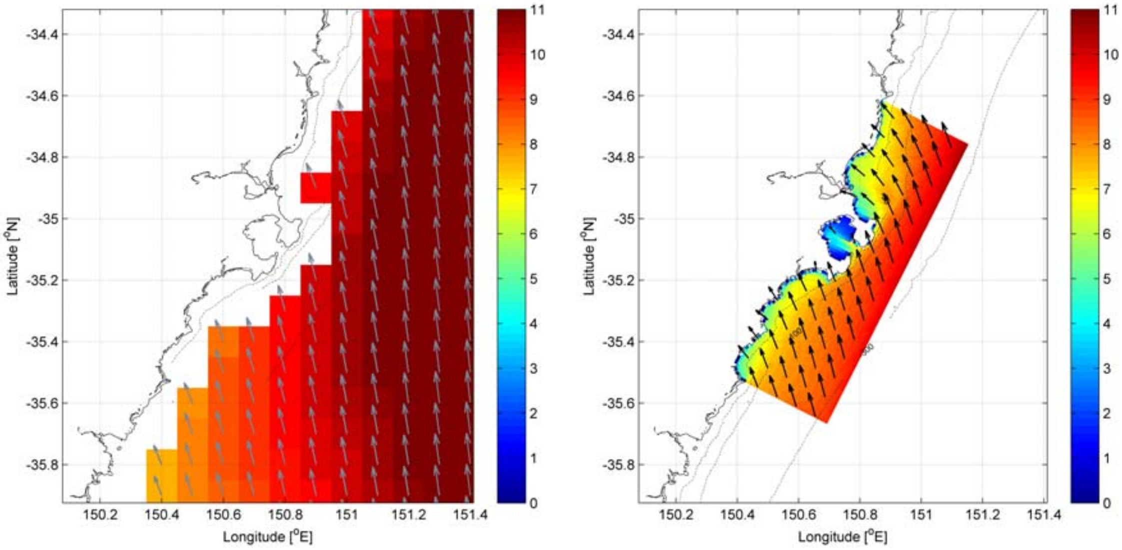


*Figure 2.15: (left panel) Hindcast wave field on the 10th May 1997 at 10 km resolution used as input to SWAN. (right panel) Modelled nearshore wave behaviour at 1km resolution.*

# 3. OVERVIEW OF CURRENT STATUS

Appropriate methods of comparative analysis of seabed physical and biological data are currently being reviewed within the Surrogates and Prediction Projects (e.g. Li and Heap, 2008). Several analytical methods will be trialled on the Jervis Bay datasets. Major tasks prior to beginning comparative analyses are: i) Completion of the collection and processing of multibeam data, and calibration of the associated backscatter signals; ii) identification/classification of species/communities from the towed-video footage; iii) taxonomic identification and counts of infauna collected in grab samples; iv) geochemical analyses and; v) collection of habitat-specific oceanographic data. Bio-physical patterns over the grid will also be evaluated against patterns recorded by the CSIRO video survey in 1990-91 to examine stability, resilience, and change in this system over a decadal time frame.

# 4. SUMMARY

The field program in Jervis Bay is providing high-quality, closely co-located physical and biological data for the CERF Marine Biodiversity Hub's surrogacy research. High-resolution bathymetry and backscatter data was obtained with the EM3002 multibeam system; and benthic habitat and biology data has and will be obtained from the video footage and seabed samples collected within the Darling Road grid and at coarser intervals across the bay. These data will be used to examine the degree to which multibeam bathymetry and backscatter can be used to differentiate soft-sediment habitats. The inclusion of systematic towed-video transects provides vital observations on the types of soft-sediment habitats within the grid, and the spatial configuration of these habitats. Following the completion of the final multibeam survey in December 2008, multibeam and video data will be compared to determine the best methods to integrate and co-interpolate these data over the surface of the grid.

The co-located seabed grab samples collected across the Darling Road grid will enable the distribution of infaunal organisms to be mapped, and an examination of the spatial correlation of infauna assemblages with changes in sediment geomorphology and geochemistry. Following the collection of oceanographic data in the grid over the next few months, hydrodynamic parameters will also be included in these models. The data will then be used to examine the relative strengths of covariance between the biological and physical parameters, and the individual or combined value of the physical parameters as surrogates of fine-scale biodiversity patterns in soft-sediment habitats. The relationships identified will then be used to predict biodiversity patterns across Jervis Bay using physical variables, and the results compared with the broad-scale seabed biological data.

This research is providing an important contribution to our understanding of the spatial complexity of both physical and biological components of soft-sediment benthic ecosystems. By applying a spatially explicit approach that integrates multi- co-located abiotic and biotic information, both the correlation between the physical variables and the composition of the associated infaunal assemblages and the utility of the physical variables as surrogates of biodiversity patterns will be determined. This research has been designed to enhance our ability to map and model patterns of benthic biodiversity and thereby better inform the management of Australia's shallow-marine environment.

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# 6. Appendix

### 6.1. EM3002 SURVEY NARRATIVE

**MV *Kimbla* Surveys (GA Survey No. GA303 and GA305)**
**GA-CERF survey, December 2007 and May-June 2008.**

- Primary Purpose: EM3002 Multibeam (Dual-head) acceptance testing.
- Secondary Purpose: Map Darling Road grid and Entrance grid as part of GA, CERF Surrogacy and SMAC programs test areas to examine methods to integrate physical and biological data layers; map high priority coastal reefs such as Point Beecroft (Grey-nurse nursery ground), and Drum and Drumsticks.

***EM3002 MULTIBEAM (DUAL-HEAD) ACCEPTANCE TESTING (Dec. 2007):***
*Survey Participants: I. Atkinson, C. Bucchanan, Dr T. Anderson (Chief scientist), J. Daniell, M. Spinoccia, J. Griffith.*
*GA Survey No. GA303 (ENO# 450038)*

**Sunday 10-12-07 – *Mobilisations day*.** Field Engineering Team to install the EM3002 Kongsberg Multibeam system on the bow-mount of the MV *Kimbla*.

**Monday 11-12-07 – *Day 1 – Initial set-up and testing*. (am)** test EM3002 using the bow-mount position. Atefacts present on the outer beams possibly due to water movement past the heads on the bow-mount position, also have a multipath interference recorded at greater than >38$^{o}$ off nadir. **(pm)** depart Jervis Bay to map the shelf-break directly off Jervis Bay coast to determine if noise and arefacts disappear in deeper water.

**Tuesday 12-12-07 – *Day 2 – Initial set-up and testing*. (am)** re-install the EM3002 Kongsberg Multibeam system in the moon-pool mount on the central hull of the MV *Kimbla.* **(pm)** test EM3002 using the moon-pool mount position. Outer beam artifacts removed but still have a multipath interference recorded at greater than >38$^{o}$ off nadir. With the exception of this artifact the data is looking good.

**Wednesday 13-12-07 – *Day 3 – testing and CERF Mapping.* (am)** map two sunken blocks (a 1m$^2$ and a 2m$^2$ block) in 10m water depth to determine how well the system resolved small objects. Minimum success, but objects appear very noisy, one side better than the other. Testing continues. **(noon)** Begin running swath tracklines over the entrance grid. Map the firefly plane wreck in the Northern part of the Jervis Bay to determine how well we can resolve a known object of a slightly larger size. Return to mapping the entrance grid.

**Thursday 14-12-07 – *Day 4 – CERF Mapping.* (am)** complete swath tracklines over the entrance grid, and begin mapping Darling Road Grid. The multipath interference is still present. Team is trying several thing to remove it, including different power sources to determine if it is caused by a power interference– so far no solution.

**Friday 15-12-07 – *Day 5 – CERF Mapping.* (am)** Continue to map Darling Road grid.
**(pm)** demobilise. End of survey.

Tara J. Anderson
Lead Scientist

***EM3002 MULTIBEAM (SINGLE-HEAD) ACCEPTANCE TESTING (May-Jun. 2008):***
*Survey Participants: I. Atkinson, C. Bucchanan, Stan Hancock.*
*GA Survey No. GA305 (ENO# 464178)*

**Thursday 29-05-08 – *Mobilisations day*.** Field Engineering Team to install the single-head EM3002 Kongsberg Multibeam system in the moon-pool mount on the central hull of the MV *Kimbla*.

**Friday 30-05-08 – *Day 1 –initial set-up testing and CERF Mapping:* (am)** Undertake initial testing; **(pm)** transit out of Jervis Bay to undertake deep water testing and mapping of Drum and Drumsticks.

**Saturday 31-05-08 – *Day 2 – CERF Mapping:* (am)** remap inner sections of Middle ground and Darling Road Grid, then transit out of Jervis Bay to map Beecroft Head (Grey-nurse nursery ground).

**Sunday 01-06-08 – *Day 3 – CERF Mapping.*** Finish mapping Beecroft Head (Grey-nurse nursery ground). Return to port @ 17:50 local time. Demobilise. End of survey.

Tara J. Anderson
Lead Scientist

## 6.2. GRAB SAMPLING: JUNE-SURVEY NARRATIVE

### MV *Kimbla* Surveys (GA Survey No. GA312 ENO# 455760)
### GA-CERF survey, Survey June 2008.

- Primary Purpose: GA Raytech Towed-Video Camera Acceptance Trials.
- Secondary Purpose: Collect towed-video and grab samples from with the Darling Road survey grid. Backup task: Collect grab samples from Bay-wide survey of Jervis Bay.

***LEG 1 (Jun. 2008): TOWED-VIDEO TESTING & SURVEY.***
*Survey Participants: Dr T. Anderson (Chief scientist), M. Tran, S. Hodgkins, S. Hancock.*

**Tuesday 17-06-08 – *Day 1 – Towed-video acceptance testing*.** Arrived at HMAS Creswell @ 0800 hr local time to mobilise on the *MV Kimbla*. Left port (HMAS Creswell) @ 1030 hrs to undertake a series of towed-video acceptance tests, including removing the wings, adding weight to the frame, putting wings on upside down, moving the camera position on the frame, and trialed the USBL tracking system). 1230 hrs picked up Tara and Maggie and continued towed-video acceptance testing. 1750 hrs trialed the low-light still camera on the towed-video system: however, the still camera was deemed ineffective as even small amounts of movement between the sled and the seabed made it impossible to capture a focused still image. Returned to port @ 1715 hrs.

**Wednesday 18-06-08 – *Day 2 (morning) – Towed-video acceptance testing continued*.** Departed port @ 0930 hrs to trial the performance of the tow-unit during two test video-transects conducted within the darling road grid (test_cam01, and test_cam02). The system was towed 1-2m above the seabed, and performed well. During the tests, GNav navigational software failed @ 1005 hrs: GPS feed disconnected and hung computer, took 20 minutes to correct. Several other problems were also identified, including a miss-match of local vs. UTC-time on different gear, and that the Gyro was not working correctly meaning that the towed-video position was not able to be calculated/generated by USBL software. ***(afternoon)*** 1200 hrs everything working correctly, so commenced video-transect survey within the Darling Road grid, and completed the first two offshore video-transects (JBcam_tx01, JBcam_tx02). Returned to port @ 1743 hrs.

**Thursday 19-06-08 – *Day 3 – Towed-video survey*.** Departed port @ 0950 hrs local time to continue towed-video survey within Darling Road grid. Four offshore video-transects (JBcam_tx03, JBcam_tx04, JBcam_tx05, JBcam_tx06), and one alongshore video-transect begun (JBcam_tx07a). Returned to port @ 1800 hrs.

**Friday 20-06-08 – *Day 4 – Towed-video survey*.** Departed port @ 0835 hrs to continue sampling alongshore video-transects. JBcam_tx07 was completed, and JBcam_tx08 were completed (JBcam_tx08) was started, however the tow cable was found to have a serious nick in it. Survey terminated @ 1130 hrs, returned to port @ 1154 hrs to demobilise.

***LEG 2 (June 2008): GRAB SAMPLING SURVEY (Bay-wide and Darling Road grid).***
*Survey Participants: Dr T. Anderson (Chief scientist), Dr L. Radke (Co-PI), Dr R. Przeslawski, M. Carey, Jodi Smith*

**Monday 23-06-08 – *Day 1 –*** Arrived at HMAS Creswell @ 1100 hr local time to mobilise on the *MV Kimbla*. Left port (HMAS Creswell) @ 1420 hrs to sample the four joint Darling Road grid and Bay-wide stations (28, 34, 56, 05). Returned to HMAS Creswell @ 1725 hrs.

**Tuesday 24-06-08 – *Day 2 –*** Departed port @ 0930 hrs with the objective of sampling the Darling Road grid. However, Navy vessel-noise testing was underway in southern Jervis Bay, and no vessels were allowed to be underway. MV *Kimbla* was given permission to work in northern-most section of Bay, so at 1020 hrs we commence the Bay-wide grab sampling survey, and completed 12 stations (Stations 45, 46, 50, 54, 53, 52, 51, 55, 49, 43, 41, 08) working from the northern section of Bay, south. Returned to port @ 1710 hrs.

**Wednesday 25-06-08 – *Day 3 –*** Departed port @ 0930 hrs to complete last four bay-wide stations (Stations 47, 48, 42, 44). As no Navy ships were operating in the Bay, @ 1140 hrs we transited to, and began sampling within the Darling Road Grid (Stations 31, 21). @ 1245 hrs we returned to dock to drop off Tara and Lynda (Tara returning to Canberra, Lynda to begin processing geochemistry samples in Huskisson Beach Motel). 1327 hrs continued sampling, completing six stations (Stations 31, 21, 06, 17, 23, 04, 33, 16), returning to port @ 1610 hrs.

**Thursday 26-06-08 – *Day 4 – Strong Wind Warning*.** No sampling due to bad weather. Rachel Przeslawski returned to Canberra.

**Friday 27-06-08 – *Day 5* –** *Diary not recorded.* Departed port @ 0830 hrs. Completed 13 stations (Stations 10, 11, 24, 30, 40, 28, 36, 15, 25, 26, 22, 20, 14), three remaining stations not sampled.

Tara J. Anderson
Jervis Bay Survey Leader

### 6.3. GRAB SAMPLING: AUGUST-SURVEY NARRATIVE

**MV *Kimbla* Survey (GA Survey No. GA309 ENO# 456396)**
**GA-CERF Survey August 2008.**
CERF/GA - Follow-up video and grab sampling survey, trial oceanographic mooring
*Leg1. Towed-video camera survey within Darling Road grid, deploy oceanographic mooring.*
*Leg2. Grab sampling survey within Darling Road grid, retrieve oceanographic mooring.*

***LEG 1 (Aug. 2008):***
FOLLOW-UP TOWED-VIDEO SURVEY and DEPLOY OCEANOGRAPHIC MOORING.
*Survey Participants: Dr T. Anderson (Chief scientist), Dr. M. Hughes, A. Potter, S. Hancock, M. Carey, Joe Nielson – invited guest from the Dept. of the Environment.*

**Sunday 24-08-08 –** Mobilisation day: Stan Hancock to train Matt Carey of how to set-up and run the towed-video camera system.

**Monday 25-08-08 – *Day 1* –** Arrived at HMAS Creswell @ 0830 hr local time to setup Oceanographic Mooring on the *MV Kimbla*. Left port (HMAS Creswell) @ 1055 hrs, and deployed the mooring @ 1111 hrs in the port entrance of HMAS Creswell. Transit to Darling road grid to undertake remaining towed-video transects. @1142 hrs USBL not working, but video test good, decided to go ahead without USBL. @1149 hrs commenced alongshore transect JBcam_tx09a, however seabed visibility became too turbid so line terminated @1321 hrs, transit to alongshore transect JBcam_tx10a (other section of JBcam_tx08) commenced @ 1358, however @1521 hrs the tow-cable found to be splitting in 5 or 6 places, so transect terminated, returned to port @ 1540 to repair and glue cable.

**Tuesday 26-08-08 – *Day 2* –** Arrived at HMAS Creswell @ 0815 hr to assess cable repairs, which were deemed okay. Departed port @ 0845 hrs to complete the three remaining towed-video transects (entire JBcam_tx11, and remaining sections of JBcam_tx10b, JBcam_tx09b). Towed-survey completed, returned to port @ 0315 hrs to demobilise. End of Towed-video Survey.

***LEG 2: (Aug. 2008):***
FOLLOW-UP GRAB SAMPLING SURVEY and RETRIEVE OCEANOGRAPHIC MOORING. *Survey Participants: Dr T. Anderson (Chief scientist), Dr L. Radke, Dr. M. Hughes, A. Potter, S. Hancock, M. Carey.*

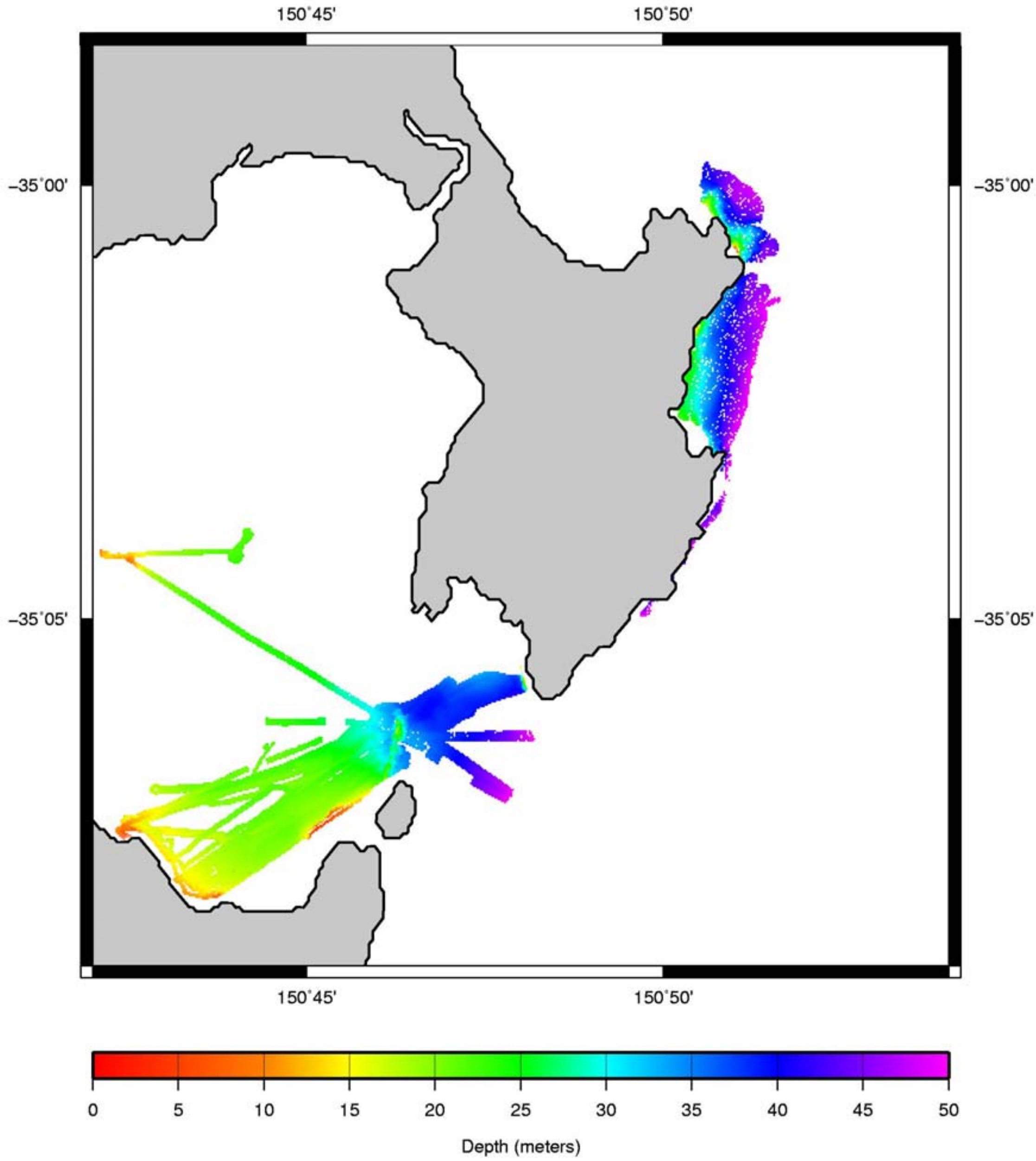
**Wednesday 27-08-08 – *Day 1* –** Arrived at HMAS Creswell @ 0840 hr local time to mobilise on the *MV Kimbla*. Left port (HMAS Creswell) @ 1245 hrs to collect grab samples from within the Darling Road grid, southern Jervis Bay. Seven stations were successfully sampled (Stations 79, 09, 70, 61, 62, 63, 69), while 2 stations (Stations 80 and 03) failed to return sample, these station will be re-sampled later in the survey. Returned to port @ 1730 hrs

**Thursday 28-08-08 – *Day 2* –** Left port (HMAS Creswell) @ 0900 hrs. 15 stations sampled (Stations 19, 27, 35, 65, 81, 13, 12, 78, 68, 74, 77, 32, 76, 75, 64) from within the Darling road grid. Returned to port @ 1740 hrs.

**Friday 29-08-08 – *Day 3* –** Left port (HMAS Creswell) @ 0835 hrs. The final 10 stations were sampled (Stations 37, 39, 66, 67, 29, 73, 18, 72, 71, 80) from within the Darling road grid. Transit to retrieve the oceanographic mooring @ 0245 hrs from port entrance of HMAS Creswell. Returned to port @ 1510 hrs to demobilise. End of Grab Survey.

Tara J. Anderson
Jervis Bay Survey Leader

### 6.4. JERVIS BAY EM3002 MULTIBEAM SWATH FROM SURVEY GA305 COLLECTED DURING THE 29TH MAY – 1ST JUNE 2008, USING A SINGLE-TRANSDUCER ARRANGEMENT.



### 6.5. SAMPLE TYPE AND LOCATION FOR ALL STATION OPERATIONS OF SURVEYS GA312 (JUNE 08) AND GA309 (AUGUST 08)

Key for sample codes

| | |
|---|---|
| JB = Jervis Bay | # = station numbers |
| WC = water column sample (A,B,C = replicate samples) | |
| GR = Grab (A,B,C = multiple grabs collected: sample type denotes grab type collected (Shipek or Van Veen) | |
| PL = Algal sample collected from Grab for analysis (A = algae type 1, B = algae type 2) | |
| Shipek = sediment samples, and geochemistry collected | |
| Van Veen = infaunal samples collected | |

| SURVEY NO. | DATE | SAMPLE ID | SAMPLE TYPE | LATITUDE | LONGITUDE | DEPTH (M) |
|---|---|---|---|---|---|---|
| GA309 | 27/08/2008 | JB_B79_WCA | Water column | -35.11168 | 150.72070 | 18.6 |
| GA309 | 27/08/2008 | JB_B79_WCB | Water column | -35.11168 | 150.72070 | 18.6 |
| GA309 | 27/08/2008 | JB_B79_GRA | Grab Shipek | -35.11168 | 150.72070 | 18.6 |
| GA309 | 27/08/2008 | JB_B79_GRC | Grab Van Veen | -35.11168 | 150.72070 | 18.6 |
| GA309 | 27/08/2008 | JB_B80_WCA | Water column | -35.11440 | 150.71260 | 15.8 |
| GA309 | 27/08/2008 | JB_B80_WCB | Water column | -35.11440 | 150.71260 | 15.8 |
| GA309 | 29/08/2008 | JB_B80_GRA2 | Grab Shipek | -35.11440 | 150.71260 | 15.8 |
| GA309 | 27/08/2008 | JB_B80_GRA_PLA | Grab Shipek | -35.11440 | 150.71260 | 15.8 |
| GA309 | 27/08/2008 | JB_B80_GRA_PLB | Grab Shipek | -35.11440 | 150.71260 | 15.8 |
| GA309 | 27/08/2008 | JB_B80_GRA | Grab Shipek | -35.11440 | 150.71260 | 15.8 |
| GA309 | 27/08/2008 | JB_A09_WCA | Water column | -35.11663 | 150.72572 | 18.8 |
| GA309 | 27/08/2008 | JB_A09_WCB | Water column | -35.11663 | 150.72572 | 18.8 |
| GA309 | 27/08/2008 | JB_A09_GRA | Grab Shipek | -35.11663 | 150.72572 | 18.8 |
| GA309 | 27/08/2008 | JB_B70_WCA | Water column | -35.12494 | 150.72362 | 15.5 |
| GA309 | 27/08/2008 | JB_B70_WCB | Water column | -35.12494 | 150.72362 | 15.5 |
| GA309 | 27/08/2008 | JB_B70_GRA | Grab Shipek | -35.12494 | 150.72362 | 15.5 |
| GA309 | 29/08/2008 | JB_B70_GRB | Grab Shipek | -35.12494 | 150.72362 | 15.5 |
| GA309 | 29/08/2008 | JB_B70_GRA_PLA | Grab Shipek | -35.12494 | 150.72362 | 15.5 |
| GA309 | 27/08/2008 | JB_A03_WCA | Water column | -35.12766 | 150.71890 | 13.2 |
| GA309 | 27/08/2008 | JB_A03_WCB | Water column | -35.12766 | 150.71890 | 13.2 |
| GA309 | 27/08/2008 | JB_A03_GRA | Grab Shipek | -35.12766 | 150.71890 | 13.2 |
| GA309 | 29/08/2008 | JB_A03_GRA | Grab Shipek | -35.12766 | 150.71890 | 13.2 |
| GA309 | 27/08/2008 | JB_B61_WCA | Water column | -35.12714 | 150.72826 | 15.9 |
| GA309 | 27/08/2008 | JB_B61_WCB | Water column | -35.12714 | 150.72826 | 15.9 |
| GA309 | 27/08/2008 | JB_B61_GRA | Grab Shipek | -35.12714 | 150.72826 | 15.9 |
| GA309 | 27/08/2008 | JB_B61_GRB | Grab Van Veen | -35.12714 | 150.72826 | 15.9 |
| GA309 | 27/08/2008 | JB_B61_GRC | Grab Shipek | -35.12714 | 150.72826 | 15.9 |
| GA309 | 27/08/2008 | JB_B62_WCA | Water column | -35.12433 | 150.73947 | 17.7 |
| GA309 | 27/08/2008 | JB_B62_WCB | Water column | -35.12433 | 150.73947 | 17.7 |
| GA309 | 27/08/2008 | JB_B62_GRA | Grab Shipek | -35.12433 | 150.73947 | 17.7 |
| GA309 | 27/08/2008 | JB_B62_GRB | Grab Van Veen | -35.12433 | 150.73947 | 17.7 |
| GA309 | 27/08/2008 | JB_B63_WCA | Water column | -35.11958 | 150.74535 | 18.6 |
| GA309 | 27/08/2008 | JB_B63_WCB | Water column | -35.11958 | 150.74535 | 18.6 |
| GA309 | 27/08/2008 | JB_B63_GRA | Grab Shipek | -35.11958 | 150.74535 | 18.6 |
| GA309 | 27/08/2008 | JB_B63_GRB | Grab Van Veen | -35.11958 | 150.74535 | 18.6 |
| GA309 | 27/08/2008 | JB_B69_WCA | Water column | -35.11917 | 150.73312 | 19.5 |

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| GA309 | 27/08/2008 | JB_B69_WCB | Water column | -35.11917 | 150.73312 | 19.5 |
| GA309 | 27/08/2008 | JB_B69_GRA | Grab Shipek | -35.11917 | 150.73312 | 19.5 |
| GA309 | 27/08/2008 | JB_B69_GRB | Grab Van Veen | -35.11917 | 150.73312 | 19.5 |
| GA309 | 28/08/2008 | JB_A19_WCA | Water column | -35.11273 | 150.73846 | 19.7 |
| GA309 | 28/08/2008 | JB_A19_WCB | Water column | -35.11273 | 150.73846 | 19.7 |
| GA309 | 28/08/2008 | JB_A19_GRA | Grab Shipek | -35.11273 | 150.73846 | 19.7 |
| GA309 | 28/08/2008 | JB_A19_GRC | Grab Shipek | -35.11273 | 150.73846 | 19.7 |
| GA309 | 28/08/2008 | JB_A27_WCA | Water column | -35.11407 | 150.73312 | 18.6 |
| GA309 | 28/08/2008 | JB_A27_WCB | Water column | -35.11407 | 150.73312 | 18.6 |
| GA309 | 28/08/2008 | JB_A27_GRA | Grab Shipek | -35.11407 | 150.73312 | 18.6 |
| GA309 | 28/08/2008 | JB_A27_GRC | Grab Shipek | -35.11407 | 150.73312 | 18.6 |
| GA309 | 28/08/2008 | JB_A35_WCA | Water column | -35.11257 | 150.76100 | 17.0 |
| GA309 | 28/08/2008 | JB_A35_WCB | Water column | -35.11257 | 150.76100 | 17.0 |
| GA309 | 28/08/2008 | JB_A35_GRA | Grab Shipek | -35.11257 | 150.76100 | 17.0 |
| GA309 | 28/08/2008 | JB_A35_GRA_PLA | Grab Shipek | -35.11257 | 150.76100 | 17.0 |
| GA309 | 28/08/2008 | JB_A35_GRA_PLB | Grab Shipek | -35.11257 | 150.76100 | 17.0 |
| GA309 | 28/08/2008 | JB_A35_GRC | Grab Shipek | -35.11257 | 150.76100 | 17.0 |
| GA309 | 28/08/2008 | JB_B65_WCA | Water column | -35.11070 | 150.76329 | 20.5 |
| GA309 | 28/08/2008 | JB_B65_WCB | Water column | -35.11070 | 150.76329 | 20.5 |
| GA309 | 28/08/2008 | JB_B65_GRA | Grab Shipek | -35.11070 | 150.76329 | 20.5 |
| GA309 | 28/08/2008 | JB_B65_GRC | Grab Shipek | -35.11070 | 150.76329 | 20.5 |
| GA309 | 28/08/2008 | JB_C81_GRA | Grab Van Veen | -35.12893 | 150.74818 | 4.8 |
| GA309 | 28/08/2008 | JB_A13_WCA | Water column | -35.11568 | 150.73285 | 19.0 |
| GA309 | 28/08/2008 | JB_A13_WCB | Water column | -35.11568 | 150.73285 | 19.0 |
| GA309 | 28/08/2008 | JB_A13_GRA | Grab Shipek | -35.11568 | 150.73285 | 19.0 |
| GA309 | 28/08/2008 | JB_A12_WCA | Water column | -35.11106 | 150.72557 | 20.0 |
| GA309 | 28/08/2008 | JB_A12_WCB | Water column | -35.11106 | 150.72557 | 20.0 |
| GA309 | 28/08/2008 | JB_A12_GRA | Grab Shipek | -35.11106 | 150.72557 | 20.0 |
| GA309 | 28/08/2008 | JB_A12_GRC | Grab Shipek | -35.11106 | 150.72557 | 20.0 |
| GA309 | 28/08/2008 | JB_B78_WCA | Water column | -35.10525 | 150.72997 | 22.0 |
| GA309 | 28/08/2008 | JB_B78_WCB | Water column | -35.10525 | 150.72997 | 22.0 |
| GA309 | 28/08/2008 | JB_B78_GRA | Grab Shipek | -35.10525 | 150.72997 | 22.0 |
| GA309 | 28/08/2008 | JB_B78_GRC | Grab Shipek | -35.10525 | 150.72997 | 22.0 |
| GA309 | 28/08/2008 | JB_B68_WCA | Water column | -35.11593 | 150.73936 | 19.0 |
| GA309 | 28/08/2008 | JB_B68_WCB | Water column | -35.11593 | 150.73936 | 19.0 |
| GA309 | 28/08/2008 | JB_B68_GRA | Grab Shipek | -35.11593 | 150.73936 | 19.0 |
| GA309 | 28/08/2008 | JB_B68_GRC | Grab Shipek | -35.11593 | 150.73936 | 19.0 |
| GA309 | 28/08/2008 | JB_B74_WCA | Water column | -35.10578 | 150.74440 | 21.9 |
| GA309 | 28/08/2008 | JB_B74_WCB | Water column | -35.10578 | 150.74440 | 21.9 |
| GA309 | 28/08/2008 | JB_B74_GRA | Grab Shipek | -35.10578 | 150.74440 | 21.9 |
| GA309 | 28/08/2008 | JB_B74_GRC | Grab Shipek | -35.10578 | 150.74440 | 21.9 |
| GA309 | 28/08/2008 | JB_B77_WCA | Water column | -35.09922 | 150.73723 | 22.3 |
| GA309 | 28/08/2008 | JB_B77_WCB | Water column | -35.09922 | 150.73723 | 22.3 |
| GA309 | 28/08/2008 | JB_B77_GRA | Grab Shipek | -35.09922 | 150.73723 | 22.3 |
| GA309 | 28/08/2008 | JB_B77_GRC | Grab Shipek | -35.09922 | 150.73723 | 22.3 |
| GA309 | 28/08/2008 | JB_A32_WCA | Water column | -35.09742 | 150.75060 | 25.0 |
| GA309 | 28/08/2008 | JB_A32_WCB | Water column | -35.09742 | 150.75060 | 25.0 |
| GA309 | 28/08/2008 | JB_A32_GRA | Grab Shipek | -35.09742 | 150.75060 | 25.0 |
| GA309 | 28/08/2008 | JB_A32_GRC | Grab Shipek | -35.09742 | 150.75060 | 25.0 |
| GA309 | 28/08/2008 | JB_B76_WCA | Water column | -35.09204 | 150.75230 | 26.0 |
| GA309 | 28/08/2008 | JB_B76_WCB | Water column | -35.09204 | 150.75230 | 26.0 |
| GA309 | 28/08/2008 | JB_B76_GRA | Grab Shipek | -35.09204 | 150.75230 | 26.0 |

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| GA309 | 28/08/2008 | JB_B76_GRC | Grab Shipek | -35.09204 | 150.75230 | 26.0 |
| GA309 | 28/08/2008 | JB_B75_WCA | Water column | -35.09731 | 150.76030 | 29.0 |
| GA309 | 28/08/2008 | JB_B75_WCB | Water column | -35.09731 | 150.76030 | 29.0 |
| GA309 | 28/08/2008 | JB_B75_GRA | Grab Shipek | -35.09731 | 150.76030 | 29.0 |
| GA309 | 28/08/2008 | JB_B75_GRC | Grab Shipek | -35.09731 | 150.76030 | 29.0 |
| GA309 | 28/08/2008 | JB_B64_WCA | Water column | -35.11808 | 150.75482 | 5.0 |
| GA309 | 28/08/2008 | JB_B64_WCB | Water column | -35.11808 | 150.75482 | 5.0 |
| GA309 | 28/08/2008 | JB_B64_GRA | Grab Shipek | -35.11808 | 150.75482 | 5.0 |
| GA309 | 28/08/2008 | JB_B64_GRC | Grab Shipek | -35.11808 | 150.75482 | 5.0 |
| GA309 | 29/08/2008 | JB_A37_WCA | Water column | -35.09846 | 150.75620 | 27.5 |
| GA309 | 29/08/2008 | JB_A37_WCB | Water column | -35.09846 | 150.75620 | 27.5 |
| GA309 | 29/08/2008 | JB_A37_GRA | Grab Shipek | -35.09846 | 150.75620 | 27.5 |
| GA309 | 29/08/2008 | JB_A37_GRC | Grab Shipek | -35.09846 | 150.75620 | 27.5 |
| GA309 | 29/08/2008 | JB_A39_WCA | Water column | -35.10605 | 150.76004 | 25.0 |
| GA309 | 29/08/2008 | JB_A39_WCB | Water column | -35.10605 | 150.76004 | 25.0 |
| GA309 | 29/08/2008 | JB_A39_GRA | Grab Shipek | -35.10605 | 150.76004 | 25.0 |
| GA309 | 29/08/2008 | JB_A39_GRC | Grab Shipek | -35.10605 | 150.76004 | 25.0 |
| GA309 | 29/08/2008 | JB_B66_WCA | Water column | -35.10350 | 150.76347 | 27.0 |
| GA309 | 29/08/2008 | JB_B66_WCB | Water column | -35.10350 | 150.76347 | 27.0 |
| GA309 | 29/08/2008 | JB_B66_GRA | Grab Shipek | -35.10350 | 150.76347 | 27.0 |
| GA309 | 29/08/2008 | JB_B66_GRC | Grab Shipek | -35.10350 | 150.76347 | 27.0 |
| GA309 | 29/08/2008 | JB_B67_WCA | Water column | -35.11071 | 150.75136 | 20.0 |
| GA309 | 29/08/2008 | JB_B67_WCB | Water column | -35.11071 | 150.75136 | 20.0 |
| GA309 | 29/08/2008 | JB_B67_GRA | Grab Shipek | -35.11071 | 150.75136 | 20.0 |
| GA309 | 29/08/2008 | JB_B67_GRC | Grab Shipek | -35.11071 | 150.75136 | 20.0 |
| GA309 | 29/08/2008 | JB_A29_WCA | Water column | -35.10316 | 150.74812 | 23.0 |
| GA309 | 29/08/2008 | JB_A29_WCB | Water column | -35.10316 | 150.74812 | 23.0 |
| GA309 | 29/08/2008 | JB_A29_GRA | Grab Shipek | -35.10316 | 150.74812 | 23.0 |
| GA309 | 29/08/2008 | JB_A29_GRC | Grab Shipek | -35.10316 | 150.74812 | 23.0 |
| GA309 | 29/08/2008 | JB_B73_WCA | Water column | -35.11084 | 150.74040 | 20.0 |
| GA309 | 29/08/2008 | JB_B73_WCB | Water column | -35.11084 | 150.74040 | 20.0 |
| GA309 | 29/08/2008 | JB_B73_GRA | Grab Van Veen | -35.11084 | 150.74040 | 20.0 |
| GA309 | 29/08/2008 | JB_B73_GRC | Grab Shipek | -35.11084 | 150.74040 | 20.0 |
| GA309 | 29/08/2008 | JB_A18_WCA | Water column | -35.10770 | 150.73514 | 20.5 |
| GA309 | 29/08/2008 | JB_A18_WCB | Water column | -35.10770 | 150.73514 | 20.5 |
| GA309 | 29/08/2008 | JB_A18_GRA | Grab Shipek | -35.10770 | 150.73514 | 20.5 |
| GA309 | 29/08/2008 | JB_A18_GRC | Grab Shipek | -35.10770 | 150.73514 | 20.5 |
| GA309 | 29/08/2008 | JB_B72_WCA | Water column | -35.11198 | 150.72679 | 20.0 |
| GA309 | 29/08/2008 | JB_B72_WCB | Water column | -35.11198 | 150.72679 | 20.0 |
| GA309 | 29/08/2008 | JB_B72_GRA | Grab Shipek | -35.11198 | 150.72679 | 20.0 |
| GA309 | 29/08/2008 | JB_B72_GRC | Grab Shipek | -35.11198 | 150.72679 | 20.0 |
| GA309 | 29/08/2008 | JB_B71_WCA | Water column | -35.12037 | 150.71848 | 15.5 |
| GA309 | 29/08/2008 | JB_B71_WCB | Water column | -35.12037 | 150.71848 | 15.5 |
| GA309 | 29/08/2008 | JB_B71_GRA | Grab Shipek | -35.12037 | 150.71848 | 15.5 |
| GA309 | 29/08/2008 | JB_B71_GRC | Grab Shipek | -35.12037 | 150.71848 | 15.5 |
| GA309 | 29/08/2008 | JB_B71_GRC_PLA | Grab Shipek | -35.12037 | 150.71848 | 15.5 |
| GA309 | 28/08/2008 | JB_B81_WCA | Grab Van Veen | -35.12893 | 150.74818 | 4.8 |
| GA312 | 23/06/2008 | JB_28_GRA | Grab Van Veen | -35.09782 | 150.74301 | 22.8 |
| GA312 | 23/06/2008 | JB_28_GRB | Grab Shipeck | -35.09821 | 150.74310 | 22.8 |
| GA312 | 23/06/2008 | JB_28_WCB | Water column | -35.09777 | 150.74260 | 21.8 |
| GA312 | 23/06/2008 | JB_28_WCA | Water column | -35.09777 | 150.74260 | 0.5 |
| GA312 | 23/06/2008 | JB_34_GRA | Grab Van Veen | -35.11066 | 150.76083 | 19.7 |

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| GA312 | 23/06/2008 | JB_34_GRB | Grab Shipeck | -35.11066 | 150.76083 | 19.7 |
| GA312 | 23/06/2008 | JB_34_WCB | Water column | -35.11129 | 150.76097 | 18.7 |
| GA312 | 23/06/2008 | JB_34_WCA | Water column | -35.11129 | 150.76097 | 0.5 |
| GA312 | 23/06/2008 | JB_56_GRB | Grab Van Veen | -35.11102 | 150.75519 | 20.2 |
| GA312 | 23/06/2008 | JB_56_GRA | Grab Shipeck | -35.11102 | 150.75519 | 20.2 |
| GA312 | 23/06/2008 | JB_56_WCA | Water column | -35.11102 | 150.75519 | 0.5 |
| GA312 | 23/06/2008 | JB_56_WCB | Water column | -35.11102 | 150.75519 | 19.2 |
| GA312 | 23/06/2008 | JB_05_GRA | Grab Van Veen | -35.11109 | 150.71608 | 17.5 |
| GA312 | 23/06/2008 | JB_05_GRB | Grab Shipeck | -35.11110 | 150.71626 | 17.5 |
| GA312 | 23/06/2008 | JB_05_GRC | Grab Shipeck | -35.11116 | 150.71509 | 17.5 |
| GA312 | 23/06/2008 | JB_05_WCA | Water column | -35.11134 | 150.71513 | 0.5 |
| GA312 | 23/06/2008 | JB_05_WCB | Water column | -35.11134 | 150.71513 | 16.5 |
| GA312 | 24/06/2008 | JB_45_WCA | Water column | -35.01839 | 150.75874 | 0.5 |
| GA312 | 24/06/2008 | JB_45_WCB | Water column | -35.01839 | 150.75874 | 13.0 |
| GA312 | 24/06/2008 | JB_45_GRA | Grab Van Veen | -35.01904 | 150.75990 | 14.0 |
| GA312 | 24/06/2008 | JB_45_GRB | Grab Shipeck | -35.01904 | 150.75990 | 14.0 |
| GA312 | 24/06/2008 | JB_46_WCA | Water column | -35.00483 | 150.74445 | 0.5 |
| GA312 | 24/06/2008 | JB_46_WCB | Water column | -35.00483 | 150.74445 | 7.8 |
| GA312 | 24/06/2008 | JB_46_PLA | Water column | -35.00526 | 150.74504 | 8.8 |
| GA312 | 24/06/2008 | JB_46_GRA | Grab Van Veen | -35.00526 | 150.74504 | 8.8 |
| GA312 | 24/06/2008 | JB_46_GRB | Grab Shipeck | -35.00526 | 150.74504 | 8.8 |
| GA312 | 24/06/2008 | JB_50_WCA | Water column | -35.01757 | 150.71933 | 0.5 |
| GA312 | 24/06/2008 | JB_50_WCB | Water column | -35.01757 | 150.71933 | 8.7 |
| GA312 | 24/06/2008 | JB_50_PLA | Water column | -35.01778 | 150.72029 | 9.7 |
| GA312 | 24/06/2008 | JB_50_GRB | Grab Shipeck | -35.01778 | 150.72029 | 9.7 |
| GA312 | 24/06/2008 | JB_50_GRA | Grab Van Veen | -35.01795 | 150.72070 | 9.7 |
| GA312 | 24/06/2008 | JB_54_WCA | Water column | -35.02855 | 150.69429 | 0.5 |
| GA312 | 24/06/2008 | JB_54_WCB | Water column | -35.02855 | 150.69429 | 10.5 |
| GA312 | 24/06/2008 | JB_54_GRA | Grab Van Veen | -35.02865 | 150.69475 | 11.5 |
| GA312 | 24/06/2008 | JB_54_GRB | Grab Shipeck | -35.02865 | 150.69475 | 11.5 |
| GA312 | 24/06/2008 | JB_53_WCA | Water column | -35.04370 | 150.70955 | 0.5 |
| GA312 | 24/06/2008 | JB_53_WCB | Water column | -35.04370 | 150.70955 | 14.0 |
| GA312 | 24/06/2008 | JB_53_GRA | Grab Van Veen | -35.04357 | 150.70921 | 15.0 |
| GA312 | 24/06/2008 | JB_53_GRB | Grab Shipeck | -35.04344 | 150.70883 | 15.0 |
| GA312 | 24/06/2008 | JB_53_GRC | Grab Shipeck | -35.04416 | 150.70975 | 15.0 |
| GA312 | 24/06/2008 | JB_52_WCA | Water column | -35.09058 | 150.71165 | 0.5 |
| GA312 | 24/06/2008 | JB_52_WCB | Water column | -35.09058 | 150.71165 | 19.0 |
| GA312 | 24/06/2008 | JB_52_GRA | Grab Van Veen | -35.09087 | 150.71115 | 20.0 |
| GA312 | 24/06/2008 | JB_52_GRB | Grab Shipeck | -35.09087 | 150.71115 | 20.0 |
| GA312 | 24/06/2008 | JB_51_WCA | Water column | -35.06486 | 150.71449 | 0.5 |
| GA312 | 24/06/2008 | JB_51_WCB | Water column | -35.06486 | 150.71449 | 17.1 |
| GA312 | 24/06/2008 | JB_51_GRA | Grab Van Veen | -35.06533 | 150.71550 | 18.1 |
| GA312 | 24/06/2008 | JB_51_GRB | Grab Shipeck | -35.06533 | 150.71550 | 18.1 |
| GA312 | 24/06/2008 | JB_51_GRC | Grab Shipeck | -35.06477 | 150.71461 | 18.1 |
| GA312 | 24/06/2008 | JB_55_WCA | Water column | -35.05480 | 150.68848 | 0.5 |
| GA312 | 24/06/2008 | JB_55_WCB | Water column | -35.05480 | 150.68848 | 9.1 |
| GA312 | 24/06/2008 | JB_55_GRA | Grab Van Veen | -35.05503 | 150.68906 | 10.1 |
| GA312 | 24/06/2008 | JB_55_GRB | Grab Shipeck | -35.05503 | 150.68906 | 10.1 |
| GA312 | 24/06/2008 | JB_55_GRC | Grab Shipeck | -35.05497 | 150.68826 | 10.1 |
| GA312 | 24/06/2008 | JB_49_WCA | Water column | -35.08046 | 150.73347 | 0.5 |
| GA312 | 24/06/2008 | JB_49_WCB | Water column | -35.08046 | 150.73347 | 22.1 |
| GA312 | 24/06/2008 | JB_49_GRA | Grab Van Veen | -35.08014 | 150.73299 | 23.1 |

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| GA312 | 24/06/2008 | JB_49_GRB | Grab Shipeck | -35.08014 | 150.73268 | 23.1 |
| GA312 | 24/06/2008 | JB_49_GRC | Grab Shipeck | -35.08047 | 150.73366 | 23.1 |
| GA312 | 24/06/2008 | JB_43_WCA | Water column | -35.08755 | 150.76337 | 0.5 |
| GA312 | 24/06/2008 | JB_43_WCB | Water column | -35.08755 | 150.76337 | 28.8 |
| GA312 | 24/06/2008 | JB_43_GRA | Grab Van Veen | -35.08826 | 150.76410 | 29.8 |
| GA312 | 24/06/2008 | JB_43_GRB | Grab Shipeck | -35.08802 | 150.76372 | 29.8 |
| GA312 | 24/06/2008 | JB_41_WCA | Water column | -35.09692 | 150.78659 | 0.5 |
| GA312 | 24/06/2008 | JB_41_WCB | Water column | -35.09692 | 150.78659 | 36.5 |
| GA312 | 24/06/2008 | JB_41_GRA | Grab Van Veen | -35.09724 | 150.78693 | 37.5 |
| GA312 | 24/06/2008 | JB_41_GRB | Grab Shipeck | -35.09703 | 150.78627 | 37.5 |
| GA312 | 24/06/2008 | JB_08_WCA | Water column | -35.12562 | 150.73033 | 0.5 |
| GA312 | 24/06/2008 | JB_08_WCB | Water column | -35.12562 | 150.73033 | 14.8 |
| GA312 | 24/06/2008 | JB_08_GRA | Grab Van Veen | -35.12612 | 150.73119 | 15.8 |
| GA312 | 24/06/2008 | JB_08_GRB | Grab Shipeck | -35.12612 | 150.73119 | 15.8 |
| GA312 | 24/06/2008 | JB_08_GRC | Grab Shipeck | -35.12648 | 150.73103 | 15.8 |
| GA312 | 25/06/2008 | JB_47_WCA | Water column | -35.05051 | 150.74080 | 0.5 |
| GA312 | 25/06/2008 | JB_47_WCB | Water column | -35.05051 | 150.74080 | 17.1 |
| GA312 | 25/06/2008 | JB_47_GRA | Grab Van Veen | -35.05127 | 150.74229 | 18.1 |
| GA312 | 25/06/2008 | JB_47_GRB | Grab Shipeck | -35.05127 | 150.74229 | 18.1 |
| GA312 | 25/06/2008 | JB_47_GRC | Grab Shipeck | -35.05221 | 150.74409 | 18.1 |
| GA312 | 25/06/2008 | JB_48_WCA | Water column | -35.03019 | 150.73355 | 0.5 |
| GA312 | 25/06/2008 | JB_48_WCB | Water column | -35.03019 | 150.73355 | 15.3 |
| GA312 | 25/06/2008 | JB_48_PLA | Water column | -35.03102 | 150.73593 | 16.3 |
| GA312 | 25/06/2008 | JB_48_GRA | Grab Van Veen | -35.03044 | 150.73427 | 16.3 |
| GA312 | 25/06/2008 | JB_48_GRB | Grab Shipeck | -35.03102 | 150.73593 | 16.3 |
| GA312 | 25/06/2008 | JB_48_GRC | Grab Shipeck | -35.03160 | 150.73695 | 16.3 |
| GA312 | 25/06/2008 | JB_42_WCA | Water column | -35.04042 | 150.76425 | 0.5 |
| GA312 | 25/06/2008 | JB_42_WCB | Water column | -35.04042 | 150.76425 | 13.5 |
| GA312 | 25/06/2008 | JB_42_GRA | Grab Van Veen | -35.04136 | 150.76686 | 14.5 |
| GA312 | 25/06/2008 | JB_42_GRB | Grab Shipeck | -35.04156 | 150.76736 | 14.5 |
| GA312 | 25/06/2008 | JB_44_WCA | Water column | -35.06592 | 150.75774 | 0.5 |
| GA312 | 25/06/2008 | JB_44_WCB | Water column | -35.06592 | 150.75774 | 20.5 |
| GA312 | 25/06/2008 | JB_44_GRA | Grab Van Veen | -35.06654 | 150.75917 | 21.5 |
| GA312 | 25/06/2008 | JB_44_GRB | Grab Shipeck | -35.06619 | 150.75839 | 21.5 |
| GA312 | 25/06/2008 | JB_31_WCA | Water column | -35.09324 | 150.74806 | 0.5 |
| GA312 | 25/06/2008 | JB_31_WCB | Water column | -35.09324 | 150.74806 | 24.0 |
| GA312 | 25/06/2008 | JB_31_GRA | Grab Van Veen | -35.09387 | 150.74832 | 25.0 |
| GA312 | 25/06/2008 | JB_31_GRB | Grab Shipeck | -35.09369 | 150.74828 | 25.0 |
| GA312 | 25/06/2008 | JB_21_WCA | Water column | -35.10235 | 150.73418 | 0.5 |
| GA312 | 25/06/2008 | JB_21_WCB | Water column | -35.10235 | 150.73418 | 21.0 |
| GA312 | 25/06/2008 | JB_21_GRA | Grab Van Veen | -35.10238 | 150.73415 | 22.0 |
| GA312 | 25/06/2008 | JB_21_GRB | Grab Shipeck | -35.10284 | 150.73428 | 22.0 |
| GA312 | 25/06/2008 | JB_06_WCA | Water column | -35.11550 | 150.71921 | 0.5 |
| GA312 | 25/06/2008 | JB_06_WCB | Water column | -35.11550 | 150.71921 | 18.0 |
| GA312 | 25/06/2008 | JB_06_PLA | Water column | -35.11531 | 150.71901 | 18.0 |
| GA312 | 25/06/2008 | JB_06_GRA | Grab Van Veen | -35.11550 | 150.71935 | 18.0 |
| GA312 | 25/06/2008 | JB_06_GRB | Grab Shipeck | -35.11531 | 150.71901 | 18.0 |
| GA312 | 25/06/2008 | JB_06_GRC | Grab Shipeck | -35.11536 | 150.71870 | 18.0 |
| GA312 | 25/06/2008 | JB_04_WCA | Water column | -35.13092 | 150.72543 | 0.5 |
| GA312 | 25/06/2008 | JB_04_WCB | Water column | -35.13092 | 150.72543 | 12.5 |
| GA312 | 25/06/2008 | JB_04_PLA | Water column | -35.13125 | 150.72580 | 13.5 |
| GA312 | 25/06/2008 | JB_04_GRA | Grab Van Veen | -35.13118 | 150.72641 | 13.5 |

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| GA312 | 25/06/2008 | JB_04_GRB | Grab Shipeck | -35.13125 | 150.72580 | 13.5 |
| GA312 | 25/06/2008 | JB_17_WCA | Water column | -35.12342 | 150.74345 | 0.5 |
| GA312 | 25/06/2008 | JB_17_WCB | Water column | -35.12342 | 150.74345 | 16.0 |
| GA312 | 25/06/2008 | JB_17_GRA | Grab Van Veen | -35.12416 | 150.74344 | 17.0 |
| GA312 | 25/06/2008 | JB_17_GRB | Grab Shipeck | -35.12387 | 150.74380 | 17.0 |
| GA312 | 25/06/2008 | JB_17_GRC | Grab Shipeck | -35.12373 | 150.74309 | 17.0 |
| GA312 | 25/06/2008 | JB_23_WCA | Water column | -35.11353 | 150.74443 | 0.5 |
| GA312 | 25/06/2008 | JB_23_WCB | Water column | -35.11353 | 150.74443 | 18.4 |
| GA312 | 25/06/2008 | JB_23_GRA | Grab Van Veen | -35.11359 | 150.74408 | 19.4 |
| GA312 | 25/06/2008 | JB_23_GRB | Grab Shipeck | -35.11447 | 150.74513 | 19.4 |
| GA312 | 25/06/2008 | JB_33_WCA | Water column | -35.10527 | 150.75404 | 0.5 |
| GA312 | 25/06/2008 | JB_33_WCB | Water column | -35.10527 | 150.75404 | 23.0 |
| GA312 | 25/06/2008 | JB_33_GRA | Grab Van Veen | -35.10588 | 150.75450 | 24.0 |
| GA312 | 25/06/2008 | JB_33_GRB | Grab Shipeck | -35.10552 | 150.75423 | 24.0 |
| GA312 | 25/06/2008 | JB_16_WCA | Water column | -35.11189 | 150.73105 | 0.5 |
| GA312 | 25/06/2008 | JB_16_WCB | Water column | -35.11189 | 150.73105 | 19.5 |
| GA312 | 25/06/2008 | JB_16_GRA | Grab Van Veen | -35.11277 | 150.73163 | 20.5 |
| GA312 | 25/06/2008 | JB_16_GRB | Grab Shipeck | -35.11257 | 150.73141 | 20.5 |
| GA312 | 27/06/2008 | JB_02_WCA | Water column | -35.12047 | 150.71567 | 0.5 |
| GA312 | 27/06/2008 | JB_02_WCB | Water column | -35.12047 | 150.71567 | 14.5 |
| GA312 | 27/06/2008 | JB_02_PLA | Water column | -35.12064 | 150.71603 | 15.5 |
| GA312 | 27/06/2008 | JB_02_PLB | Water column | -35.12064 | 150.71603 | 15.5 |
| GA312 | 27/06/2008 | JB_02_GRA | Grab Shipeck | -35.12064 | 150.71603 | 15.5 |
| GA312 | 27/06/2008 | JB_10_WCA | Water column | -35.12062 | 150.72949 | 0.5 |
| GA312 | 27/06/2008 | JB_10_WCB | Water column | -35.12062 | 150.72949 | 16.5 |
| GA312 | 27/06/2008 | JB_10_GRB | Grab Shipeck | -35.12038 | 150.73003 | 17.5 |
| GA312 | 27/06/2008 | JB_10_GRA | Grab Van Veen | -35.12038 | 150.73003 | 17.5 |
| GA312 | 27/06/2008 | JB_11_WCA | Water column | -35.12803 | 150.73445 | 0.5 |
| GA312 | 27/06/2008 | JB_11_WCB | Water column | -35.12803 | 150.73445 | 16.5 |
| GA312 | 27/06/2008 | JB_11_PLA | Water column | -35.12835 | 150.73509 | 15.5 |
| GA312 | 27/06/2008 | JB_11_GRA | Grab Van Veen | -35.12835 | 150.73509 | 15.5 |
| GA312 | 27/06/2008 | JB_11_GRA | Grab Shipeck | -35.12835 | 150.73509 | 15.5 |
| GA312 | 27/06/2008 | JB_24_WCA | Water column | -35.11909 | 150.75078 | 0.5 |
| GA312 | 27/06/2008 | JB_24_WCB | Water column | -35.11909 | 150.75078 | 14.0 |
| GA312 | 27/06/2008 | JB_24_GRA | Grab Van Veen | -35.11902 | 150.75050 | 15.0 |
| GA312 | 27/06/2008 | JB_24_GRA | Grab Shipeck | -35.11902 | 150.75050 | 15.0 |
| GA312 | 27/06/2008 | JB_30_WCA | Water column | -35.11530 | 150.75504 | 0.5 |
| GA312 | 27/06/2008 | JB_30_WCB | Water column | -35.11530 | 150.75504 | 15.5 |
| GA312 | 27/06/2008 | JB_30_PLA | Water column | -35.11477 | 150.75562 | 16.5 |
| GA312 | 27/06/2008 | JB_30_GRA | Grab Van Veen | -35.11477 | 150.75562 | 16.5 |
| GA312 | 27/06/2008 | JB_30_GRA | Grab Shipeck | -35.11477 | 150.75562 | 16.5 |
| GA312 | 27/06/2008 | JB_40_WCA | Water column | -35.10839 | 150.76534 | 0.5 |
| GA312 | 27/06/2008 | JB_40_WCB | Water column | -35.10839 | 150.76534 | 25.0 |
| GA312 | 27/06/2008 | JB_40_GRA | Grab Van Veen | -35.10839 | 150.76509 | 26.0 |
| GA312 | 27/06/2008 | JB_40_GRB | Grab Shipeck | -35.10839 | 150.76509 | 26.0 |
| GA312 | 27/06/2008 | JB_38_WCA | Water column | -35.10044 | 150.76143 | 0.5 |
| GA312 | 27/06/2008 | JB_38_WCB | Water column | -35.10044 | 150.76143 | 27.0 |
| GA312 | 27/06/2008 | JB_38_GRA | Grab Van Veen | -35.10044 | 150.76143 | 28.0 |
| GA312 | 27/06/2008 | JB_38_GRB | Grab Shipeck | -35.10044 | 150.76143 | 28.0 |
| GA312 | 27/06/2008 | JB_36_WCA | Water column | -35.09215 | 150.75548 | 0.5 |
| GA312 | 27/06/2008 | JB_36_WCB | Water column | -35.09215 | 150.75548 | 26.0 |
| GA312 | 27/06/2008 | JB_36_GRA | Grab Van Veen | -35.09180 | 150.75534 | 27.0 |

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| GA312 | 27/06/2008 | JB_36_GRB | Grab Shipeck | -35.09180 | 150.75534 | 27.0 |
| GA312 | 27/06/2008 | JB_15_WCA | Water column | -35.10583 | 150.72646 | 0.5 |
| GA312 | 27/06/2008 | JB_15_WCB | Water column | -35.10583 | 150.72646 | 21.0 |
| GA312 | 27/06/2008 | JB_15_GRA | Grab Van Veen | -35.10558 | 150.72612 | 22.0 |
| GA312 | 27/06/2008 | JB_15_GRB | Grab Shipeck | -35.10558 | 150.72612 | 22.0 |
| GA312 | 27/06/2008 | JB_25_WCA | Water column | -35.10215 | 150.74171 | 0.5 |
| GA312 | 27/06/2008 | JB_25_WCB | Water column | -35.10215 | 150.74171 | 21.4 |
| GA312 | 27/06/2008 | JB_25_GRA | Grab Van Veen | -35.10216 | 150.74197 | 22.4 |
| GA312 | 27/06/2008 | JB_25_GRB | Grab Shipeck | -35.10216 | 150.74197 | 22.4 |
| GA312 | 27/06/2008 | JB_26_WCA | Water column | -35.10902 | 150.74918 | 0.5 |
| GA312 | 27/06/2008 | JB_26_WCB | Water column | -35.10902 | 150.74918 | 20.0 |
| GA312 | 27/06/2008 | JB_26_GRA | Grab Van Veen | -35.10852 | 150.74892 | 21.0 |
| GA312 | 27/06/2008 | JB_26_GRB | Grab Shipeck | -35.10852 | 150.74892 | 21.0 |
| GA312 | 27/06/2008 | JB_22_WCA | Water column | -35.10740 | 150.74121 | 0.5 |
| GA312 | 27/06/2008 | JB_22_WCB | Water column | -35.10740 | 150.74121 | 20.0 |
| GA312 | 27/06/2008 | JB_22_GRA | Grab Van Veen | -35.10767 | 150.74072 | 21.0 |
| GA312 | 27/06/2008 | JB_22_GRB | Grab Shipeck | -35.10767 | 150.74072 | 21.0 |
| GA312 | 27/06/2008 | JB_20_WCA | Water column | -35.11806 | 150.74022 | 0.5 |
| GA312 | 27/06/2008 | JB_20_WCB | Water column | -35.11806 | 150.74022 | 18.3 |
| GA312 | 27/06/2008 | JB_20_GRA | Grab Van Veen | -35.11826 | 150.74017 | 19.3 |
| GA312 | 27/06/2008 | JB_20_GRB | Grab Shipeck | -35.11826 | 150.74017 | 19.3 |
| GA312 | 27/06/2008 | JB_14_WCA | Water column | -35.12270 | 150.73651 | 0.5 |
| GA312 | 27/06/2008 | JB_14_WCB | Water column | -35.12270 | 150.73651 | 17.2 |
| GA312 | 27/06/2008 | JB_14_GRA | Grab Van Veen | -35.12309 | 150.73659 | 18.2 |
| GA312 | 27/06/2008 | JB_14_GRB | Grab Shipeck | -35.12309 | 150.73659 | 18.2 |
| GA312 | 27/06/2008 | JB_07_WCA | Water column | -35.12232 | 150.72328 | 0.5 |
| GA312 | 27/06/2008 | JB_07_WCB | Water column | -35.12232 | 150.72328 | 15.8 |
| GA312 | 27/06/2008 | JB_07_PLA | Water column | -35.12232 | 150.72328 | 16.8 |
| GA312 | 27/06/2008 | JB_07_GRA | Grab Van Veen | -35.12232 | 150.72328 | 16.8 |
| GA312 | 27/06/2008 | JB_07_GRB | Grab Shipeck | -35.12232 | 150.72328 | 16.8 |
| GA312 | 27/06/2008 | JB_01_WCA | Water column | -35.11583 | 150.70874 | 0.5 |
| GA312 | 27/06/2008 | JB_01_WCB | Water column | -35.11583 | 150.70874 | 13.5 |
| GA312 | 27/06/2008 | JB_01_GRB | Grab Shipeck | -35.11583 | 150.70874 | 14.5 |