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Southeast Tasmania Temperate Reef Survey Post-Survey Report

June 13–26, 2008 and February 23–March 14, 2009

S.L. Nichol, T.J. Anderson, M. McArthur, N. Barrett, A.D. Heap, P.J.W. Siwabessy, B. Brooke

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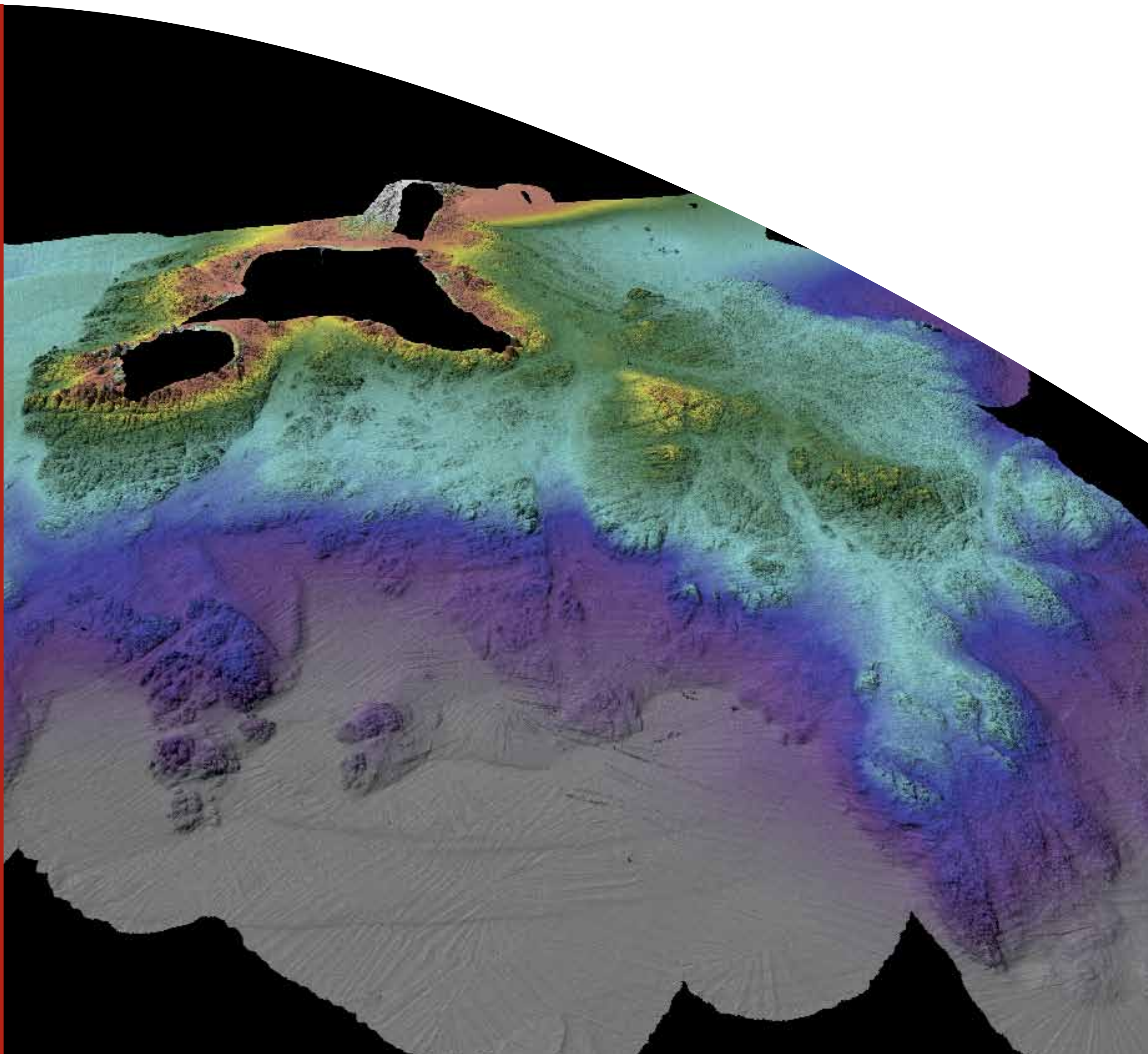

APPLYING GEOSCIENCE TO AUSTRALIA'S MOST IMPORTANT CHALLENGES

GEOSCIENCE AUSTRALIA SURVEY GA0315

Southeast Tasmania Temperate Reef Survey

Post-Survey Report

JUNE 13 – 26, 2008
and
FEBRUARY 23 – MARCH 14, 2009

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by

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Executive Summary

This report provides a description of the CERF Marine Biodiversity Hub survey of southeast Tasmanian temperate reefs, aboard *RV Challenger*, as part of the Hub's Surrogates Program. The survey was undertaken as a collaboration between the Tasmania Aquaculture and Fisheries Institute (TAFI, University of Tasmania) and Geoscience Australia (GA), and was completed in two stages during 2008 and 2009. The purpose of field surveys in the Surrogates Program is to collect high-resolution, accurately co-located physical and biological data to enable the robust testing of a range of physical parameters as surrogates of patterns of benthic biodiversity at relatively fine spatial scales. The objective is to test these relationships in strategically selected areas that are representative of much more extensive benthic environments, and where the bio-physical data collected complement existing data for these areas.

This report describes the methods employed in the mapping and video characterisation of shallow-shelf temperate reef habitats across seven survey sites in southeast Tasmania: Freycinet Peninsula; Maria Island; Tasman Peninsula (Fortescue area); Port Arthur; Huon Estuary/D'Entrecasteaux Channel; The Friars; and Tinderbox (D'Entrecasteaux Channel). Preliminary results are provided of the analysis of multibeam sonar and underwater video data. Examples of the types of biota encountered in the towed video and stills images, and initial interpretations of the benthic communities are also provided. In addition, initial results are presented from the deployment of an Autonomous Underwater Vehicle (AUV) to collect high resolution photographs of reefs and associated biota.

For the seven sites surveyed, the geomorphology of the nearshore and shelf is characterised by a mix of hard and soft seabed features that provide a range of potential habitat types. The most extensive reefs are formed where outcrops of bedrock extend offshore from headlands and nearshore islands, with small areas of reef occurring as isolated patch reefs on the shelf. Away from the reefs, the seabed is typically sediment covered and flat. The morphology of the mapped reefs ranges from high relief reefs, which rise several tens of metres above the surrounding seafloor (e.g. The Hippolyte Rocks), to low relief reefs that are only a few metres high and often partially covered in sediment (e.g. Freycinet Peninsula, outer shelf). In detail, reef morphology displays strong geological control, as shown by the highly fractured dolerite reef surface at The Friars and the stepped morphology of some inshore sandstone reefs along the Tasman Peninsula. Reefs in the more sheltered areas of Port Arthur and the Huon River / D'Entrecasteaux Channel are less extensive than along the open coast, occurring as narrow zones of hard-ground along shorelines and surrounding small islands. Otherwise, the mapping in these areas mostly reveals relict landforms such as incised river channels, drowned terraces and other soft sediment features (e.g. pockmarks).

In this survey, large linear areas of seafloor were video-taped and the video footage used to characterise the benthic habitats evident in five of the seven survey areas. A range of benthic habitats was identified including high-relief bedrock reef at The Hippolyte Rocks, low-lying and partially sediment-covered bedrock in the Freycinet Marine Protected Area (MPA), transitional patch reef adjacent to sandy seabed at the margin of bedrock exposures, and extensive sand flats. A variety of sand wave and rippled habitats was often recorded in and around the reefs themselves. Biological habitats were also diverse with several distributional patterns recorded. The most dominant pattern was a strong depth zonation, with a kelp forest zone (dominated by *Ecklonia radiata*) in water depths < 45 m, which quickly transitioned into a sponge-dominated deep reef zone (reef depths > 45 m). Beyond the reefs, the shelf sediments were often carpeted with screw shells and where present in high densities provided hard substrata for a range of suspension-feeding invertebrates. Although this depth pattern was very consistent between locations, some differences were observed. For example, differences in the level of exposure to wave energy between locations appeared to influence the density and structure of these zones. Kelp morphologies were thinner and longer in more exposed sites (e.g. The Friars), while sponges here were less dense and smaller in size. Screw shells, which occurred extensively on shelf sediments and within the sheltered inlets and channels of the Huon Estuary and Port Arthur, varied in their density between locations. The densest shell beds were recorded north of the Nuggets, while

sparse screw shells were recorded in areas of higher wave energy (e.g. around The Friars) and where the substratum was muddy (e.g. Huon Estuary).

In future work, the morphological characteristics of reefs in the study area will be quantified by a range of metrics, including slope, relief, rugosity and surface curvature. These parameters will be used to test for co-variance with spatial and bathymetric patterns in reef biological assemblages, as defined by the video characterisations. This analysis for co-variance will also consider variations in reef biological communities that may be a function of differences in wave energy regime between the study sites.

The aim of this work is to improve our understanding of the degree of influence of physical characteristics on the spatial distribution of biological communities that exist on temperate reefs. Significantly, this assessment will incorporate a statistical measure of the degree to which derived physical parameters can be used as surrogates to map and model patterns of marine biodiversity. In turn, these outputs can be used to better inform the management of similar shallow marine systems elsewhere in Australia.

1. Introduction

This report provides a description of the activities completed during the CERF Marine Biodiversity Hub survey of the Southeast Tasmanian Shelf, aboard *RV Challenger*, as part of the Hub's Surrogates Program. The survey was undertaken as a collaboration between the Tasmania Aquaculture and Fisheries Institute (TAFI, University of Tasmania) and Geoscience Australia (GA), and was completed in two stages: June 13 – 26, 2008 and; February 23 – March 14, 2009. The purpose of field surveys in the Surrogates Program is to collect high-quality, accurately co-located physical and biological data to enable the robust testing of a range of physical parameters as surrogates of patterns of benthic biodiversity. The objective is to test these relationships in strategically selected, spatially discrete areas that are representative of much broader benthic environments, and where the bio-physical data collected complement existing data for these areas.

This report describes the methods employed in the mapping and video characterisation of shallow-shelf temperate reef habitats of southeast Tasmania. Preliminary results are provided of the analysis of multibeam sonar and underwater video data. Examples of the types of biota encountered in the towed video and stills photography, and initial interpretations of the benthic communities encountered, are also provided. The report also presents preliminary results from high resolution reef photographs collected in the same area by an Autonomous Underwater Vehicle (AUV) that is part of the Integrated Marine Observing System (IMOS) (Appendix A).

In addition to the southeast Tasmania survey, the Surrogates Program has completed field surveys in Jervis Bay (Anderson et al., 2009; Przeslawski et al., 2009), on the Carnarvon shelf (Brooke et al., 2009) and on Lord Howe Island shelf (Linklater, 2009). Results from the Lord Howe shelf survey will also be presented in a Geoscience Australia Record.

1.1. AIMS OF THE TASMANIAN REEF SURVEY

The main aim of the survey was to acquire data to enable a range of physical environmental parameters of nearshore and shelf reefs in southeast Tasmania to be tested as surrogates of patterns of benthic biodiversity. Two datasets were collected: (1) high resolution multibeam bathymetry and seabed acoustic reflectance (backscatter) from previously identified areas of reef and surrounding seafloor, and (2) underwater video footage for representative transects across reefs and surrounds.

1.2. STUDY AREA

The southeast Tasmanian study area is divided into seven survey sites (Fig. 1.1). These sites were chosen as representative examples of shallow-shelf temperate reefs in the region and include areas with pre-existing ecological information plus areas not previously studied. The survey sites include:

- Freycinet Peninsula
- Maria Island
- Tasman Peninsula (Fortescue)
- Port Arthur
- Huon / D'Entrecasteaux Channel
- The Friars
- Tinderbox (D'Entrecasteaux Channel)

All seven sites are described in this report.

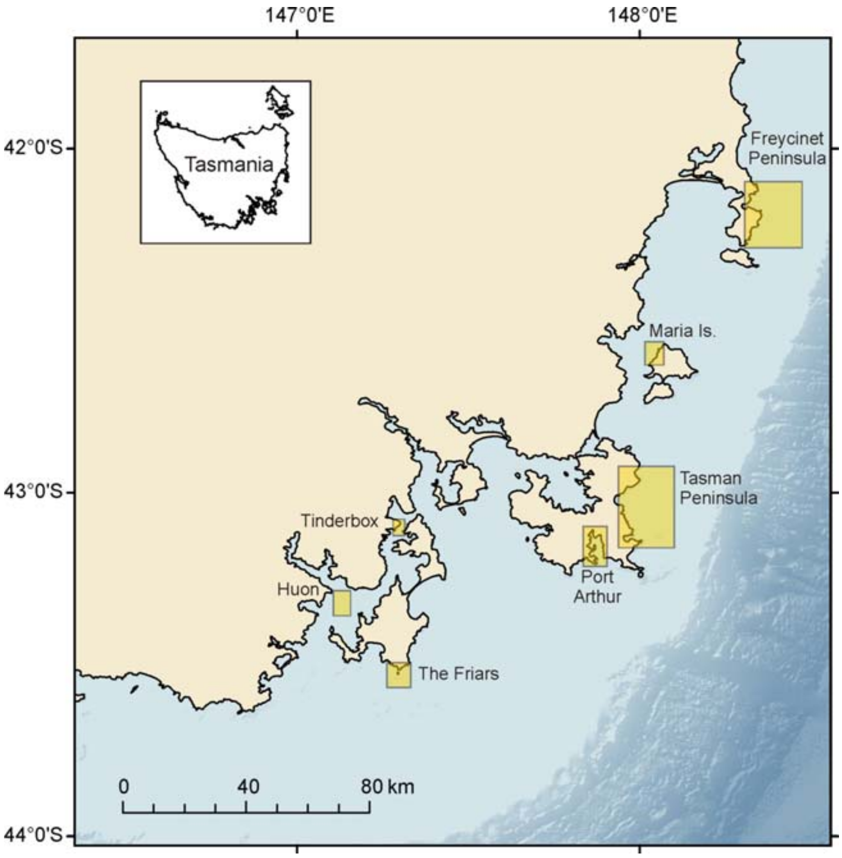


Figure 1.1: Location of study sites along the shelf and coast of southeast Tasmania mapped during June 2008 and February-March 2009.

1.3.SAMPLING STRATEGY AND METHODS OVERVIEW

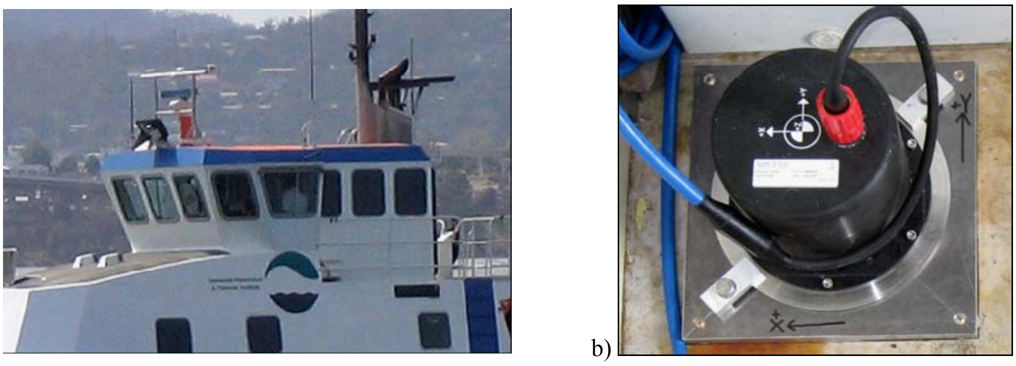
The survey was completed in two stages: Stage 1 was undertaken from 13th to 26th of June, 2008 and involved multibeam mapping of the Tasman Peninsula, Huon/D'Entrecasteaux Channel, Maria Island and Port Arthur sites. Stage 2 occurred from 23rd of February to 14th of March, 2009 and involved additional mapping at the Tasman Peninsula, Huon/D'Entrecasteaux Channel and Port Arthur sites, and new mapping at the Freycinet Peninsula and The Friars sites. Stage 2 of the survey also involved collection of underwater towed video in all mapped areas, with the exception of Maria Island.

Bathymetric mapping
Bathymetric mapping was undertaken using the *RV Challenger* with a *Simrad* EM3002(D) 300 kHz multibeam sonar (MBS) system in single transducer mode. Motion referencing and navigation data were collected using an *Applanix* Position and Orientation system, coupled with a *C-Nav* GPS system (Figs. 1.2 – 1.4). EM3002 data were acquired using Kongsberg's *Seabed Information System* (*SIS*) software. This software provides a high level of real-time information on the helmsman display and supports *Applanix* true heave logging used in post-processing of multibeam data to reduce heave artefacts so that the quality of bathymetric data is optimal. During the survey, vessel speed varied between 5 and 10 knots, with slower speeds for inshore and shallow water areas. Initial processing of the multibeam data to account for tides and vessel motion (pitch, roll and heave) was completed during the survey using *Caris Hips* and *Sips* v6.1 software. Final processing to remove more complex artefacts, such as elevation errors caused by dynamic draft of the vessel, was completed after the survey at Geoscience Australia. Bathymetric images presented in this report are of sun-shaded digital elevation

models produced using *ER Mapper* v7.1 based on grids at a spatial resolution of 3 m for all areas, except Tasman Peninsula which is shown at 4 m grid resolution. In addition, *Fledermaus* v7.0 software was used to generate representative 3D perspective views and profiles across reefs.

a) b)

Figure 1.2: a) The Tasmanian Aquaculture and Fisheries Institute (TAFI) 20 m survey research vessel *Challenger* on slips; b) Simrad EM3002 transducer installed on the hull of the *RV Challenger*.



a) b)

Figure 1.3: a) C-Nav GPS receivers mounted on the wheelhouse of *RV Challenger*; b) The Applanix Position and Orientation system installed on the deck of RV *Challenger* directly above the EM3002 transducer.

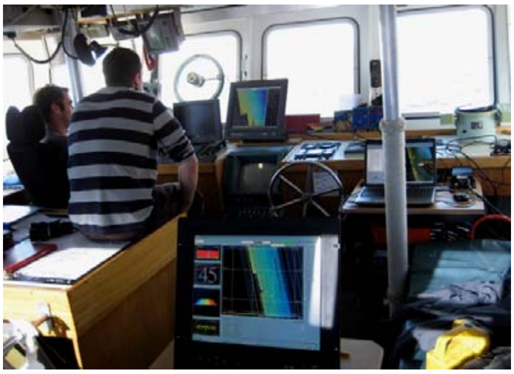


Figure 1.4: Wheelhouse of RV *Challenger* showing the EM3002 operator display (foreground) and the helmsman display on the bridge.

Backscatter processing methods
The Simrad EM300 multibeam backscatter data were processed using CMST-GA MB Process v8.11.02.1, a multibeam backscatter processing toolbox co-developed by Geoscience Australia and Centre for Marine Science and Technology (CMST), Curtin University of Technology (Heap et al., 2009). The fully processed backscatter coefficients were corrected for transmission loss and insonification areas based on the equation given in Talukdar et al. (1995). The incidence angle and coordinates on the seafloor, X-Y and depth (Z) were then calculated. The full process within the toolbox involved the following steps:

1. Conversion from the Simrad raw ALL data format into Matlab data format;
2. Calculation of the absolute X, Y, Z position and the incidence angle θ for each beam and each ping;
3. Removal of the system transmission loss;
4. Removal of the system model;
5. Calculation of the surface backscattering strength, which involves correction for transmission loss and area; and
6. Removal of the angular dependence.

A technique for removing the angular dependence developed by the CMST was applied to the data (cf., Gavrilov et al., 2005). Removing the local mean angular trend also filters out large-scale variations due to change, either sharp or gradual, in the seabed properties along the swath line. To recover this useful information and obtain absolute values of backscatter strength, the angularly equalised backscatter strength within the sampling window is increased by adding the window-mean backscatter level at a specified reference angle (in this case a moderate angle of 25° was used).

Towed-Video Methods
Seafloor observations and real-time characterisation of seabed habitats and associated biota were made from underwater video along representative transects in all survey areas, except for Maria Island. At each station, the Geoscience Australia *RayTech* small towed-video system was deployed from the stern of *RV Challenger* (Fig. 1.5) and towed at 0.5 to 1.5 knots at a height of approximately 2 m above the seabed for a distance sufficient to capture the reef and surrounding habitats; ranging from 200 m to 1.1 km .

Figure 1.5: *RayTech* small towed-video system being deployed from the stern of *RV Challenger.*

To characterise along-shore and off-shore habitat transitions in each survey area, primary transects were allocated perpendicular to the shoreline and secondary transects (e.g. Fortescue region) were run parallel to shore, intersecting primary transects. Primary transects traversed the greatest depth gradient, and were initiated as close to shore or islands as was safely navigable (approximate 20-30 m water depth on the RV *Challenger*), and extended out beyond the deepest reefs to characterise both the reef-sediment interface and the adjacent shelf habitat. In areas of deep reefs, transects were run across and beyond each reef (e.g. Roxys Reef).

Seabed habitats and biota were characterised in real-time using C-BED (Characterisation of the Benthos and Ecological Diversity) the 3-tiered characterisation scheme of Anderson et al. (2008) that records substratum composition, bedform-relief, and presence of macro- biota. C-BED characterisations were recorded in real-time at 30 second intervals along each transect, or more frequently across transition zones. At each 30-second location, the seabed was evaluated for a period of 15-seconds (i.e. 5 seconds prior to and 10 seconds following the GPS fix) to characterise the seabed. Substrata composition (i.e. rock, boulders (>25.5cm), cobbles (6.5-25.5 cm), gravel, sand and mud) was categorised by primary (>50% cover) and secondary (>20% cover) percent-cover following the protocol of Stein et al. (1992) and Yoklavich et al. (2000). For example, if the seabed was comprised of >50% mud and >20% rock the substratum composition was classified as 'mud-rock'; alternatively >70% mud was classified as 'mud-mud'. This enabled substrata to be subsequently coded as 0%, 20%, 50%, or 70% cover (Anderson and Yoklavich, 2007). 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) (for more detail see Anderson et al., 2007). Biota composition was recorded in two ways. First, percentage cover (<25%, 26-50%, 51-75%, >75%) was recorded for the significant habitat-forming organisms, such as Kelp, *Ecklonia radiata*, sponges, and the invasive NZ screw shell, *Maoricolpus rosea*. Second, the presence of all benthic macro-organisms were recorded, identified to species (e.g. the kelp, *Phyllospora comosa*, and stripey trumpeter, *Latris lineata*), class (e.g. starfish, brittlestar, and featherstars), growth form (e.g. massive sponges, encrusting sponges, and digitate sponge), or broad ecological categories (fish, invertebrates, and algae).

C-BED characterisations were entered into 'GNav Real-time GIS Tracker' software (© Gerry Hatcher, 2002) using a 142 key Cherry programmable keyboard (© Cherry, 2008), which took between 3-12 seconds, and required a two-person team (i.e. observer and data-enterer; Fig. 1.6). The precise location of the towed-video system was tracked using a USBL (Ultra-short Baseline) acoustic tracking system so that the position of video footage could be accurately correlated with physical features identified in the multibeam bathymetry. USBL navigation (UTC date, time, latitude, and longitude) was captured for each data-entry and logged continuously (1-2 second fixes) to provide navigational tracks for all video transects, with a visual date/time stamp recorded onto the video image. All video footage was recorded to digital tape and copied to portable hard drives. At the time of report writing, no video has been post-processed.

Figure 1.6: Real-time video display of underwater towed video (left), GPS navigation display and keyboard used for habitat characterisations of reef and surrounding areas.

1.4. TIMETABLE AND PERSONNEL

The timing and personnel involved in the survey are listed in Table 1.1. Appendix C includes a daily log of activities for both stages of the survey.

Table 1.1: Science crew and their roles on *RV Challenger* for the CERF southeast Tasmania survey.

Staff & Organisation	Role & Time on Survey
June 2008 Survey: 13/6/08 to 26/6/08	
Matthew McArthur, GA	Ecologist (18/6 – 23/6)
Cameron Buchanan, GA	Multibeam sonar operator (entire leg)
Ian Atkinson, GA	Multibeam/electronics (13/6 – 15/6)
Neville Barrett, TAFI	Ecologist (22/6 – 24/6)
Hugh Pederson, TAFI	Ecologist (15/6 – 18/6)
Vanessa Lucieer, TAFI	GIS Spatial analyst (19/6)
Feb-March 2009 Survey: Leg 1 23/2/09 to 4/3/09	
Andrew Heap, GA	Cruise Leader/Geomorphologist (entire leg)
Tara Anderson, GA	Ecologist/video acquisition (25/2 – 27/2)
Matthew McArthur, GA	Ecologist/video acquisition (25/2 – 4/3)
Cameron Buchanan, GA	Multibeam sonar operator (entire leg)
Michele Spinnocia, GA	Multibeam sonar operator (23/2 – 25/2)
Ian Atkinson, GA	Multibeam/electronics (entire leg)
Neville Barrett, TAFI	Ecologist/video acquisition (23/2 – 26/2)
Nicole Hill, TAFI	Ecologist/video acquisition (27/2 – 4/3)
Justin Hulls, TAFI	Video acquisition/ecology (26/2 – 4/3)
Feb-March 2009 Survey: Leg 2 4/3/09 to 14/3/09	
Scott Nichol, GA	Cruise Leader/Geomorphologist (entire leg)
Matthew McArthur, GA	Ecologist/video acquisition (entire leg)
Cameron Buchanan, GA	Multibeam sonar operator (entire leg)
Ian Atkinson, GA	Multibeam/electronics (entire leg)
Nicole Hill, TAFI	Ecologist/video acquisition (4/3 – 6/3)
Jan Seiler, TAFI	Ecologist/video acquisition (9/3 – 13/3)
Justin Hulls, TAFI	Video acquisition/ecology (entire leg)

2. Morphology of Temperate Reefs and Adjacent Seabed

2.1 INTRODUCTION

The total mapped area covers 308 km^2 with water depths ranging from 3–115 m. The total area of reef mapped is 61.3 km^2, divided between 13 reef systems in the seven survey sites (Table 2.1). For all areas, reefs are well defined bathymetric features of exposed bedrock with sharp boundaries separating adjacent areas of flat seabed. In some cases the deeper part of the reef has a thin sediment cover leaving only the taller rock outcrops exposed. Broadly, reefs are classified into two types: inshore reefs located directly seaward of headlands and sections of rocky shoreline, and offshore reefs located on the mid-shelf as isolated features and, in some cases, surrounding islands. The following sections provide a description of reef form and structure, as interpreted from digital elevation models of the bathymetry in each survey site, from north to south. Prominent geomorphic characteristics are also noted.

Table 2.1: Multibeam mapping coverage, including reef areas, along the southeast Tasmanian coast.

Survey site	Area mapped (km^2)	Reef area mapped (km^2)	Reef water depth (m) Min.	Max.
Freycinet Peninsula	83			
Inshore reefs		1.43	15	70
Outer reefs		17.27	90	115
Maria Island	2.9	0.34	8	17
Tasman Peninsula	117			
Pirates Bay		2.67	10	57
Waterfall Bay		3.23	10	70
The Hippolyte Rocks		2.13	10	98
Other Inshore Reefs		6.40	10	85
Port Arthur	17.2	2.80	3	65
The Friars				
North	33.7	17.81	9	75
South	7.6	6.88	45	75
Huon River	39	0.36	5	20
Tinderbox	7.6	0.07	5	20
TOTAL	**308**	**61.31**		

2.2 FREYCINET PENINSULA

Mapping at the Freycinet Peninsula survey site focused on the eastern side of the peninsula and included sections of inshore reef in the northern part of Thouin Bay, seaward of The Nuggets islands, and extended across the shelf to two areas of offshore reef (Fig. 2.1 & 2.2). The mapped area of reefs in Thouin Bay covers 0.3 km^2, divided between two reefs that extend 400–500 m from rocky headlands and associated with high backscatter intensity peaking around -16 dB. Water depths on these reefs increase from 20–40 m across a rock surface with maximum local relief of 6 m (Fig. 2.3). At The Nuggets, the main reef covers 0.9 km^2 and extends up to 800 m offshore to a water depth of 70 m. A small (0.2 km^2) isolated patch reef is located about 1 km further offshore from The Nuggets, in 70–75 m water depth, is characterised by high backscatter intensity with an average of -16 dB and is encircled by seabed with slightly lower backscatter intensity, with an average of -21 dB (Fig. 2.4). Both reefs at The Nuggets have an irregular surface, with relief on the larger reef up to 15 m and an overall height of 30 m. The patch reef is 25 m high with local relief of up to 10 m (Fig. 2.3). The irregular surface is also clearly identified in the backscatter imagery (Fig. 2.4).

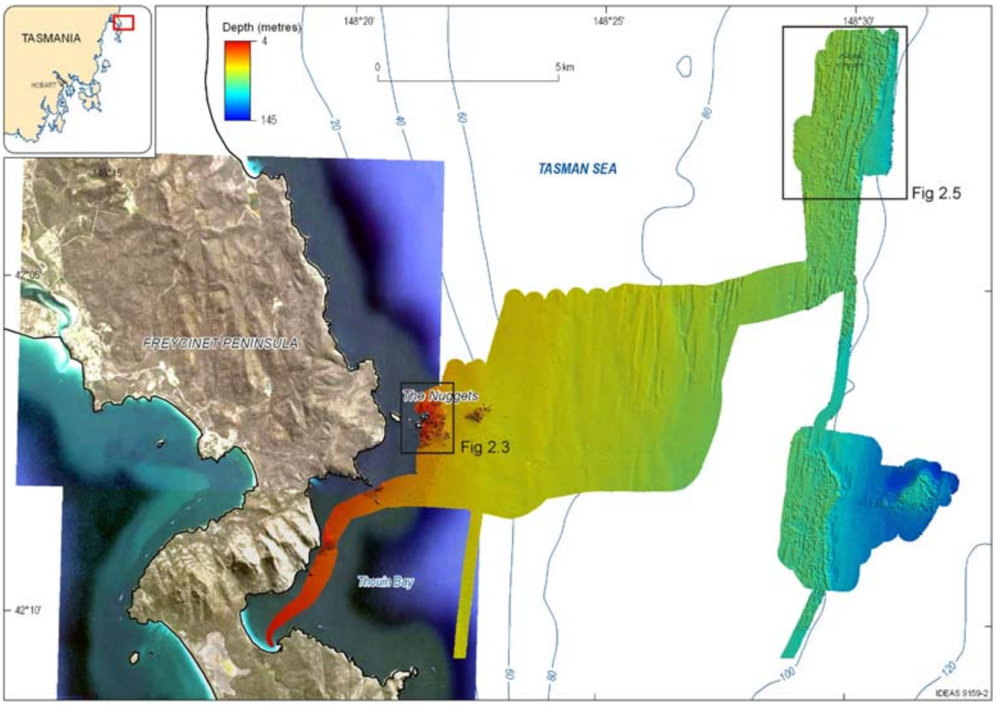


Figure 2.1: Multibeam sonar bathymetry map of reefs and adjacent areas offshore from Freycinet Peninsula.

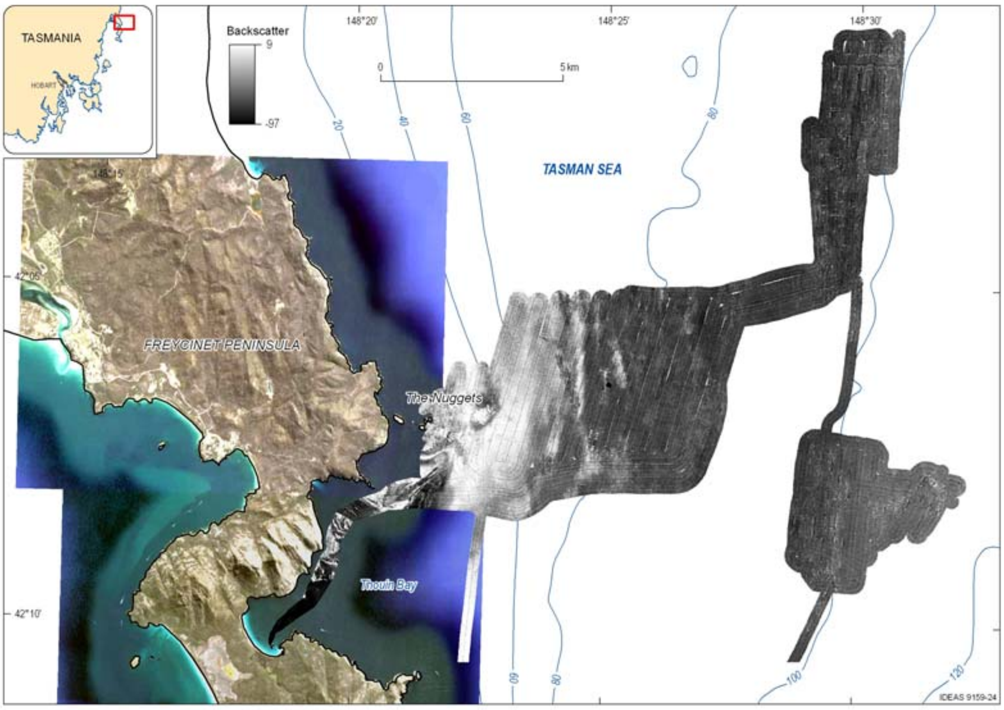


Figure 2.2: Multibeam backscatter imagery of reefs and adjacent areas offshore from Freycinet Peninsula.

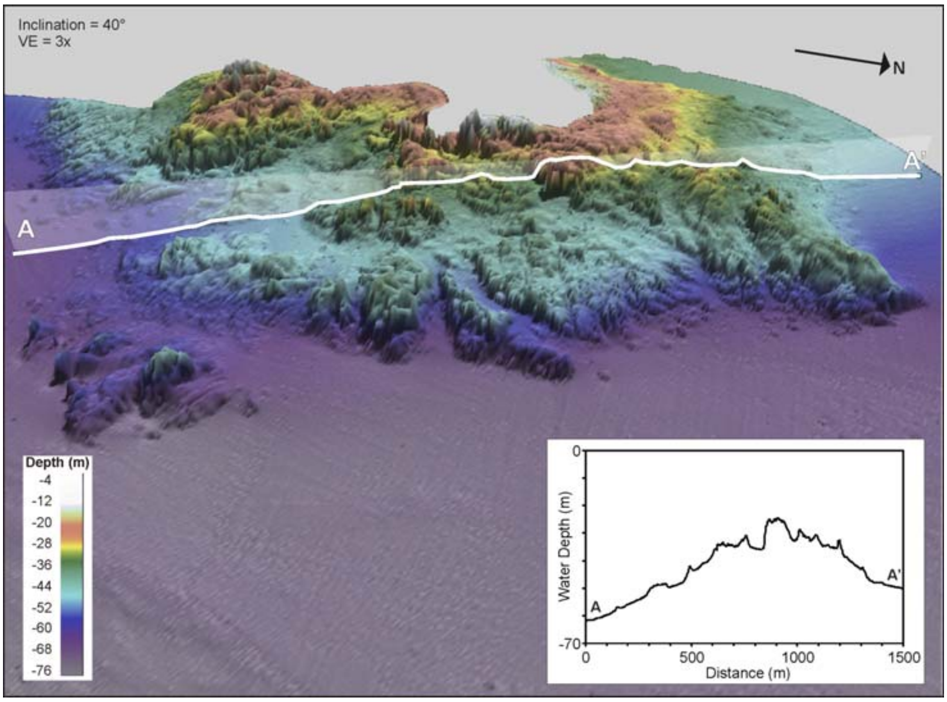


Figure 2.3: Perspective view and representative profile (inset) of inshore reefs located seaward of The Nuggets islands, Freycinet Peninsula. Location of reef shown in Fig. 2.1.

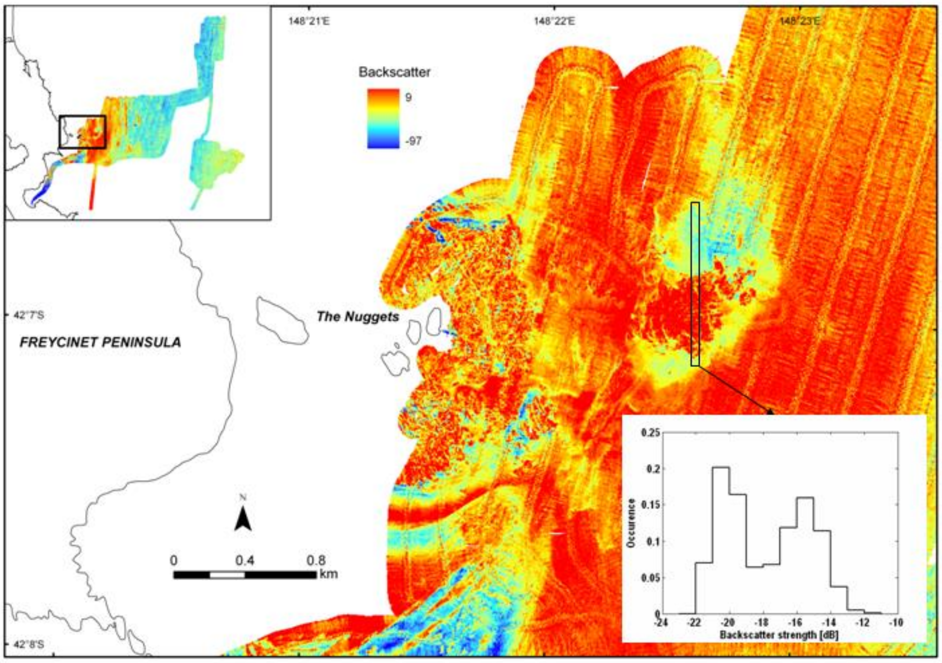


Figure 2. 4: Backscatter map and histogram (inset) of inshore reefs seaward of The Nuggets islands, Freycinet Peninsula.

The offshore reefs at the Freycinet survey site are located approximately 12 km east and northeast of Freycinet Peninsula in water depths of 95–104 m. The two areas mapped include 17 km^2 of low relief reef that rises 4–6 m above the adjacent seabed along its outer edge and is characterised by a series of semi-continuous parallel ridges that are aligned north-south and are 2–4 m high, 50–100 m wide and up to 3 km long (Fig. 2.5). This feature however is not so obvious in the backscatter imagery. Areas between the ridges are relatively flat and sediment covered. The sediment cover on this reef decreases the backscatter intensity by 3–4 dB so that it has a different backscatter profile to the inshore reef. Ridges of similar height are also mapped across the mid shelf in 80–90 m water depth. However, these ridges are 200–500 m wide and blanketed by sediment. The rest of the mapped area of the shelf in the Freycinet area is relatively featureless with an average seaward gradient of 0.1–0.2°. The backscatter imagery clearly divides the mid shelf into inshore areas with high backscatter intensity and offshore areas with lower backscatter intensity. It also clearly draws sharp boundaries between presumably different seabed habitat types in a narrow strip east of Thouin Bay.

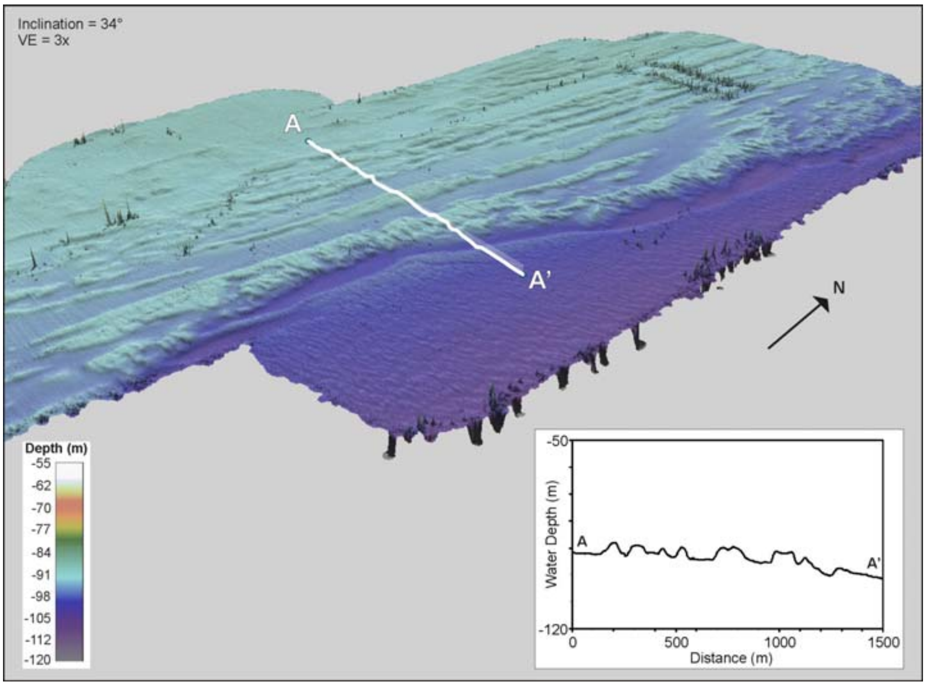


Figure 2.5: Perspective view and representative profile (inset) of low relief reefs located on the mid to outer shelf offshore from Freycinet Peninsula. Location of reef shown in Fig 2.1

2.3 MARIA ISLAND

The mapped area is located adjacent to the northwest shore of Maria Island (inside the park boundary) and covers a 2.9 km^2 strip that is 7.5 km long and 300–700 m wide (Fig. 2.6 & 2.7). Three patches of reef were mapped, covering a total area of 0.34 km^2. These reefs occur in water depths of 8–17 m and rise 1–3 m above the surrounding seabed. They have a discontinuous sediment cover and local relief is less than 1 m. The backscatter intensity for these three reef patches is typically high, with an average of -17 dB. No evidence of irregular surfaces is observed within individual reef patches in the backscatter imagery. To the south of these reefs, the seabed in 24 m water depth is flat and incorporates two partially mapped channels that are 3–4 m deep. Apart from patches of irregular intensity, the channels are not clearly observable in the backscatter imagery. In areas other than the channels, the backscatter imagery seems quite homogeneous and featureless which is consistent with the flat seabed in this area.

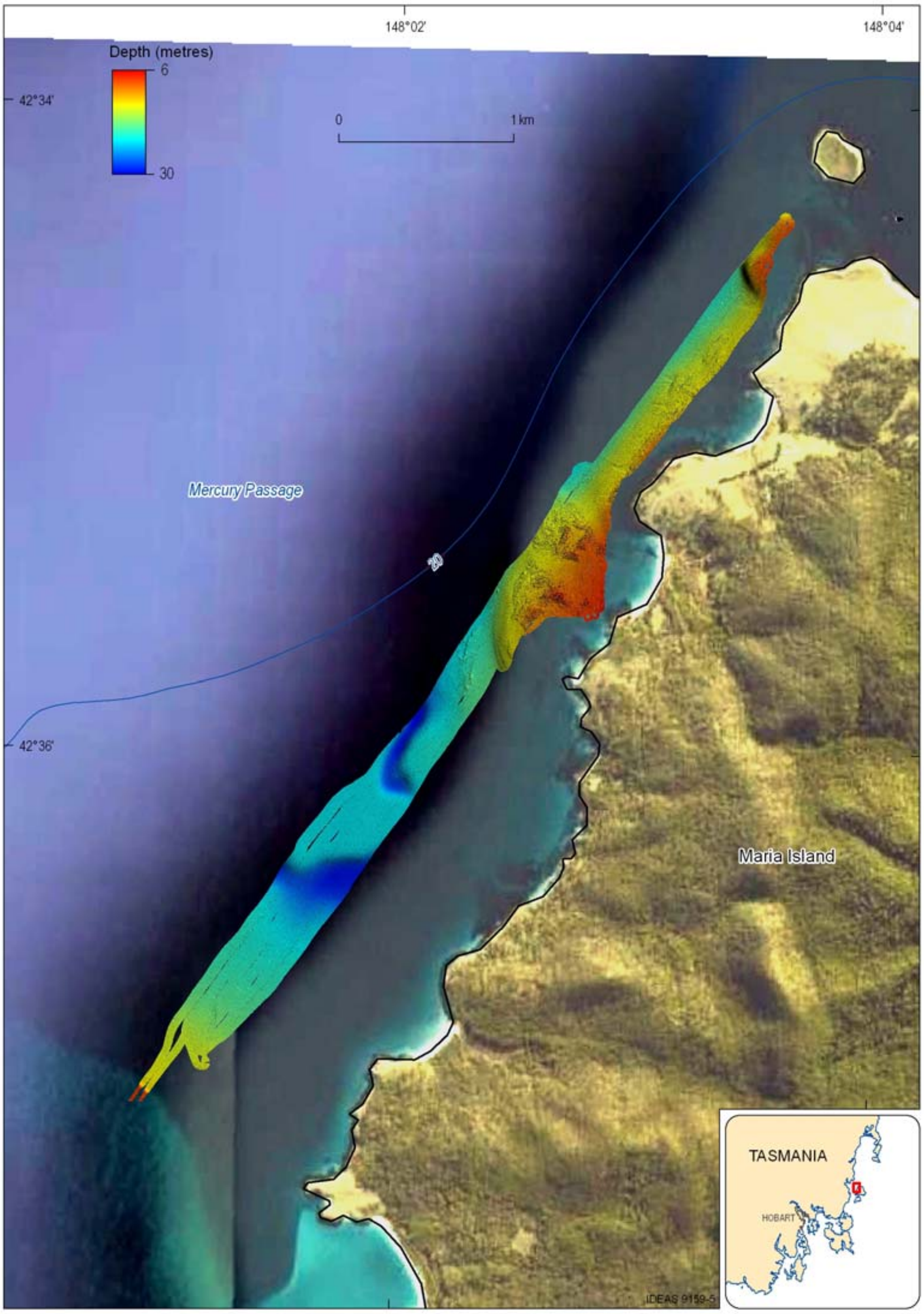


Figure 2.6: Multibeam sonar bathymetry map of reefs and adjacent areas along the western side of Maria Island.

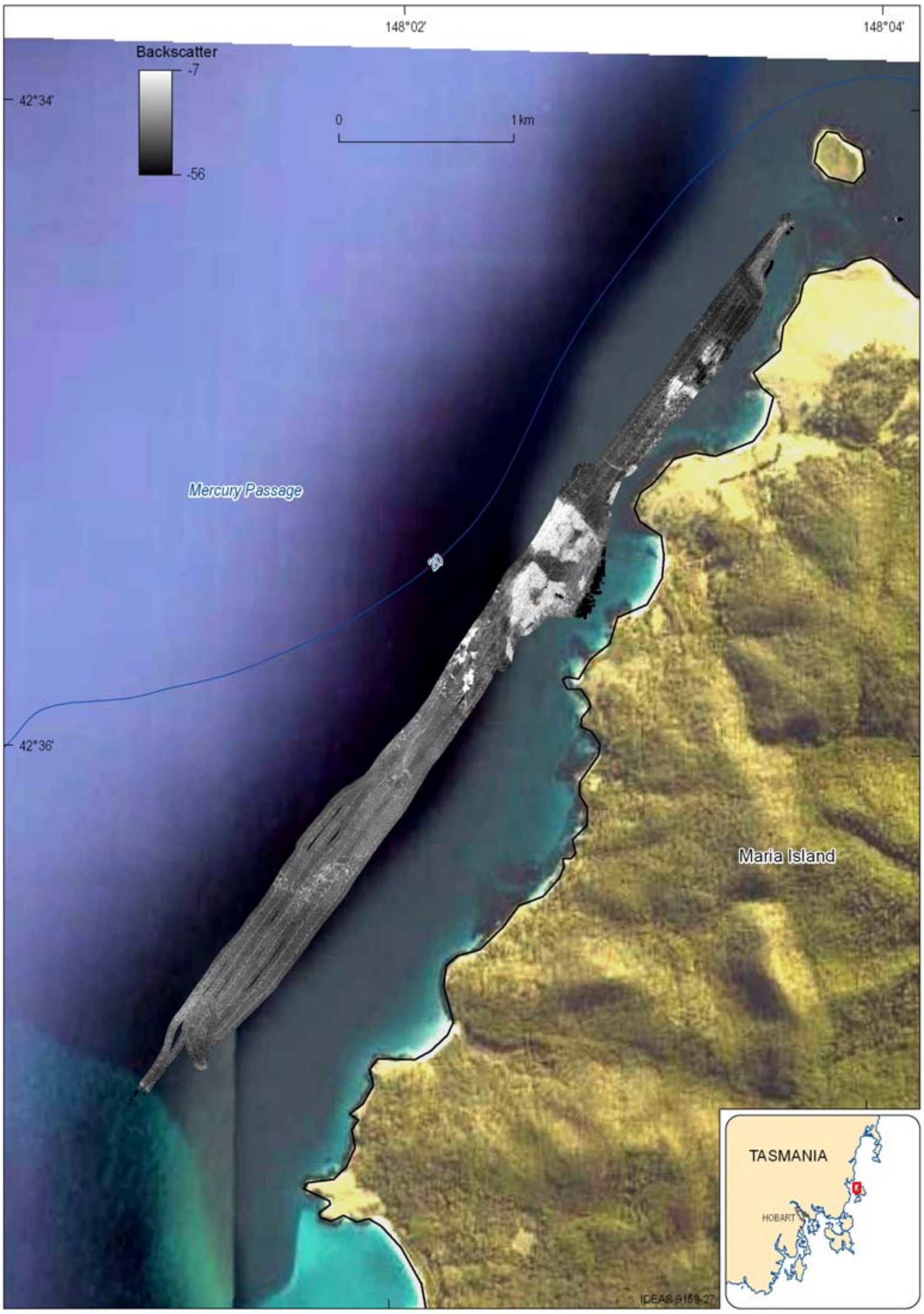


Figure 2. 7: Multibeam backscatter imagery of reefs and adjacent areas along the western side of Maria Island.

2.4 TASMAN PENINSULA

The mapped area at the Tasman Peninsula site covers 117 km^2, incorporating 14.4 km^2 of reefs in Pirates Bay, Waterfall Bay, Fortescue Bay, offshore from High Yellow Bluff, Deep Glen Bluff, O'Hara Bluff and Cape Hauy, and The Hippolyte Rocks (Fig. 2.8 & 2.9). In addition, a small patch reef on the mid shelf was mapped north of The Hippolyte Rocks. This site is characterised by high backscatter intensity in both inshore and offshore reef patches, and relatively lower backscatter intensity elsewhere. The morphology of reefs in this area ranges from relatively subdued surfaces formed on sandstone to irregular dolerite and granite reefs. Low relief sandstone reefs are stepped in cross-section and have an average slope of 2–3 degrees with flat areas that are partly sediment covered. Examples of low relief sandstone reef are the inshore reefs at High Yellow Bluff, Pirates Bay and Cape Hauy where local relief is <1 m. Reefs with irregular relief are characterised by a blocky structure with individual dolerite and granite blocks 10–30 m high, some forming isolated mounds and ridges. Examples are mapped offshore from O'Hara Bluff, Deep Glen Bluff and The Hippolyte Rocks. At these localities, the transition between reef and adjacent sediment covered seabed is abrupt and often marked by a steep rocky slope.

The largest area of continuous reef at the Tasman Peninsula site surrounds The Hippolyte Rocks, covering 2.13 km^2 in water depths that range from 10 to 90 m (Fig. 2.10). The reef is an outcop of Devonian Granite (373.8 ± 2.6 Ma; Black et al., 2005) and comprises three bathymetric highs that rise 20–30 m above the deeper parts of the reef, which in places is draped in sediment (e.g., below 60 m water depth). The high points of The Hippolyte Rocks reef have a distinct blocky structure with near-vertical faces. Toward its outer edge, the reef gradient reduces to 5–7^{o} and local relief is mostly less than 2 m. As with other reefs in the area, the boundary with adjacent sandy seabed is well defined. The irregular surface of reefs surrounding The Hippolyte Rocks is also evident in backscatter data (Fig. 2.11). The mean backscatter intensity is approximately -16 dB, which is typical for all reefs in this survey site. Clear boundaries between different seabed surfaces are evident and well defined in the backscatter imagery (Fig. 2.11). All other reefs in the area seem to have this similar character of well defined boundaries.

The remaining part of the Tasman Peninsula survey site extends 6 km offshore to 85 m water depth and is characterised by a featureless shelf with a smooth concave profile on an average gradient of 0.5^{o}. Backscatter intensity across the mapped area is low to moderate. The isolated patch reef mapped in this area is at 80 m water depth, covering 0.17 km^2 and rising 20 m above the surrounding seabed and characterised by moderate to high backscatter intensity (Fig. 2.11).

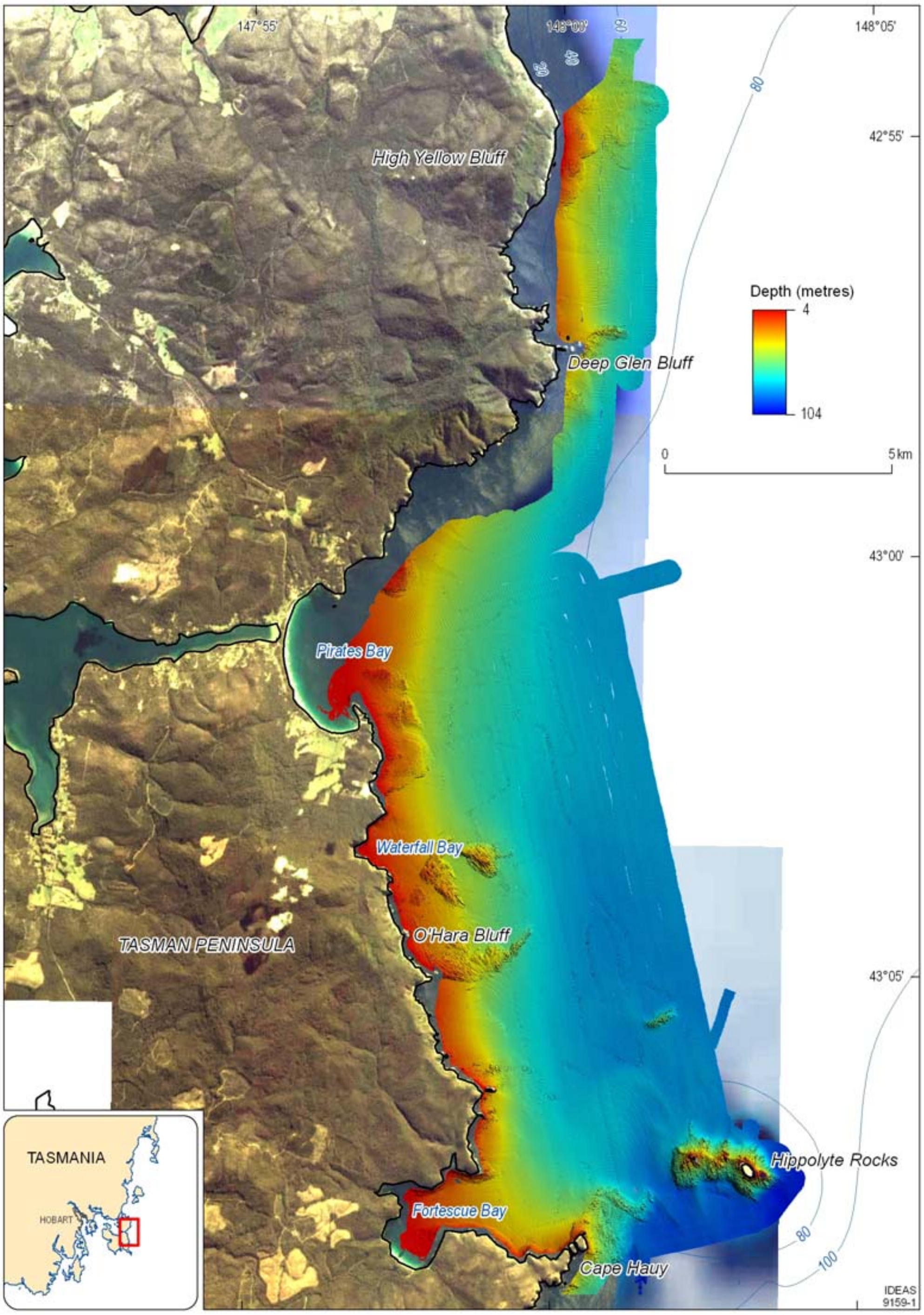


Figure 2.8: Multibeam sonar bathymetry map of reefs and adjacent areas offshore from Tasman Peninsula.

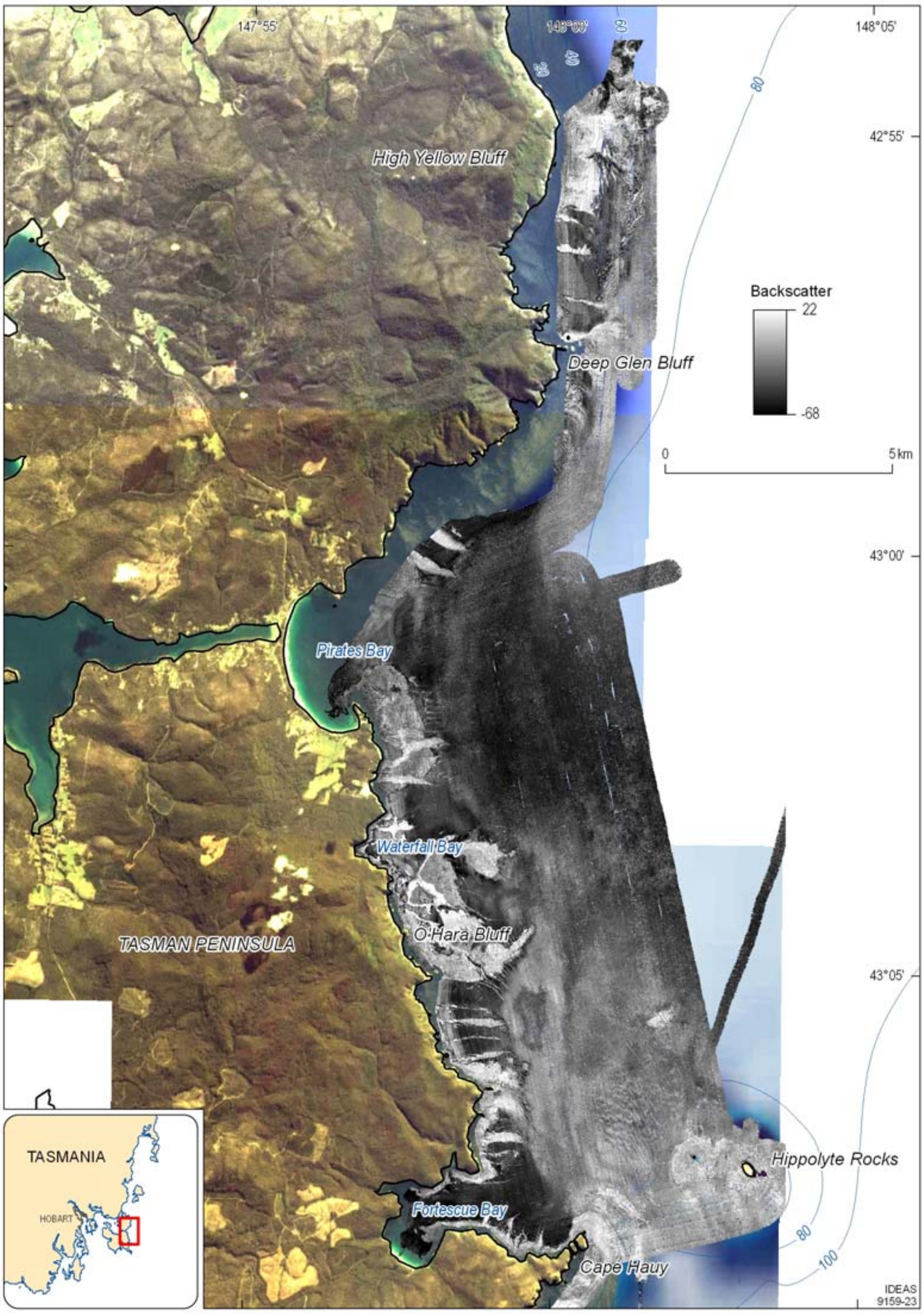


Figure 2.9: Multibeam backscatter imagery of reefs and adjacent areas offshore from Tasman Peninsula.

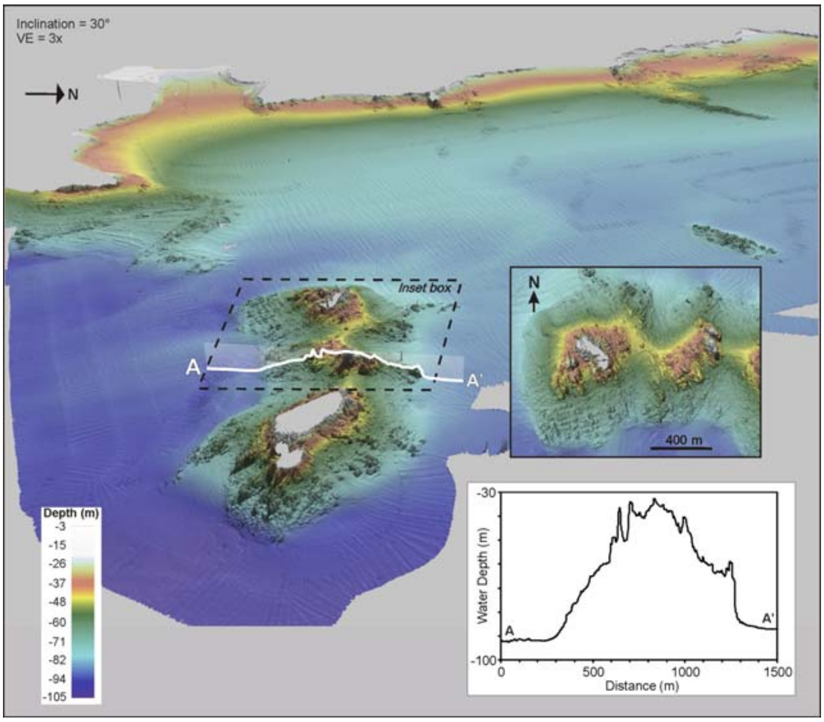


Figure 2.10: Perspective view and representative profile (inset) of reefs surrounding The Hippolyte Rocks located offshore from Tasman Peninsula.

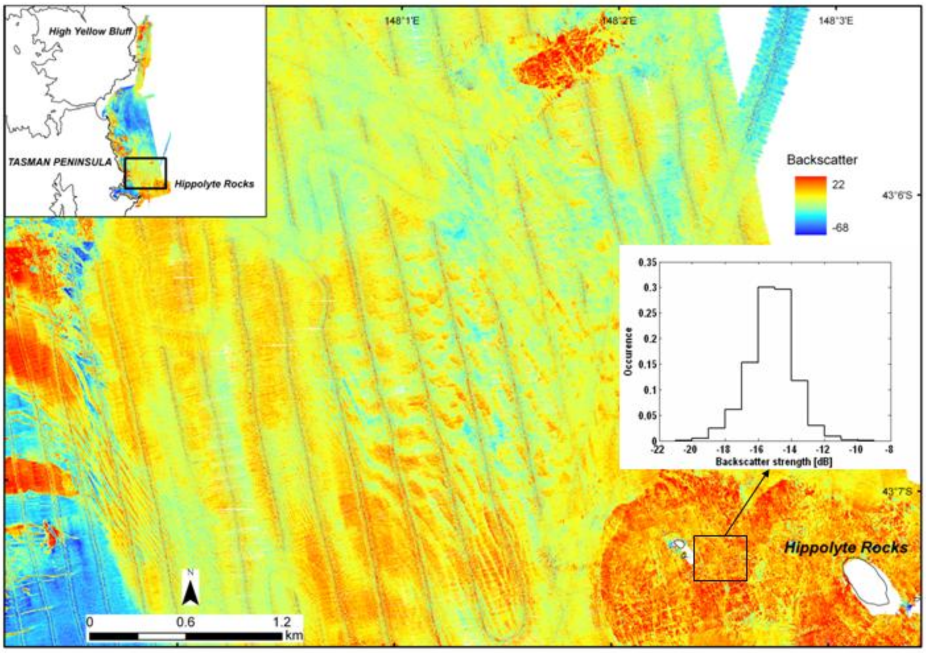


Figure 2. 11: Backscatter map and representative histogram (inset) of reefs surrounding The Hippolyte Rocks. Note backscatter contrasts across a field of bedforms (sand waves) west of The Hipploy te Rocks.

2.5 PORT ARTHUR

The Port Arthur site covers an area of 17.2 km^2 that includes the 6.7 km length of the main basin and extends to a section of inshore reef located to the southwest of Port Arthur (Fig. 2.12 & 2.13). The bathymetry of Port Arthur is characterised by a north-south oriented channel along the valley axis that deepens seaward from 30 m to 50 m but terminates gradually about 1.8 km landward of the valley mouth. The backscatter intensity is lowest within the channel, except for localised areas of higher backscatter associated with bathymetric highs. The channel is flanked by terraces that sit in water depths of 18–20 m and slope gently to the channel on a gradient of $<1^o$. In the upper reaches of the mapped area the terraces are irregular in outline and in places form isolated mounds up to 14 m high. Seaward of the channel, the seabed in outer Port Arthur is relatively flat with an average water depth of 30 m.

Areas of mapped reef in Port Arthur are located along the eastern and western shorelines, with the largest covering 0.5 km^2 along a 3 km section of the western shore. In addition, a small (0.09 km^2) isolated patch reef was mapped just inside the entrance to Port Arthur in 28-30 m water depth. All these mapped reef areas produce strong acoustic returns (average -16 dB) including the isolated patch reef (Fig. 2.14). At its widest, the reef along the western shore extends 450 m and forms a stepped rocky surface to a maximum water depth of 30 m. Local relief across the reef is 1–3 m. In contrast, the patch reef has a highly irregular surface with relief of up to 5 m. This is also identified in the backscatter imagery (Fig. 2.14). The contrast of backscatter intensity between this isolated patch reef and adjacent, surrounding seabed surface of different kind is very well defined.

The area of mapped reef outside Port Arthur covers 1.7 km^2 and extends approximately 1 km from the shoreline (below Mount Brown) to a maximum water depth of 65 m (Fig. 2.15). The reef in this area is characterised by an irregular rock surface with discontinuous sediment cover, becoming more continuous across the outer part of the reef below about 55 m water depth. Local relief is generally less than 1 m, but increases to 10–15 m across isolated rock mounds that form submarine extensions to small headlands.

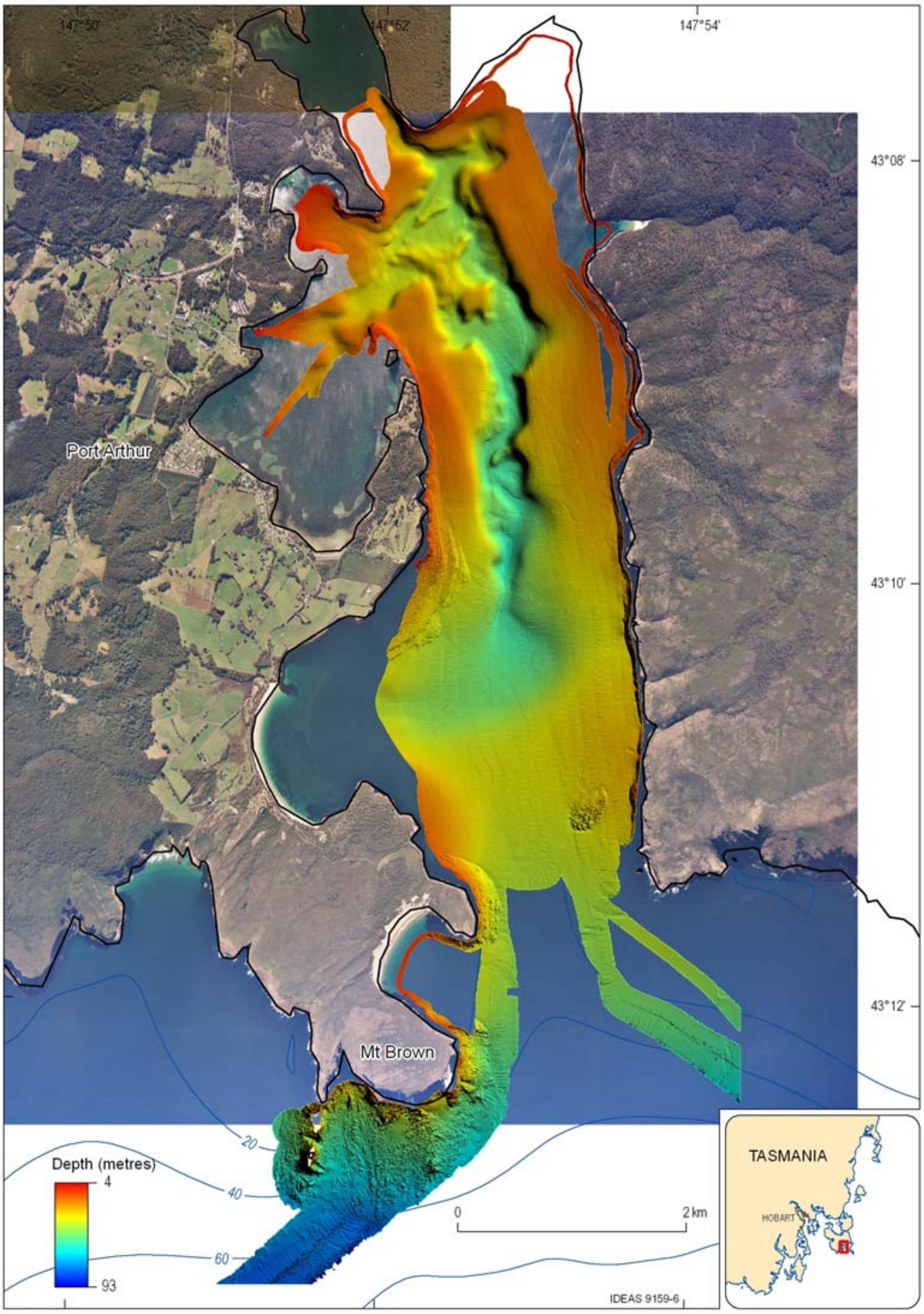


Figure 2.12: Multibeam sonar bathymetry map of reefs and seabed within Port Arthur, extending to reef located to the southwest below Mt Brown.

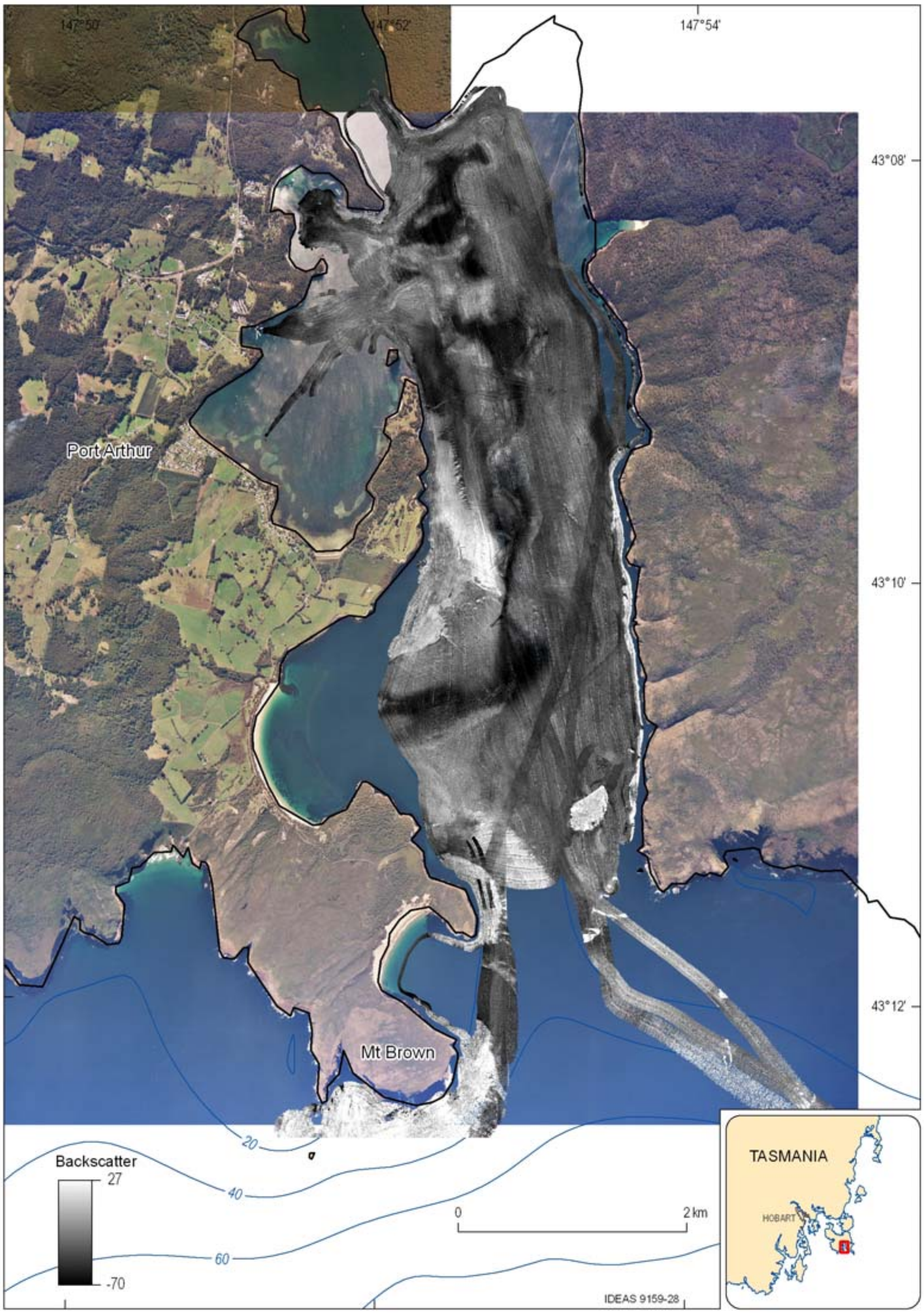


Figure 2.13 : Multibeam backscatter imagery of reefs and seabed within Port Arthur, extending to reef located to the southwest below Mt Brown.

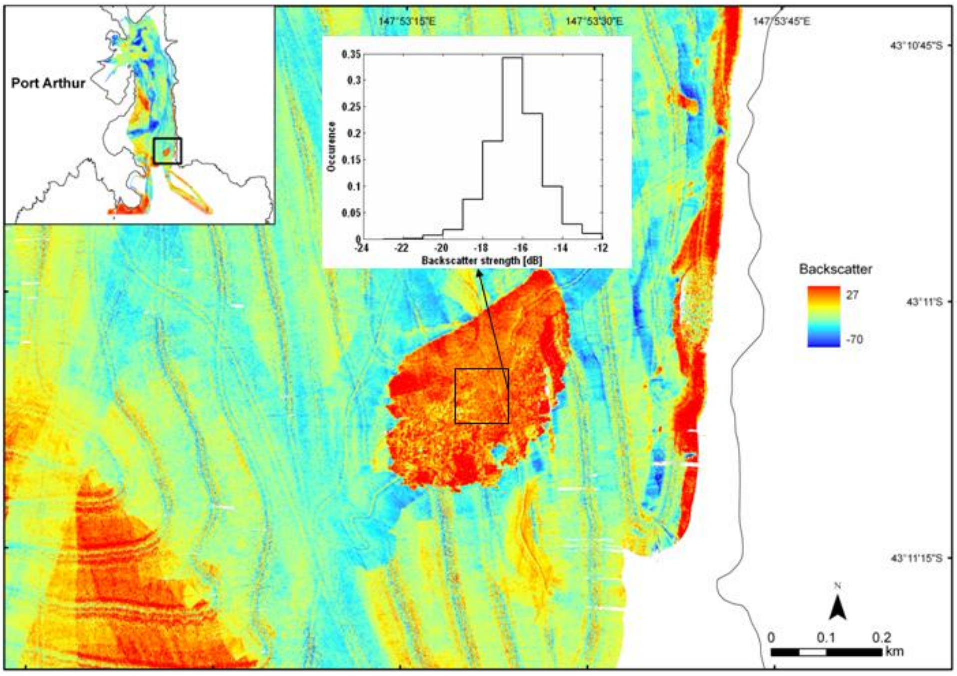


Figure 2.14: Backscatter map and representative histogram (inset) of isolated patch reef and surrounding seabed inside the eastern entrance to Port Arthur.

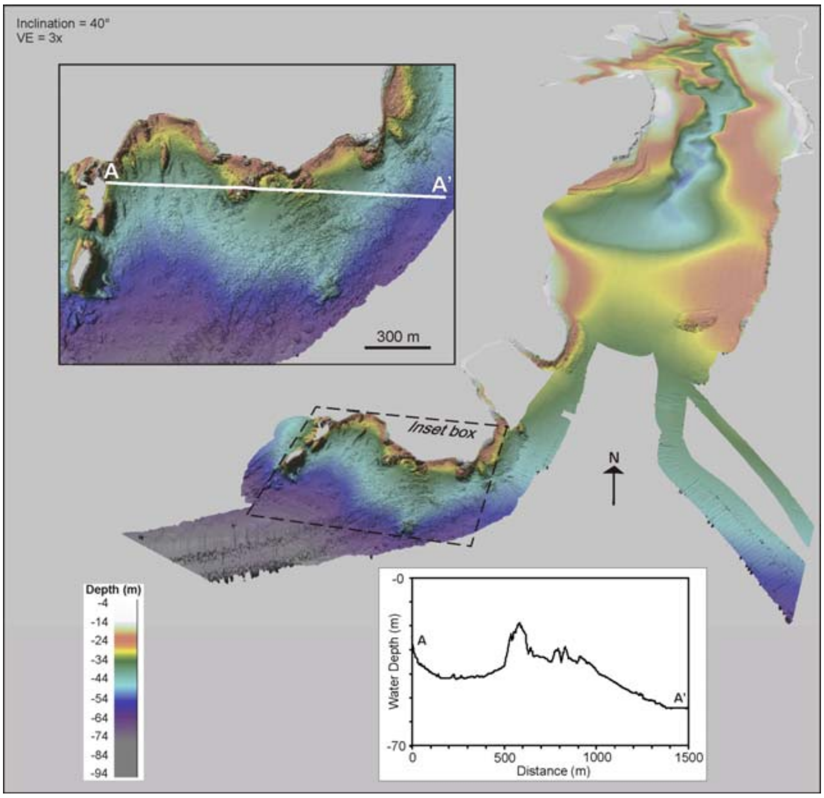


Figure 2.15: Perspective view of the bathymetry in Port Arthur with insets showing an enlarged map and representative profile across nearshore reef to the southwest of Port Arthur.

2.6 THE FRIARS

The Friars are a group of islets and rock outcrops located about 1 km south of the southern tip of Bruny Island (Fig. 2.16 & 2.17). The islets are formed from dolerite characterised by columnar jointing structure and numerous fractures. Mapping at The Friars survey site was divided into northern and southern sub-areas. The northern area covers 34 km^2 and includes 18 km^2 of semi-continuous reef that extends up to 4 km from The Friars. Water depths across the reef range from 9 to 75 m, with a sharply defined boundary to adjacent areas of flat sandy seabed. In profile, the reef slopes outward from The Friars with a gradient of ~3–5^o but is highly dissected by a network of linear fractures that are up to 5 m deep and 50 m wide (Fig. 2.18). The reef surface is also highly irregular along the western side of The Friars where mounds up to 16 m high occur. The outer part of the reef has a more subdued topography with broad areas of near-horizontal reef, but also with linear fractures up to 2 m deep. In plan view, the outline of the reef is highly irregular, particularly along the southern and western edges where a series of sandy re-entrants separate reef promontories.

The southern Friars survey area is located 3.5 km to the southwest of the edge of the northern Friars area in water depths of 45–75 m (Fig. 2.16). The mapped area covers 7.6 km^2, of which 6.9 km^2 is reef. The reef morphology is similar to the outer part of reef in the northern survey area at The Friars, with a near-horizontal but highly dissected surface and a highly irregular outline. Local relief associated with linear fractures is up to 12 m, although relief of about 5 m is more common.

A notable characteristic of The Friars area is well defined acoustic boundaries between different seabed surfaces (Fig. 2.19). An example in the northeast divides the area into an area of low backscatter intensity (-25 dB) and an area of high backscatter intensity (-15 dB). The other prevailing feature of the Friars survey area is high backscatter intensity overall, with typical values of -16 dB. In the northwest of the mapped area a well defined boundary in backscatter intensity occurs over a relatively flat seabed surface (Fig.2.17). The backscatter intensity on this particular surface is 4 dB higher than the average of the adjacent seabed. There are some other areas that have backscatter intensity 4 dB higher than adjacent areas. These highest backscatter intensities are associated with reefs that have relatively regular, flat surfaces in contrast to the more common irregular surfaces. In the middle south of the northern Friars survey area, the backscatter imagery is quite unique as it reveals step features with well defined boundaries between steps.

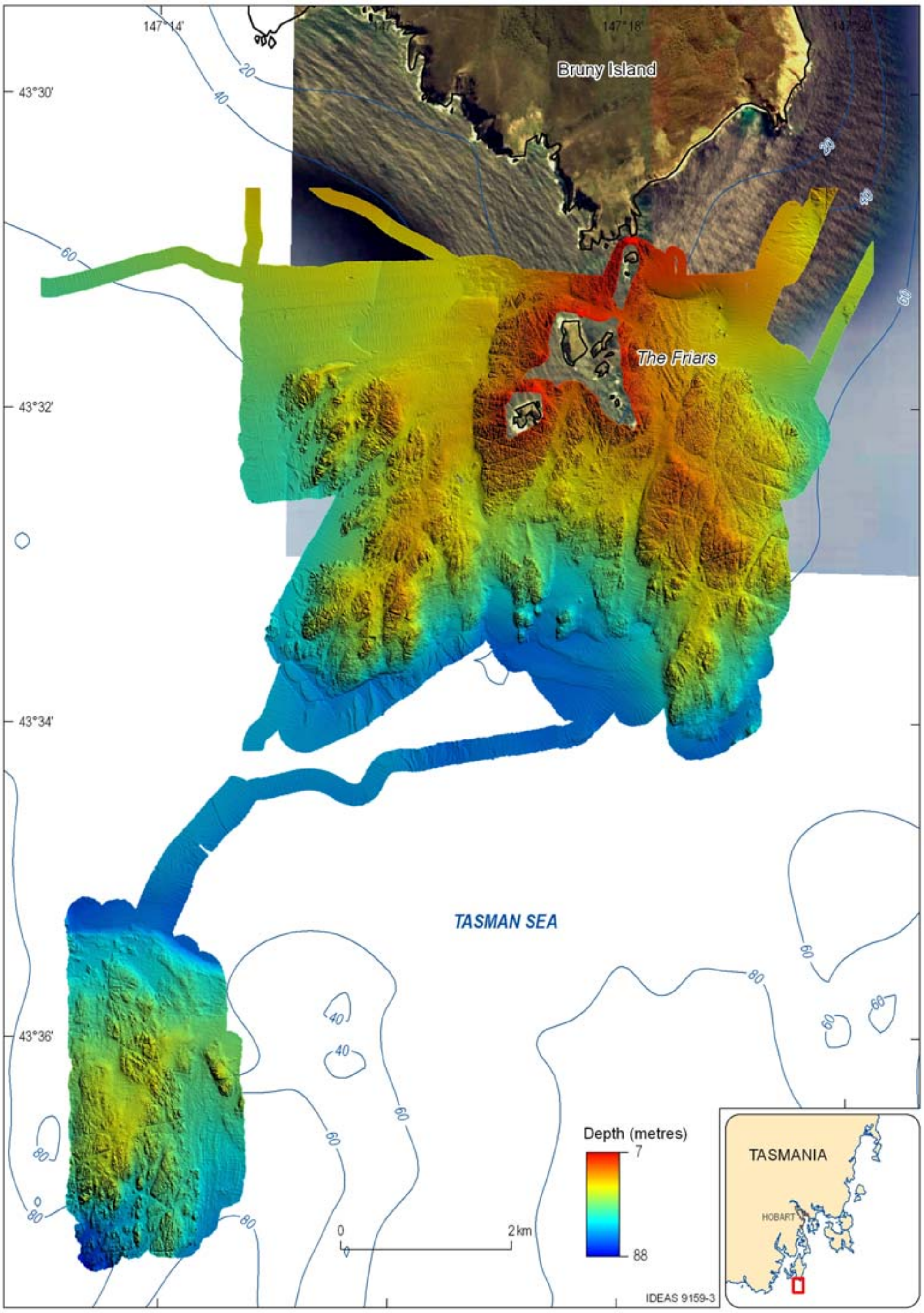


Figure 2.16: Multibeam sonar bathymetry map of reefs surrounding The Friars islets, south of Bruny Island.

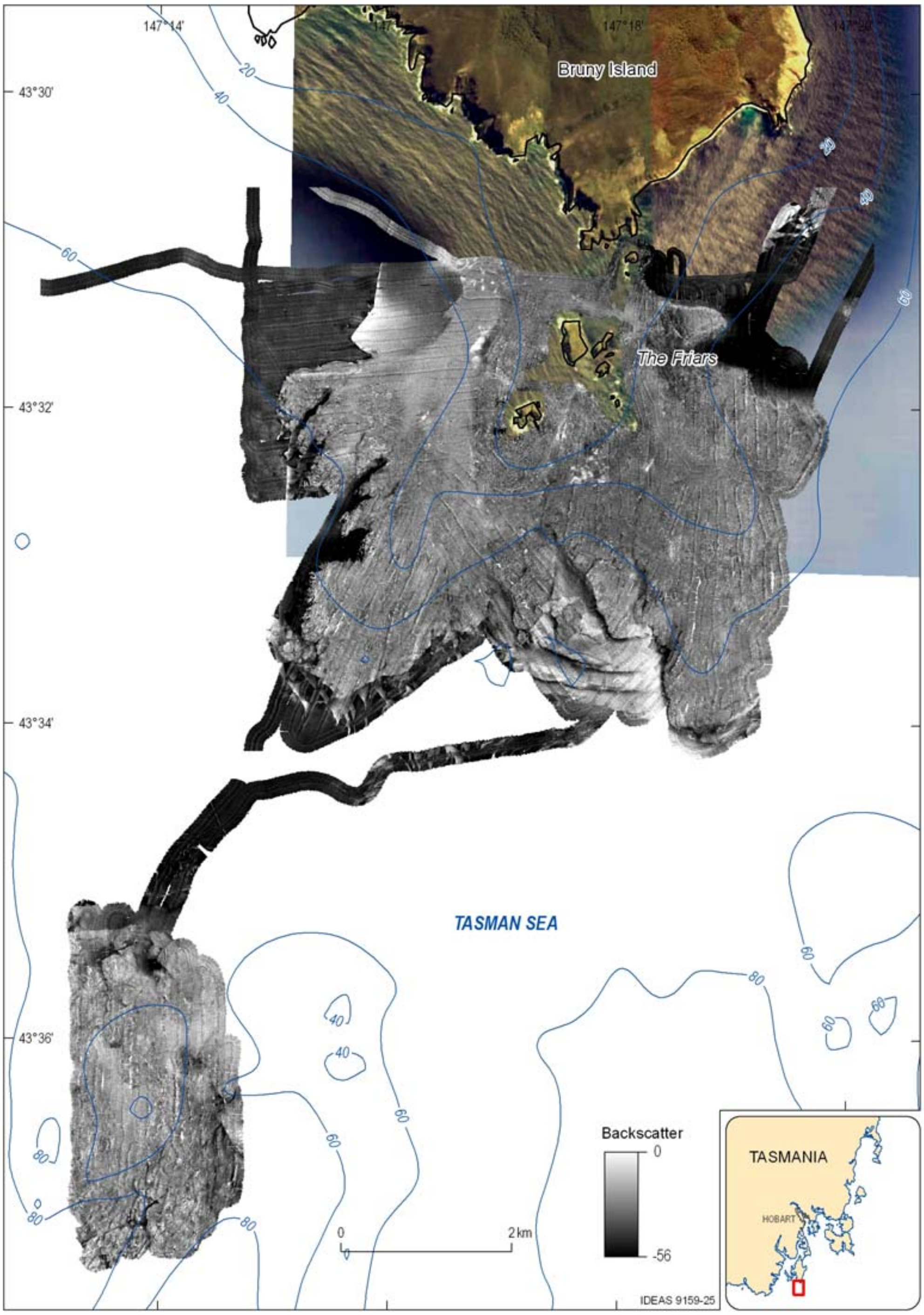


Figure 2.17: Multibeam backscatter imagery of reefs surrounding The Friars islets, south of Bruny Island.

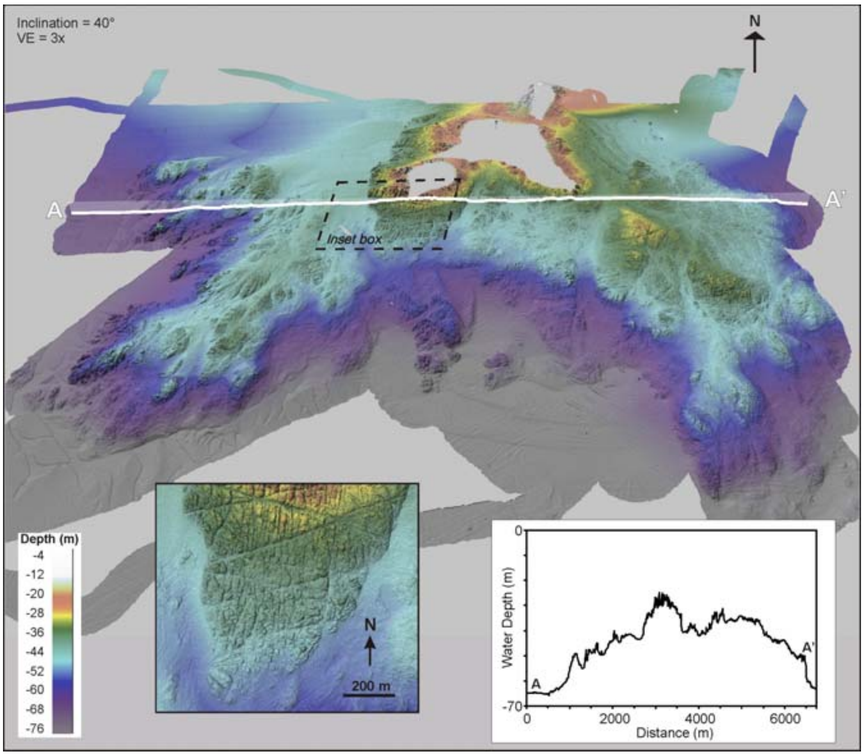


Figure 2.18: Perspective view of the bathymetry surrounding The Friars islets, with insets showing detail of fractures in dolerite rock and a representative profile across the reef.

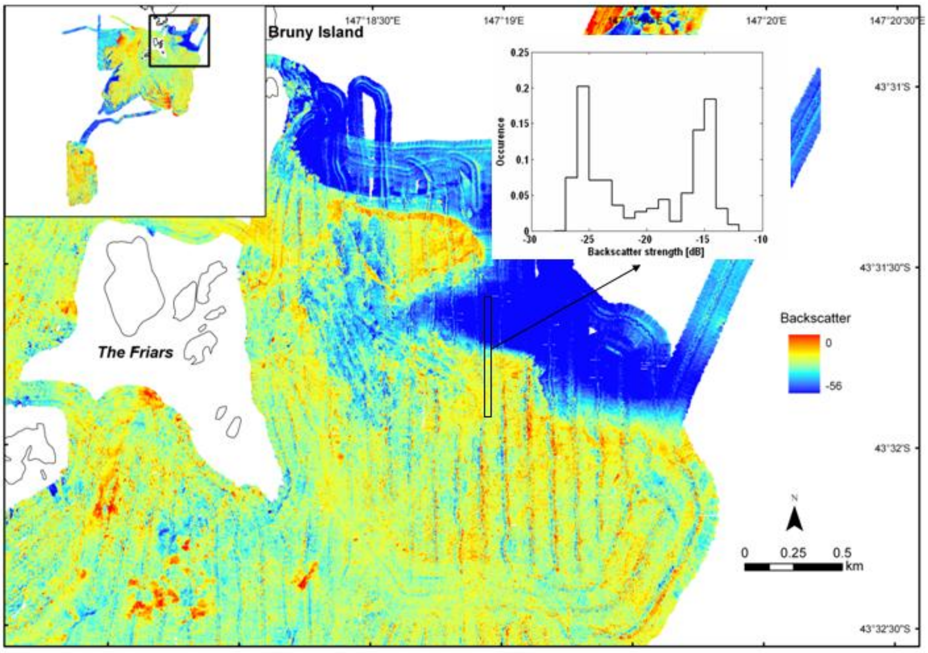


Figure 2.19: Backscatter map and representative histogram for an area east of The Friars, showing a well defined acoustic boundary at the reef edge.

2.7 HUON RIVER

The mapped area of the Huon River Estuary extends 12.5 km along the lower reaches of the estuary and into the D'Entrecasteaux Channel, covering an area of 39 km^2 (Fig. 2.20 & 2.21). The seabed in this area is characterised by two basins connected by a narrow incised channel with flanking terraces. Average water depth in the basins is 40 m and 50–55 m in the channel, shoaling to approximately 25 m on the adjacent terraces. The two basins are acoustically similar, characterised by low acoustic returns. The narrow channel connecting the basins mostly produces relatively low acoustic returns. It is however not the case in entrances adjacent to both basins. The average backscatter intensity of the two basins and a small proportion of the channel is approximately -30 dB. Mapped rocky reefs are restricted to an area of 0.2 km^2 surrounding Butts Reef, a 200 m wide extension to the western edge of Huon Island, an area of 0.03 km^2 around Zuidpool Rock and several isolated patches of low relief reef on the terraces (Fig. 2.22). Like reefs in other survey areas, the rocky reefs in the Huon River survey area are characterised by relatively high backscatter intensities (average -17 dB), although values are 1–2 dB lower than reefs in other survey areas. This lower backscatter intensity in the Huon River is likely due to sediment (mud) cover on the reef.

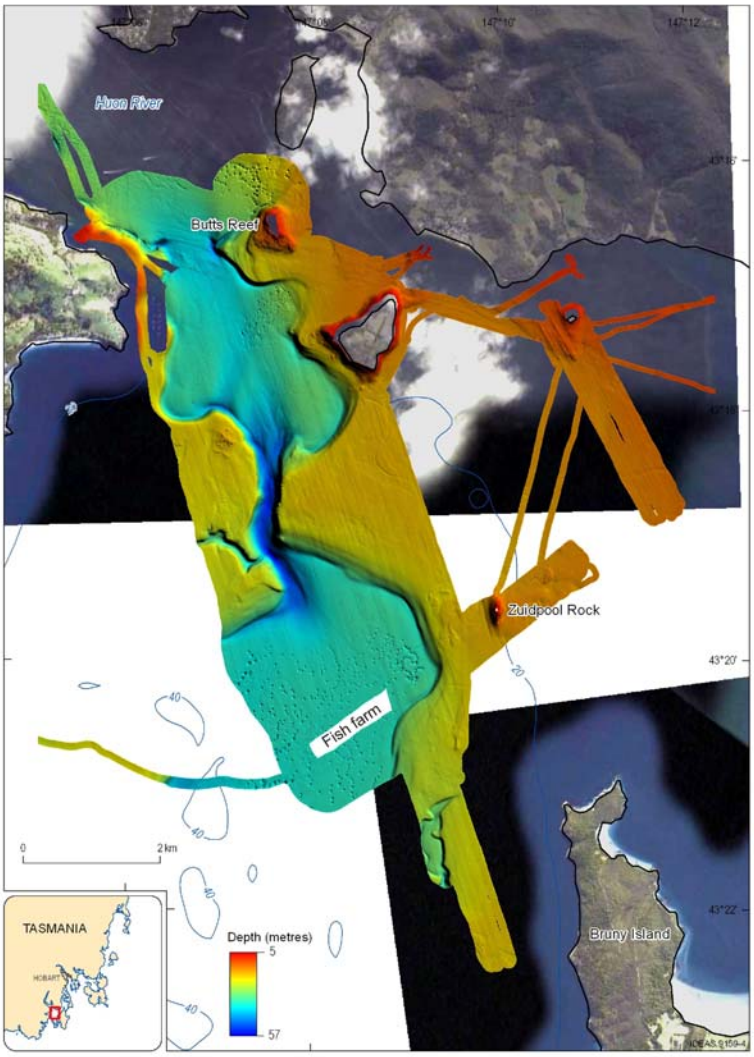


Figure 2.20: Multibeam sonar bathymetry map of the Huon River survey area.

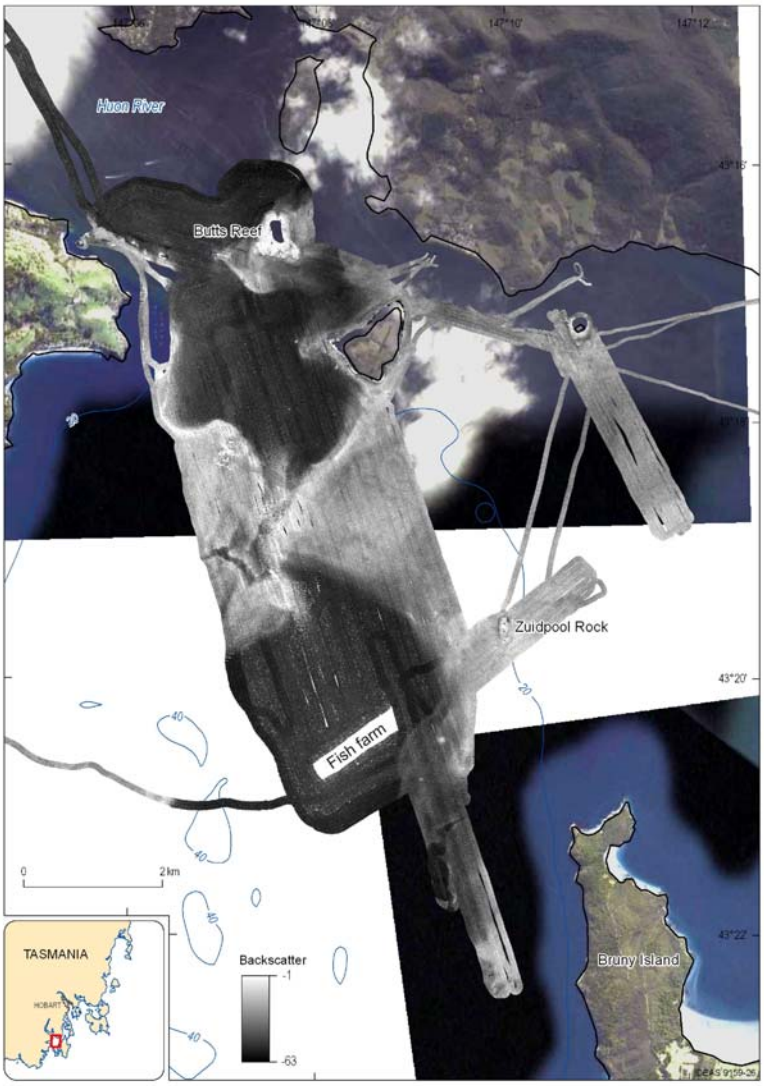


Figure 2.21: Multibeam backscatter imagery of the Huon River survey area.

The seabed is mostly smooth and featureless across the terraces and basins of the Huon River estuary, with the exception of three areas of the basins that have fields of small pockmarks (Fig. 2.22). The pockmarks form circular depressions 50–70 m in diameter and up to 2 m deep. The most extensive pockmark field is in the southern basin, which incorporates about 200 depressions in an area of 4.6 km^2. In this area, some pockmarks are arranged along lines with less than 10 m spacing. These pockmarks are acoustically transparent and therefore not observed in the backscatter imagery.

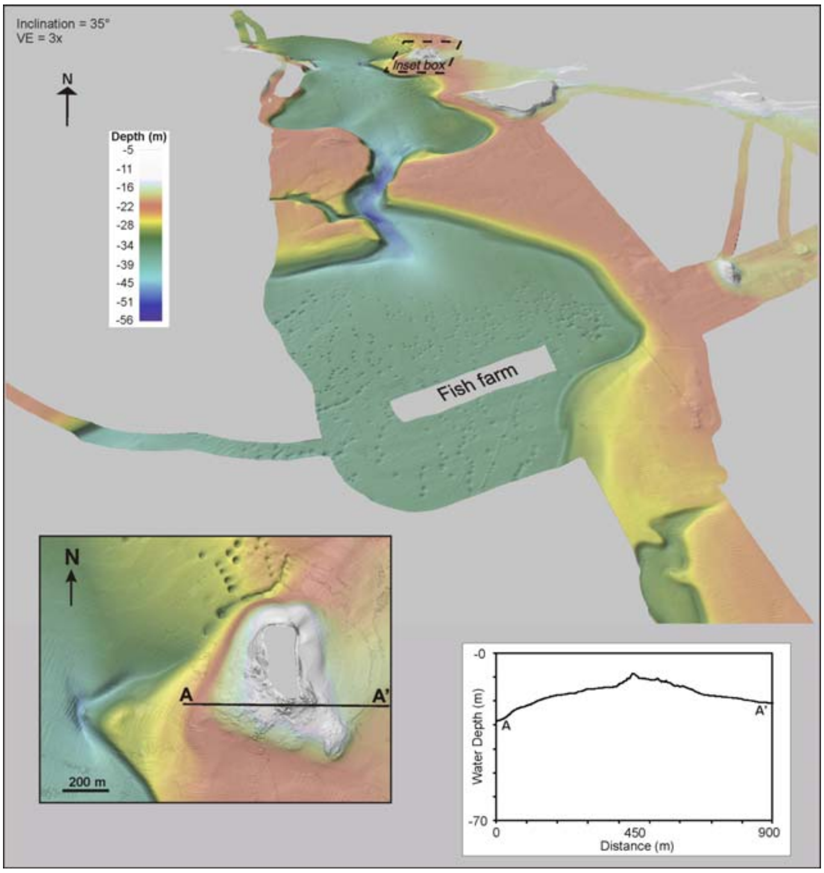


Figure 2.22: Perspective view of the bathymetry in the Huon River with insets showing enlarged map and representative profile of Butts Reef. Note pockmark features in the foreground of the perspective image.

2.8 TINDERBOX

The Tinderbox survey site is located at the northern end of D'Entrecasteaux Channel between Bruny Island and the mainland (Fig 2.23 & 2.24). The mapped area covers 7.6 km^2 and includes a channel and flanking shoals formed in soft sediment. The only area of mapped reef is located along the northern edge of the survey area, adjacent to a section of rocky shoreline in 20 m water depth, covering an area of 0.07 km^2. Water depths across the shoals range from 12 to 25 m, reaching to 51 m in the channel. The seabed of the channel and adjacent shoals is smooth.

The channel occupying most of the Tinderbox survey area is partially defined by its acoustic backscatter intensity, in contrast to the channel of similar morphology in Port Arthur that is well defined by its backscatter signature. The Tinderbox channel is divided into an area in the northeast half with high backscatter intensity (-17 dB) and an area with lower backscatter intensity (-29 – -25 dB) in the southwest half, extending to adjacent flat topped bathymetric highs in the southeast. While bathymetric highs within the channel in Port Arthur are characterised by having higher backscatter intensities than surrounding seabed surfaces, this is not the case for the bathymetric highs at the northeast end of the channel in the Tinderbox survey area. A possible explanation for this difference is that the channel in the Tinderbox survey area is characterised by different sediment types.

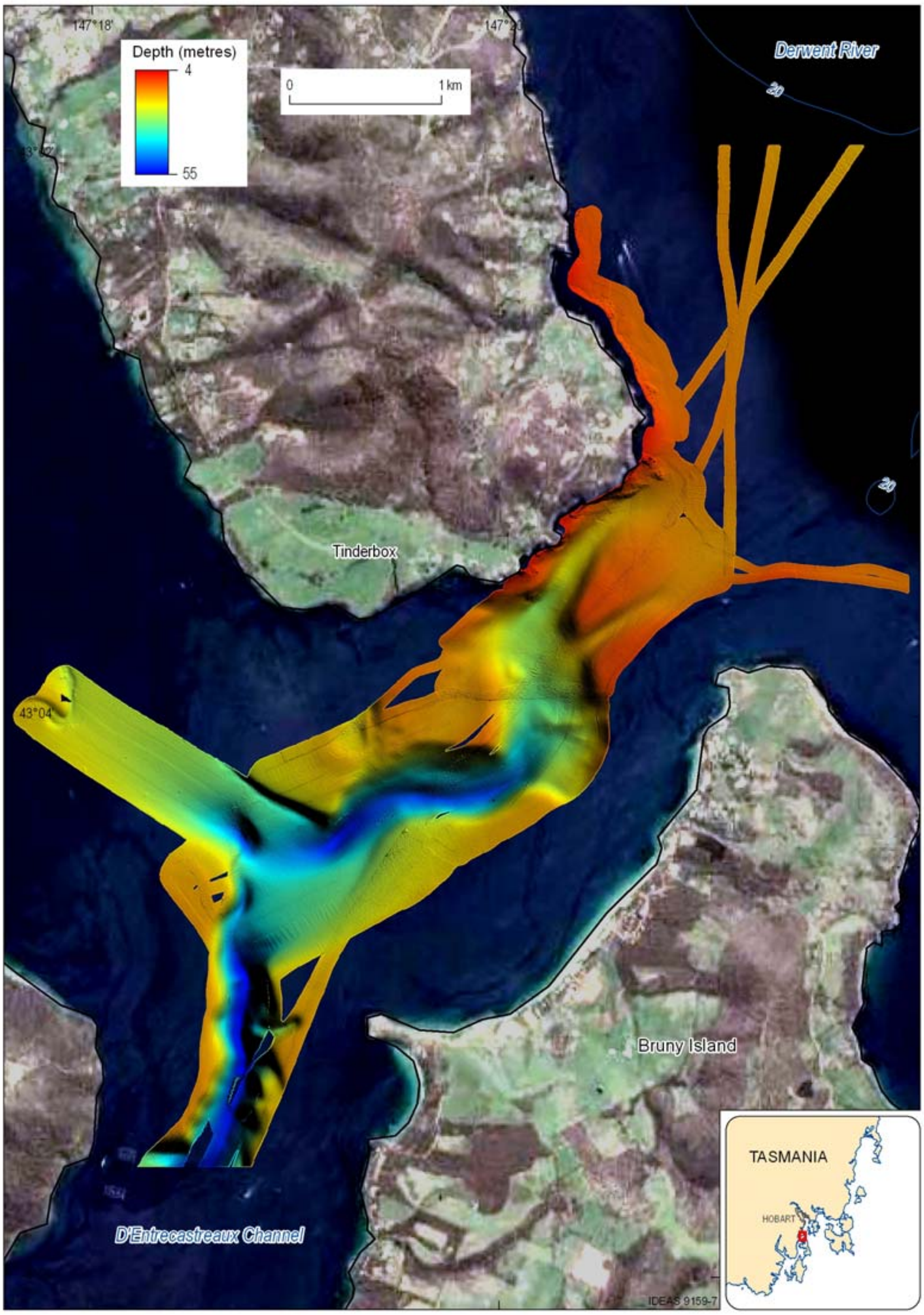


Figure 2.23: Multibeam sonar bathymetry map of the Tinderbox survey area.

Figure 2.24: Multibeam backscatter imagery of the Tinderbox survey area.

2.9 SUMMARY

For the seven sites surveyed along the coast of southeast Tasmania, the geomorphology of the nearshore and shelf is typically a mix of hard and soft seabed features that provide a range of potential habitat types. The most extensive reefs are formed where outcrops of bedrock extend offshore from headlands and nearshore islands, with only small areas of isolated patch reefs on the shelf. All these reefs produce strong acoustic returns because of the high contrast in acoustic impedance between reef surfaces and seawater above. Away from the reefs, the seabed is typically made of sandy sediment and featureless, mostly associated with low backscatter intensity. Some contrast exists in the morphology of reefs, ranging from high relief reefs that are several tens of metres high (e.g. The Hippolyte Rocks) to low relief reefs only a few metres high that are partly covered in sediment (e.g. Freycinet Peninsula, outer shelf). Sediment covered, low relief reefs are typically associated with slightly lower backscatter intensity. In detail, reef morphology displays strong geological control, as shown by the highly fractured dolerite reef surface at The Friars and the stepped morphology of some inshore sandstone reefs along the Tasman Peninsula. Some of the reefs identified with relatively flat, regular surfaces are associated with the strongest acoustic returns. Reefs in the more sheltered areas of Port Arthur and the Huon River / D'Entrecasteaux Channel are less extensive than along the open coast, occurring as narrow zones of hard-ground along shorelines and surrounding small islands. Otherwise, the seabed mapping in these sheltered areas mostly reveals relict incised river channels, drowned terraces and other soft sediment features (e.g. pockmarks).

The origin of the pockmarks in the Huon River area is not clear, although their size excludes any biological mechanism for their formation. Given that the pockmarks occur in the basins and not on the terraces, it is possible that they relate to processes of gas escape from organic-rich soft sediments leading to localised collapse. Although the pockmarks are acoustically transparent, the difference in sediment surface between the nearby basins and the terraces is distinct. The basins produce the lowest acoustic returns whereas the terraces give relatively high acoustic returns and the boundaries between them are very well defined. The linear arrangement of some pockmarks also suggests a plane (fault?) of weakness within the sediment, along which gas has escaped. If this hypothesis is correct, then the lack of pockmarks in the terrace sediments could be explained by the terrace sediments being relatively compact and low in organic content; an assumption that would be consistent with the terraces being drowned river terraces of Late Pleistocene age. The pockmarks require further investigation, with sediment cores likely to provide an indication of their origin.

3. Seabed Habitats and Their Biological Assemblages

3.1 INTRODUCTION

A central aim of the CERF Marine Biodiversity Hub Surrogates Program is to examine the relationship between physical variables (e.g. oceanography, multibeam derivatives, seabed sediment type, etc.) and the distribution and abundance of benthic faunal and floral assemblages, and thereby identify the degree to which physical variables can be used as surrogates to predict patterns of benthic marine biodiversity. Temperate reefs provide complex habitat for marine fauna and flora, and a variety of physical attributes, such as bathymetry, exposure, geomorphology, depth, and fine-scale rugosity are known to be important in structuring marine assemblages (e.g. Syms, 1995; Gratwicke and Speight, 2005; Anderson et al., 2009). In this chapter, we describe the video surveys undertaken to characterise seabed habitats and the distribution and abundance of benthic marine flora and fauna on the deep reefs of southeast Tasmania.

Underwater towed video surveys were conducted in areas previously identified as priority sites and mapped by multibeam sonar in the first phase of the Surrogates Program Tasmanian survey work. Priority sites included coastal reefs (Blowhole, Waterfall Bluff, and O'Hara Bluff) and offshore reefs (The Hippolyte Rocks and Roxys Reef) in the Fortescue region; onshore reefs (The Nuggets) and offshore reefs (Freycinet Commonwealth MPA) off the Freycinet Peninsula; and offshore reefs of the Friars (inside and outside the Huon Commonwealth MPA). In addition, sites in the Huon River (D'Entrecasteaux Channel) and Port Arthur were selected as secondary 'bad weather' locations, with hard and soft-sediment sites targeted. The combination of rocky reefs and soft sediment habitats at locations from Freycinet in the north to the Friars in the south provides regional coverage and generality of the survey, while replicate towed-video transects within each location provides an estimate of variability within and between deep-reef and coastal locations. Characterisation of seabed habitats inside and outside the Commonwealth MPA's provides additional baseline data that can help to inform the management of these areas.

Table 3.1: Towed-video sampling effort by location along the southeast Tasmanian coast.

Survey site	No of video transects	No. of video characterisations	water depths sampled (m)	
			Min.	Max.
Tasman Peninsula	23	2009	15	80
Fortescue Bay (inshore)	*2*	*37*	15	30
Fortescue coast (inshore)	*11*	*1567*	15	60
The Hippolyte Rocks (offshore)	*8*	*306*	20	80
Roxys Reef (offshore)	*2*	*99*	75	80
Freycinet Peninsula	14	1508	20	110
The Nuggets (inshore)	*6*	520	20	60
offshore MPA	*8*	988	80	110
The Friars	8	857	20	80
North Friars	*4*	*422*	20	80
South Friars	*4*	*435*	40	80
Huon River	3	374	10	45
Port Arthur	7	797	15	70
TOTAL	**55**	**5545**		

3.2 TASMAN PENINSULA

Fortescue Coast (inshore habitats)

Two towed-video transects were run within Fortescue Bay in depths of 15-30 m, as part of initial video system testing (Fig. 3.1). The habitats surveyed within Fortescue Bay were dominated by flat sand (69%) with patches of low-relief rock and boulders (30% combined) that were covered in the kelp, *Ecklonia radiata* (26%), with some *Macrocycstis pyrifera* recorded in the shallowest depths (~15 m). Following these trials, the inshore reef area along the Fortescue coast between Pirates Bay and O'Hara Bluff was surveyed. To characterise coastal reef habitats and their biota, and to identify alongshore and offshore transitions in habitat and biota types relative to the multibeam maps, seven primary transects were run perpendicular to the shore in depth ranging from 15-60 m, while two longer secondary transects were run parallel to shore (Table 3.1, Fig. 3.1). The Fortescue coast was characterised by inshore reefs extending from a rocky shoreline (37% of all substrata surveyed) surrounded by soft-sediment habitats (62% of all substrata surveyed), while gravel and boulders comprised the remaining substrata (1%). The three inshore reef complexes (Blowhole, Waterfall Bluff, and O'Hara Bluff) were characterised by high relief (15% of all rocky substrata) substratum in the central and shallowest (<40 m) parts of each reef, while deeper sections had moderate (38% of the reefs) and low (25% of the reefs) relief substrata. In contrast, the deeper sections of these reefs were for the most part, flat (23% of the reefs). The soft-sediment habitats that surrounded these reefs in the nearshore were characterised by sand waves, while sand rippled habitats occur between and adjacent to the deeper parts (>60 m) of the reefs, and flat sandy sediments occurred offshore beyond the reefs.

The coastal reefs of Fortescue Bay were characterised by the macroalga *Phyllospora comosa* to 20 m water depth, moderate to dense *Ecklonia radiata* to 44 m depth, and dense and vibrant sponge communities consisting of massive, digitate, and fan-like growth forms at depths of 44-80 m (Fig. 3.2a). Adjacent to the rocky reefs, a halo of bare sand extended for tens of metres characterised by sand wave and sand rippled habitats with few associated organisms, while the flat sandy sediments offshore were characterised by high densities of the introduced New Zealand screw shell, *Maoricolpus roseus*. *M. roseus* is a suspension-feeding gastropod (Family Turritellidae) found on a range of benthic habitats, particularly soft-sediments, in water depth of 3-50 m, and was introduced to Tasmania in the 1920's (Edgar, 1997; Bax et al., 2003). The shell of this species is heavily calcified and resistant to abrasion - even in high energy environments - allowing it to persist for long periods (geological time scales) after the snail has died (Nicastro et al., 2009). The accumulation of screw shell debris on soft-sediment environments, therefore, offers potential habitat structure for other species. In this survey, where screw shells occurred in high densities on the seabed (i.e. > 50-75% cover) they provide hard substrata for a range of sessile invertebrates to colonisation. As a consequence, hard-substratum associated sponge and invertebrate populations have extended beyond the inshore reefs out across the soft-sediment habitats of the shelf. Although screw shells had been recorded from numerous sites around south-eastern Tasmania (Edgar, 1997), both the high densities of screw shells and the associated extension of reef-associated sponges and other invertebrates over shelf sediments is a new finding.

Hippolyte Rocks

The Hippolyte Rocks form the crown of steep-sloping and highly fractured bedrock reef, and are positioned mid-way across the shelf approximately 3 km offshore of Cape Hauy (Fig. 2.8). The reef surrounding the Hippolyte Rocks was surveyed to examine whether deep offshore reefs differed significantly from the adjacent coastal reefs and to determine the extent that the exposure gradient around the rocks influenced the spatial and depth distributions of the biota. Eight video transects, each approximately 600 m in length and perpendicular to the emergent rocks, were surveyed around the Hipploye Rocks in water depths of 20-80 m (Fig. 3.1, Table 3.1). The subtidal reef comprised 55% of the substrata within transects, and is part of a submergent reef that extends 200-300 m out from the emergent rocks. This steep-sloping reef was characterised by considerably more high relief substrata (67% of the reef) than coastal reefs, with some moderate relief (26% of the reef), but negligible areas of low or flat relief substrata (5% and 2% of the reef, respectively). The base of the reef (~80 m) also differed from those along the coast. The reef-sand interface on the coast was discrete (< tens of m's wide) and characterised by low or flat relief, whereas the reef base at the Hippolytes consisted of a much wider transitional zone of patchy reef-sand habitat (150-250 m wide) that was characterised by mostly high (44%) and moderate (38%) relief rock surrounded by flat soft-sediments. Beyond this rock-sand transition zone, soft-sediment shelf habitats were characterised by mostly flat (76% of shelf soft-sediments) or subtly rippled (18% of shelf soft-sediments) sandy sediments, with sand waves (6% of shelf soft-sediments) recorded only on the western-most side of the island group.

A similar depth zonation sequence of kelp, sponge and screw-shell distributions found on the coastal reefs was also observed across the depth range of the Hippolyte Rocks (Figs. 3.2, 3.3). The upper wave-influenced slopes (<45 m) of the Hippolyte Rocks were covered in moderate to dense *Ecklonia radiata*, and were also habitat for patches of *Caulerpa* sp. (kelp). In contrast to the coastal reefs, no *Phyllospora comosa* was recorded in depths > 20 m around the islands – although it is important to note that the depth zone where *Phyllospora* is likely to occur (< 20 m) was not sampled due to the navigational issues of working close to the rocks. The highly fractured bedrock of the slopes between 45-80 m water depth, like the coastal reefs, were covered in dense and vibrant sponge communities, again consisting of massive, digitate, and fan-like growth forms. At the base of the subtidal reef, the transitional patchy reef-sand zone was characterised by dense sponge and sea whip communities, while shells were present in low to moderate densities in the flat sand matrix between the patch reefs. Beyond the patch-reef zone, a brief zone of bare sand was recorded, beyond which the introduced NZ screw shell lined the seafloor in patchy moderate to high densities. As with inshore shelf sediments, screw shell beds created an extensive substratum for encrusting invertebrates, such as sponges, and enabled these hard-substrata requiring populations to extend out across the soft-sediment habitats of the shelf. Video transects undertaken in this survey only sampled out onto the sediments adjacent to reefs so it is unclear how far offshore these invasive screw shell beds extend. As no samples were collected during this survey it is also unclear what the proportion of live to dead shells is, but this ratio may help to explain the occurrence, distribution, and local abundance of the sessile invertebrates colonising these screw shell beds.

A variety of fish species was recorded from the video transects, although video is unlikely to be an adequate method to estimate fish populations. The most common and abundant fish species recorded on both the inshore Fortescue locations (19% of characterisations) and at the offshore Hippolyte Rocks (45% of characterisations) was butterfly perch (*Caesioperca lepidoptera*), which were often observed in large schools comprising hundreds of individuals. The next most commonly recorded species was the rosy wrasse (*Psuedolabrus psittaculus*) found at only 4% of inshore locations, but 28% of locations at the Hippolyte Rocks. Other species recorded inshore and offshore included gurnard (family Triglidae), half-masked stingaree (*Urolophus cruciatus*), baitfish, banded morwong (*Cheilodactylus spectabilis*), blue-throat wrasse (*Notolabrus tetricus*) and crimson wrasse (*Suezichthys aylingi*). Species recorded only inshore were Shaw’s cow fish (*Aracana aurita*) and red cod (*Psuedophycis bachus*). Similarly, Apogonidae, bullseye (family Pempherididae), bastard trumpeter (*Latridopsis forsteri*), jackass morwong (*Nemadactylus macropterus*) and rosy perch (*Callanthius australis*) were only recorded offshore.

Roxys Reef

Two video transects were surveyed across a small (~680 x 240 m) isolated rock outcrop in 80 m water depth, 3 km to the north of The Hippolyte Rocks known locally as Roxys Reef (Fig. 3.2, Table 3.1). The two transects were run in a criss-cross pattern, with the first transect (stn13cam15) run in a west to east direction, and the second transect (stn13cam16) run in a north-east to south-west direction. Roxys Reef was characterised by high (62%), moderate (28%), and low (10%) relief rock outcrop, while the surrounding shelf sediments are characterised by flat sand.

Roxys Reef lies in water depths below the lower limit of algal distribution and consequently was completely covered by a diverse and dense sponge community (100% occurrence at >75% density). The sponges include encrusting, vase, fan, and digitate sponges (100% occurrence), with massive sponges occurring in 70% of all characterisations (Fig. 3.4). Sea whips were also present within the sponge community, particularly around the deeper regions of the reef and along the reef-sand interface (58% of reef characterisations). Reef-associated fish include butterfly perch as the most common species recorded (93% of characterisations), followed by gurnard (*Helicolenus percoides*) (25%), rosy wrasse (20%), and red cod (5%), with baitfish, bullseye, leatherjacket, jackass morwong, and rosy perch also recorded (<2%).

The surrounding shelf sediments were characterised by a halo of flat sand around the reef that was mostly devoid of taxa, while beyond this area the flat sands of the shelf were characterised by screw shells (98% occurrence) in low (78%), moderate (12%) and high (6%) densities. Attached to the screw shells were invertebrates and sponges (combined occurrence of 71% of shelf characterisations) that were mostly small in size (< 15 cm in height) and in low densities (≤10 % cover), with rare occurrences of low (8%), moderate (2%) or high (2%) densities. Two butterfly perch and one rosy wrasse were recorded adjacent to patch reefs, but no other fish were recorded on these shelf sediments.

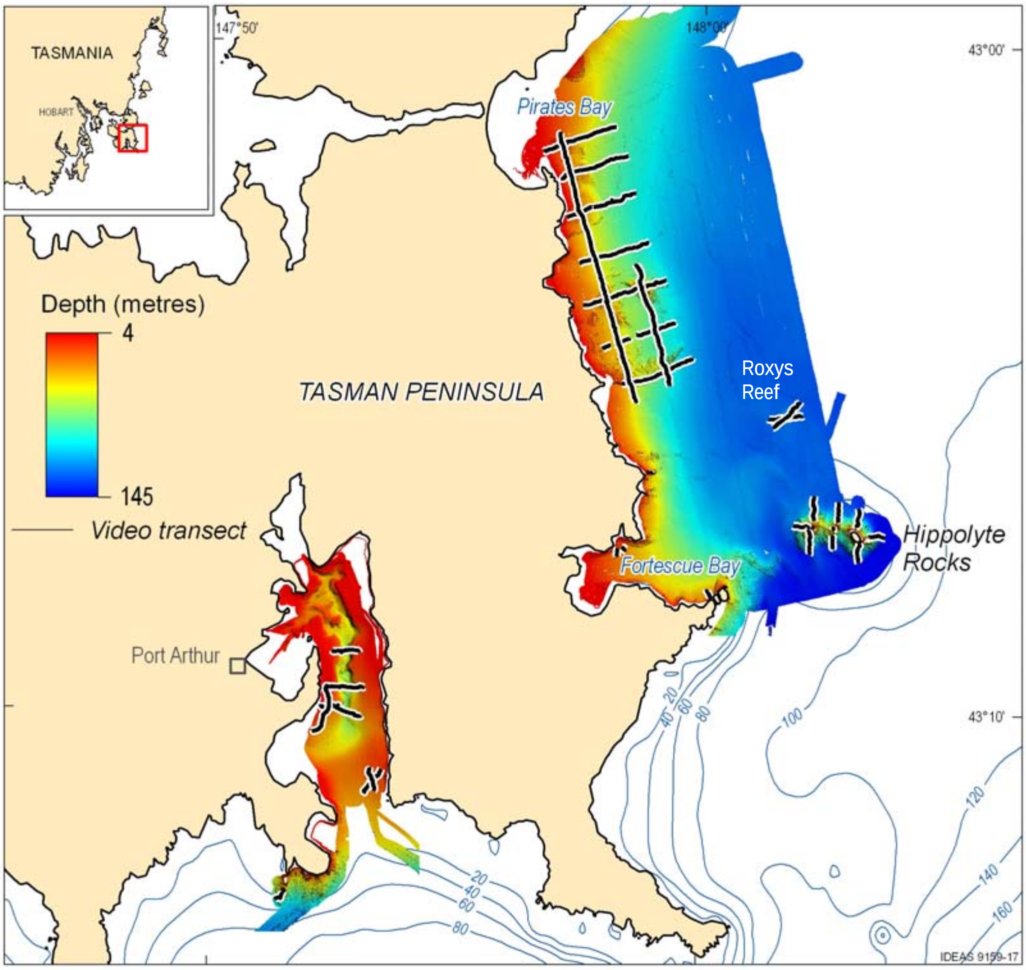


Figure 3.1: Location of the 21 towed-video transects in the Tasman Peninsula area (including 11 transects on the Fortescue coast, eight transects around the Hippolyte Rocks and two transects across Roxys Reef), and the seven transects surveyed in Port Arthur.

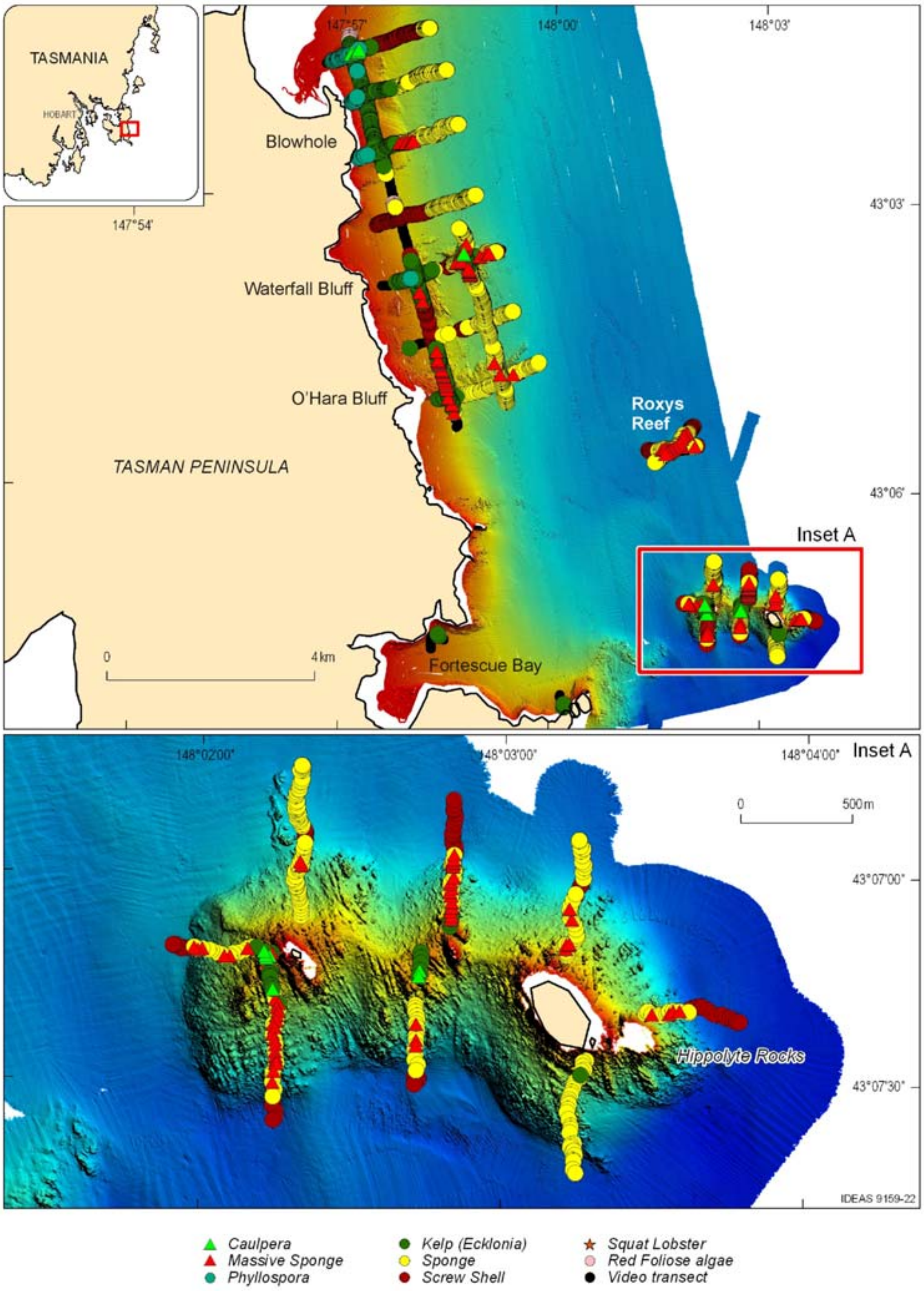


Figure 3.2: The spatial distribution of the main habitat forming biota in the Tasman Peninsula area. Inset A shows an enlarged view of the biota around the Hippolyte Rocks. Circle size indicates percentage cover for kelp, sponge and screw shells, as follows: o 1-25%, o 26-50%, O 51-75%, O >75%.

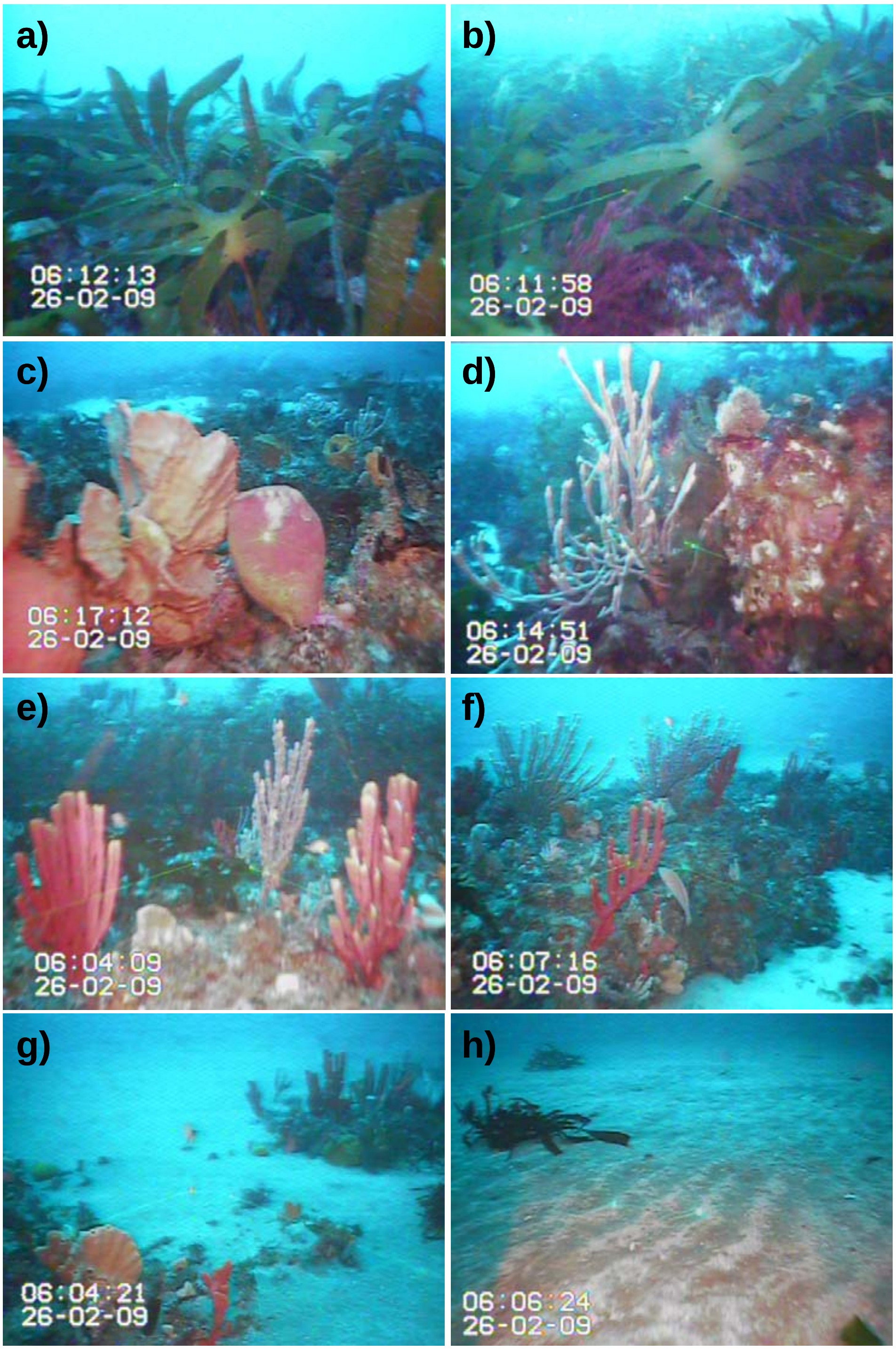


Figure 3.3: Video images of habitats and biota of the Fortescue coast (stn04cam06C). a) Dense *Ecklonia. radiata* kelp forest (20 m depth); b) mixed kelp and foliose red algae (25 m); c) Roxys reef (~50 m) covered in dense sponges featuring several large fan-shaped sponges; d) Roxys reef (~50 m) covered in moderately dense sponges featuring a large digitate sponge; e-f) base of the reef (~55 m) covered in moderately dense sponges with large digitate and smaller encrusting sponges, but devoid of sea-whips; g) reef edge (transitional zone, 60 m) with patch reefs covered in sponges but again devoid of sea-whips; h) subtle sand ripples between Waterfall and O'Hara Bluffs (~45 m), with sparse drift kelp.

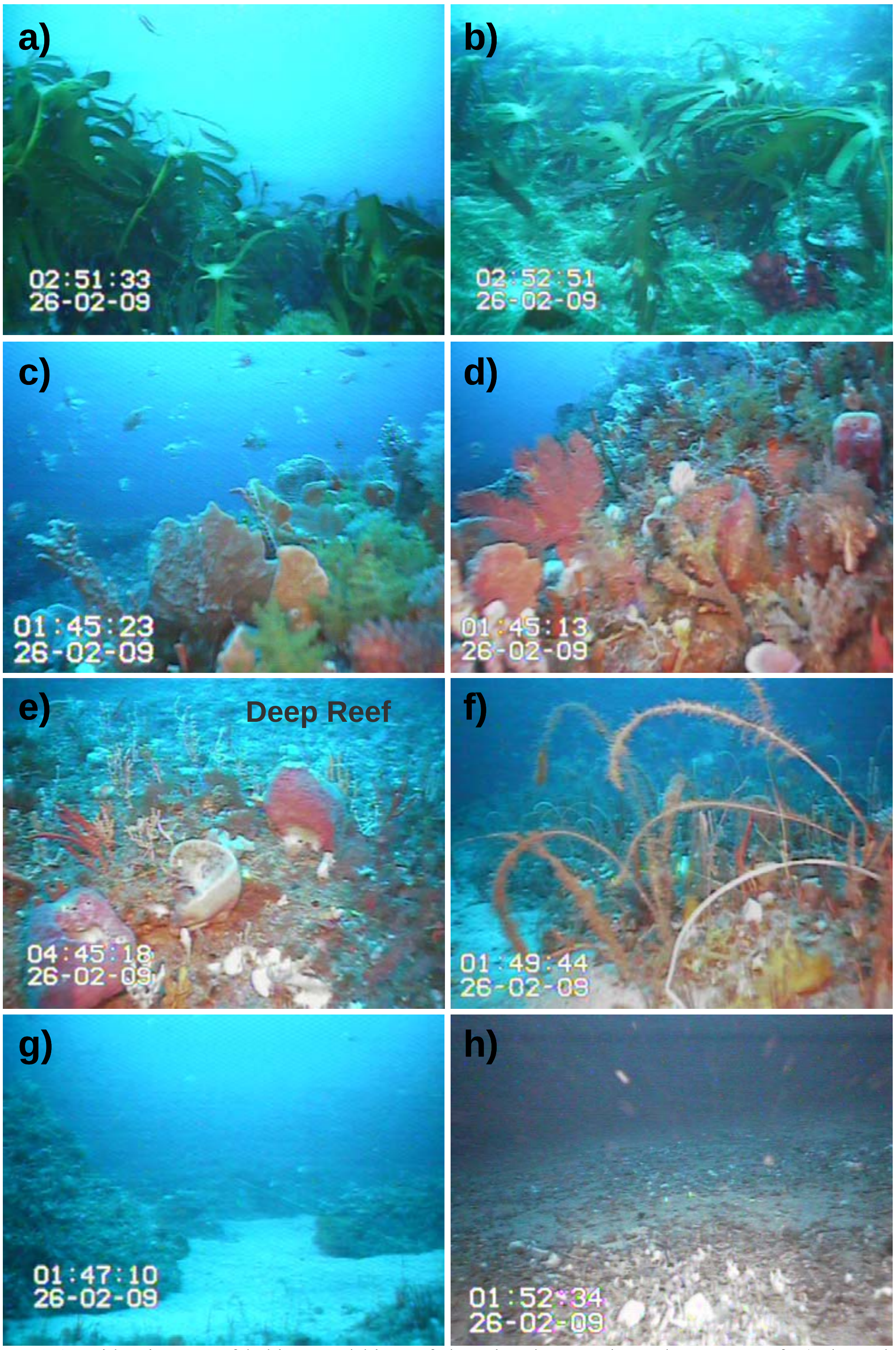


Figure 3.4 : Video images of habitats and biota of the Hippolyte Rocks and Roxys Reef. a) dense kelp, *Ecklonia radiata* (~20 m, Stn10cam12); b) mixed kelp and *Caulerpa* sp. (~25 m, Stn10cam12); c) Roxys reef slopes (55-65 m, stn08cam10) densely covered in diverse sponges with some bryozoans; e) Roxys Reef (75 m, stn13cam15) densely covered in a variety of sponges; f-g) reef-sand transition zone at the base of the Hippolytes (stn08cam10) with patch reefs densely covered in sponges and sea-whips; h) Shelf sediments with high densities of screw shells carpeting the seabed and generating habitat for small sponges and other sessile invertebrates (80 m, stn08cam10).

3.3 FREYCINET PENINSULA

The Nuggets (inshore Freycinet)

Six video transects were surveyed at The Nuggets, in water depths of 20-60 m, sampling both the large reef surrounding the Islands and a second isolated small reef 600 m to the east (Fig. 3.5, Table 3.1). Two main habitats were recorded: those of the bedrock reefs at The Nuggets (47% rock and 2% boulders), and those of the adjacent soft-sediments (35% sand and 9% shell). The Nuggets Reefs were characterised by a mixture of moderate, low, and high relief rock outcrop (53%, 24%, 23%, respectively) that extend approximately 1 km out from the islands before transitioning into the surrounding soft-sediments, which were characterised by flat (90%) and rippled (7%) sands, with rare occurrences of hummocky and sand wave habitats (1% each).

The reefs around The Nuggets were characterised by a similar depth zonation of kelp, sponge and screw-shell distribution to those observed along the Tasman Peninsula (Fig. 3.6, Fig. 3.7). The reefs around the Nuggets were characterised by high to moderate density *Ecklonia radiata* kelp canopies (10% of all reef locations) down to ~40 m water depth, with understorey species characterised by coralline paint (11%), red foliose algae (2%), and sponges (2%), while one patch of *Phyllospora comosa* (<1%), was recorded. Unlike the healthy bright kelp plants of the Fortescue area, patches of *Ecklonia* plants at The Nuggets were covered in encrusting epifauna (such as encrusting bryozoans, like *Membranipora membranacea*), and the blades of many plants were also necrotic. *Ecklonia radiata* are known to suffer from localised to even large scale die-offs where plants deteriorate, become heavily encrusted with epiphytes and/or epifauna, and die (Schiel, 2003). The health and condition of *Ecklonia* plants has been related to virus-like pathogens (Eastern et al., 1995), boring amphipods (Haggitt and Babcock, 2003), and environmental conditions such as El Nino and La Nina; with the spatial pattern and scale of the die-off useful in distinguishing the causes of mortality (Cole and Syms, 1999). Although The Nuggets are more northerly and are less exposed to the prevailing southerly swells than either The Friars or the Hippolyte Rocks, it is unclear whether the health and condition of plants in this region are related to the spread of pathogens, differences in swell intensities, or the differing influence of the EAC and sub-Antarctic water masses between these sites.

Deeper sections of the reef surrounding The Nuggets (40-60 m) were dominated by a mixture of sponges (82% of rock habitats) and bryozoans (39%), with sea whips (30%), and crinoids (10%) also common. The sponge assemblage in these depths was characterised by a diverse and dense sponge cover (76% of rock habitats had >75% sponge cover) that included digitate (82% of rock habitats), encrusting (81%), fan and vase (81% combined), and massive (22%) growth forms, although more massive forms were recorded on the deeper isolated reef than on the main reef surrounding The Nuggets. The high occurrence of bryozoans (often present in 10-25% cover) interspersed amongst the sponge assemblage was a distinctive feature of The Nuggets compared with the other reef sites surveyed. Fish recorded around The Nuggets include butterfly perch (57% of reef characterisations), rosy wrasse (21%), banded and jackass morwong (2%), with various leatherjackets (family Monacanthidae), half-masked stingaree, scorpion fish, striped trumpeter, blue-throat wrasse, boarfish (*Pentaceropsis recurvirostris*), bullseye, jackass morwong and red cod also recorded (<1%). Adjacent to The Nuggets, soft-sediment habitats were characterised by high occurrence of screw shells (66% of soft-sediment characterisations) that were often found in extremely high densities (Fig. 3.7g-h), and the presence of sponges (23%) and sea whips (6%). A range of fish species was also recorded in the adjacent soft-sediments and included rosy wrasse (4%), butterfly perch (4%), half-masked stingaree (2%), with gurnard, Shaw's cow fish *(Aracana aurita*), spiny pipehorse (*Solegnathus spinosissimus*), scorpion fish, sparsely-spotted stingaree (*Urolophus paucimaculatus*), jackass morwong, leatherjackets, and skates (family Rajiidae) also recorded (<1%).

MPA reefs (offshore Freycinet)

Eight video transects were surveyed within the Freycinet Commonwealth MPA, targeting low profile reefs (Fig. 3.1, Table 3.1). Although the multibeam imagery clearly depicts low-lying linear reef features in this area (Fig. 2.3), the tow-video footage of these areas shows largely undifferentiated sand (59%) and shelly sand (41%) sediments, with little to no visible difference between the low-lying reefs - which appear to be covered in a veneer of sediment - and the adjacent soft-sediment areas (Fig. 3.8). While soft-sediment areas characterised by bioturbation (e.g. deep burrows in the sediment) clearly identified the absence of surficial hard substrata, other areas were far less obvious. For example, while high numbers of sessile invertebrates, which require hard substrata for attachment, were frequently recorded throughout the offshore region, no clear delineations between hard and soft substrata were observed. In some situations sponge and gorgonian assemblages were combined with a slight increase in slope suggesting a veneer of sediment covering a low-lying reef, while in other locations similar sponges, that also require attachment, appeared to be growing in soft-sediment. The occurrence of a variety of often unidentified small invertebrates, including those that do grow in soft-sediments (e.g. seapens) made it difficult to infer where the boundaries to these reefs were.

Irrespective of substrata type, the Freycinet MPA was characterised by areas of low density sponges of mostly small sizes (64% of all characterisations), with some slightly larger digitate sponges (15%), and rare occurrences of massive sponges (1%). Areas devoid of sponges were characterised by bioturbation including pits and mounds (55% and 53% respectively), and other taxa such as sea pens (13%), and two instances of the volute mollusc *Cymbiola magnifica* (Fig. 3.8). High-density patches of brittlestars were recorded at the eastern-most edge of several transects (Fig. 3.6a). The brittlestar aggregations comprised multiple species and were observed their arms up actively feeding (Fig. 3.8f, Appendix A.8). Importantly, these brittlestar aggregations coincided with the mapped boundaries of the reefs and the more cryptic transitions seen in video (i.e. between low-density sponge areas and bioturbated sediments), albeit in only a few locations (1% of characterisations). Finally, fish species recorded on the offshore reef system included gurnard, skate, spiny pipehorse, scorpion fish, flathead, leatherjackets, striped trumpeter (<1%).

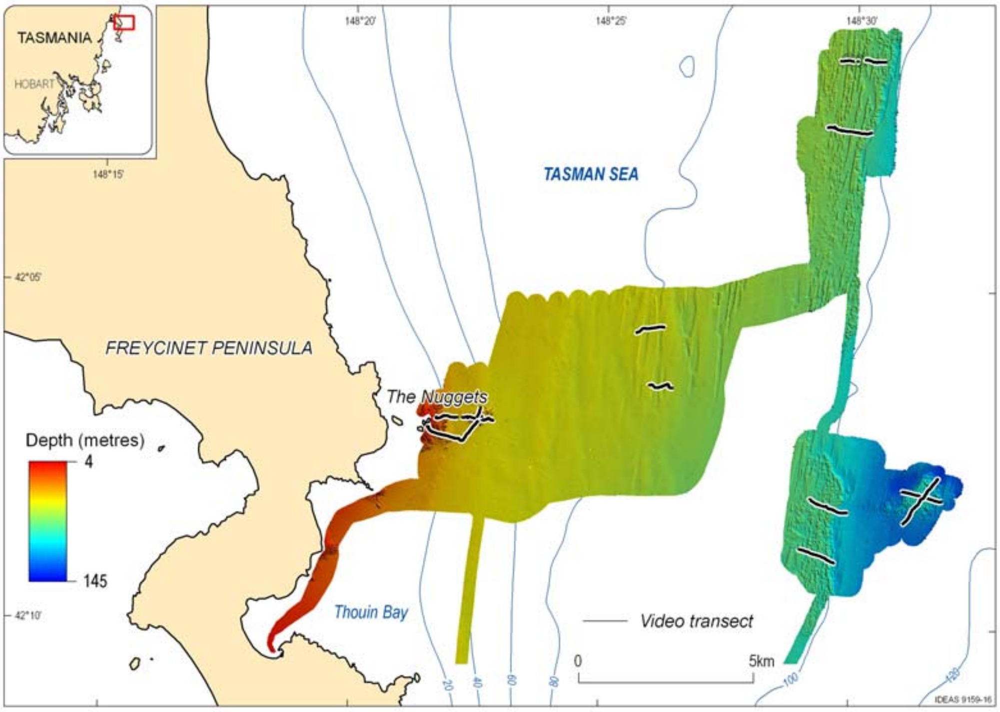


Figure 3.5: Location of towed-video transects offshore from Freycinet Peninsula, including six transects at the Nuggets (inshore), and eight transects across the low-lying reefs in the Commonwealth MPA.

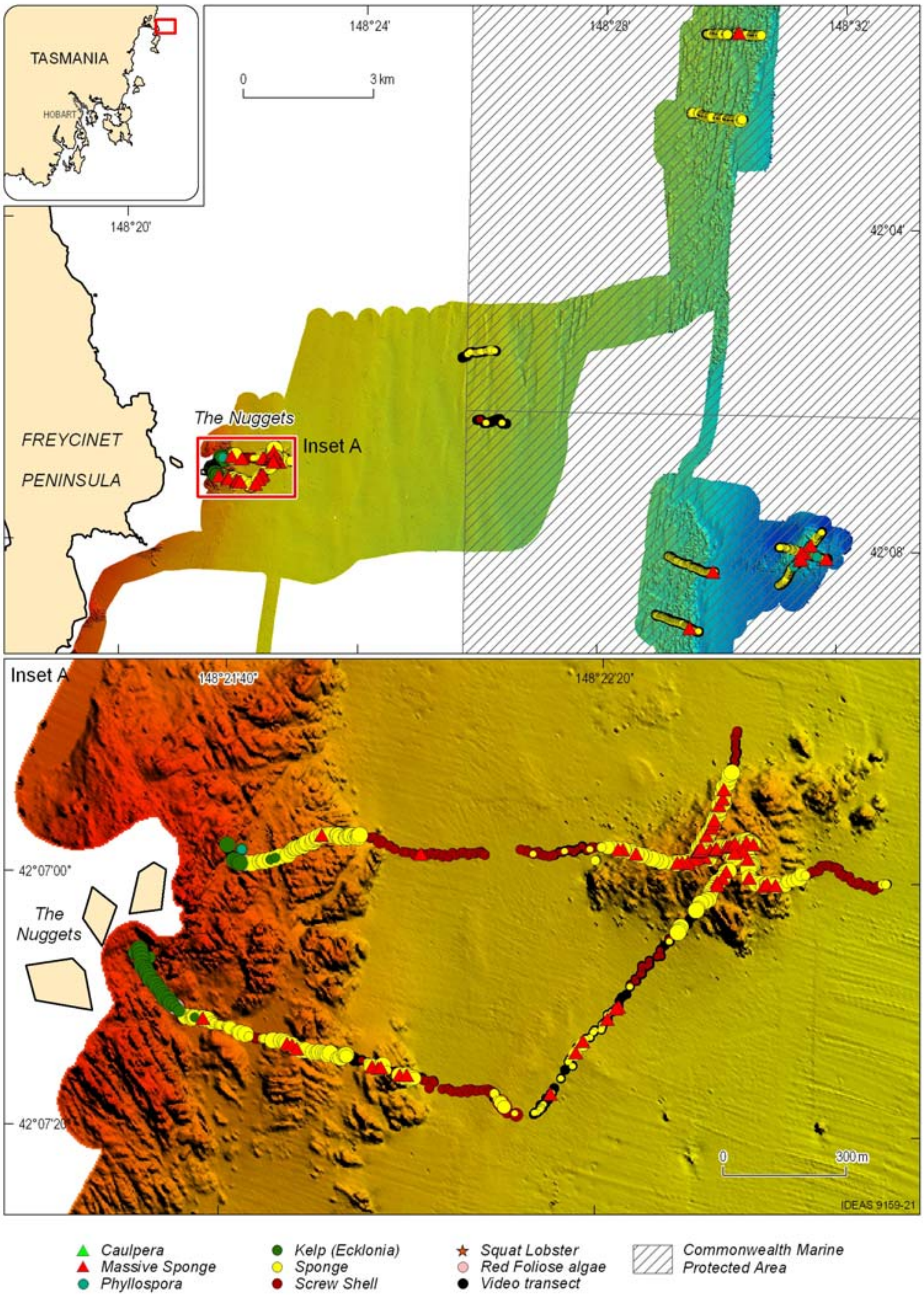


Figure 3.6: The spatial distribution of the main habitat-forming biota east of the Freycinet Peninsula, including The Nuggets (inshore) and the Freycinet Commonwealth MPA. Inset A shows an enlarged view of the biota types on the reefs around The Nuggets and on the isolated reef 600m east of The Nuggets. Circle size indicates percentage cover for kelp, sponge and screw shells, as follows: o 1-25%, o 26-50%, O 51-75%, O >75%.

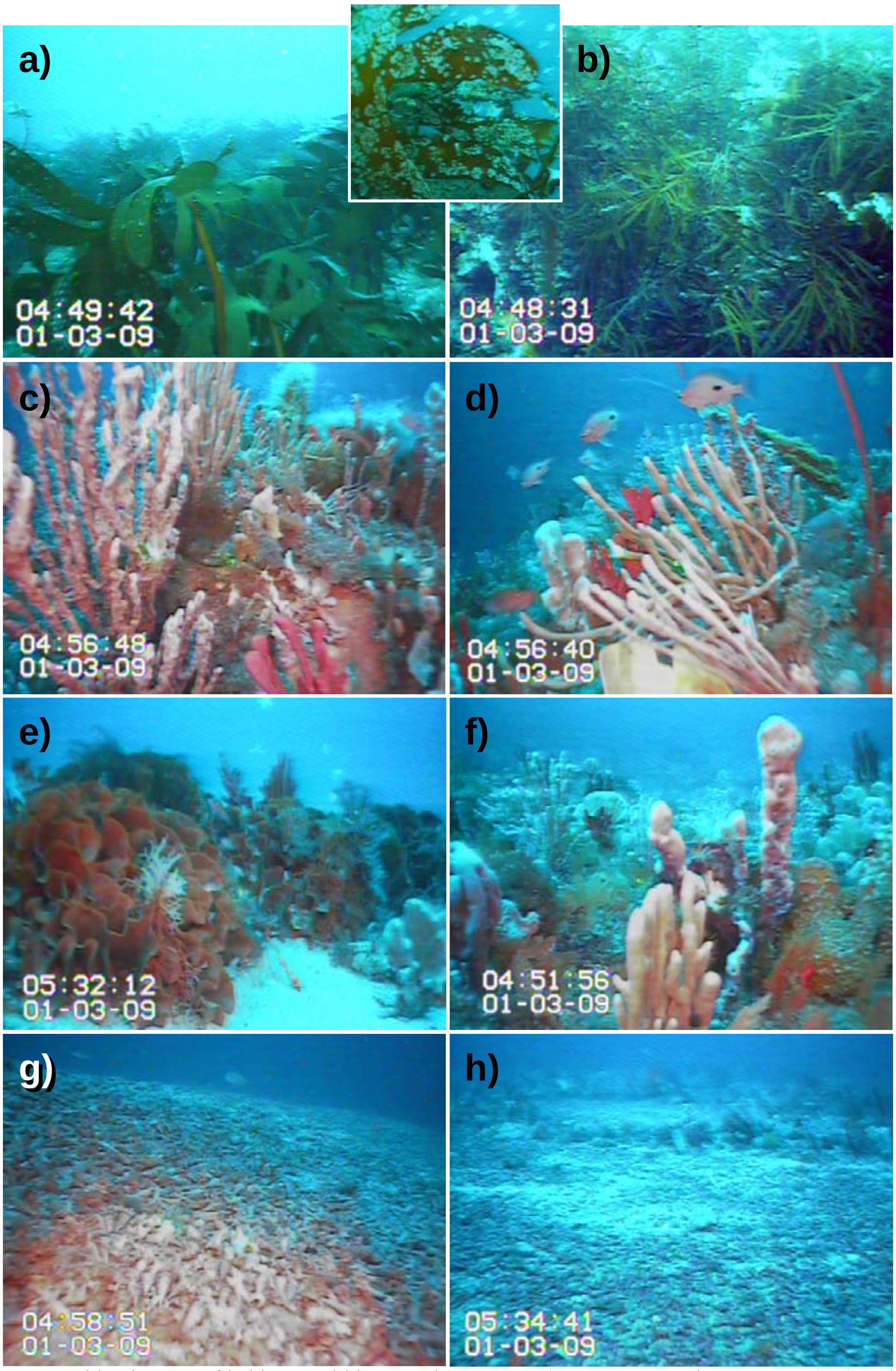


Figure 3.7: Video images of habitats and biota at The Nuggets (stn23cam26 and stn23cam27). a) *Ecklonia radiata* kelp forest (30 m) (inset shows necrotised, bryozoan covered *E. radiata* blades at 35 m); b) *Phyllospora comosa* in a discrete patch among *E. radiata* forest at 30 m; c-d) deep reef (40 m) densely covered in sponges, here featuring digitate sponges and butterfly perch; e) Patch reef habitat at the base of the Nuggets (60 m, stn23cam27) covered with large bryozoan colonies and sponges; f) deep sponge-dominated reef (~45 m, stn23cam26) with a diversity of growth forms; g-h) high density screw shell beds adjacent to the isolated reef east of the Nuggets.

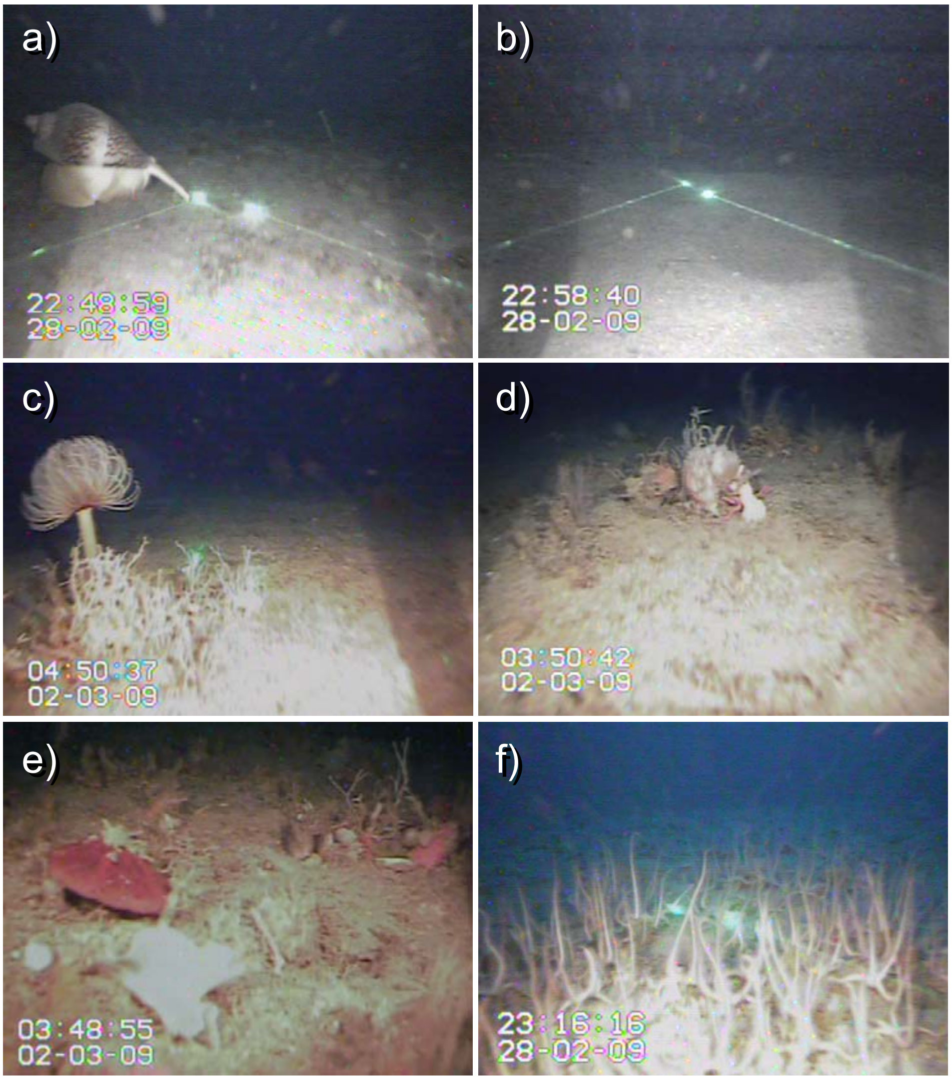


Figure 3.8: Video images of the habitats and biota of the Freycinet Commonwealth MPA. a) a giant volute (*Cymbiola magnifica*) and low densities of invertebrates (~80 m, stn19cam22); b) bare sand between reef structures (~85 m, stn19cam22); c) sabellid fan worm surrounded by unidentified invertebrates (~80 m, stn27cam35); d-e) sediment-covered-bedrock (~85 m) with low densities of invertebrates, including small sponges, hydroids and unidentified taxa (~75 m, stn26cam34); f) sediment-covered-bedrock covered by dense aggregations of filter feeding brittlestars (~80 m, stn28cam36).

3.4 THE FRIARS

The deep complex reefs surrounding The Friars were surveyed by eight video transects, each between 150-300 m in length. Four of the transects were surveyed across the reefs of the north Friars in water depths of 20-80 m, while the remaining four transects surveyed the reefs of the south Friars in water depths of 40-80 m (Fig. 3.9, Table 3.1). The reefs of both the north and south Friars were characterised by moderate to low relief rocky reefs (48% and 35% respectively) with a few high relief (7%) rocky areas located in the shallowest sections of the reefs. Soft substrata adjacent to the reefs comprised either sand rippled (9%) or flat sand (1%) habitats associated with sediment-filled gullies located between the lower sections of the reefs. However, the majority of transects surveyed in this region sampled habitats within the reef system, and did not traverse out onto the adjacent shelf sediments.

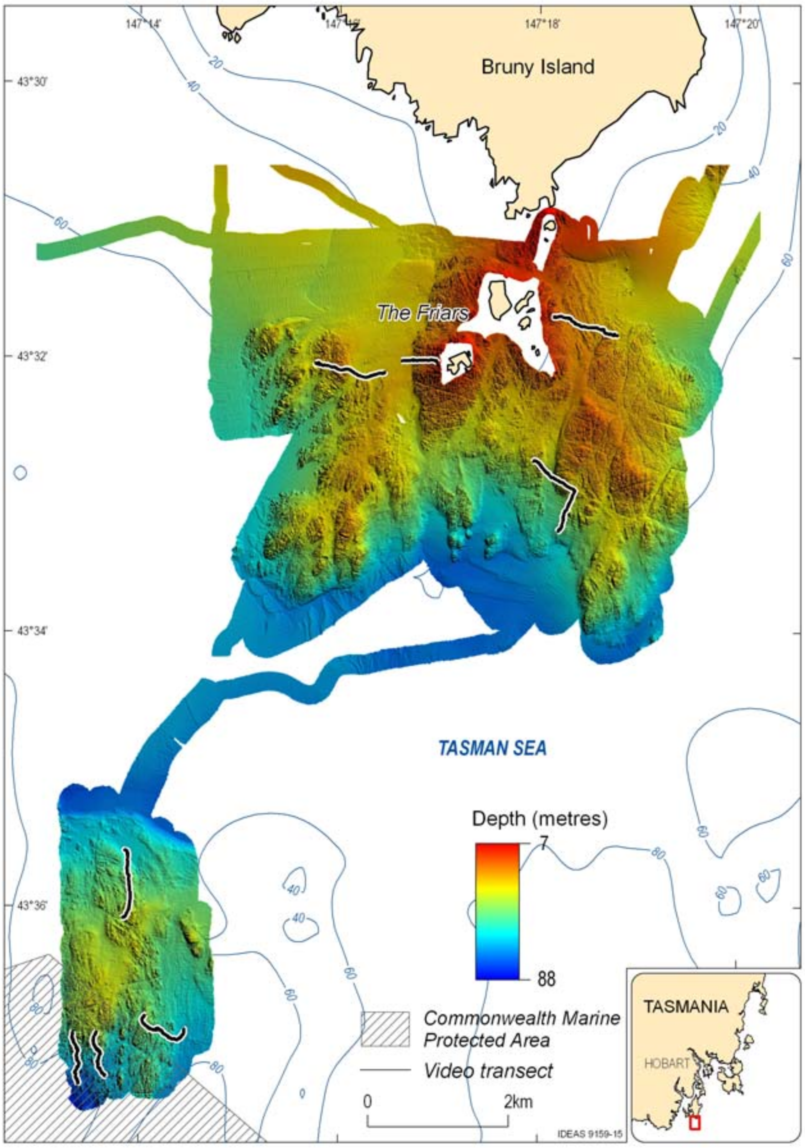


Figure 3.9: Location of towed-video transects in The Friars area, including four video transects in the north Friars, and four video transects in the south Friars with the two southern most transects located within the Huon Commonwealth MPA.

The northern reefs of The Friars, like those of the Fortescue area and The Nuggets, were also characterised by a similar depth zonation of kelp and sponge, although transects did not extend off the reefs so it is unclear whether screw shells occur adjacent to these reefs (Fig. 3.10, Fig. 3.11). The shallower sections of the north Friars reef (20-40 m) were characterised by moderate to low density *Ecklonia radiata* kelp forest (9% of The Friars locations). *Phyllospora comosa* was recorded, but occurs only rarely (1%) in these depths. Plant morphologies of *Ecklonia radiata* were highly variable, and may be shaped by the physical conditions they are subjected to (Schiel, 2003). *Ecklonia* plants around The Friars had longer and thinner blade morphologies than plants from the Fortescue and The Nuggets, and appeared to have a higher incidence of blade damage possibly due to higher wave energy in this exposed area. Understory kelp species were dominated by red foliose algae (19% occurrence in north Friars), with coralline paint (2%), *Caulerpa* sp. (1%), and sponges also recorded. Deeper parts of the reefs (> 40 m) were characterised by sponges (82% occurrence), in moderate (43%) to low (33%) densities. Although the sponge assemblages of the Friars were diverse and include a broad variety of growth forms, overall individual sponges were considerably smaller than those recorded in the Fortescue area, and were rarely found in high densities (10% of all Friars locations) (Fig. 3.11c-f; Appendix A.9). Amongst the sponge assemblage, sea whips (25%), foliose reds, and bryozoans (9%) were also recorded, but again, unlike the Fortescue region, no dense structure-forming taxa were recorded. The low-lying patchy outcrops at the base of the reef also supported low densities of small sponges.

The reefs of the south Friars were devoid of *Ecklonia radiata* kelp communities seen in the shallow regions of the north Friars (depths <40 m). However, the sponge-dominated assemblages of the deep reefs (> 40 m) in both the north and south Friars appeared similar both in their relief and in having moderately dense sponge assemblages that comprised diverse but small-sized sponges.

A variety of fish species was recorded at both the north and south Friars that were similar to those recorded at the Hippolyte Rocks. The most common and abundant fish species recorded was the butterfly perch (28% occurrence at north Friars, and 43% occurrence at south Friars), with low occurrences of Rosy Wrasse (7% north Friars, 1% south Friars). Other fish species recorded at the north Friars included the banded morwong (2%), the blue-throat wrasse (2%), and unknown leatherjackets, bastard trumpeter (*Latridopsis forsteri*) and jack mackerel (*Trachurus declivus*) (<1%); while species recorded at the south Friars included striped trumpeter and red cod (<1%).

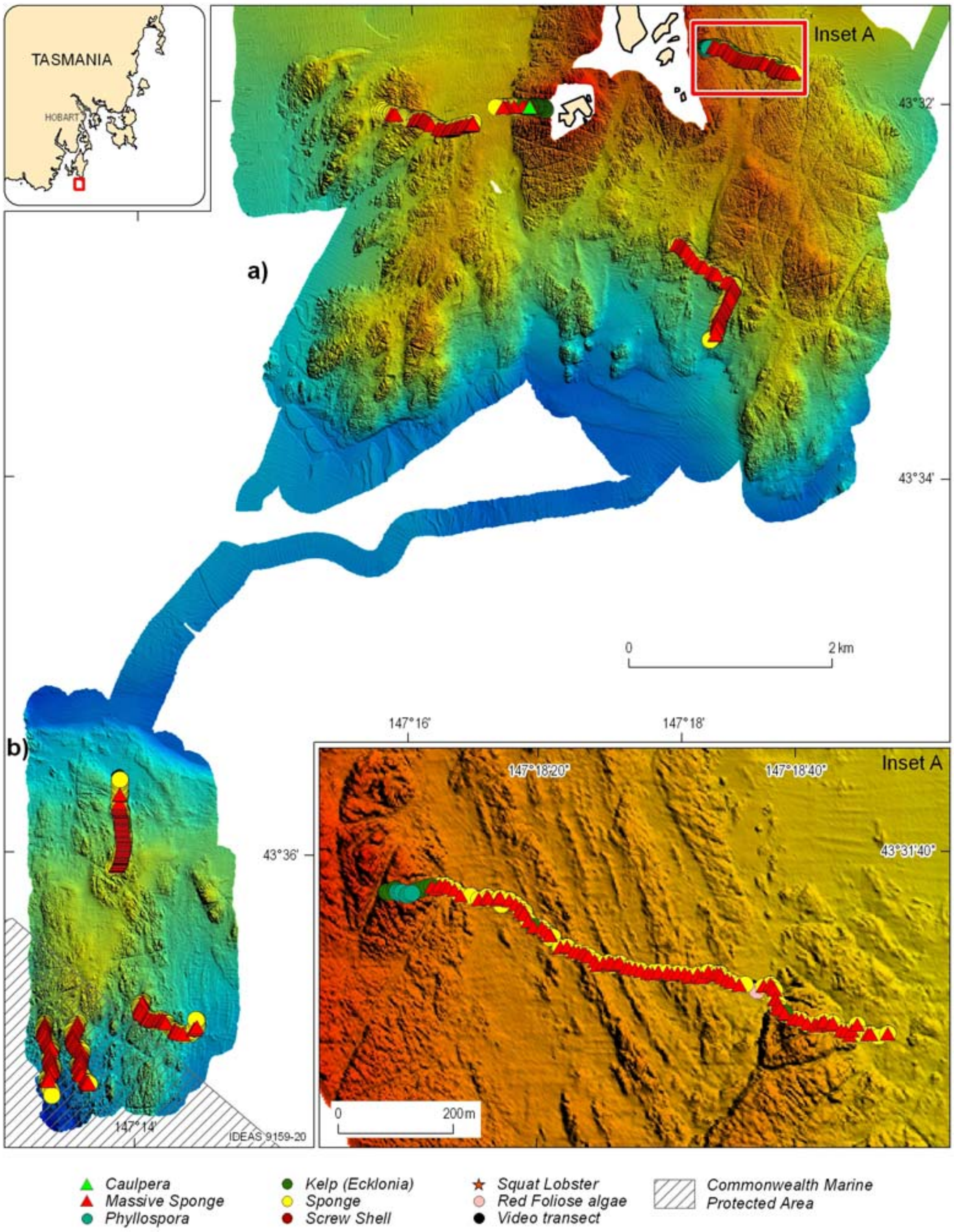


Figure 3.10: The spatial distribution of the main habitat forming biota on a) north and b) south reefs of The Friars survey area. Inset A shows an enlarged view of transect stn40cam51 on the north Friars reef. Circle size indicates percentage cover for kelp, sponge and screw shells, as follows: o 1-25%, o 26-50%, O 51-75%, O >75%.

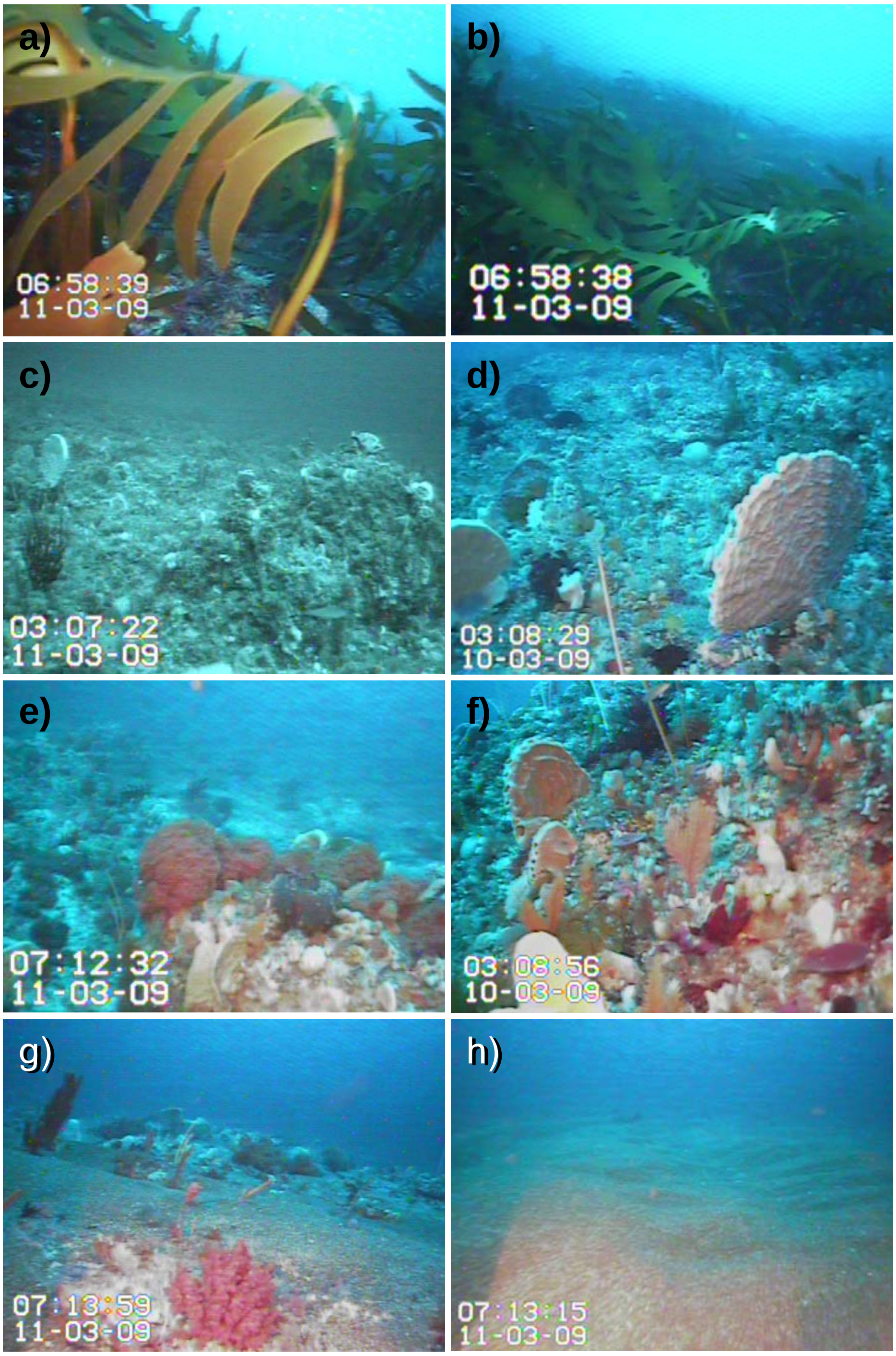


Figure 3.11: Video images of habitats and biota at The Friars. a-b) *Ecklonia radiata* forests with very long stipes and narrow blades (~20 m, stn40cam51); c-d) deep reefs of the south Friars (~50m, stn36cam47) with moderately dense sponge assemblages comprising diverse but mostly small-sized sponges; e-f) deep reefs of the nouth Friars with dense sponge assemblage interspersed with bryozoans (~60 m, stn40cam51) and sparse sea whips (~40 m, stn34cam44); g) transitional patch reef habitat at the base of the reef with sponges and bryozoans (~75 m, stn40cam51) ; h) coarse sand adjacent to the reefs (~70 m, stn40cam51).

3.5 HUON RIVER

Three video transects were surveyed at the Huon River site in the D'Entrecasteaux Channel, in water depths of 10-45 m (Fig. 3.12, Table 3.1). Three main habitat types were recognised for this area: Flat sandy habitats (49%) recorded on the terraces adjacent to the channel in water depths of 20-30 m; the deeper muddy channel habitat (45%) in 30-50 m water depths, and several discrete rock outcrops (6%) of mostly low to moderate relief (54% and 42% respectively) (Fig. 3.13).

A variety of biological habitats and biota were recorded along the three transects (Figs. 3.13, 3.14). The sandy terraces of the Huon River were characterised by bioturbation in the form of mounds and pits (77 and 76% respectively), moderate occurrences but low densities of introduced NZ shrew shells (10% cover in 46% of sand bank locations) and moderate occurrences of squat lobsters (*Munida gregaria*) (42% occurrence). The north Pacific seastar, *Asterias amurensis*, was also recorded in sandy sediments (16%) near rock outcrops. The deeper muddy channel have both higher levels of bioturbation (90% occurrence of both mounds and pits) and higher occurrences of squat lobsters (82% occurrence) than the adjacent sand terraces, but conversely had considerably fewer screw shells (12% occurrence) and no *Asterias amurensis*. Only two fish species, flathead (<2%) and numbfish (<1%), were recorded from these soft-sediment habitats.

Rocky outcrops and reefs within the Huon River were dominated by foliose red algae (73% of rock areas), and low densities of small sponges (67%) including digitate (46% of rock areas), encrusting (30%), fan (18%), and massive (12%) growth forms. The shallowest sections of the reef (10-15 m) were characterised by low to high density patches of *Ecklonia* (42%), while deeper reef areas (15-20 m) were often characterised by dense patches of *Caulerpa* species (21%) particularly around Zuidpool Rock. In comparison with coastal reefs the reefs within the Huon River were home to lower sponge biomass per unit area but conspicuously more foliose red algae and *Caulerpa* species. Like the reef-sand interface of the Hippolyte Rocks, but unlike the other reefs within the Huon River, the base of the reefs around Zuidpool Rock supported a dense patch of sea-whips (15% of rock areas). Fish associated with these reefs included the blue-throat wrasse (2% occurrence) and butterfly perch (1%).

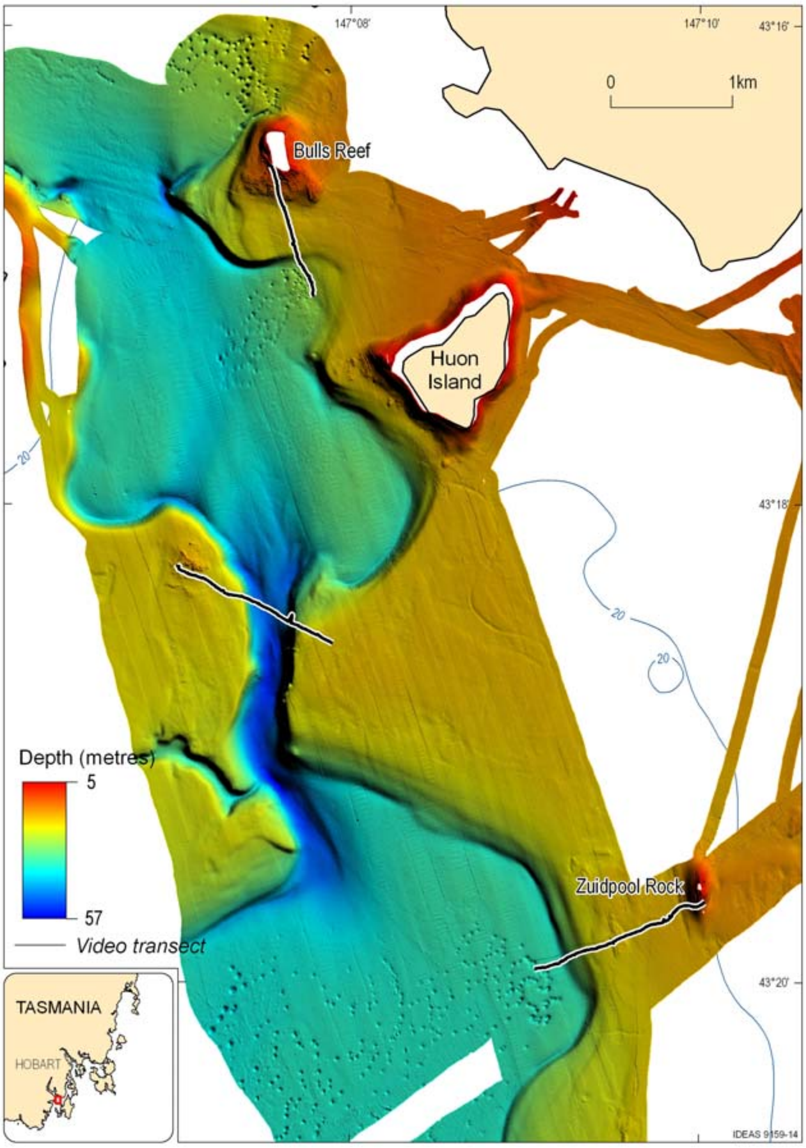


Figure 3.12: Location of the three towed-video transects in the D'Entrecasteaux Channel, Huon River.

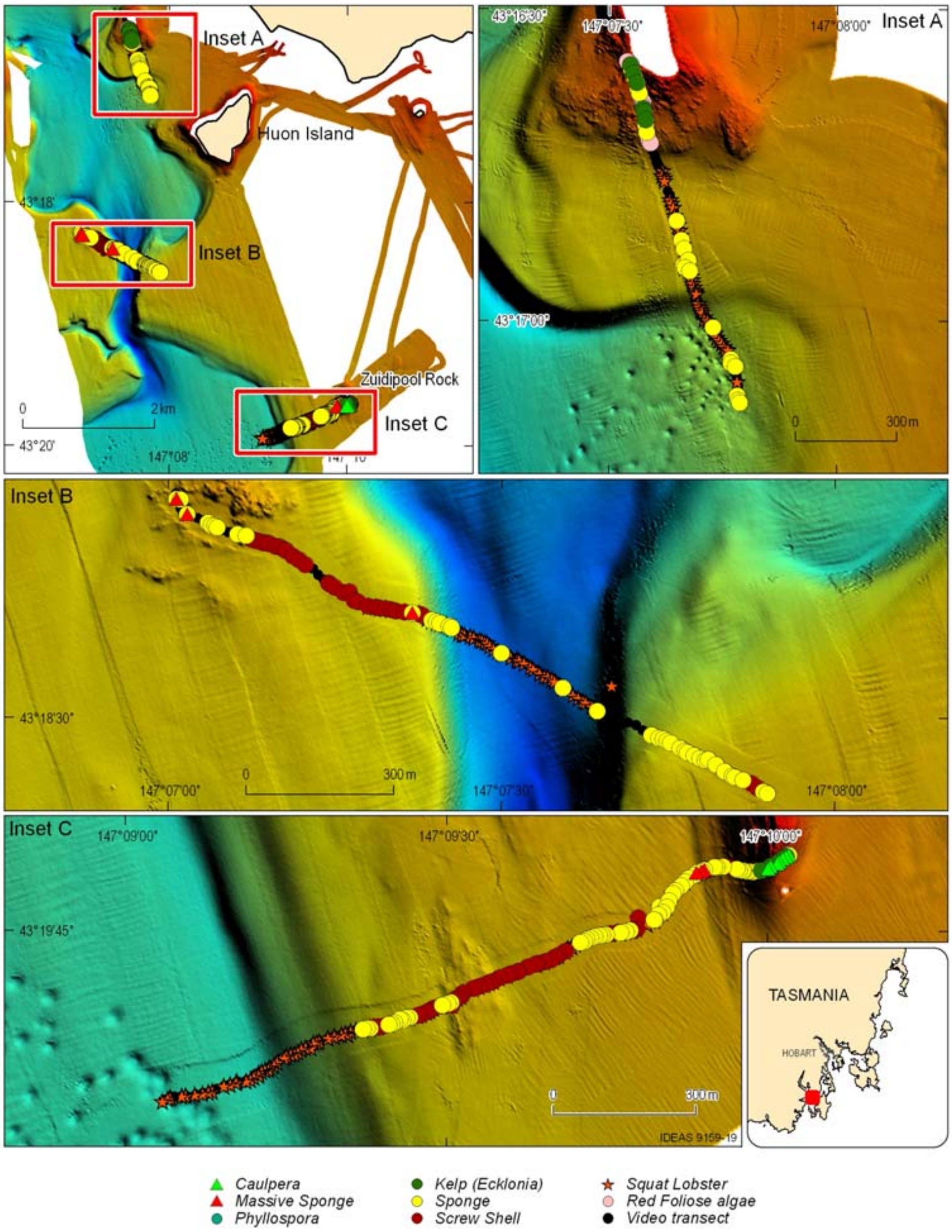


Figure 3.13: The spatial distribution of key biota in the D'Entrecasteaux Channel, Huon River. Inset A - stn41cam52 on the southern side of Butts Rock; Inset B - stn42cam53 traversing the Huon channel; Inset C - stn43cam54 on the southern side of Zuidpool Rock. Circle size indicates percentage cover for kelp, sponge and screw shells, as follows: o 1-25%, o 26-50%, o 51-75%, O >75%.

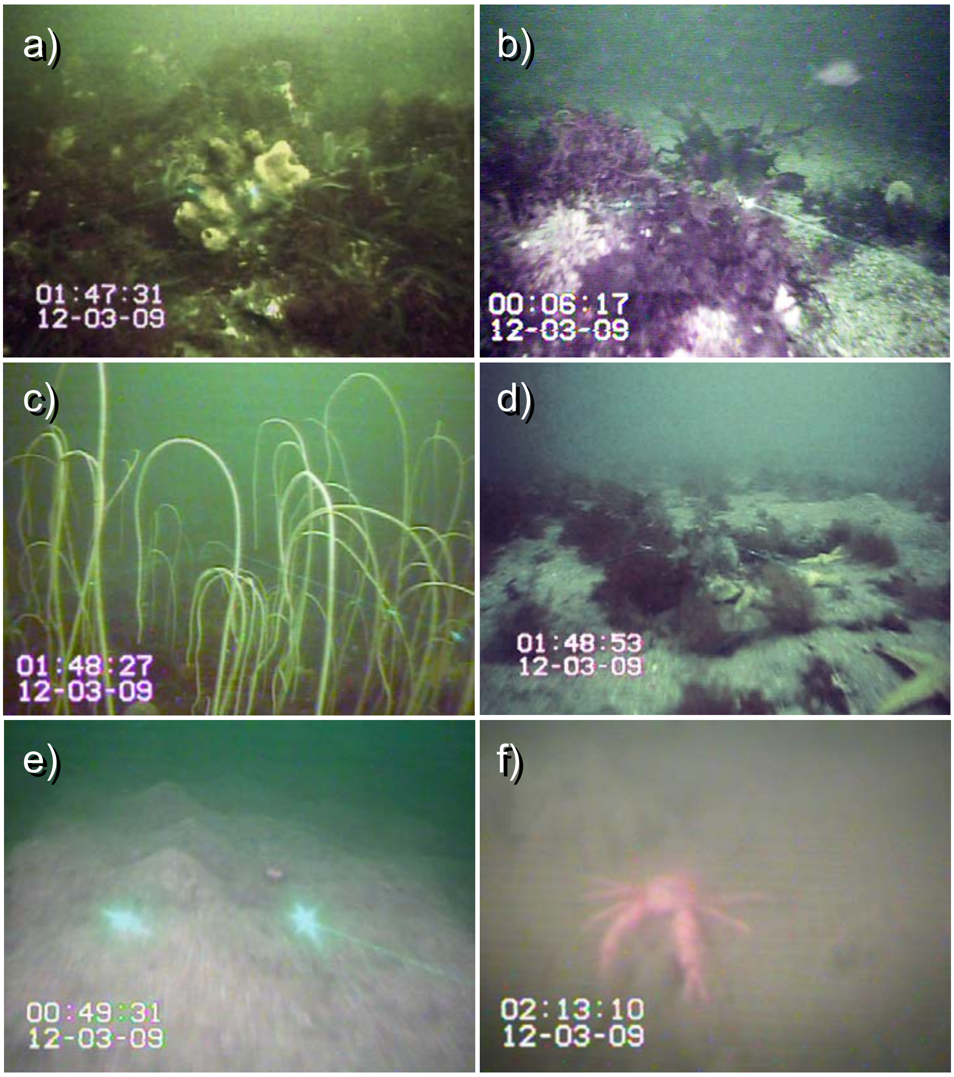


Figure 3.14 : Video images of habitats and biota of the D'Entrecasteaux Channel, Huon River. a) rocky outcrop covered with foliose red algae, *Caulerpa* sp., and sponges (~15 m, stn41cam52); b) base of outcrop covered with foliose red algae and sponges with drift algae on the adjacent coarse sands (~20 m, stn41cam52); c) edge of reef with dense sea whips and foliose red algae (~20m, stn43cam54); d) sand terraces adjacent to channel filamentous with patchy red alga and the introduced seastar, *Asterias amurensis*, (~25 m, stn43cam54); e) bare sand in the transition from the sand terraces into the palaeo channel of the Huon River (~30 m, stn42cam53); f) squat lobster (likely *Munida haswelli*) on the muddy seafloor of the palaeo channel (~45 m, stn43cam54).

3.6 PORT ARTHUR

Six video transects were surveyed within Port Arthur, in water depths of 15-30 m and an additional video transect was surveyed in water depths of 20-70 m on the south-western side of Black Rock - an isolated reef outside the Port Arthur (Fig. 3.15, Table 3.1). Within Port Arthur, sand was the most common substrata (52% of Port Arthur characterisations) present in mostly flat (55% of sandy sediments) or rippled (31%) bedforms, with hummocky/irregular bedforms (13%) less common, while sand waves (1%) were rare. Rock outcrop was the next most common substrata (43% of Port Arthur characterisations) and was associated with two outcrops, one long reef lying along the western flank of the channel, and a second smaller isolated reef near the mouth of the inlet (Fig. 2.8). These rocky outcrops were characterised by low (46% of rocky areas) to moderate (37%) relief rocky reefs with areas of high (11%) or flat (4%) relief less common. The remaining 5% of the seabed was characterised by shelly sediments mostly found adjacent to rocky outcrop areas.

Like the previous coastal and offshore areas, habitats within the Port Arthur region also reflect a depth zonation of kelp, sponge and screw-shell distributions, but these zones were less distinct and contain other, often dominant, biota such as red foliose algae and *Caulerpa* sp. (Fig. 3.16). Rocky outcrops within Port Arthur (except Black rock) occurred with a depth range of 15-40 m and were characterised by *Ecklonia radiata* kelp canopies (71% of the rock habitats) in a mixture of moderate (26%), low (25%), and high (20%) densities, foliose red alga (61%), low to moderate densities of sponges (50%), and *Caulerpa* sp. (33% of the reef), with rare occurrences of *Phyllospora comosa* (1%) in the shallowest sections of the reefs (i.e. 15-20 m). Deeper parts of these reefs (30-40 m) were characterised by diverse sponge assemblages that included fan and vase (26% combined), digitate (25% occurrence in reef habitats), massive (24%) and encrusting (4%) sponge growth forms in a mixture of high (36%), moderate (28%), and low (27%) density cover. Crinoids (*Chinolia trichoptera*) were also common over much of the reef (27% of reef characterisations); with bryozoans (4%) and sea whips (2%) also recorded. Fish associated with the reef included butterfly perch (12% of reef characterisations), rosy wrasse (8%), and the blue-throat wrasse (3%), jack mackerel (2%); while other species recorded included leatherjackets, bastard trumpeter, banded morwong, cale fish, senator wrasse, and skate (<1%). Shell habitats, which surrounded the reef, were characterised by drift algae and rare occurrences of sand-associated (e.g. flathead) and reef-associated species (blue-throat wrasse) (<2%).

Sand habitats within Port Arthur were characterised by patchy drift algae (69% occurrence within sand habitats), bioturbation including pits and mounds (57% and 54% occurrence respectively), screw shells (36% occurrence in ≤10 % cover), the 11-armed starfish (*Coscinasterias muricata*) (10% occurrence), and rare occurrences of echiurans (*Ikeda* sp.) (6%), scallops (*Pecten fumatus*) (1%), sea pens and sea whips (≤1%). Fish associated with sandy sediments include flathead (2%), half-masked and sparsely-spotted stingaree (<2%).

Black Rock

A single video transect (stn32cam42) was surveyed on the south-west side of Black Rock., located 1.5 km south-west of Port Arthur inlet (Fig. 3.17). The rocky reef, which comprised 89% of the area surveyed, was characterised by high relief (36% of all Black rock locations) and steep sloping bedrock in the shallows closest to Black Rock, with more moderate (32%) to low (21%) relief bedrock in the deeper sections of the reef, while the base of the reef was intersected by rippled sand gullys (11%). The shallow high-relief areas of the reef were characterised by *Ecklonia radiata* kelp (9%) and occasional patches of *Caulerpa* (2%). Deeper sections of the reef (40-70 m) were characterised by sponges (42%) and bryozoa (9%). This deep sponge assemblage occurred in high (24%), moderate (11%) and low (7%) density cover and included fan and vase (41 % combined), digitate (39%), massive (19%) and encrusting (2%) sponge growth forms. Fish species included perch (13%), jack mackerel (9%), rosy wrasse (5%), with leatherjackets, bastard trumpeter, the blue-throat wrasse, and banded morwong also recorded in low numbers (<3%).

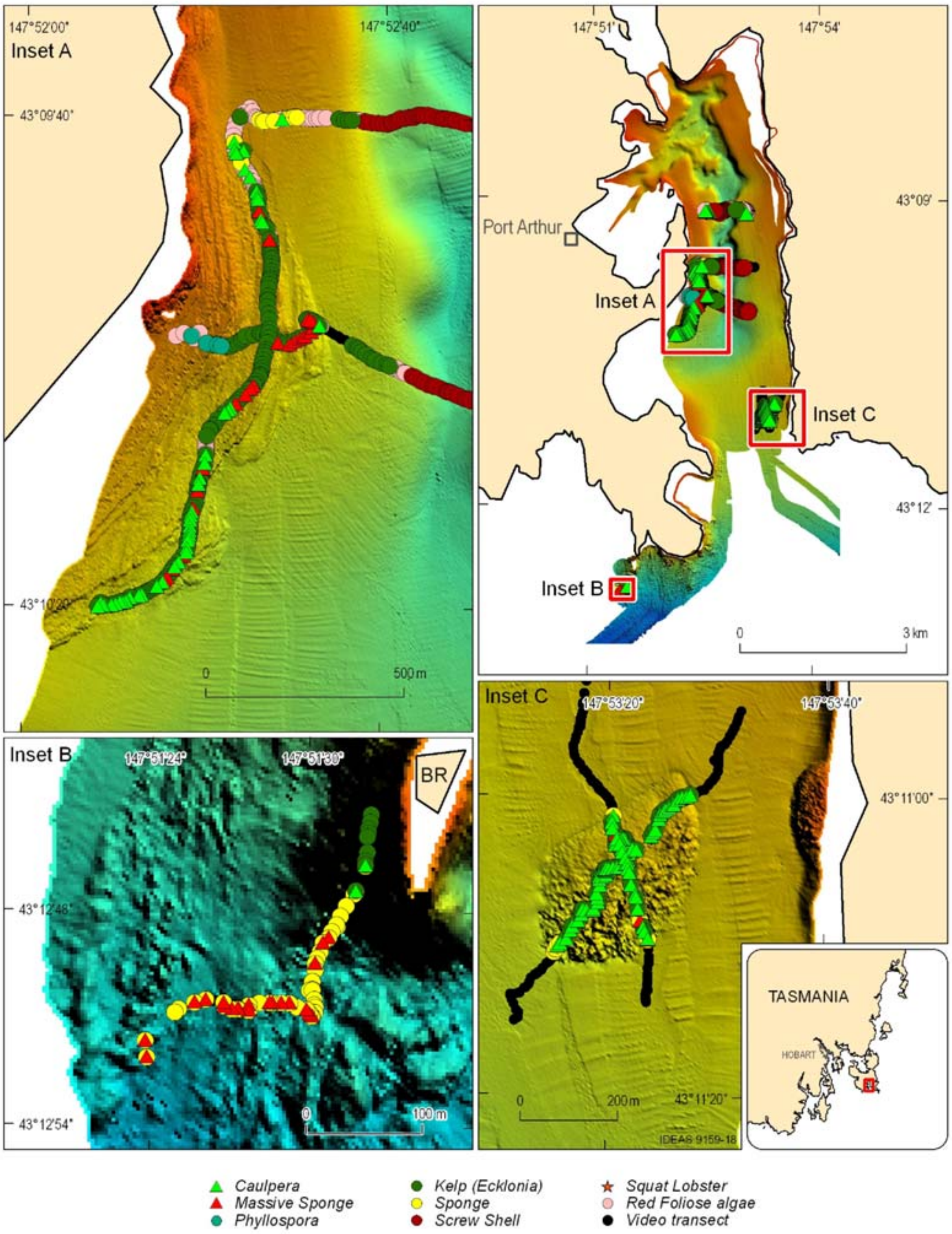


Figure 3.15: The spatial distribution of the main habitat forming biota in Port Arthur. Inset maps show enlarged views of reef biota; A) reef on the western flank of the channel; B) reef on the south-western side of Black Rock (BR); C) isolated reef at the entrance. Circle size indicates percentage cover for kelp, sponge and screw shells, as follows: o 1-25%, o 26-50%, O 51-75%, O >75%.

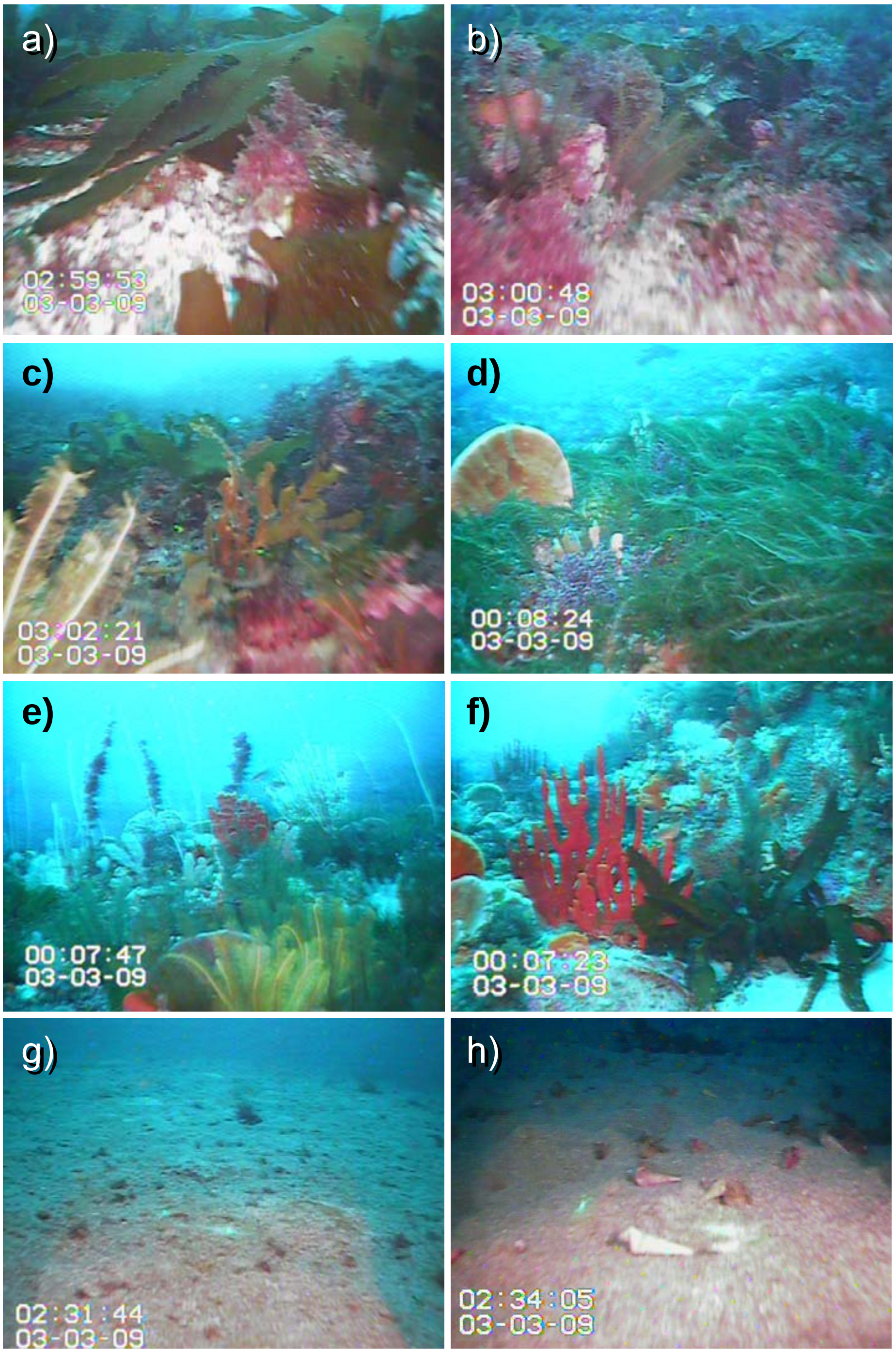


Figure 3.16: Video images of habitats and biota within Port Arthur inlet. a) reef along the western flank of the inlet with *Ecklonia radiata* kelp forest and understorey foliose red algae (~15 m, stn30cam41); b-c) western reef with foliose red algae interspersed by kelp and crinoids (~20 m, stn30cam41); d) entrance reef densely covered in *Caulerpa* sp. and sponges (~30 m, stn29cam37); e-f) entrance reef densely covered in suspension feeding assemblages including sponges, sea whips and crinoids (~30 m, stn29cam37); g-h) sand terraces at the margin of the channel with low densities of screw shells (~30 m, stn30cam39).

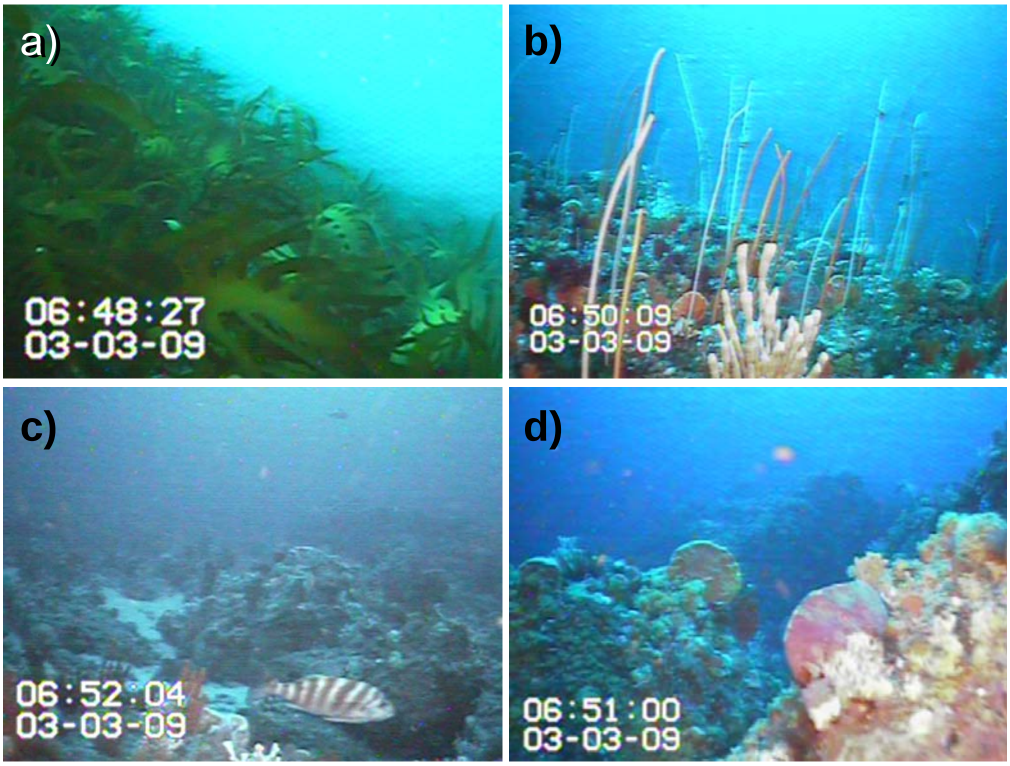


Figure 3.17: Video images of habitats and biota at Black Rock (stn32cam42). a) dense *Ecklonia radiata* kelp forest (~20 m); b) reef slope densely covered by suspension feeding invertebrates dominated by sponges and interspersed by sea whips (~40 m); c) deep reef with moderate densities of sponges and small sand channels and banded morwong (*Cheilodactylus spectabilis*) (~60 m); d) deep reef with moderate relief and high densities of suspension feeding assemblages dominated by sponges and bryozoans (~60 m).

3.7 SUMMARY

Towed-video provides an excellent method to both ground-truth multibeam data (bathymetry and backscatter intensity) and to characterise finer-scale benthic habitats and biota (~1 m), and will be combined with other datasets to examine bio-physical relationships. In this survey, large linear areas of seafloor were video-taped and characterised from five areas encompassing a total of 10 locations spanning Freycinet Peninsula in the north to The Friars in the south. Within these areas, a range of benthic habitats was identified. Temperate reefs, which were the primary focus of the survey, were found to vary dramatically between areas, from the high-relief steep-sloping bedrock of The Hippolyte Rocks to the low-lying sediment-covered-bedrock of the Freycinet MPA, as well as transitional patch reef habitats at the base of reefs, and shelf sediments. Transitional patch-reef habitats were also recorded at the reef-sand interface around the base of well defined reefs, such as the reefs surrounding The Hippolyte Rocks. Shelf sediments were also surveyed, and while homogenous sand flat areas were recorded away from the reefs, a variety of sand wave and rippled habitats were often recorded in and around the reefs themselves. Biological habitats were also diverse with several distributional patterns recorded. The most dominant pattern was of a strong depth zonation, with a kelp forest zone (dominated by *Ecklonia radiata*) in water depths < 45 m which quickly transitioned into a sponge-dominated deep reef zone (reef depths > 45 m). Beyond the reef, shelf sediments were littered with screw shells and where present in high densities provided hard substrata for a range of suspension-feeding invertebrates. Although this depth pattern was very consistent between locations, some differences were observed. For example, differences in the level of physical exposure between locations appeared to influence the density and structure of these zones. Kelp morphologies were thinner and longer in more exposed sites (e.g. The Friars), while sponges were less dense and smaller in size. Screw shells, which occurred extensively over shelf sediments and within the sheltered inlets and channels of the Huon and Port Arthur, varied in their density between locations, with the densest beds recorded in the north off the Nuggets, while few screw shells were recorded in areas of higher wave energy (e.g. around The Friars) and where the substratum was muddy (e.g. Huon channel).

4. Summary and Future Work

The Marine Biodiversity Hub has collected high resolution bathymetry data and video footage across targeted areas of reef habitat and adjacent seabed on the nearshore and shelf of southeastern Tasmanian. The mapped areas of reef represent a range of physical settings, from exposed high wave energy conditions at The Friars and Hippolyte Rocks to sheltered estuarine environments in the Huon River Estuary and Port Arthur. In addition, differences in local geology between the study sites have produced contrasts in reef morphology; notably high relief dolerite and granite reefs and low relief sandstone reefs that extend from headlands.

In future work, the morphological characteristics of reefs in the study area will be quantified by a range of metrics, including slope, relief, rugosity and surface curvature, among others. These parameters will in turn be used to test for co-variance with spatial and bathymetric patterns in reef biological assemblages, as defined by the video characterisations. This analysis for co-variance will also consider variations in reef biological communities that may be a function of different energy regimes, as provided by the differing degrees of wave exposure that exists between the study sites.

This research will contribute to our understanding of the spatial distribution of biological communities that exist on temperate reefs, and allow for an assessment of the strength of association of these communities with a range of physical characteristics of reef habitats. Significantly, this assessment will incorporate a statistical measure of the degree to which derived physical parameters can be used as surrogates to map and model these patterns of marine biodiversity. In turn, these outputs can be used to better inform the management of similar temperate shallow rocky marine systems elsewhere in Australia.

5. Acknowledgements

This work has been funded through the Commonwealth Environment Research Facilities (CERF) programme, an Australian Government initiative supporting world class, public good research. The CERF Marine Biodiversity Hub is a collaborative partnership between the University of Tasmania, CSIRO Wealth from Oceans Flagship, Geoscience Australia, Australian Institute of Marine Science and Museum Victoria.

We acknowledge and thank those who contributed to the success of the Marine Biodiversity Hub southeast Tasmanian temperate reef field survey. In particular, we thank all those who participated in field surveys (listed in Table 1.1), including: the Master of the *RV Challenger* Matthew Francis and mate Jack Gibson; Ian Atkinson, Stephen Hodgkin, Craig Wintle, Andrew Hislop, Ray DeGraaf, and Matt Carey of Geoscience Australia's Field and Engineering Support for survey preparation, production, installation and management of survey equipment, and field logistics; Cameron Buchanan, Ian Atkinson, James Daniell and Michele Spinoccia from GA for multibeam acoustic data collection and processing; Mike Sexton for pre-survey multibeam acoustic processing prior to the second survey; Gerry Hatcher (US Geological Survey) for GNav software assistance and trouble shooting; Nicole Hill, Justin Hulls, Vanessa Lucieer and Jan Seiler (University of Tasmania) for their assistance on the vessel and background knowledge of the Tasmania Shelf; Stefan Williams, Oscar Pizarro, Michael Jakuba, Duncan Mercer and George Powell (University of Sydney's Australian Centre for Field Robotics) for field operation of the Autonomous Underwater Vehicle and Tim O'Hara (Museum Victoria) for advice on brittlestar taxonomy. We would also like to thank Rebecca Jeremenko and Kathy Elliott for their assistance with travel and pre-survey logistics, and Anna Potter for GIS support. Figures were prepared by Murray Woods (GA). Satellite images used in maps are from Google Earth. Alix Post, Martyn Hazelwood (GA) and Nic Bax (CSIRO) provided helpful reviews of this report.

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Appendix A: Autonomous Underwater Vehicle Deployments

During the development of the research plan for Marine Biodiversity Hub multibeam sonar surveys in southeastern Tasmania, an opportunity arose to trial an autonomous underwater vehicle (AUV) (Fig. A.1). The AUV is part of the Integrated Marine Observing System (IMOS) AUV Facility operated by The Australian Centre for Field Robotics (ACFR) at The University of Sydney, led by Dr Stefan Williams. The AUV *Sirius* is able to obtain high resolution multibeam sonar and spatially rectified fine-scale stereo still photographs of the seafloor, providing the opportunity to image fine-scale habitat features and count individual benthic fauna and flora. Data collected by AUV can therefore facilitate the examination of biological complexity and physical surrogacy at a scale finer than possible with towed-video.

The aims of the AUV survey were to: i) examine the fine-scale relationships between the marine flora and fauna and the physical nature of these seabeds,; ii) compare data collected at different scales as collected by the AUV, towed-video and multibeam, and; iii) integrate the three scales to examine the use of physical surrogates in predicting marine assemblages within temperate rocky reef systems.

Figure A.1: Deployment of Autonomous Underwater Vehicle *Sirius* from R.V. Challenger.

A successful funding application was made to IMOS for access to this facility and the AUV was deployed in Tasmanian waters for two dedicated AUV surveys during October 2008 and May 2009. The two AUV surveys were undertaken in the same areas as the multibeam and towed video survey on the University of Tasmania's research vessel, the R.V. Challenger. The first survey in October 2008 targeted the coastal and offshore reefs of the Fortescue and Port Arthur areas, while the second survey in April 2009 targeted the reefs in and out of the Freycinet and Huon Commonwealth MPA's and the Huon/D'Entrecasteaux Channel. The overall survey design was based on achieving representative coverage of the range of habitat types and depths initially planned to be tested within the Surrogates project, as well as obtaining sufficient spatial coverage to add generality to the observed towed-video patterns. The location of each AUV mission was nested within the broader-scale EM3002 multibeam and towed-video surveys, while the pre-programmed grid path run during each mission was a compromise between the intersecting-grid type design that allows for multiple crossing of the primary track and is essential for geo-referencing the AUV's position, and the need to sample the variability within and between depth zones and locations. During each mission, high-resolution multibeam and photographic imagery were collected 2-3 m above the seafloor along a 1-10 km pre-programmed grid path. Multibeam bathymetry was collected using a Imagenex 837 DeltaT Profiling 260 kHz system, flown at 2 m above the seabed providing a 4 m wide swath. Bathymetry and backscatter data were gridded to 10 cm resolution at the ACFR. Photographic images were taken every second along the seafloor using a stereo camera system with approximately >40% overlap to enable photographic images to be combined as a mosaic and provide a continuous interwoven 2-3 m wide image of the seafloor along the path of the mission (Fig. A.2). In order to correctly mosaic seabed imagery, geo-located photographs were processed using SLAM image-recognition software whereby identical features seen in sequential photographs were aligned and stitched together. The same technique was used to align the multiple cross tracks of the grid so that identical features seen on intersecting tracks were also aligned and stitched together to create a single mosaic image for the entire trackline.

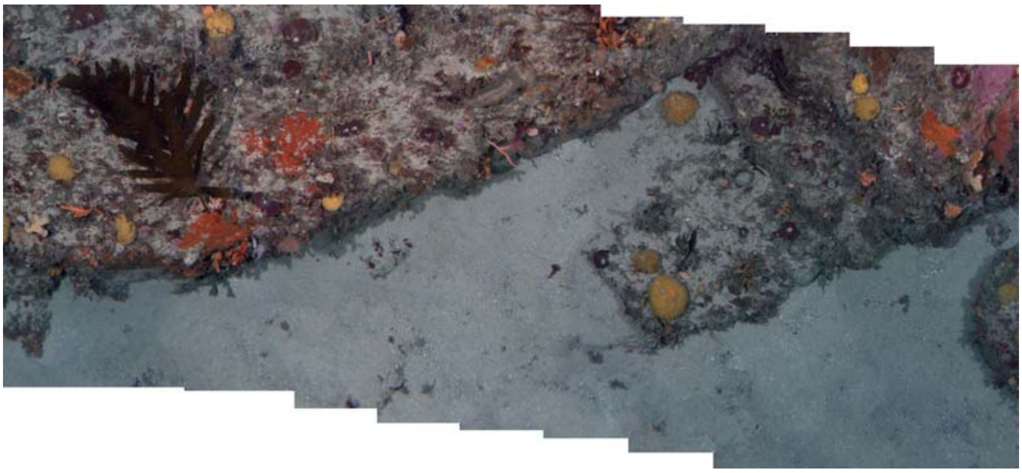

Figure A.2: Composite mosaic of AUV derived images from 60 m water depth offshore from Waterfall Bluff, Tasman Peninsula.

AUV Survey October 2008

The first survey was undertaken from the 6-16 of October 2008, and began within a series of AUV missions to test the ability of the AUV to be deployed and operated in the exposed coastal environments of eastern Tasmania. A combination of good weather and careful vessel operation ensured the safe deployment and retrieval of the AUV, and meant that a greater number of data-collecting missions were completed. Coastal currents stronger than 1 knot were also identified as an impediment to mission success due to the inability of the AUV to maintain course heading or speed over the seafloor; while elevated water turbidity can reduce the value of both the multibeam and photographic data. However, neither water turbidity nor current strength impeded data collection during this or the subsequent survey. Overall, the AUV was highly effective at operating both in these coastal environments and over the potentially hazardous rocky terrain of the deep reef habitats.

Following initial testing, data-collecting missions were undertaken in the Tasman Peninsula area (Fig. A.3). First, five AUV missions were undertaken on the coastal reefs along the Fortescue coast (High Yellow Bluff, Deep Glen Bluff, Blowhole, Waterfall Bluff, and O'Hara Bluff) spanning water depths of approximately 18 - 60 m and extending from the coastal reef out over the adjacent shelf sediments. Second, six missions were undertaken around the Hippolyte Rocks, with one mission over Deep Reef - located 3 km north of Hippolyte Rocks in 80 m water depth. As survey outcomes exceeded expectations, additional missions were undertaken in Port Arthur and in the Huon River.

At Port Arthur, two successful AUV missions were undertaken, the first on an isolated patch reef and associated sediments at the mouth of the Port, and the second across the deep sedimentary basin within the channel (Fig. A.4). In the Huon River the last two days were used to survey the drowned river channel, as well as the rocky reef and pothole features (possibly 'seeps') near Butts Reef (Fig. A.5). Due to poor visibility near Butts Reef, a second attempt was made to survey the seabed from Zuidpool Rock westwards across the river channel. Imagery collected on this mission in water depths less than 20 m was of moderate quality, but water quality became exceedingly worse as the AUV progressed into the deeper water of the channel. The survey terminated at this stage as poor weather and water clarity restricted further operation.

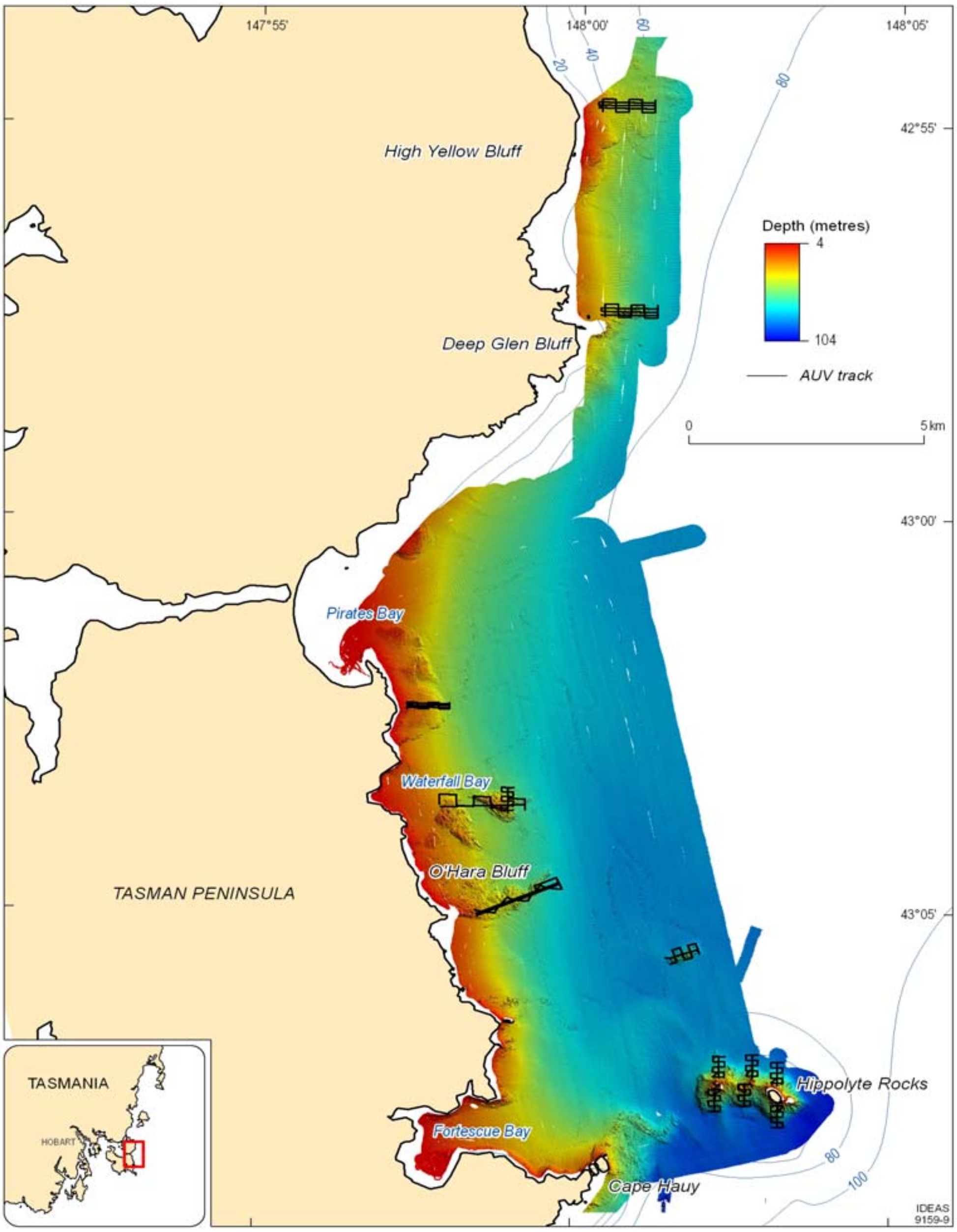

Figure A.3: Location of AUV tracks in the Tasman Peninsula survey area.

AUV Survey May 2009

The second AUV survey was undertaken during the period 4-14 May 2009 at sites inside and outside of the Freycinet and Huon Commonwealth MPAs. As with the first survey, AUV missions were nested within the broader-scale EM3002 multibeam bathymetry and intermediate-scale towed-video surveys. For the Freycinet MPA region, a total of five missions were undertaken, with one mission undertaken inshore on the reef adjacent to The Nuggets, and four offshore across the low-lying reefs of the Freycinet MPA (Fig. A.6). For the Huon MPA region, four missions were undertaken across the mapped section of reef in the south Friars. Three missions were undertaken within the Huon MPA, while the fourth was undertaken immediately north of the MPA boundary (Fig. A7). All missions were successfully completed ahead of schedule. An additional 15 AUV missions were surveyed in the soft sediment areas near Isle Du Phoques and on coastal reef near St Helens as part of University of Tasmania research programs (scallop and *Centrostephanus* urchin projects) unrelated to Marine Biodiversity Hub research.

Image processing

Multibeam bathymetry and stereo imagery were successfully collected from all Marine Biodiversity Hub priority locations. The stereo photographs collected from both surveys have been processed by the Centre for Field Robotics (ACFR) team, with the stereo photographs along the grid-pattern of each mission now in a mosaic. These mosaics of the seabed can be viewed in 3-dimensions using OSG-Sight software.

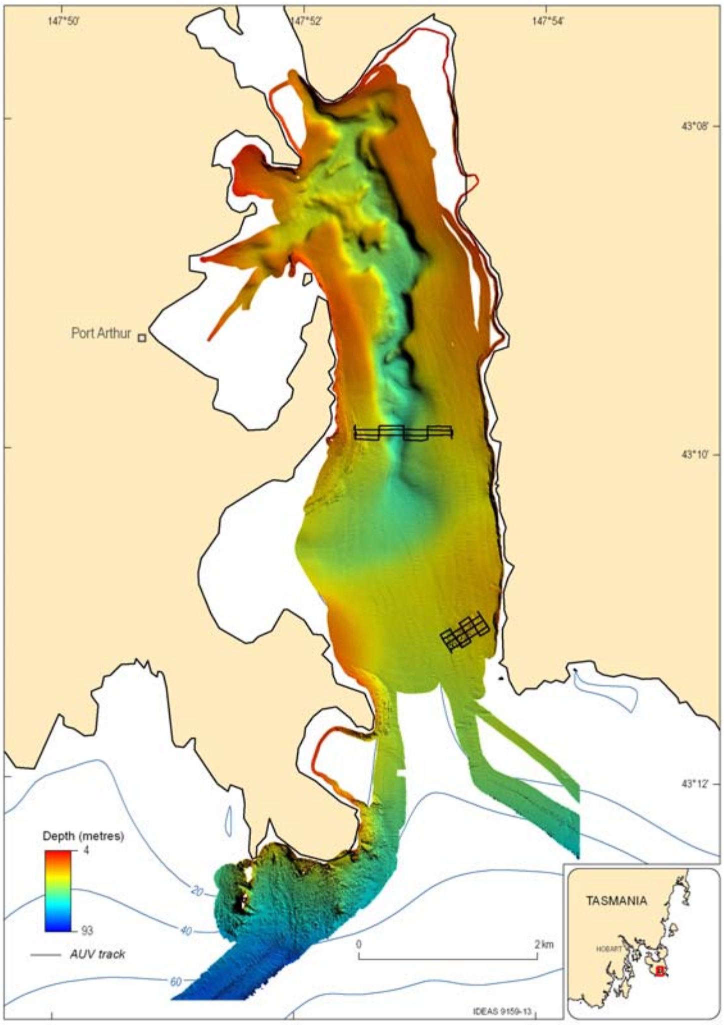

Figure A.4: Location of AUV tracks in Port Arthur.

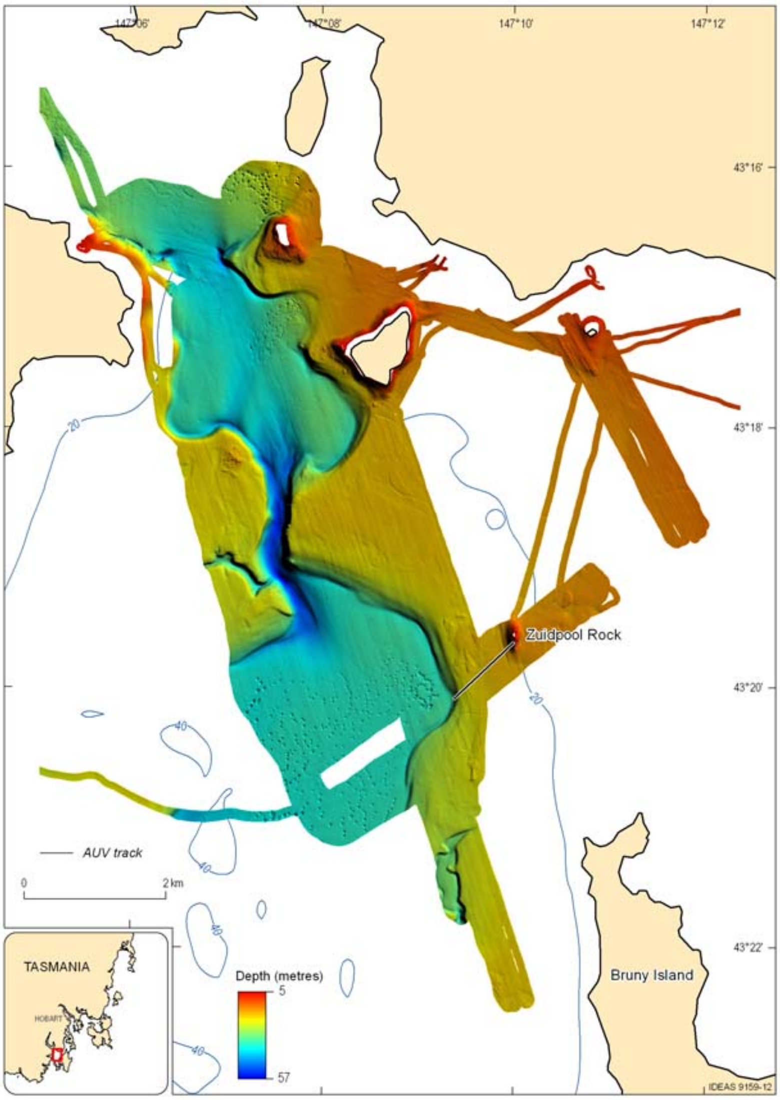

Figure A.5: Location of AUV track to southwest of Zuidpool Rock in the Huon River survey area.

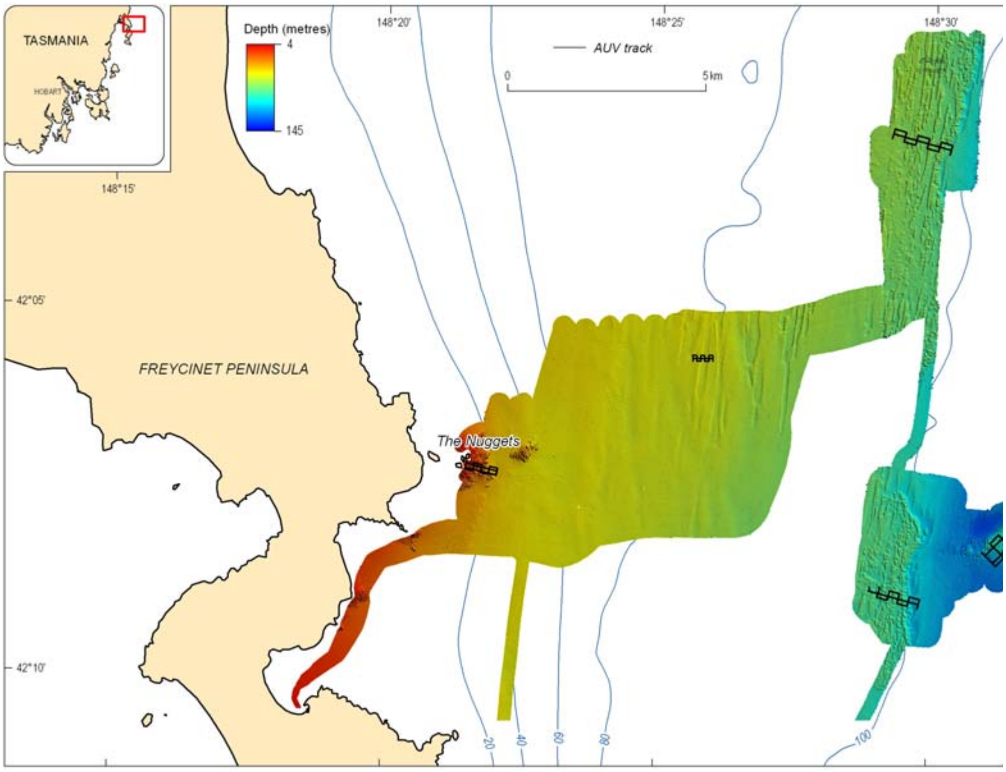

Figure A.6: Location of AUV tracks in the Freycinet Peninsula survey area.

The field robotics team in collaboration with researchers from Geoscience Australia and the University of Tasmania are currently working towards comparing the broad-scale EM3002 imagery with the fine-scale bathymetry collected by the AUV. Biological data will be post-processed in two ways. First, as part of a Marine Biodiversity Hub PhD project undertaken by Jan Seiler, the number of large mobile invertebrates (urchins, seastars, lobsters etc) and fishes is currently being scored from each non-overlapping AUV image (i.e. every 10th image) from selected missions to determine the occurrence and distribution of large motile species relative to bathymetric features and physical setting. Second, the AUV stereo imagery from all missions will be processed during October to March 2010 using the freely available Coral Point Counts software (CPCe, Kohler and Gill, 2006). Photographs will be scored to obtain percentage cover of substrata and biota types, while key taxa will be counted. The number of photographs processed will be a compromise between attaining adequate replication for each habitat type, depth zone and location, while still being able to be processed within the time limits of the project. The methodologies used to process AUV data are expected to produce finer-resolution patterns that will also be directly comparable with the broader-scale data obtained by Geoscience Australia and CSIRO.

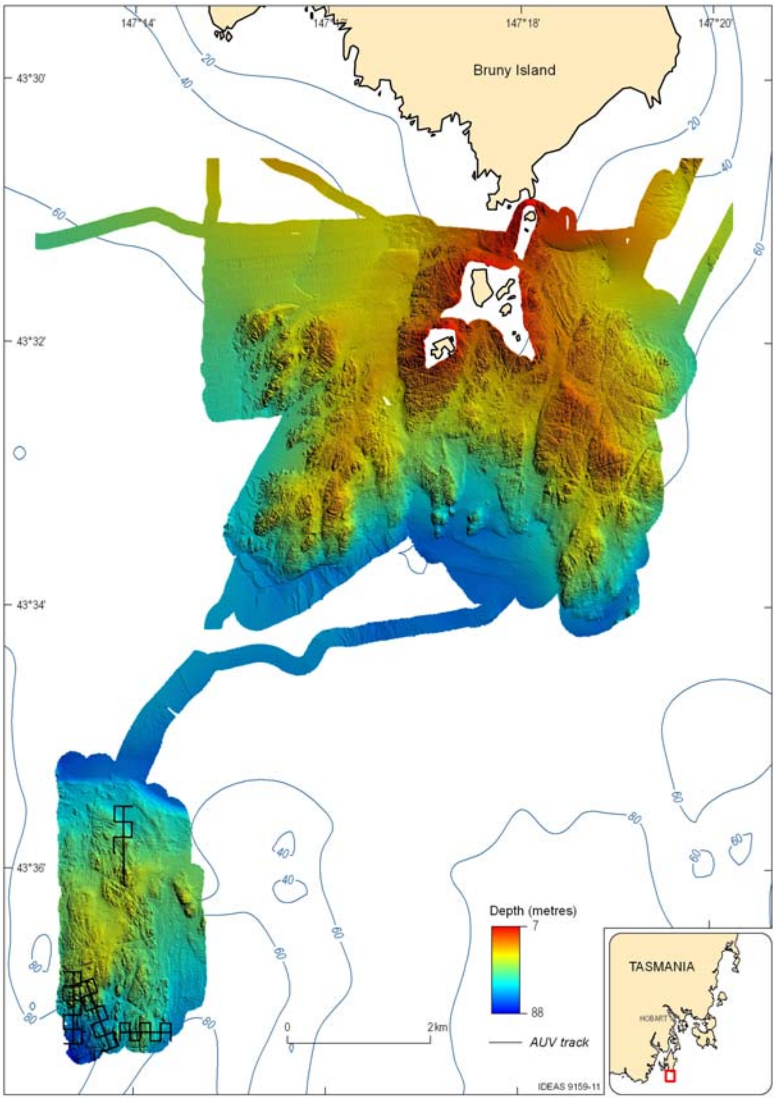

Figure A.7: Location of AUV tracks on the south Friars, incorporating reef located inside and outside the Huon Commonwealth MPA.

Preliminary findings

Initial interpretations of the AUV imagery are consistent with the description given in the towed video section of this report. In all areas, reefs shallower than approximately 40 m water depth were dominated by the kelp, *Ecklonia radiata*, below which invertebrates dominate and fully replace the kelp by 45 m. The reefs of the Fortescue region were characterised by a high percentage cover of massive sponges and other highly structural sponges such as digitate sponges. In contrast to coastal reefs around the Fortescue region, the deeper offshore reefs (60-80 m water depth) (e.g. Hippolyte Rocks and Deep Reef) had a significant cover of other filter feeding invertebrates such as sea-whips and gorgonians. A similar complex structure was found on the deep inshore reef at The Nuggets on the Freycinet Peninsula, but not on the low-lying offshore reefs within the Freycinet MPA or on the moderate-relief reef of the south Friars (either inside or outside of the Huon MPA). The low-lying reef system of the Freycinet MPA was generally sand covered, or at least covered in a biogenic layer that obscured the substrata. However, underlying bedrock was clearly close to the surface as the shape and raised slope features could often be identified, and habitat-requiring organisms, such as gorgonians and sponges, were often present. Differentiation of the sediment-covered-bedrock from sediment areas was also possible where bioturbation was visible (e.g. burrows that penetrated the sediments), or where rippled features on the sediment surface were observed. On the areas presumed to be sediment-covered-bedrock, the sponge cover was relatively sparse and comprised mostly small sponges rather than larger structure-forming sponges. As a result, these offshore low-lying reef systems provided little refugia to motile species such as fishes. Possibly as consequence of this, far fewer fish species were observed over these areas compared with the other reef systems surveyed. However, one distinct biological feature of the Freycinet area was the patchy distribution of brittle-star aggregations, often comprised of multiple species, which were located at the reef-sand interface where detrital algal material was also present (Fig. A.8).

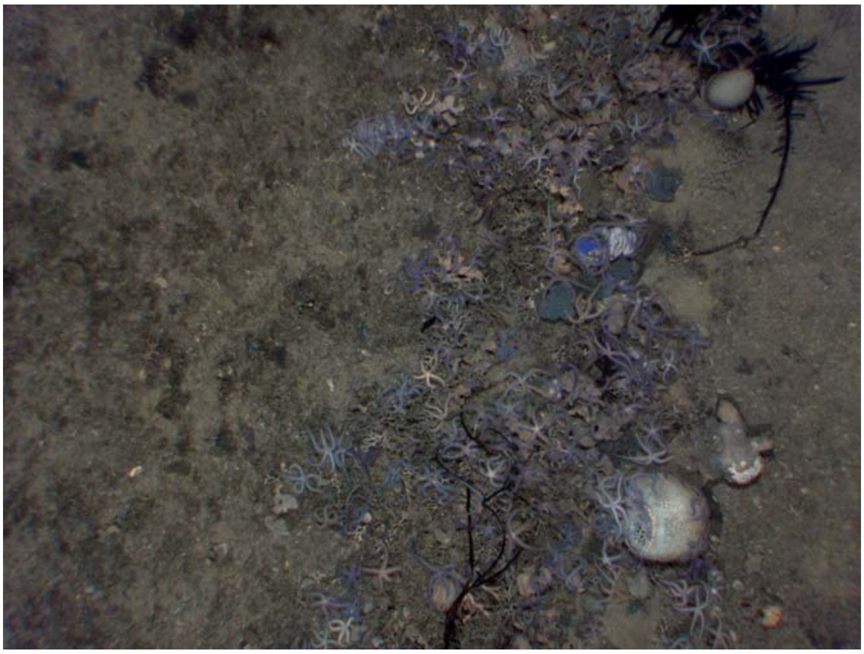

Figure A.8: AUV image showing aggregation of brittle stars in the MPA area offshore from Freycinet Peninsula.

On the southern reefs surveyed (The Friars and Huon MPA), while there was a reasonably high cover and diversity of sponges, the overall height of the sponge "canopy" was greatly reduced relative to assemblages in the Fortescue region. This difference may reflect differences in wave exposure between locations, with the southern location of the Friars exposed to significantly larger prevailing SW swells that are likely to increase physical damage from waves and sand scouring, resulting in the possible "pruning" of the sponge assembly. Importantly, however, these offshore reefs were characterised by a far greater abundance of the southern rock lobsters, *Jasus edwardsii*, than observed at other AUV locations, often with several lobsters recorded per image (Fig. A.9).

Some initial observations of soft sediment habitats suggest that wave exposure is an important factor influencing surface sediments at deeper sites, but that this pattern is more pronounced in southern locations. For example, in the Huon MPA sediments recorded in 60-80 m water were usually strongly rippled and devoid of obvious epibenthos. In contrast, the deep surface sediments of the Freycinet MPA – the most northern location - had far less rippling and the presence of some benthic fauna, such as the New Zealand screw shell, scallops and sponges. Conversely, although the invasive New Zealand screw shell was a dominant feature of the epifauna along the south-eastern coast of Tasmania, highest densities of screw shells were recorded in the north directly adjacent to The Nuggets. Intermediate screw-shell densities were recorded along the Fortescue coast and offshore reefs as well as along the channel banks of the Port-Arthur channel and Huon River. In contrast, low densities of screw shells were recorded in the deep channel of the Huon River, while no screw shells were observed in the sediment areas of the Friars. Water movement within the Huon channel was considerably greater than the adjacent banks, while the reefs of the Friars are exposed to much higher wave action than the more northern reefs. Consequently, rather than a clear latitudinal pattern, screw shell densities and distributions may reflect differences, and possibly a threshold, in water movement intensities. However, where screw shells are present in moderate-high densities they form their own biogenic substrata, upon which other organisms settle and grow.

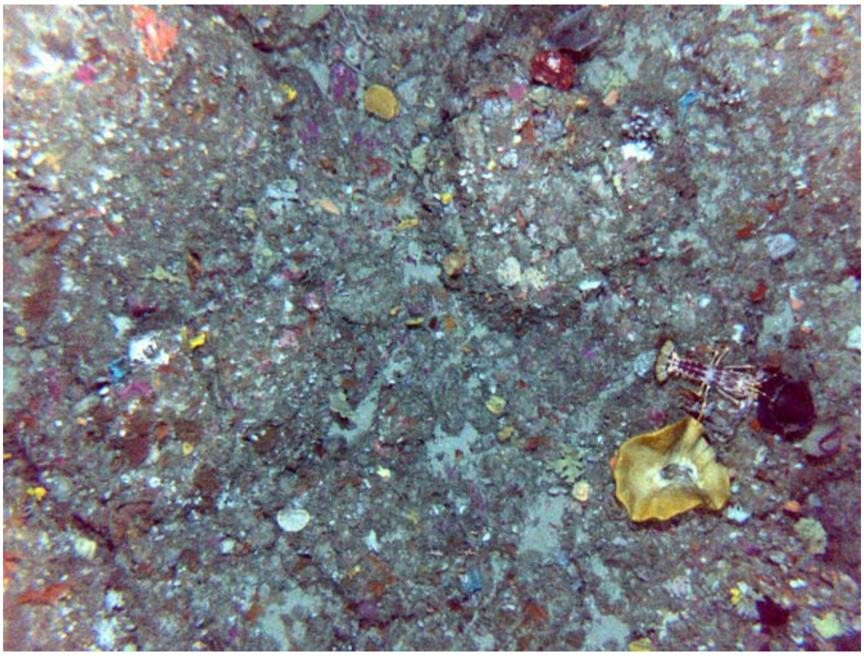

Figure A.9: AUV image showing small sponges and a lobster (centre, right) on rock outcrop in the MPA area offshore from The Friars.

Finally, the AUV imagery was able to resolve key taxa, such as urchins and crayfish that were not well observed by the towed-video survey. As mentioned above, this has enabled the examination of the spatial distribution and abundance of these species. A positive result of this has been a better understanding of the depth distribution and potential impact of the sea urchin, *Centrostephanus rodgersii*, on deeper and previously un-sampled assemblages. *C. rodgersii* has recently extended its southern distribution into eastern Tasmanian waters, where it has formed large urchin barrens across reefs that had previously been dominated by canopy-forming kelps and understorey assemblages. It was previously thought that the barrens may extend into deeper water and decimate the deep reef sponge assemblages. However, based on preliminary findings of this AUV survey *C. rodgersii* has not been recorded in the deep sponge habitats, but rather appears to be restricted to the algal zone.

N. Barrett (TAFI) and T. Anderson (GA)

Appendix B: Details of Towed-Video Transects.

Video Transect	Location	UTC Date/ Time	Start Latitude	Start Longitude	End Latitude	End Longitude	Duration
CAM01_test	O'Hara	25/02/09 02:00:06	-43.1264	147.9751	-43.1283	147.9720	0:12:59
CAM02_test	O'Hara	25/02/09 02:52:59	-43.1379	148.0036	-43.1352	148.0024	0:15:00
STN01CAM03	O'Hara	25/02/09 03:47:57	-43.0848	147.9728	-43.0784	147.9965	0:35:03
STN02CAM04	O'Hara	25/02/09 04:49:17	-43.0762	147.9660	-43.0695	147.9904	0:46:54
STN03CAM05	Waterfall	25/02/09 05:56:41	-43.0690	147.9651	-43.0586	147.9880	1:06:06
STN04CAM06A	Waterfall	25/02/09 07:24:37	-43.0649	147.9675	-43.0514	147.9620	0:31:05
STN04CAM06b	Waterfall	25/02/09 21:42:17	-43.0220	147.9512	-43.0526	147.9628	1:10:02
STN04CAM06c	Hippolyte Rks	25/02/09 05:59:31	-43.0895	147.9774	-43.0638	147.9670	1:02:38
STN05CAM07	Hippolyte Rks	25/02/09 23:41:22	-43.1185	148.0388	-43.1122	148.0387	0:36;23
STN06CAM08	Hippolyte Rks	26/02/09 00:35:45	-43.1241	148.0546	-43.1287	148.0541	0:16:59
STN07CAM09	Hippolyte Rks	26/02/09 01:10:41	-43.1223	148.0577	-43.1225	148.0630	0:15:59
STN08CAM10	Hippolyte Rks	26/02/09 01:43:51	-43.1200	148.0535	-43.1152	148.0542	0:15:39
STN09CAM11	Hippolyte Rks	26/02/09 02:17:52	-43.1189	148.0470	-43.1137	148.0473	0:19:10
STN10CAM12	Hippolyte Rks	26/02/09 02:53:04	-43.1198	148.0454	-43.1253	148.0452	0:23:05
STN11CAM13	Hippolyte Rks	26/02/09 03:26:38	-43.1206	148.0373	-43.1266	148.0374	1:01:23
STN12CAM14	Hippolyte Rks	26/02/09 03:57:07	-43.1199	148.0373	-43.1197	148.0317	0:14:23
STN13CAM15	Deep Reef	26/02/09 04:36:56	-43.0933	148.0229	-43.0924	148.0345	0:21:48
STN13CAM16	Deep Reef	26/02/09 05:11:43	-43.0889	148.0335	-43.0954	148.0247	0:22:53
STN14CAM17	O'Hara	26/02/09 07:19:42	-43.0548	147.9581	-43.0494	147.9814	0:38:56
STN15CAM18	Waterfall	26/02/09 20:45:27	-43.0268	147.9456	-43.0206	147.9701	0:42:37
STN16CAM19	Waterfall	26/02/09 21:46:40	-43.0337	147.9516	-43.0278	147.9742	0:48:22
STN17CAM20	Waterfall	26/02/09 22:55:54	-43.0433	147.9535	-43.0372	147.9770	0:46:38
STN18CAM21	O'Hara	27/02/09 00:17:29	-43.0853	147.9893	-43.0547	147.9771	1:08:00
STN19CAM22	Freycinet	28/02/09 22:47:37	-42.0269	148.4941	-42.0269	148.5097	0:32:41
STN20CAM23	Freycinet	01/03/09 23:54:26	-42.0433	148.4903	-42.0444	148.5049	0:25:59
STN21CAM24	Freycinet	01/03/09 01:56:43	-42.0946	148.4277	-42.0932	148.4374	0:17:48
STN22CAM25	Freycinet	01/03/09 02:33:19	-42.1075	148.4322	-42.1081	148.4404	0:18:01
STN23CAM26	Nuggets	01/03/09 04:50:49	-42.1161	148.3612	-42.1161	148.3689	0:15:51
STN23CAM27	Nuggets	01/03/09 05:22:12	-42.1184	148.3586	-42.1219	148.3699	0:28:44

STN24CAM28	Nuggets	01/03/09 06:01:31	-42.1162	148.3754	-42.1160	148.3698	0:11:18
STN24CAM29	Nuggets	01/03/09 06:20:54	-42.1160	148.3754	-42.1167	148.3808	0:17:29
STN24CAM30	Nuggets	01/03/09 06:47:48	-42.1161	148.3751	-42.1133	148.3761	0:08:00
STN24CAM31	Nuggets	01/03/09 21:01:07	-42.1159	148.3763	-42.1219	148.3704	0:17:21
STN25CAM32	Freycinet	02/03/09 00:57:29	-42.1350	148.5304	-42.1328	148.5169	0:23:28
STN25CAM33	Freycinet	02/03/09 02:22:03	-42.1408	148.5171	-42.1293	148.5291	0:42:01
STN26CAM34	Freycinet	02/03/09 03:36:26	-42.1350	148.4862	-42.1381	148.4993	0:25:54
STN27CAM35	Freycinet	02/03/09 04:34:10	-42.1471	148.4830	-42.1505	148.4949	0:21:25
STN28CAM36	Port Arthur	02/03/09 23:19:17	-43.1526	147.8843	-43.1521	147.8753	0:14:50
STN29CAM37	Port Arthur	03/03/09 00:02:40	-43.1875	147.8865	-43.1818	147.8922	0:25:11
STN29CAM38	Port Arthur	03/03/09 00:34:29	-43.1812	147.8883	-43.1872	147.8899	0:15:36
STN30CAM39	Port Arthur	03/03/09 01:08:39	-43.1662	147.8713	-43.1682	147.8857	0:25:14
STN30CAM41	Port Arthur	03/03/09 02:57:23	-43.1609	147.8736	-43.1723	147.8690	0:24:07
STN31CAM40	Port Arthur	03/03/09 02:28:08	-43.1610	147.8736	-43.1611	147.8863	0:20:40
STN32CAM42	Black Rock	03/03/09 06:48:27	-43.2125	147.8590	-43.2148	147.8565	0:11:26
STN34CAM44	Friars	10/03/09 03:03:24	-43.5341	147.2625	-43.5353	147.2742	0:20:06
STN34CAM45	Friars	10/03/09 03:32:18	-43.5340	147.2829	-43.5338	147.2769	0:11:13
STN35CAM46	Friars	10/03/09 04:30:22	-43.5460	147.2989	-43.5545	147.3030	0:25:04
STN36CAM47	Friars	11/03/09 02:54:51	-43.6153	147.2264	-43.6208	147.2278	0:18:11
STN37CAM48	Friars	11/03/09 03:25:21	-43.6153	147.2224	-43.6218	147.2233	0:22:33
STN38CAM49	Friars	11/03/09 04:03:24	-43.6134	147.2344	-43.6150	147.2407	0:20:24
STN39CAM50	Friars	11/03/09 04:50:58	-43.6014	147.2305	-43.5930	147.2313	0:17:44
STN40CAM51	Friars	11/03/09 06:56:25	-43.5285	147.3023	-43.5307	147.3132	0:24:45
STN41CAM52	Huon River	12/03/09 00:05:27	-43.2764	147.1256	-43.2856	147.1298	0:20:36
STN42CAM53	Huon River	12/03/09 00:47:55	-43.3042	147.1168	-43.3098	147.1318	0:24:11
STN43CAM54	Huon River	12/03/09 01:47:27	-43.3277	147.1672	-43.3325	147.1509	0:27:31

Appendix C: Summary Log of Survey Activities

Survey 1: June 13 - 26, 2008

13th June – Matt Francis and Jack Gibson put the RV *Challenger* on the Domain slipway. Craig Wintle, Ian Atkinson and Cameron Buchanan begin installing sonar, motion reference and GPS instruments.

14th June – RV *Challenger* comes off the slip and calibration testing begins in the Derwent River.

15th June – With calibration complete, Craig Wintle and Ian Atkinson depart for Canberra. Hugh Pederson joins the vessel which transits to the Fortescue area of interest and begins acquiring data.

16th June – Fortescue acquisition continues.

17th June – Fortescue acquisition continues.

18th June – Fortescue acquisition continues. Hugh Pederson leaves the vessel and is replaced by Matt McArthur.

19th June – RV *Challenger* acquires swath data over The Sisters to the north of the Fortescue area and transits to Maria Island to cover a small patch of reef on the island's northwest. Vanessa Lucieer aboard vessel for the day.

20th June – RV *Challenger* heads south along the shore of the Fortescue area and makes several passes over the deeper parts of Fortescue Bay before transiting to Port Arthur.

21st June – Acquired data in Port Arthur before the RV *Challenger* transits to the D'Entrecasteax Channel.

22nd June – Neville Barrett joins the vessel which begins acquiring data in the D'Entrecasteax Channel.

23rd June – D'Entrecasteax data acquisition continues. Matt McArthur leaves the vessel.

24th June – D'Entrecasteax acquisition continues, after which the RV *Challenger* transits back to the Derwent.

25th June – RV *Challenger* goes back on the Domain slipway. Craig Wintle and Ian Atkinson fly in from Geoscience Australia and begin removal of sonar, motion reference and GPS systems.

26th June – Sonar removal is completed RV *Challenger* comes off the slipway and everyone returns home.

Survey 2: February 23 – March 14, 2009

23rd Feb – Mobilisation in morning. Left CSIRO wharf 02:15 UTC to complete testing of MBS and tow video in the Derwent River. Returned to wharf to fix hydraulic leak. Transited to Tasman Peninsula, departing wharf at 04:30 UTC. Anchored overnight at Port Arthur.

24th Feb – Depart Port Arthur 19:00 UTC and continued transit to Fortescue survey area. Began swath mapping at Hipploytes followed by gap-filling at Waterfall inboard areas. Anchored overnight at Pirates Bay.

25th Feb – Tara Anderson and Matthew McArthur join the vessel, Michele Spinnocia disembarked. Transit to Fortescue area to test underwater camera. Two tow-video transects completed. Transit to O'Hara Bluff and complete two camera tows, then to Waterfall for two camera tows. Anchored overnight at Pirates Bay.

26th Feb – Completed camera tows at O'Hara Bluff (two tows), Hippolyte Rocks (10 tows). Anchored overnight at Pirates Bay. Neville Barrett disembarked and Justin Huls embarked.

27th Feb – Completed camera tows at O'Hara Bluff (five tows) then transited north to Freycinet Peninsula area. Tara Anderson disembarked and Nicole Hill embarked.

28th Feb – Mapping of Freycinet Peninsula area inside the Freycinet Commonwealth Marine Protected Area (MPA); coverage across low relief reefs. Overnight anchorage in Wineglass Bay.

1st March – Continued mapping of low relief reefs in MPA offshore Freycinet Peninsula. Completed four video tows in same area. Then transited to the Nuggets for further mapping and five video tows. Overnight anchorage in Wineglass Bay (dolphins for company on transit).

2nd March – Completed one final video tow at the Nuggets then commenced mapping low relief reefs in area to southeast of MPA. Completed four video tows over same area. Transited to Port Arthur for shelter as bad weather forecast. Overnight anchorage in Port Arthur.

3rd March – Completed mapping in Port Arthur to fill gaps from 2008 survey, and extended coverage to Stuarts bay, Safety Cove and Black Rock. Completed six video tows in Port Arthur and one outside at Black Rock. Overnight anchorage in Port Arthur wharf. End of leg 1.

4th March – Handover to leg 2 at Port Arthur wharf. Andrew Heap disembarked and Scott Nichol embarked. Re-fuelling completed also. Departed 01:00 UTC to complete small area of mapping in Port Arthur then transited across Storm Bay to Bruny Island (rough seas). Arrived Bruny Is 05:00 UTC and mapped small area of inshore reef to southeast of Piersons Point. Transited along D'Entrecasteaux channel for anchorage in Simpsons Bay overnight.

5th March – Transited southwest along D'Entrecasteaux to check sea conditions. Strong SE wind with short seas. Too rough for camera deployment in the Huon area. Transited north to complete mapping of inshore reefs at northern end of Bruny Island. Completed one video tow at the Tinderbox site (Bruny Is). Transited to CSIRO wharf, arrived 06:00 UTC (17:00 hrs local).

6th March – In port. Seas to south of Hobart still too rough for video work. Day used for boat maintenance, provisioning and backup of video data. Cameron Buchanan also worked on processing of swath data.

7th - 8th March – In port. Crew of RV *Challenger* scheduled rest days. Geoscience Australia staff in Hobart.

9th March – Survey resumes. Depart CSIRO wharf 23:15 UTC and transit south to The Friars. Arrived 04:00 UTC and commenced mapping in 2 m swell, but conditions improving. Mapped until 08:00 UTC then anchored off Mangana Bluff on the east side of Bruny Is.

10th March – Continued mapping in The Friars area in morning. Camera tows completed at three sites in The Friars area in afternoon. Transited to Cloudy Bay for anchorage overnight.

11th March – Tranisted to The Friars to complete gap filling then to extend mapped area to the southeast into the State MPA. Completed four video tows in the MPA area. Transited to eastern side of The Friars to complete small area of gap filling and one video tow in same area. Transited to the Huon River for anchorage overnight in Port Esperance. Arrived 21:00 hrs local.

12th March – Mapping in the Huon area to fill gaps from 2008 survey and extend the coverage slightly to the north and east. Completed sound velocity cast in Huon mapping area, then completed three video tows. Resumed gap filling in map area until 04:15 UTC (15:15 local), then transited to Hobart. Arrived CSIRO wharf 18:30 local.

13th March – Demobilisation begins at CSIRO wharf, including back up of multibeam sonar and video data to external hard drives. Andrew Hislop arrives to begin removal of multibeam sonar equipment and video gear. All Geoscience Australia staff disembark and overnight in Hobart.

14th March – Demobilisation of gear continues at CSIRO wharf (Field and Engineering Support staff). Scott Nichol, Matthew McArthur and Cameron Buchanan return to Canberra.

A. Heap and S. Nichol (GA)