Australia's Integrated Marine Observing System Autonomous Underwater Vehicle Facility

Stefan Williams, Oscar Pizarro, Michael Jakuba,
Ian Mahon and Matthew Johnson-Roberson
Australian Centre for Field Robotics, The University of Sydney
Email: stefanw@acfr.usyd.edu.au

This paper describes the current status of Australia's Integrated Marine Observing System (IMOS) Autonomous Underwater Vehicle (AUV) Facility. IMOS is an initiative to provide critical infrastructure to support marine science in Australia. IMOS was established 'to transform the way in which marine observational data is collected, from the current fragmented research proposal or institutional driven basis, to one in which the acquisition and provision of critical observational data on Australia's ocean environment is determined by a national strategic approach' [3]. The objective of the IMOS AUV Facility is to provide the marine science community around Australia with access to AUV systems, with a particular emphasis on surveying of benthic habitats.

Benthic acoustic and optical imaging AUVs have become effective complements to traditional survey methods; however their use has been largely restricted to exploratory missions at depths and in regions difficult to map at high resolution by other means [4,5,14]. To address pressing questions about the effect of climate change and direct anthropogenic impacts on coastal and deep sea benthic ecology, AUVs must start operating in a monitoring capacity. So far, these efforts have largely focused on physical oceanographic [8] or pelagic phenomena [6]. The proven ability of benthic imaging AUVs to rapidly and cost-effectively deliver high resolution, accurately geo-referenced, and precisely targeted optical and acoustic imagery makes AUVs ideally suited to the kinds of repeat surveys that will be necessary to monitor changes in the benthos, particularly beyond diver depths. Changes in community structure and benthic cover derived from precisely registered maps collected at regular intervals will provide stakeholders with data critical to the effective management of marine parks and fisheries where the benthos provides a food source or plays a role in the lifecycle of the target species.

The University of Sydney's Australian Centre for Field Robotics leads the IMOS AUV Facility and operates a SeaBED-class [10] ocean-going AUV called *Sirius* designed primarily to create high-resolution optical and acoustic 3D reconstructions of the sea floor. A suite of navigation instruments in concert with state of the art terrain-relative navigation are employed to geo-reference data from the vehicle. The AUV is decoupled from the support ship while surveying hence it is possible to precisely target surveys on areas of interest, including repeat surveys of the same areas of the seafloor. The AUV follows the seafloor at constant altitude resulting in consistent lighting and high quality imagery that lends itself to automated processing, and we have attained promising habitat classification results using both supervised and unsupervised techniques.

The AUV has been operated on cruises around the country, providing high-resolution seabed surveys of selected sites in support of marine studies. These have included assessing benthic habitats off the Ningaloo Reef, Western Australia; documenting drowned shelf edge reefs at multiple sites along the Great Barrier Reef [11]; surveying of proposed Marine Parks and cuttlefish spawning grounds in South Australia [13]; documenting rocky reef sites along the Tasman Peninsula and in the Huon MPA in Tasmania [12]; and describing biological assemblages associated with deep coral reef systems at Scott Reef in WA. Highlights from these deployments are presented in Figures 1 and 2, illustrating the role of the AUV in the context of cruise objectives and demonstrating how the high-resolution, 3D seafloor models are being used to better understand benthic habitats at depth.

IMOS supports deployment of the *Sirius* AUV through the AUV Facility by making the vehicle available to scientists on a competitive basis for marine projects in Australia.

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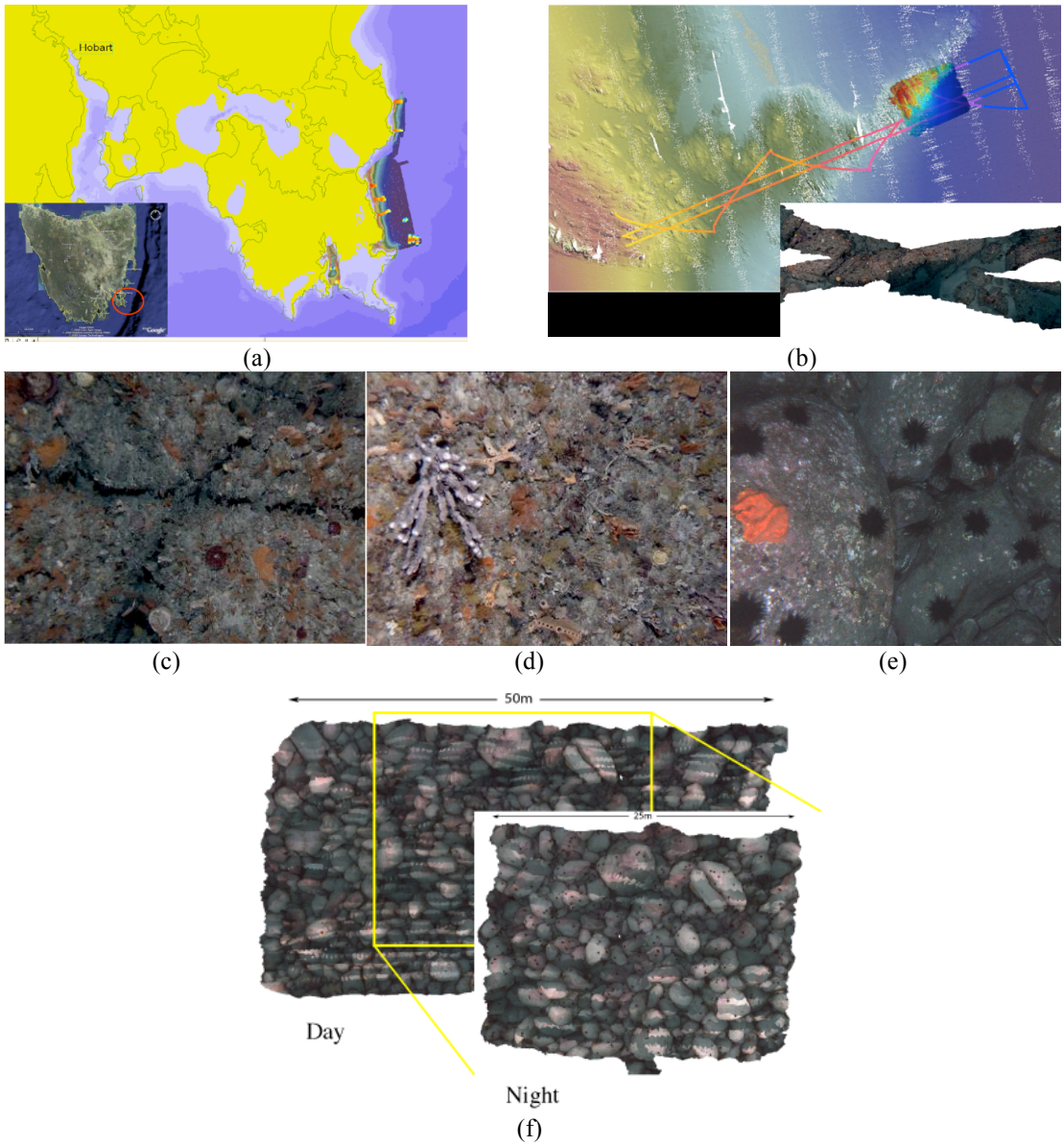

Figure 1 – (a) AUV dives undertaken on the Tasman Peninusla in October 2008 overlaid on prior ship-borne multibeam collected by Geoscience Australia. The AUV profiles are colour coded by depth. (b) Detailed ship borne bathymetry with two AUV imaging dive profiles overlaid. Detailed bathymetry collected by the vehicle from a 20m altitude at the eastern edge of the reef is overlaid on the orginal ship-borne bathymetry showing the interface between the rocky reef and the deeper, sandy substrate. The inlay shows details of a high resolution, three dimensional seafloor model generated using the vehicle's stereo imaging data. (c)-(d) Sample images from rocky reefs on the Tasman peninsula (e) Night time image over urchin barrens at St Helens (f) Day and night 3D mosaics from surveys of urchin barrens illustrating the ability of the AUV to revisit a previous survey for monitoring change in the environment. In this case, urchins are seen to emerge at night, forming large scale urchin barrens.

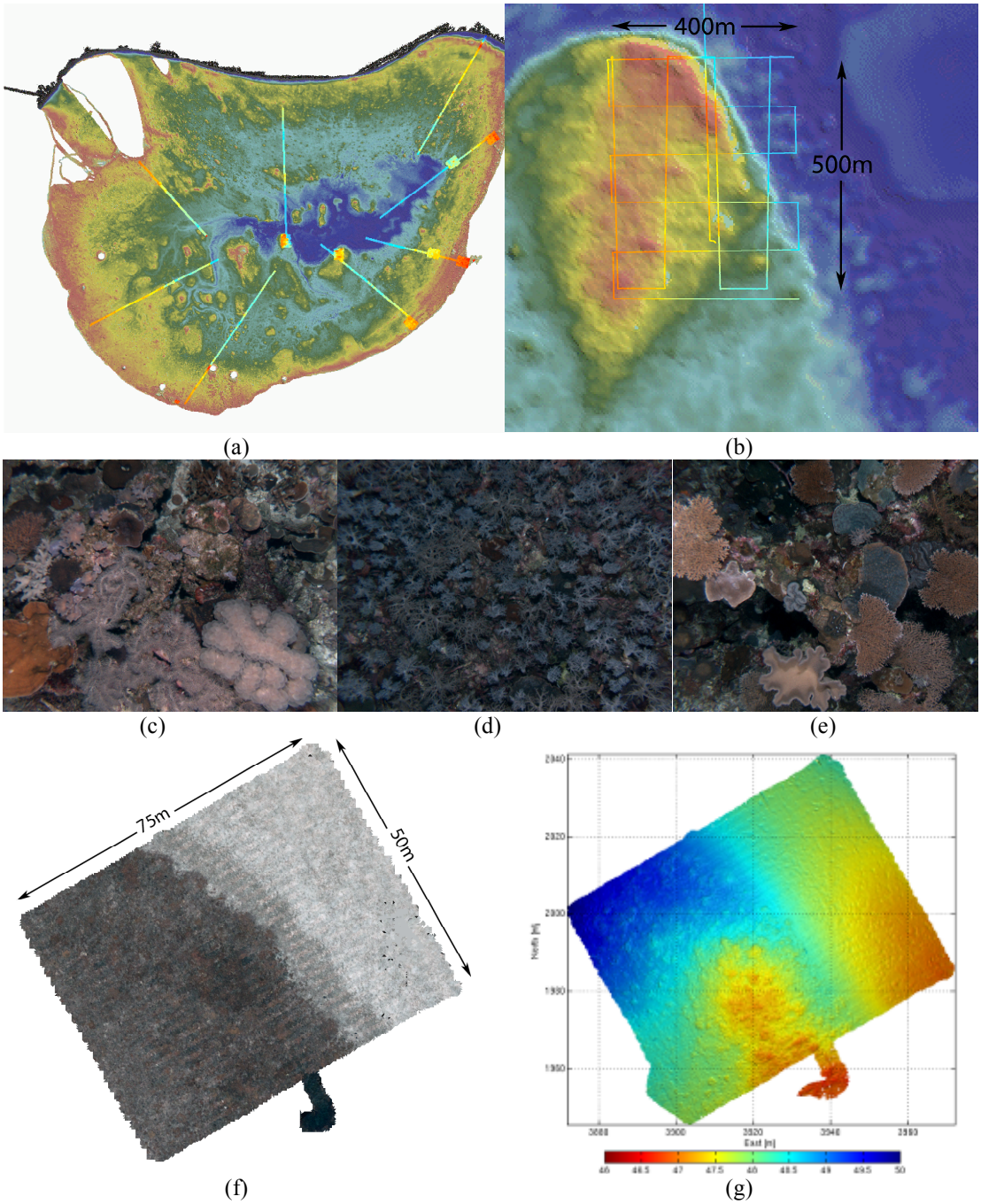

Figure 2 – (a) Ship-based multibeam map of the South Scott Reef lagoon collected during the two week campaign in July-August 2009. AUV dive tracks are overlaid on the bathymetry and are coloured by inferred depth of seafloor to illustrate the extent of coverage and design of survey profiles. (b) Details of one grid survey overlain on the detailed bathymetry. This dive was targeting a particular seafloor feature located near the centre of the lagoon. (c)-(e) Examples of the imagery collected from this particular dive and illustrate the variety of coral communities imaged by the vehicle. (f) Reconstruction of an area of seafloor at the edge of a coral reef community. The site was targeted as the interface between coral and sandy habitats. Revisiting sites such as these will allow ecologists to monitor rates of changes to these environments (g) Fine scale multibeam bathymetry collected by the AUV in the same area.