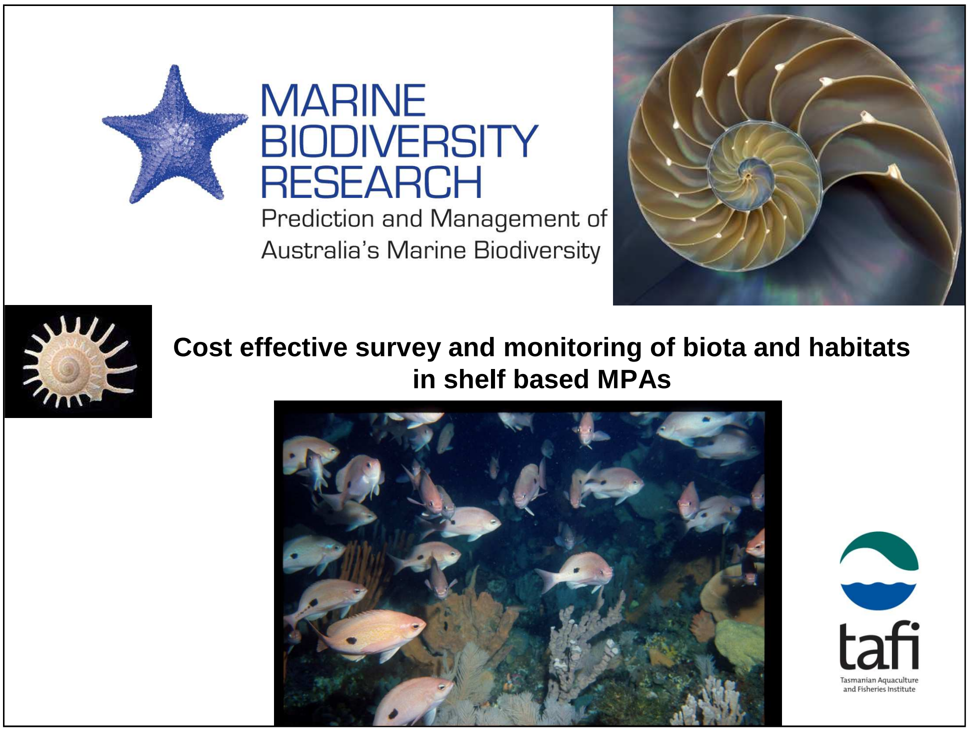
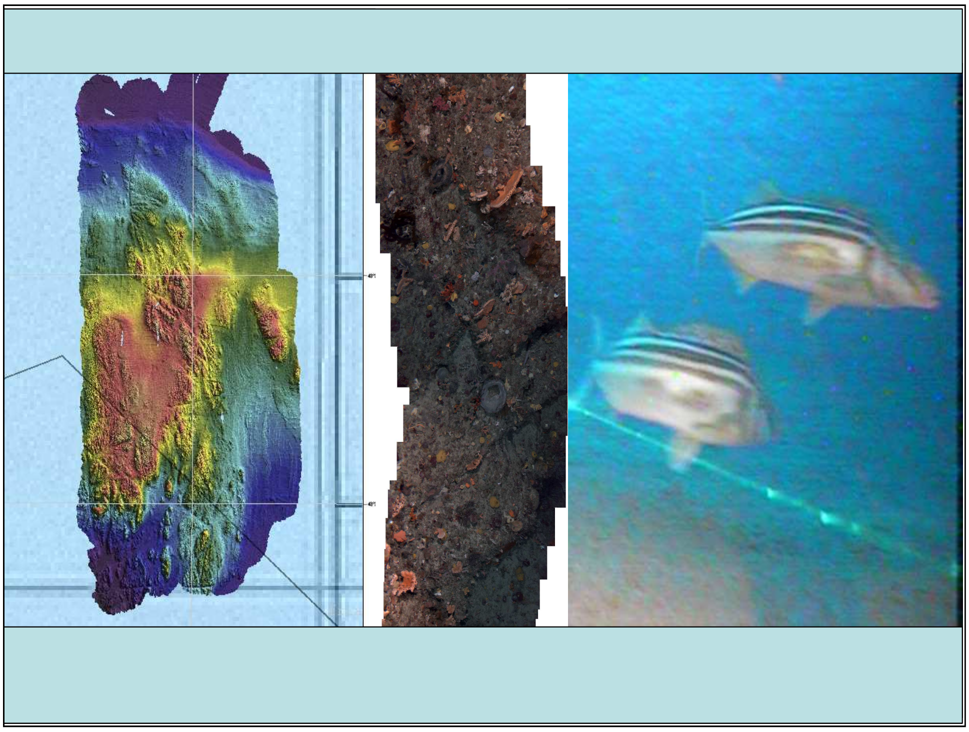
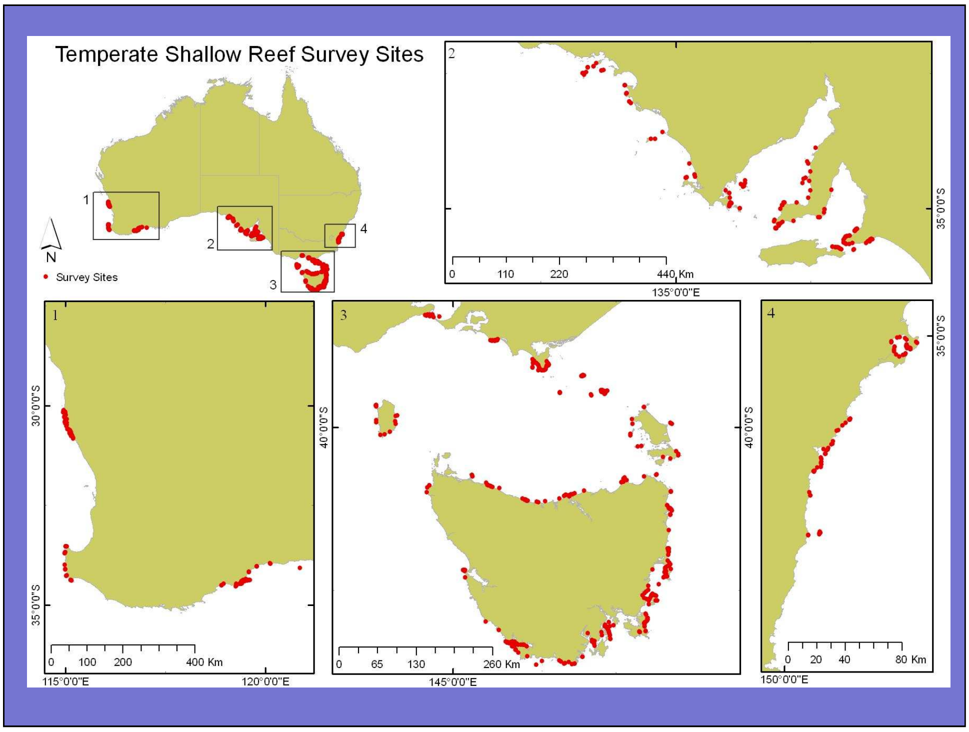


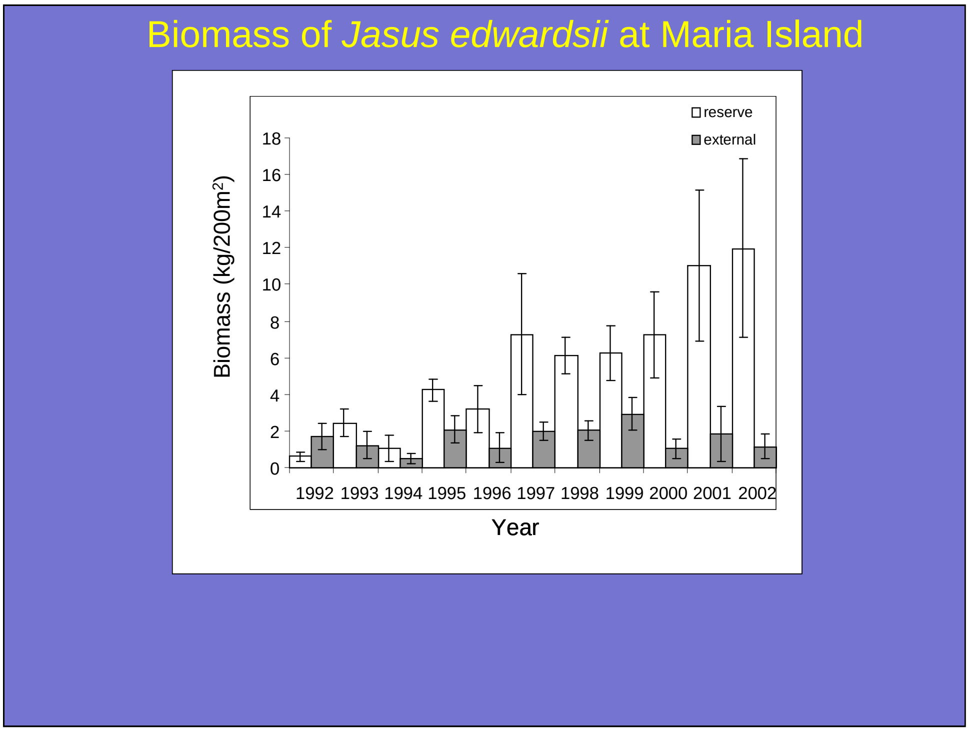
Part of our core work at TAFI over the past 18 years has been thinking in the space of how to monitor MPAs cost effectively, and what components do we want to monitor to most effectively detect MPA related change. Clearly protection related change may operate at the level of target and bycatch species, but there may also be secondary or tertiary processes operating that we might like to document and understand that have significant implications for ecosystem based management. What techniques cost-effectively provide information across this broad requirement?



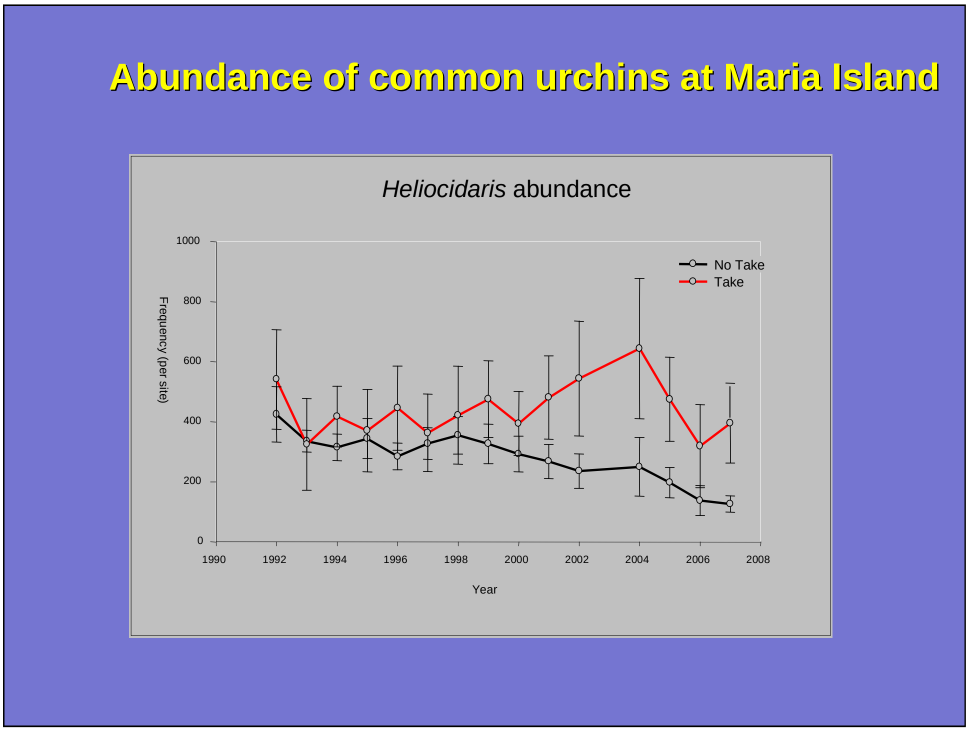
Certainly any monitoring program needs to bring a range of tools to bear to answer the questions and we have been exploring some of these in more detail within the CERF Marine Biodiversity Hub. Initial mapping is needed to describe and quantify the habitat assets present and to plan effective biological surveys, and new multibeam sonar techniques are well suited to this task (left image). To non-intrusively sample benthic biodiversity techniques such as high resolution imagery obtained by Autonomous Underwater Vehicles (centre image) can provide highly detailed biodiversity level data on benthic biota, while other visually based techniques such as towed video (right image), baited underwater video or diver based surveys can collect robust data at the target species and by-catch species level.



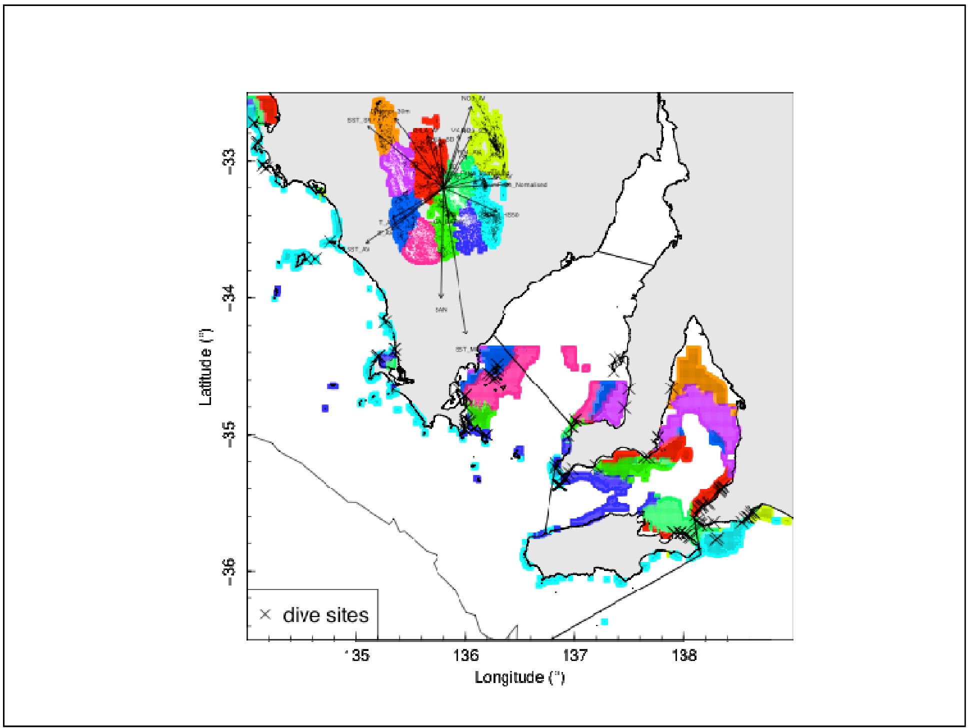
Our history of involvement with MPA related research begun in Tasmania in 1992 with the establishment of a detailed diver based (Underwater Visual Cencus) monitoring program in newly declared MPAs, and slowly expanded throughout temperate Australia as new MPAs were declared or proposed. The UVC surveys record details of both target species size distributions and abundances, as well as similar information on bycatch species and broader ecosystem attributes such as algal cover and species richness. With surveys underway in multiple MPAs we can look at the patterns that are region specific, those that are widespread and the time frames within which they occur. The rationale for this work is to not only measure the "performance" of MPAs following protection, but also, by using them in a reference role, informing management of the adequacy of management strategies in off-reserve areas to ensure fishing activities are not having widespread system-wide impacts. If they are, to feed back this information to develop more ecosystem-based management approaches to these fisheries.



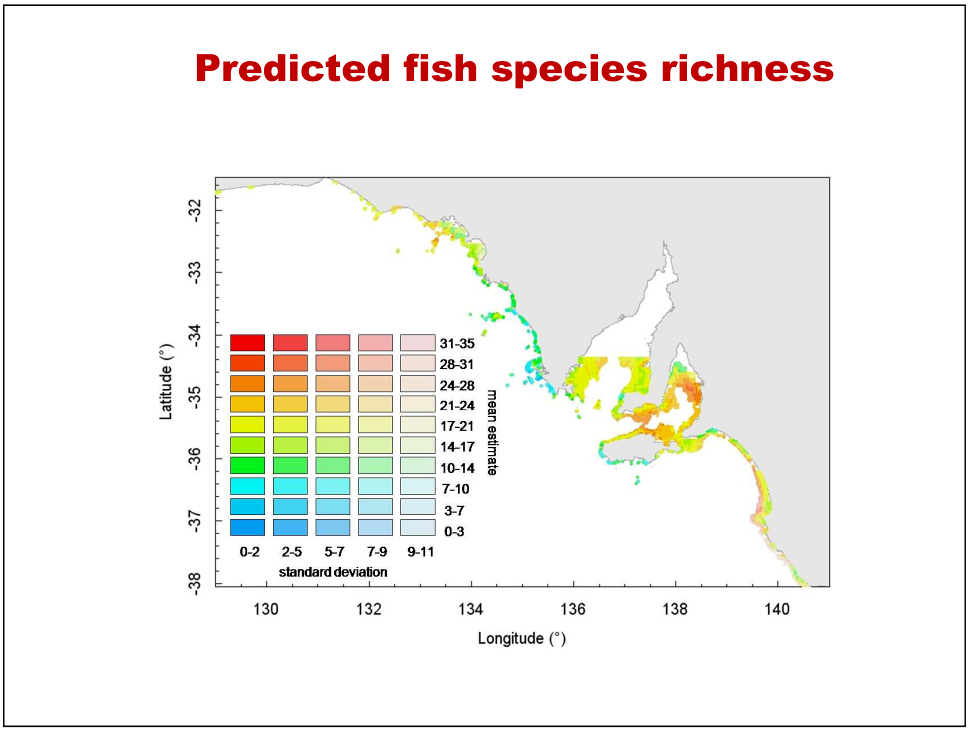
A typical response in an MPA is often the recovery of a heavily targeted species. In this case lobsters within the Maria Island MPA in Tasmania responded slowly but surely to protection. The important thing to note is that it did take some time to detect a biologically meaningful change (so you can't always expect a quick response), but despite that, these changes can be large, in this case a tenfold increase in the biomass of a very important predator in ten years. Something else to note is the importance of "control" sites outside the MPAs to ensure responses can be contrasted with what is happening in surrounding areas. This data was collected by UVC by divers, but could equally been collected by lobster potting surveys (another cost –effective and relatively non-intrusive survey method if you just want detailed information on this species of interest).



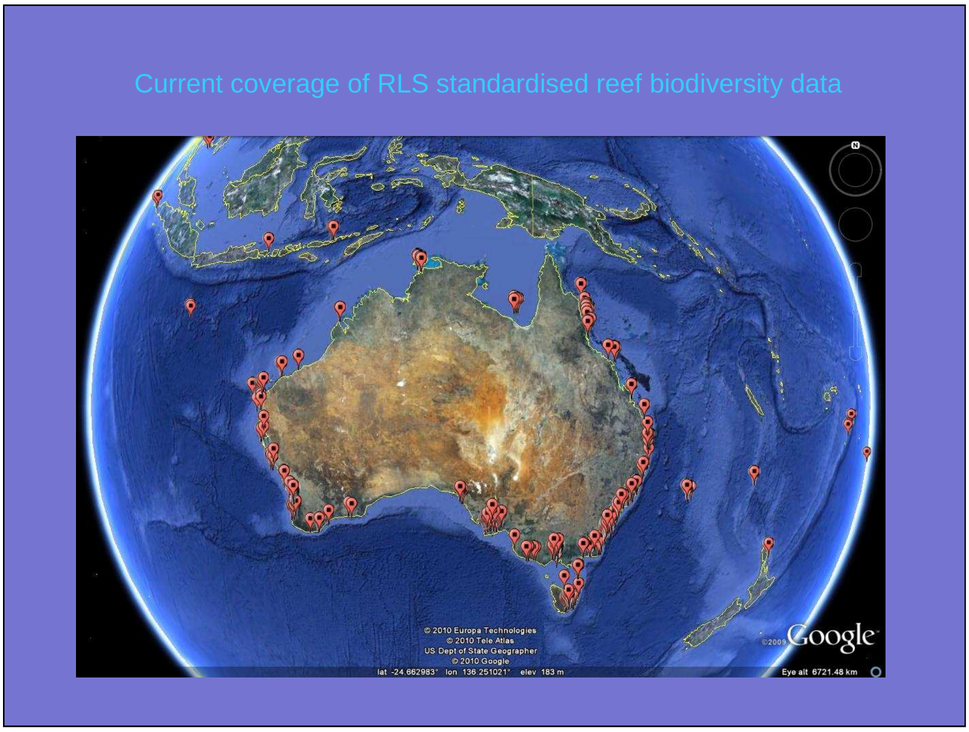
Again from Maria Island, we have shown that the increase in lobster numbers has had secondary consequences, resulting in the eventual decline in sea urchin numbers within the MPA relative to control sites. These urchins are a major prey item of lobsters but did not initially respond to the lobster increase as the response firstly required lobster numbers to increase, and then for lobsters to grow big enough to eat the large urchins that were too big for the lobsters to tackle initially (when the reserve was declared this area was very heavily fished and all large lobsters had been removed. All that remained were animals smaller than the minimum legal size limit). This figure shows the time-lag that typically happens before secondary or more system0wide responses can occur following protection. Again. This data was collected by UVC by divers while conducting other surveys (such as fish abundance) in a method that is cost-effective for a program looking at more than just target species responses.



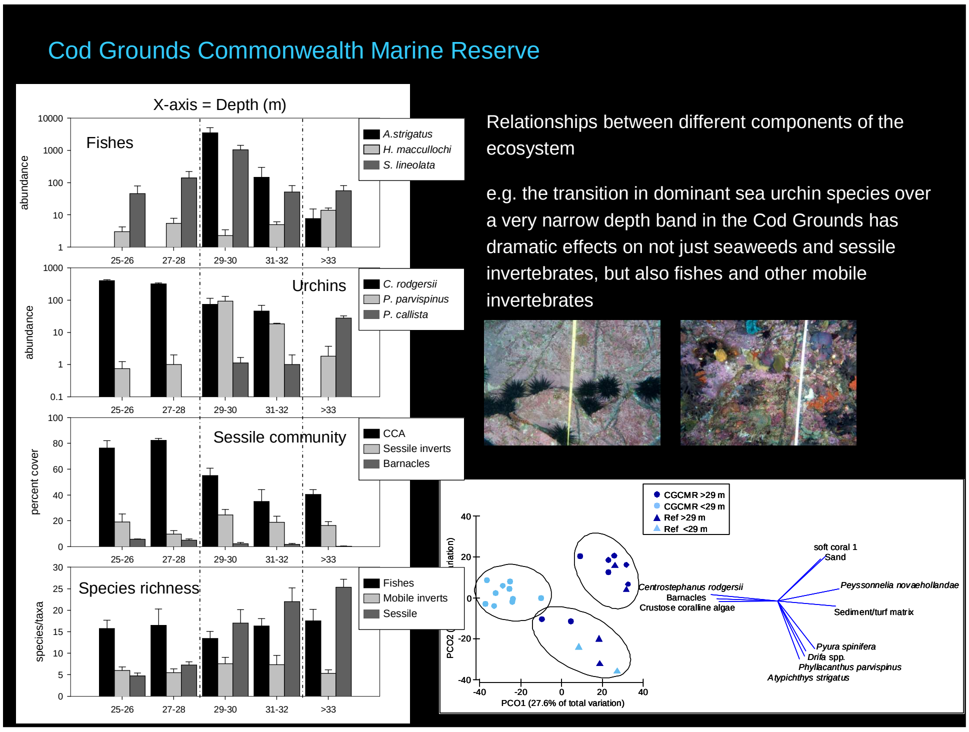
As similar surveys have been conducted widely across Temperate Australia, we have a wealth of information to not only monitor MPA responses but also to better inform the conservation of biodiversity through identification of patterns in the distribution of this diversity and potentially matching that with a planning process that aims to capture and protect this diversity in a representative way via MPAs or in other conservation measures. In this instance, we have been actively involved with colleagues from CSIRO within the CERF Marine Biodiversity Hub to develop and test methods of predicting patterns of biodiversity more widely, using physical surrogates such as depth, wave exposure, nutrient loading, temperature, salinity, sediment loading etc that may strongly structure where individual species and biological assemblages occur. We examine the strength of each surrogate by looking at relationships with data from a range of biological survey sites (shown above as black crosses) and then using a range of statistical methods, we predict biological distributions based on these relationships across the broader areas where we have appropriate physical data. The assumption here is that physical data is often cheaper to collect (remote sensing etc) and so development of such techniques may help make biodiversity prediction much more cost-effective. In this figure we show the patterns of Beta diversity of macro-algae across a section of South Australia.



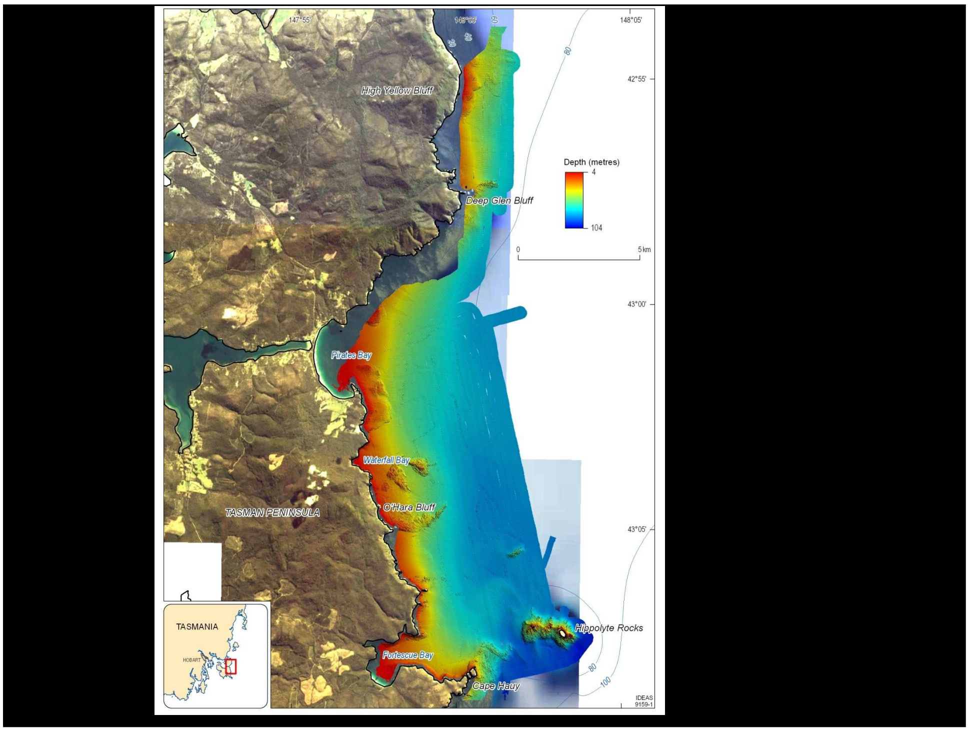
This is a similar prediction, but this time it shows Alpha diversity, simply the areas predicted to have the highest level of diversity at a particular location (i.e. hotspots).



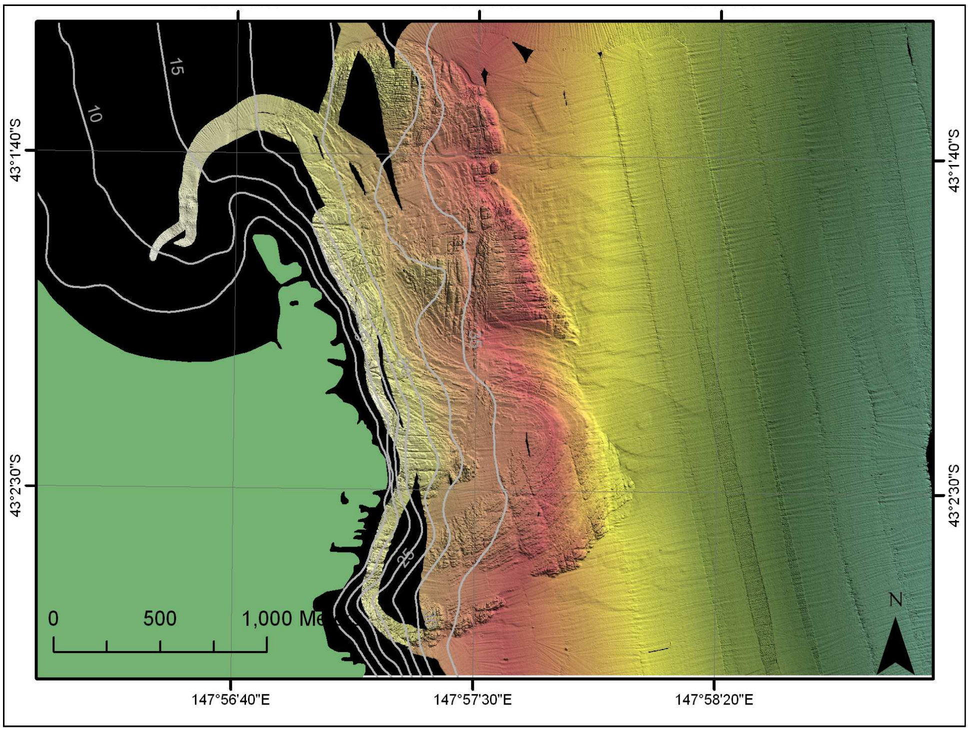
Clearly even while inshore surveys are relatively cost-effective, there may be other ways to make this process even more cost effective for particular data requirements. One way we have been examining within a CERF Significant Project grant, has been the engagement of volunteer divers to undertake such work. This program,(that we named ReefLifeSurvey) essentially takes divers with an existing high level of training and interest, and trains them in biological survey methods. This program has been very successful, and had generated coverage by thousands of sites and surveys around most of Australia and the indo-pacific rim. This data can be used in a range of ways from MPA and climate change monitoring, state-of-Environment reporting, and biodiversity pattern description and prediction.



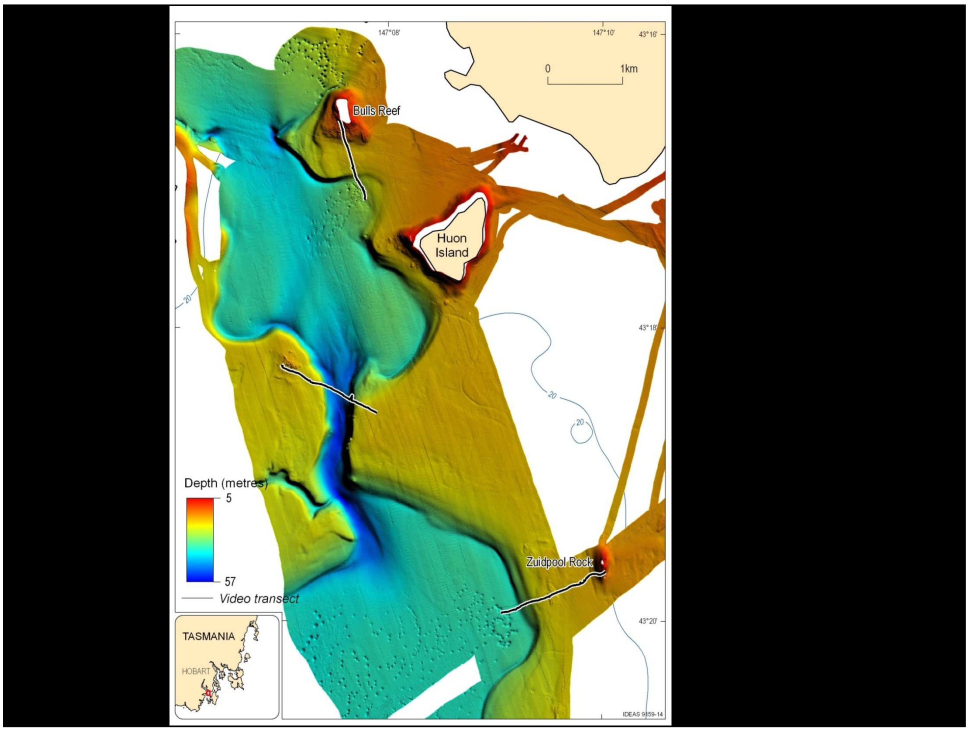
While the Commonwealth has only a limited part of its estate in shallow, diveable waters, the application of such cost-effective monitoring methods in these likely to be important into the future as both community engagement and as a reliable way of gathering detailed long-term data that otherwise would not be available. The above figure shows some results from a recent ReefLifeSurvey survey undertaken in the Commonwealth managed Cod Grounds MPA in NSW and indicates the extent and quality of data able to be collected by these volunteers.



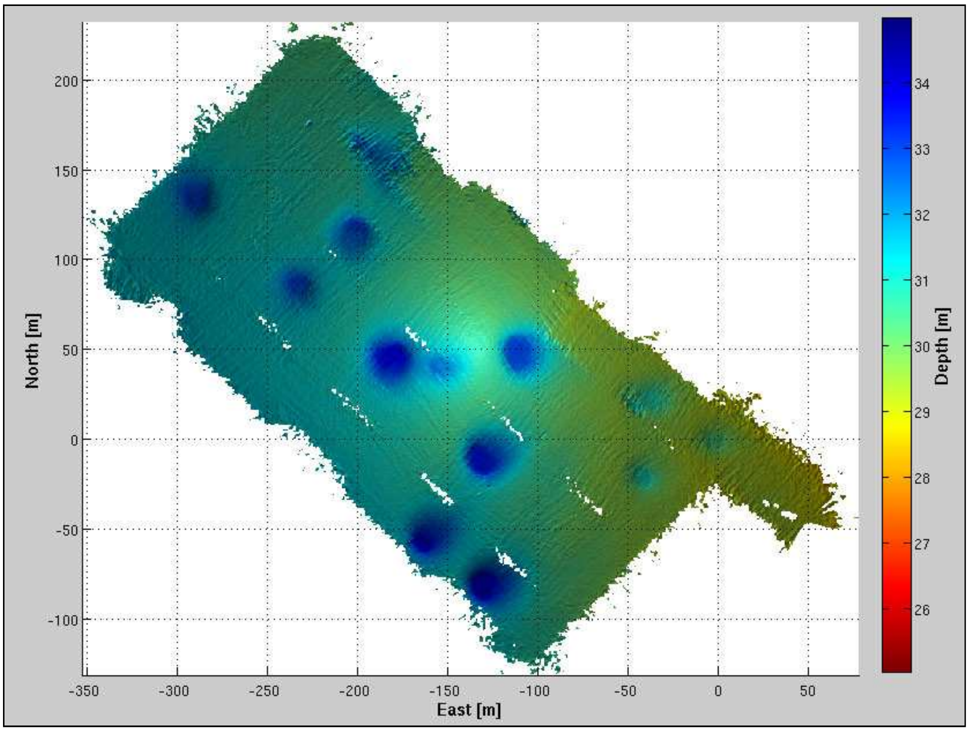
While much of our earlier work focussed in shallow water MPAs, we have recently extended this thinking offshore, and within the CERF Marine Biodiversity Hub we have been working closely with our partner agencies such as Geosciences Australia to explore the most appropriate techniques in this deeper environment on the shelf. There areas are often intensively fished but are very poorly understood ecologically, especially the ecological impacts of fishing activities, given their remote nature. Deep reefs are subject to fisheries such as lobster and stripey trumpeter in Tasmanian waters, and to lobster and snapper fisheries moving up the eastern seaboard. Associated sediments are often heavily trawled within the SE scale-fishery, with target species including flathead and latchet. Some areas are also heavily dredged for scallops. To study and describe these deep environments we need both cost-effective and non-intrusive methods (especially for use within MPAs) to describe the distribution of habitats, the abundance and size distribution of target and bycatch species, and overall patterns and condition of benthic biodiversity. Within our current work within the CERF Hub we have trialled new high resolution multibeam sonar tools as a surrogate for predicting the distribution of habitats and related patterns of biodiversity and shown that it is a useful tool for both of these applications. Particularly when we can derive physical parameters such as slope, depth, aspect and hardness from this information. Clearly we cannot rapidly survey all of our shelf MPA waters using this technique, but appropriate stratified sampling of each individual MPA in shelf waters (additionally informed by stakeholder knowledge) would quickly allow the core range of habitat assets to be identified, allowing important areas to be surveyed sufficiently to inform planning for biological surveys within a monitoring program to be properly targeted and planned.



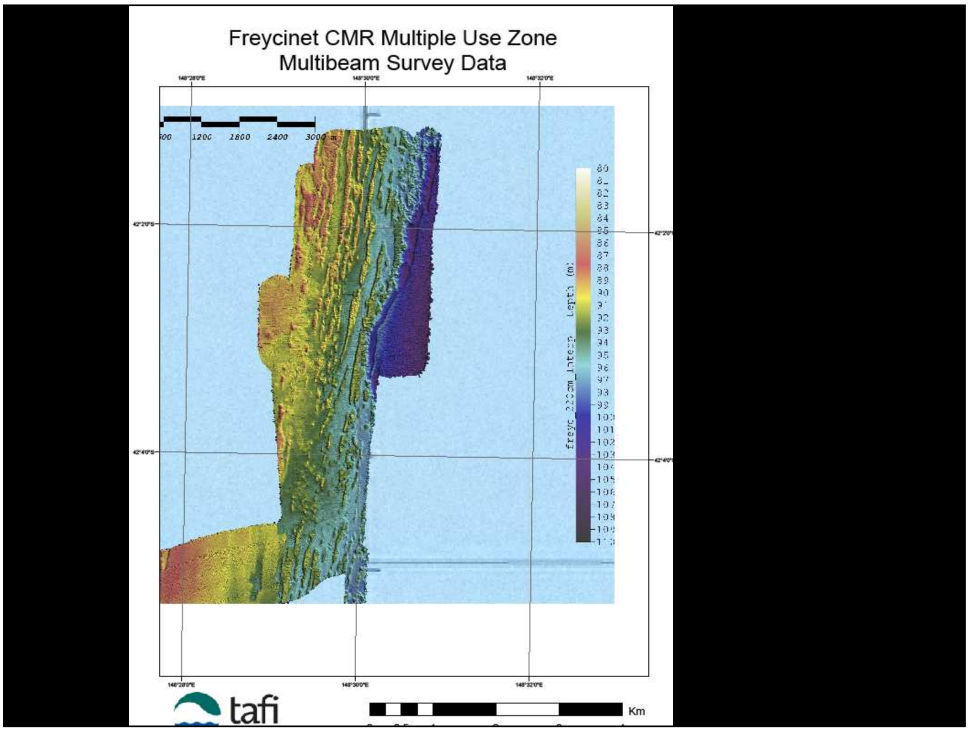
Multibeam sonar methods at high resolution can quickly detect habitat features that may structure the associated seabed biota, allowing more precise predictions of the presence of particular biological assemblages to be predicted. In this case, reef extending offshore from Pirates Bay (SE Tas) shows very distinct bedding features which indicate that it is of sandstone-like bedrock. This differs greatly from the boulder-field reefs found further south (derived from dolerite) which may have a very different biology associated with them. We are currently testing the strength of these relationships within the CERF Hub.



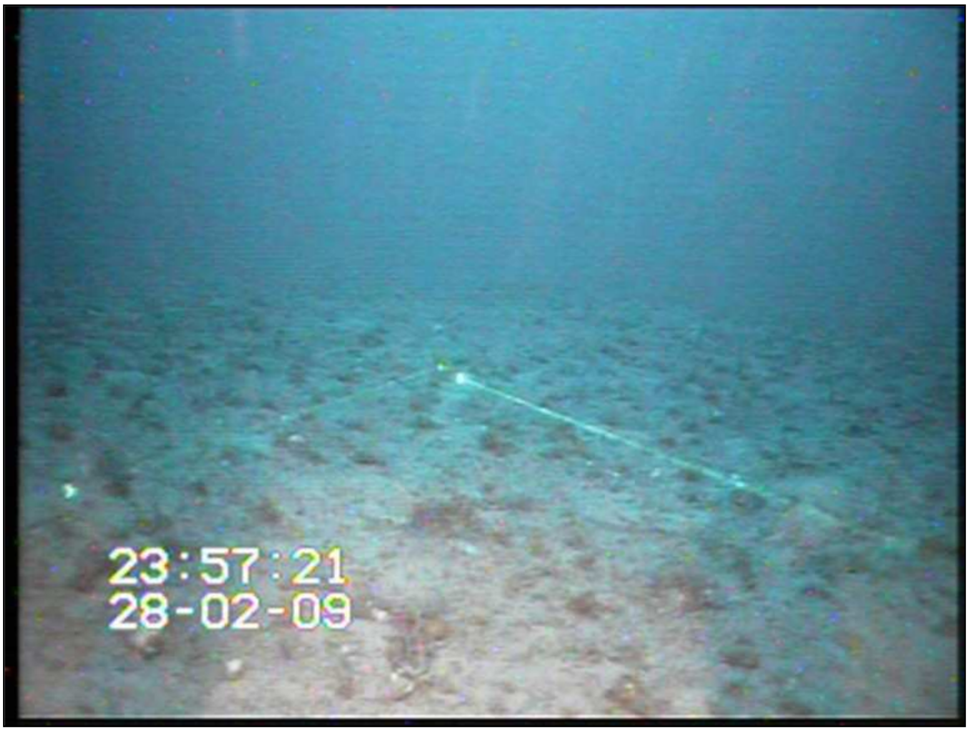
While mapping is underway, it not only allows detection of habitat features that are known to exist in the area, but also unknown ones, that may also have significant ecological values. In the image above (in the D'Entrecasteaux Channel) we can see the drowned river valley of the Huon River, formed during previous glacial periods. While we knew this feature was there, we didn't know about the dense nests of "pock-marks" found in the mid-upper area of the image.



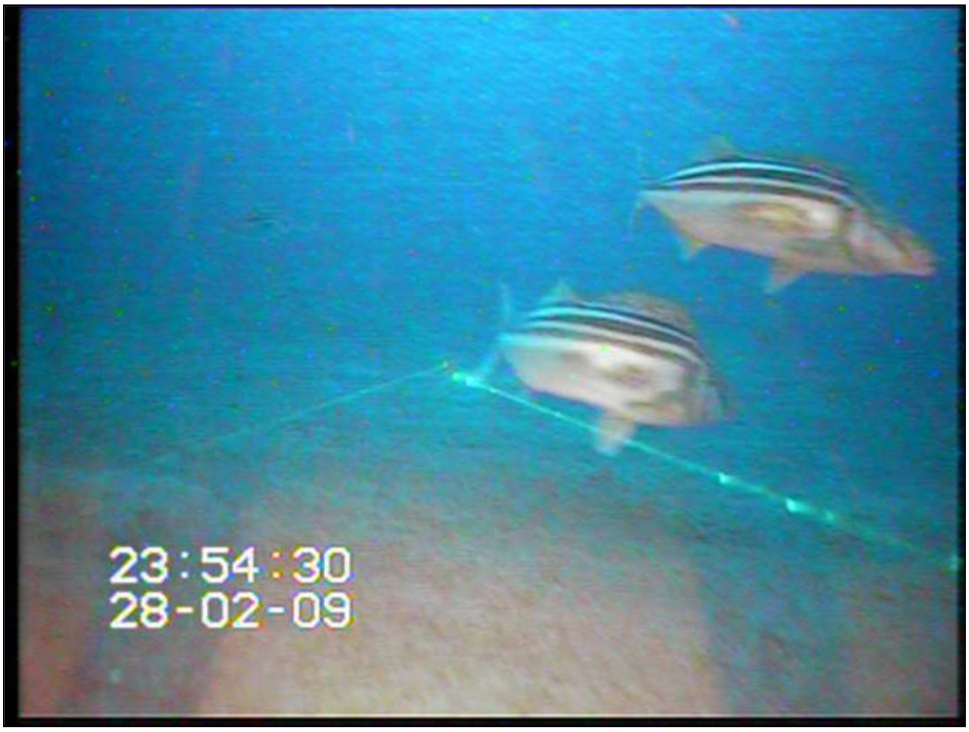
In this close up of these marks we can see that they are fairly regularly sized, approximately 20 m across and 2 m deep. WE now suspect them to be slump features associated with off-gassing of buried organic sediments, but they were certainly unknown before this mapping work was undertaken and may have their own unique biological community.



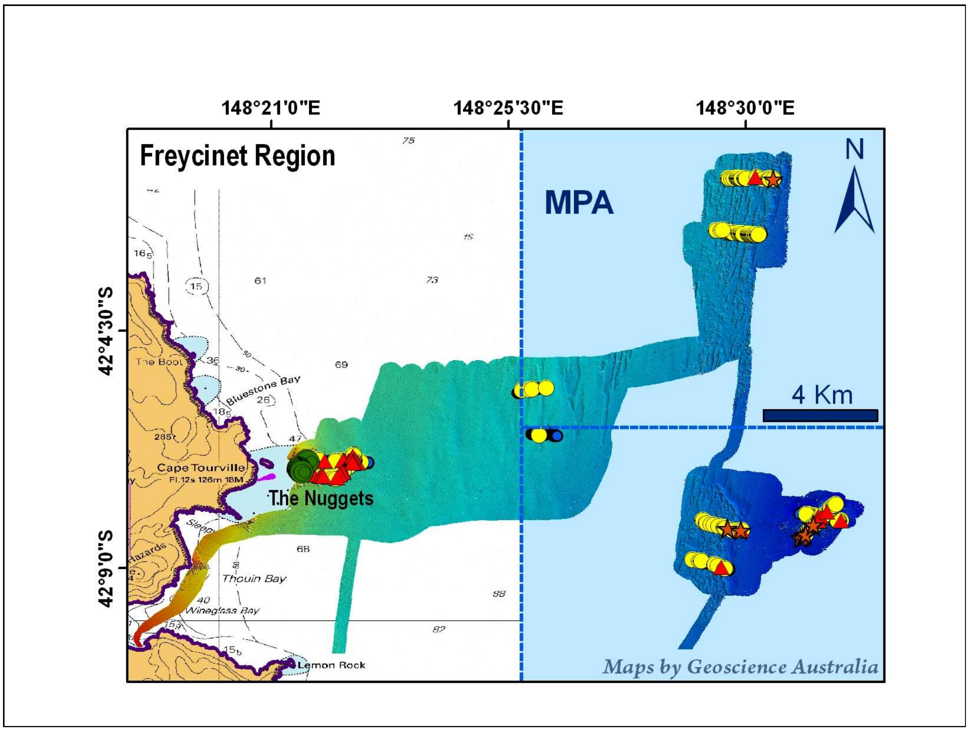
In a similar fashion, we went looking for deep reef systems in the Freycinet CMR in which to set up biological survey sites. We went to positions indicated by fishermen that were spots frequented by stripey trumpeter-a reef associated species. When we mapped these areas we found interesting long-linear features that appeared to run parallel to the coast and for many Km. They were not particularly high, and resemble drowned dune systems. We are still unclear as to whether they are emergent bedrock or are calcified dunes drowned without erosion by rapid sea-level rise. What is evident is that they are a unique habitat feature and, as they continue over a long distance, may act as a migratory pathway for many species that live at these depths (90-100 m).



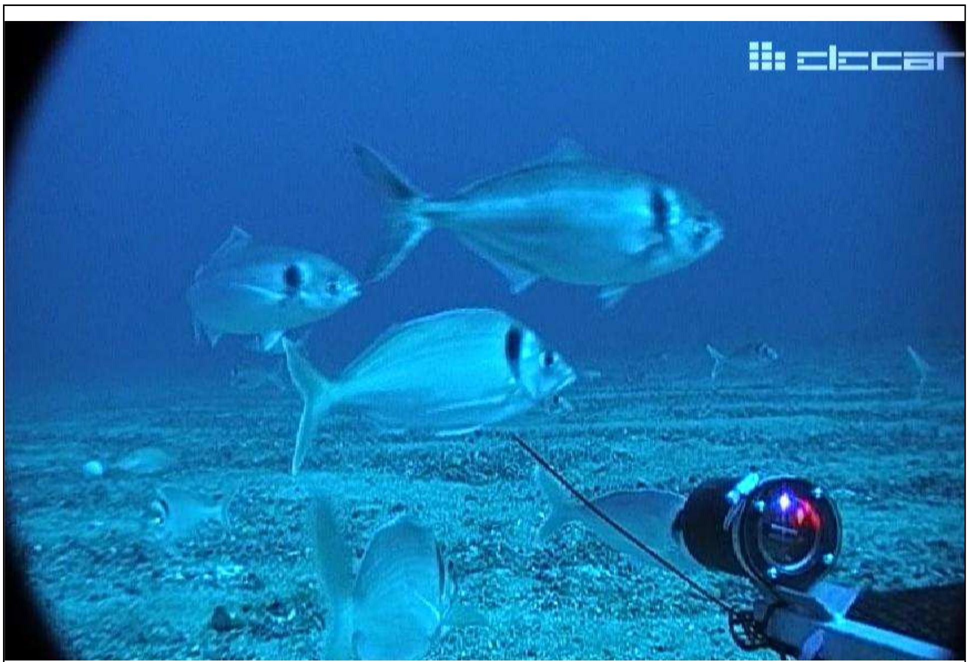
When we survey these reefs with the GA towed Video they had very little profile and were sediment covered so very difficult to differentiate from surrounding soft substrates. We assumed therefore that they probably did not support reef assiciated species like trumpeter.



But we were wrong. At one of the lower profile reef systems in the Freycinet CMR we encountered a school of stripey trumpeter as indicated would be there by our commercial fishermen contacts, so clearly, despite these “linear reefs” being quite different from “typical” reef systems they have an important habitat function for such species. Overall, the use of towed video is certainly a cost-effective way of examining the nature of some of these mapped habitats and in defining the presence and absence of some epi-benthic species such as the trumpeter shown here.



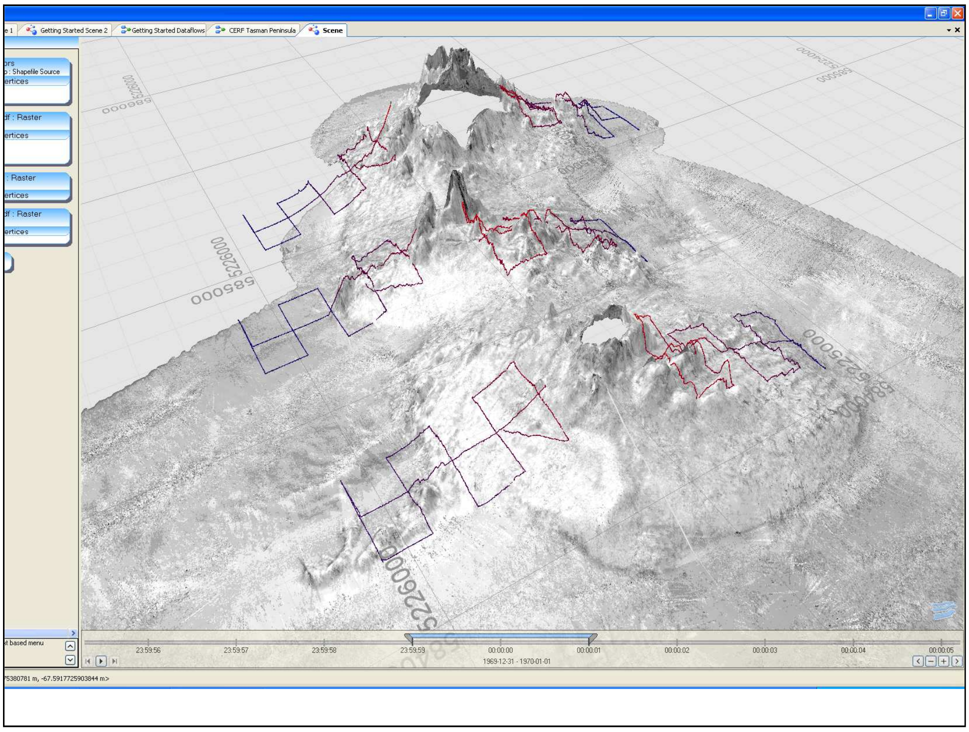
One component of this survey work entailed the real-time scoring of video tows, utilising a method developed by Dr Tara Anderson of GA, which allows typical habitat features (such as substrate type and complexity, sponge cover and height, algal cover) and large detectable species of interest (e.g. Ecklonia kelp, stripey trumpeter) to be scored in 15 second intervals while underway, and then is immediately available for mapping via GIS applications at the end of the tow. This method provides a very rapid assessment of broad-scale patterns at any particular location.



We have been trialling baited underwater video as another component of our CERF Hub work in deep water habitats. This method is quite effective in detecting many of the target species found associated with deep reef systems (and/or adjacent sediments). It can be used to detect habitat based, depth or spatially related patterns, and particularly patterns associated with MPA protection. One advantage of the stereo version we have been using here is that we can use the images to accurately measure the size of fishes as well as abundance. This is important in an MPA context as changes following protection are usually just as important with respect to size as they are with respect to increasing abundance, particularly where fisheries regulations impose minimum size limits to which the stocks are often fished down to.

This is an embedded video showing a stripey trumpeter. This is a heavily fished species in Tas and is potentially reef resident, so in no-take MPAs we would expect to see an increase in size as well as abundance following protection. It is one on the "iconic" Tas species that a monitoring program would want to document adequately.

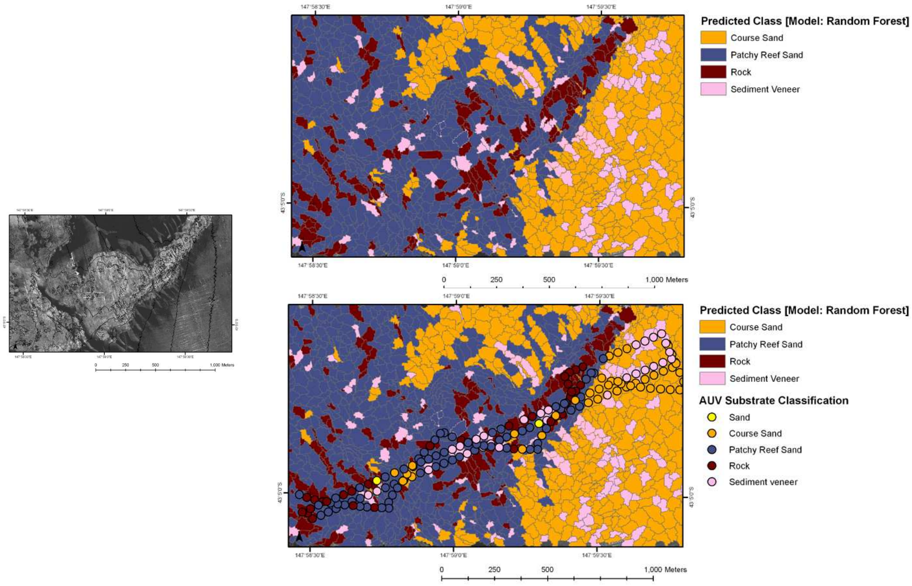
Recently as part of CERF Hub research we have been trialling the use of Autonomous Underwater Vehicles for surveying deep water habitats. This tool, a relatively recent development for use in this field, is a facility of IMAS that we were fortunate enough to be able to access via a grant application to them to facilitate our Hub research. The AUV allows us to gather spatially precise (i.e. we know exactly where it comes from and can go back there again to repeat it in future) high resolution stereo still imagery. Because it is in stereo, this imagery can be used to generate complex 3-D reconstructions of the seabed for use in better defining seabed complexity, as well as looking at spatial relationships in the imagery and providing a great tool for visualising this information for stakeholders and management. Another advantage of the stereo imagery is that we can use there to gain a good size estimation of each species identified, so we can track size distributions through time and with protection. Examples might include the size of flathead, latchet and scallops, all species seen regularly in the sediment habitats surveyed Because the imagery is at such high resolution (and doesn't have the blur associated with towed-video images) we can use it to generate species level biodiversity data in many cases, using a non-intrusive method. This allows us to generate biodiversity inventories at our survey sites, and to examine the relationship of this diversity with physical attributes such as depth, exposure, reef complexity etc that can be both derived from the AUV imagery and ship-borne multibeam data collected from the same area. Being able to couple species level identification and size estimation with a method that allows precise re-sampling through time, offers exciting opportunity for the first time to measure growth rates of sponges and other deep-sea invertebrates etc so we can predict rates of recovery from disturbance such as trawling.



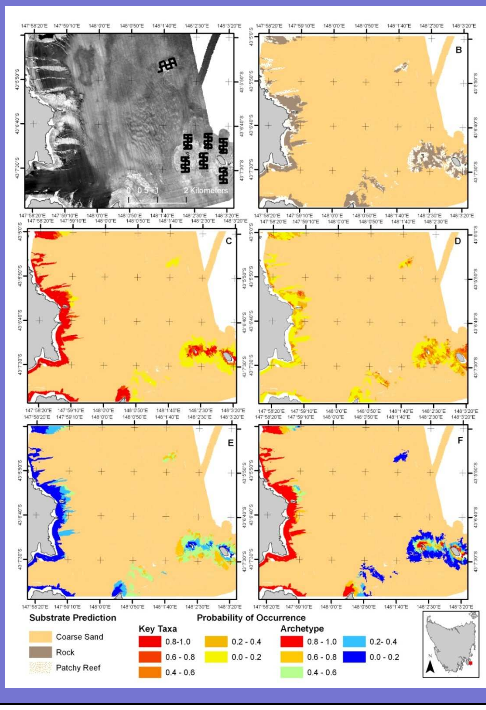
This image shows recent CERF Hub AUV tracks over the seabed on The Hippolyte, a large offshore rock that extends to 80 m depth off the Tasman Peninsula (SE Tas) which was mapped by multibeam sonar by GA as part of this work. The aim was to match up the various datasets to test the predictive capacity of the multibeam sonar to both differentiate distinct habitat types and to take this one step further by predicting the distribution of components of the biota over this space (in a similar manner to the inshore reef prediction described earlier).

Method 6

6. Prediction

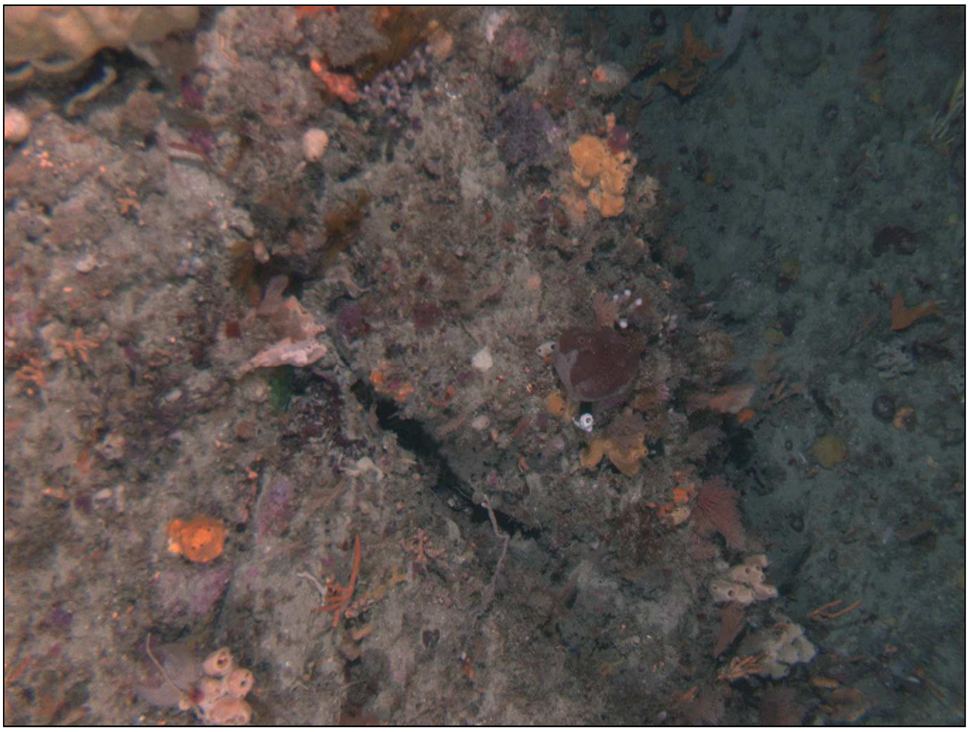


A first step in testing the effectiveness of multibeam sonar as an effective surrogate method for detecting habitat variation was developing predictions of habitat classes based on various multibeam sonar attributes (top panel). Basic habitat classes derived from these predictions were then validated against classed derived from the AUV imagery (lower panel) with a high degree of agreement between the predictions and the observed patterns.

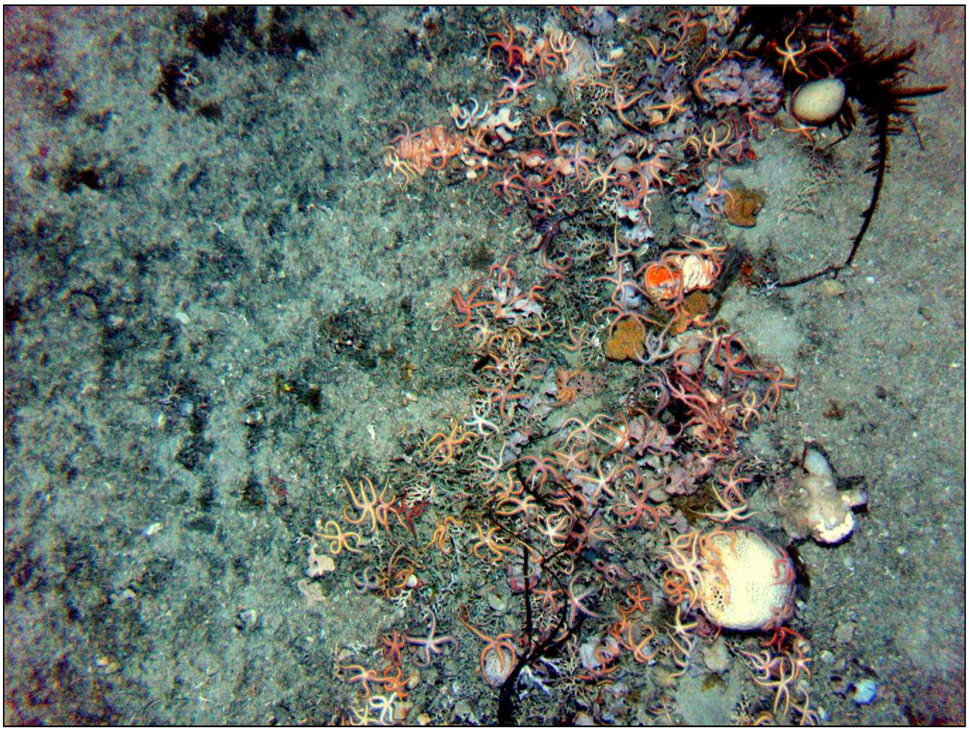


Without going into detail, this figure shows some of the predictions made by combining the multibeam and AUV datasets. The top panels shown here give the prediction of habitat distribution made from the various sonar outputs, the middle two panels show predictions of the distribution of several biotic components, and the lower panels show predictions for the distribution of two "species archaetypes" over this space.

An AUV image showing the degree of resolution of the imagery. We are working with the AUV group from University of Sydney to provide further improvements to this resolution to further aid our ability to differentiate individual species, as part of work being undertaken through Super Science funding.

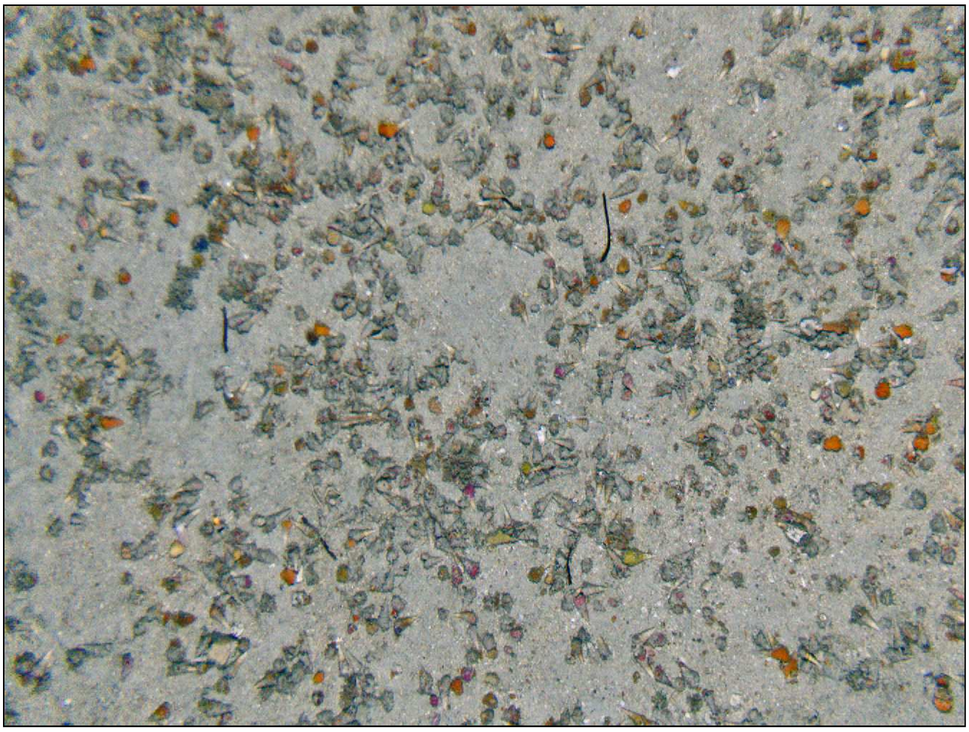


Another component of our work (and an extension of work initiated by the CERF Hub) within the Super Science project and the AUV team is related to developing methods to automate habitat identification and distinct patterning in the imagery that may relate to biodiversity attributes, including change detection. Manually scoring imagery is time-consuming and we are examining approaches to avoid this step.



Future development work proposed by the AUV team involves individual species recognition, and we hope to be closely associated with this work in the future if a recent grant proposal to develop this approach is successful.

Clearly AUV based techniques can collect data at a range of scales from overall biodiversity and habitat type to individual target species. Night time deployment of the AUV proved to be particularly effective at detecting lobsters, and may be a good future technique for estimating abundance and size distributions of these species in MPAs where non-invasive techniques are required.



As well as monitoring native species, the high resolution imagery is good for detecting and monitoring introduced pests, in the case of the image above, the invasive New Zealand Screw shell.

We are actively involved with the AUV facility over the next few years as part of long-term climate-change related observing of coastal and deep water assemblages along the eastern and western temperate seaboard. This is at least in part, incorporated with MPAs wherever possible. We hope to continue our development of this tool as a cost effective monitoring method for deep water habitats on the shelf, particularly within an MPA context, within the proposed NERP Marine Biodiversity Hub, and along with the other suite of tools (Multibean sonar, towed video, BRUVS, ReefLifeSurvey etc) work towards developing the most cost-effective approaches towards the integrated approach needed to adequately document and monitor the health the Commonwealth’s offshore biodiversity assets.