Marine Biodiversity Hub

National Environmental Science Programme

Project showcase and future research prioritisation workshop report

(27 to 28 March 2017)

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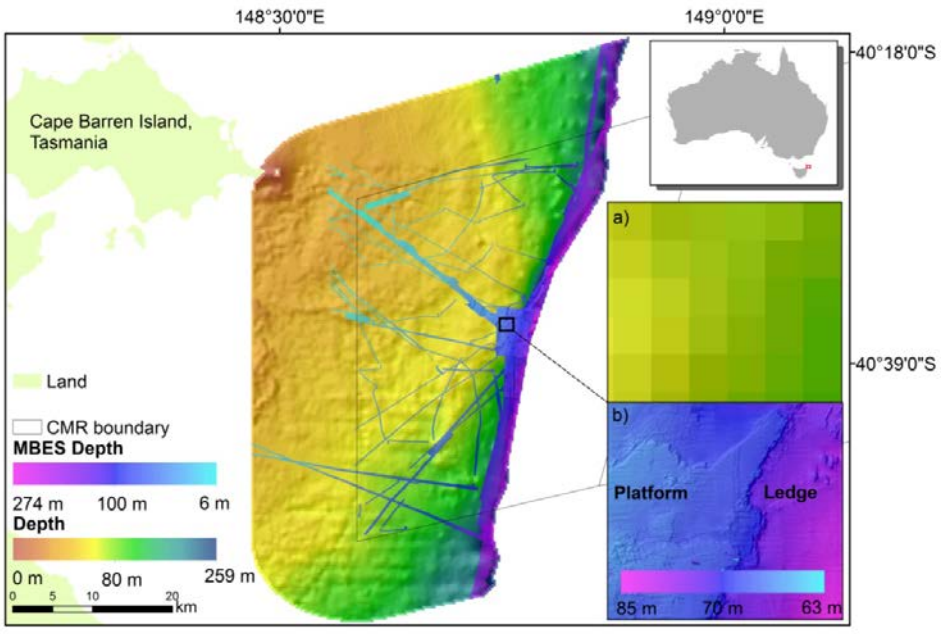
NESP Theme D:
Understanding biophysical, economic and social aspects of the marine environment

May 2017



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Important Disclaimer

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EXECUTIVE SUMMARY

The NESP Marine Biodiversity Hub held a two day workshop in Hobart on 27-28th March 2017 to showcase work undertaken so far in Theme D since the beginning of the Hub, outline future proposed work within the theme, and work with key stakeholders to align research with management needs.

All four of the Themes four projects are designed to be closely integrated with management needs and with each other, to provide the required knowledge to manage and monitor the Commonwealth Marine Reserve (CMR) network. Feedback from the workshop participants (including a significant Parks Australia representation) indicated that the work was indeed closely aligned with information needs, and that work to data, as well as proposed future work, was progressing along lines that met management expectations.

Discussions on day 1 included overviews of linked data visualisation products developed outside the Hub (e.g. SeaMap Australia and FishMap) that build on Hub research to further meet information needs. An overview of Marine Protected Areas (MPA) science and management links within NSW was informative in evaluating how a mature science program can meet management needs. Likewise, an overview of the Reef Integrated Monitoring and Reporting Program (RIMREP) developed by the Great Barrier Reef Marine Park Authority (GBRMPA) was informative of how mature monitoring programs can be evaluated and integrated into the adaptive management process. This initiated discussion on the need to develop a similar process for the CMR network, albeit one at a much earlier stage in the process of management and monitoring than that in the GBR.

Day 2 of the workshop focussed on refining plans for the D1 and D3 projects within the Theme. This was guided by presentations from Parks Australia (PA) on research priorities, including those for CMR surveys as well as data visualisation tools such as a CMR eAtlas. The extensive discussions that followed assisted in the restructuring of D1 and D3 programs to best meet the needs of Parks Australia and the wider Department of the Environment and Energy (DOEE). As PA are now funding the development of the CMR eAtlas, D1 discussions focussed on how to best deliver the information required by the atlas, rather than developing an atlas itself. This discussion was informed significantly by a list of research and information priorities supplied by PA.

For D3, discussions around prioritisation of future surveys focussed on a framework of key drivers, including a nationally consistent approach using Standard Operating Procedures (SOP), integration with management needs and national programs, and meeting priorities identified by Parks Australia. Hub partners will now take these guidelines to develop a package of potential surveys to be supported by the Hub and undertaken over the 2018-20 period, with decisions on survey priorities to be made by the Hub leadership.

1. WORKSHOP BACKGROUND AND OBJECTIVES

The NESP Marine Biodiversity Hub Theme D held a workshop in Hobart on 27-28th March to (1) bring the Hub's Theme D researches together with end users and to engage with stakeholders to provide an overview on progress and (2) to refine the forward research program for 2018 and onwards.

The first day of the workshop was essentially showcasing the research to date, outlining future directions, and reviewing progress in the MPA monitoring and management space in other states as well as the GBR. This first day was an open workshop and attended by a range of interested researchers, PhD students and stakeholders, while the second day was more focussed on discussions between core D1 and D3 staff, Hub leaders and theme leaders with DOEE/PA staff, to refine project deliverables and priorities, including prioritisation of data access/visualisation products, and prioritisation of future surveys in CMRs.

The research covered by the projects within the theme includes:

(1) National data collation, synthesis and visualisation to support sustainable use, management and monitoring of marine assets- a project focussed to date on synthesis of data from NW Australia based on data available from hub partners. Future work includes extending this nationally and developing appropriate visualisation tools.

2 Development of standard operating protocols to underpin monitoring programs via appropriate survey design, condition assessment and trend detection. These protocols are essential to underpin national cooperation in such programs and include protocols for widely used techniques including multibeam sonar mapping, Baited underwater video (benthic and pelagic), AUV-based visual surveys.

3. Preparing for and implementing monitoring of CMRs and the status of marine biodiversity assets on the continental shelf. This project has currently identified and collated all shelf-based mapping data in Australia where possible and utilised the information to revise the known distribution of shelf reef systems, and identify significant gaps in our known mapping coverage. It has developed a national classification scheme for shelf hard substrates, undertaken new surveys in the Hunter CMR in NSW, and made progress in collating current knowledge of CMRs in temperate Australia. Future proposed work includes facilitating progress towards a national integrated monitoring program, development of monitoring approaches suitable for CMRs, and assisting in the prioritisation of new CMS surveys.

4. Expanding our spatial knowledge of marine biodiversity to support future best-practice reviews. This project has focussed on furthering our understanding of the biodiversity of deep water faunal assemblages, a significant component of commonwealth waters that are difficult to access and survey. The faunal relationships observed are improving our understanding of the processes that geographically structure these, providing the potential to update and revise our current marine bioregionalisation.

Further details of these areas are expanded below.

Workshop Introduction:

The introduction outlined the broad drivers of our need to develop effective inventory and monitoring programs for the Commonwealth CMR network and commonwealth waters in general, including key NESP priorities and those of the National Marine Science Plan.

The Marine Biodiversity Hub Theme D aims to understand the biophysical, economic and social aspects of the marine environment. More specifically, the objectives of Theme D include developing nationally consistent and cost-effective tools and approaches to data acquisition in CMRs in order to monitor and understand impacts and risks in the marine environment, and enhancing the capacity of researchers and industry to collect information that supports decision-making. There are four interlinked projects in Theme D:

- Project D1: National data collation, synthesis and visualisation to support sustainable use, monitoring and management of marine assets,

- Project D2: Standard operating procedures (SOPs) for survey design, condition assessment and trend detection,

- Project D3: Preparing for, and implementing monitoring of CMRs and the status of marine biodiversity assets on the continental shelf, and

- Project D4: Expanding our spatial knowledge of marine biodiversity to support future best-practice reviews.

The general aims of Theme D and the specific objectives of the four Theme D projects are strongly aligned with the requirements of Parks Australia in supporting the development of effective CMR management and monitoring programs. This Theme D workshop therefore offers the opportunity for the researchers in Theme D to engage with CMR managers in Parks Australia, and the wider management community within DOEE to review the progress of the research program and to identify future research priorities for delivering information to Parks Australia to support management plans.

Parks Australia Overview:

Parks Australia is transitioning to managing six times the current Commonwealth Marine Reserve (CMR) network, with the anticipated release of new management plans for the 40 CMRs in the North, North-west, South-west, Temperate East and Coral Sea reserve networks by end of 2017. For effective management and monitoring of these reserves, Parks Australia will require an inventory of the environmental assets within CMRs, baseline information on environmental parameters, the establishment of environment monitoring, modelling and reporting within an adaptive management framework (similar to the RIMPEP approach for the GBR). Importantly, Parks Australia needs management-ready and easily accessible information based on robust science. Parks Australia is keen to work with the NESP Marine Biodiversity Hub and the broader marine science community to provide guidance of future investment in scientific research based on a range of drivers (e.g. pressure from fishing, offshore resources industry and climate change), and adopt the most cost-efficient and

effective management methods. Parks Australia recognises this is a challenging task, and suggests that the first five to ten years will represent a 'discovery/inventory' phase for many CMRs. This phase will require partnerships wherever possible, both for research and compliance. At present only the SE network and several minor reserves have management plans in place, allowing studies to incorporate management prescriptions within their designs. It is anticipated that plans for the new network may be released in May 2017, but that with consultation periods and review, the enactment of plans may be later in the year. To some degree, targeting early surveys in areas where plans are already in place is seen as a priority.

2. THEME D ACHIEVEMENTS AND PROGRESS

2.1 NESP Project D1 - National data collation, synthesis and visualisation to support sustainable use, monitoring and management of marine assets

Project D1 is collaboration between AIMS, GA and UWA and leverages previous research undertaken through the CERF and NERP programmes along with stakeholder knowledge to improve ecosystem understanding for management in the North and North-west Regions. In the past two years (2015-16 and 2016-17) the goals of the project were: increase the accessibility of existing research and data products to end users including marine managers, regulators and the general public; identify knowledge gaps and develop strategies to address these, and; improve ecosystem understanding of KEFs and CMRs through predictive modelling. The key outputs of the project included:

- a science workshop that identified existing environmental and biological data in the North and North-west regions;
- a stakeholder workshop that liaised with key stakeholders to discuss research needs in the North and North-west regions;
- the establishment of the North West Atlas webpage for the dissemination of management-friendly scientific information and products (www.nwatlas.org);
- the physical and biological data gap analysis in the North and North-west regions, and;
- predictive modelling of marine habitats in two priority areas: Ancient Coastline KEF and Oceanic Shoals CMR.

Reports from the science workshop and stakeholder workshop are available on the marine Biodiversity Hub website.

During this workshop, achievements and outcomes from work completed for the last three key outputs listed above was presented, and are summarised below.

2.1.1 North West Atlas

The North West Atlas (http://northwestatlas.org) is part of a group of on-line atlases delivered through a common platform (eAtlas) developed by AIMS. It is a web portal to share and find spatial data, maps and photos and other scientific information for the North and North-west marine regions. The North West Atlas features an interactive map gallery that enables users to discover individual marine physical and biological data and to explore data with interactive synthesis demos. For example, users are able to discover “Where has multi-beam bathymetry data been collected around Australia?” through the interactive map gallery (Figure 1). Users are also able to explore current scientific knowledge and data about the Oceanic Shoals CMR through an interactive demo (Figure 2). However, the North West Atlas does not host datasets for direct access.

Figure 1: An interactive map gallery in the NW Atlas: Where has multi-beam data been collected near Australia?

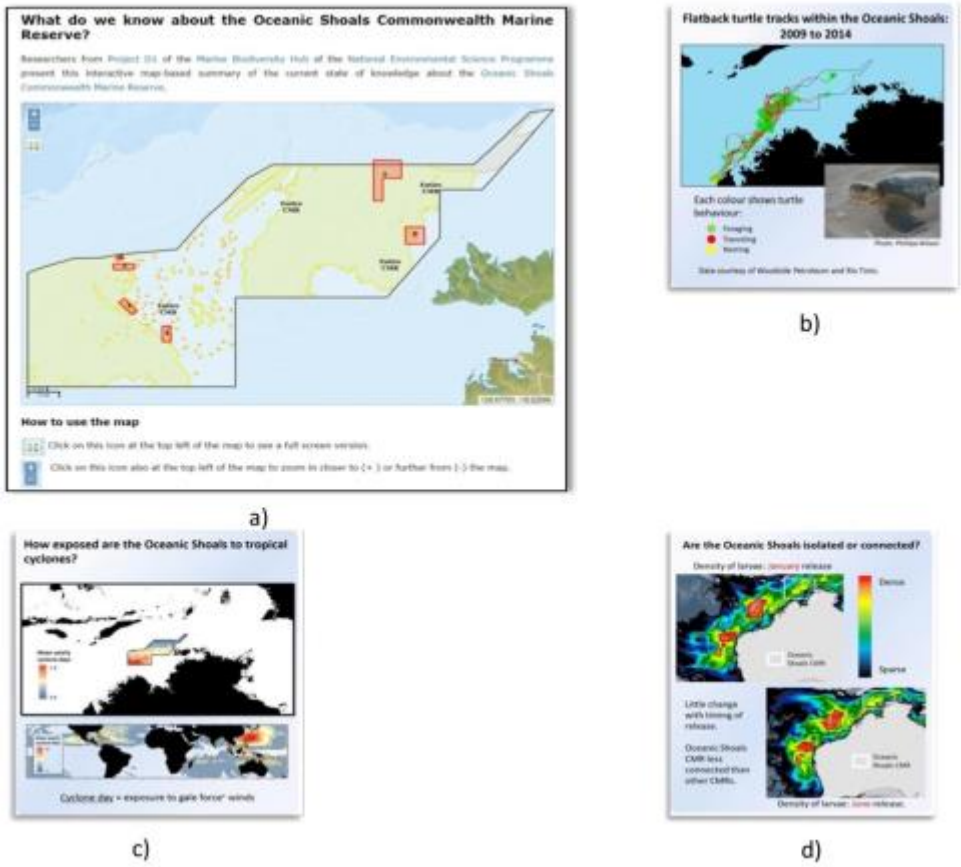

Figure 2: Oceanic Shoals CMR interactive demo; a) main interface; b) exploring turtle tracks from the demo; c) exploring cyclone exposure from the demo; d) exploring connectivity from the demo.

As of Dec 2016, the datasets that are viewable and synthesised through the North West Atlas are summarised in Table 1.

Table 1: Number of datasets viewable in the NW Atlas listed by geographic area / CMR and access history

	N and NW regions gap analysis	*Oceanic Shoals*	*Glomar-Rankin*	*Montara shoals*	*Total*
Viewable data not allowed to be published any other way	0	5	4	10	19
Viewable data not yet published any other way	0	33	8	23	64
Interact with data online more easily than was previously possible	0	55	0	0	55
Interact with data online that was not previously online	32	10	0	0	42
Total	32	103	12	33	180

2.1.2 Data Gap Analysis

There are 29 Key Ecological Features (KEFs) and 21 CMRs in the North and North-west regions. Project D1 has conducted a physical and biological data gap analysis in these KEFs and CMRs to provide guidance for predictive spatial modelling and target field surveys. Specifically, we want to answer the following three questions:

- Where have key biota ever been observed the most?
- Where could we build a model if only we have more biological data?
- Where could we build a model if only we had more bathymetry data?

Both biological and physical data used for the gap analysis were obtained from a range of publically available datasets. For the biological data, they were extracted from:

- The Atlas of Living Australia (http://www.ala.org.au/),
- The Western Australian Museum (www.australianmuseum.net.au/,(
- Ocean Biogeographic Information System (http://www.iobis.org/),
- Global Biodiversity Information Facility (http://www.gbif.org/),

- Pelagic BRUVS data from the University of Western Australia (http://www.uwa.edu.au)
- Demersal BRUVS data from the Australian Institute of Marine Science (http://www.aims.gov.au),
- BRUVS from FinPrint (https://globalfinprint.org/),
- Opportunistic observations from the University of Western Australia (http://www.uwa.edu.au), and
- Underwater towed video real-time observations from the Australian Institute of Marine Science (http://www.aims.gov.au).

The results of the gap analysis indicate that Kimberley CMR contains more than 15% of all known observations across all six benthic biota classes. However, these observations only cover between 4% and 11% of the CMR area for these classes. Ashmore and Cartier Island CMRs have the highest percentage area (> 30%) covered by the benthos observations. For demersal fishes, sharks and rays, Gulf of Carpentaria CMR contains more than 15% of all observations. Relatively, demersal observations are more widespread within several of the smaller CMRs including Ashmore reef, Cartier Island, Dampier and Montebello. For the pelagic fishes, sharks and rays, several CMRs contain more than 15% of all observations. Pelagic fish observations are not widespread in any CMR; while, pelagic sharks and rays are widespread across Cartier Island and Ningaloo CMRs. In terms of megafauna, only Kimberley CMR contains more than 15% of all observations across all CMRs. Marine mammal observations are widespread in Ashmore Reef and Limmen CMRs. Sea turtles are widespread in many of the CMRs including Kimberley.

In summary, hard coral observations are abundant in Ningaloo CMR; soft coral observations abundant in Kimberley CMR; sponge observations are abundant in Ningaloo and Kimberley CMRs; brittle star and mollusc observations are abundant in Ashmore Reef CMR; demersal and pelagic fish observations are abundant in Gulf of Carpentaria; marine mammals are abundant in Kimberley and Argo-Rowley Terrace CMRs; sea turtles observations are abundant in Kimberley CMR.

The physical datasets used for the gap analysis include:

- Bathymetry data held by Geoscience Australia (GA) and Royal Australian Navy (RAN) hydrographic office,
- Sediment observations held in Geoscience Australia's MARS database, and
- In-situ oceanography datasets including temperature, salinity, chlorophyll, oxygen, turbidity, current and wave parameters obtained from IMOS, CSIRO, BOM and RAN.

The results indicate that 19% of the area in the 21 CMRs of the North and North-west regions is covered by high-quality mulitbeam data; 7% of this area is covered by RAN bathymetry; and 25% of the area is covered by at least one of the two bathymetry sources. In terms of the sediment samples, in the North and North-west regions, there are only 533 samples within the CMRs, compared to 3700 samples outside CMRs. For the oceanographic data, they cover 37% of the area in the CMRs of the North and North-west regions. The physical data coverages of five representative CMRs are shown in Table 2. It indicates that generally, the CMRs in the deeper waters (e.g., > 200m) have greater multibeam bathymetry coverage and smaller

oceanographic data coverage than those in the shallow waters. However, some CMRs such as Eighty Mile Beach have little coverage for any physical data.

Table 2: Physical data coverage of five CMRs

MPA_NAME	Depth Zone	Multibeam (%)	All Bathy (%)	MARS points (N)	Oceanographic (%)
Argo-Rowley Terrace	Deep	20	22	16	16
Gascoyne	Deep	42	44	63	34
Kimberley	Shelf	8	16	75	73
Oceanic Shoals	Shelf	9	20	90	56
Eighty Mile Beach	Shelf	0	4	1	3

2.1.3 Predictive habitat modelling

Marine observation data are often sparse due to the cost of collecting them in the vast marine estate, especially in remote CMRs. Spatial predictive habitat modelling is a practical and effective alternative to not only fill the information gaps but also improve the knowledge of marine ecosystem. In Project D1, we have used high-quality physical and biological data collected in the Oceanic Shoals CMR to conduct predictive habitat modelling and illustrate the utility of such modelling in a management context. Three predictive habitat modelling examples are briefly described in this report.

In AIMS, spatial predictive models were developed for several benthic species and used to predict the distributions of these species across the entire Oceanic Shoals CMR. The final benthic habitat map was constructed as shown in Figure 3. The validation from in-situ samples indicates that the overall prediction accuracy is 83%; the prediction was most accurate for Alcyons (94%) and least accurate for seagrass (48%). Importantly, this predictive modelling exercise showed the possibility of extending fine-scale (e.g., 2m) models developed at local areas to the entire CMR at coarse-scale (Figure 4).

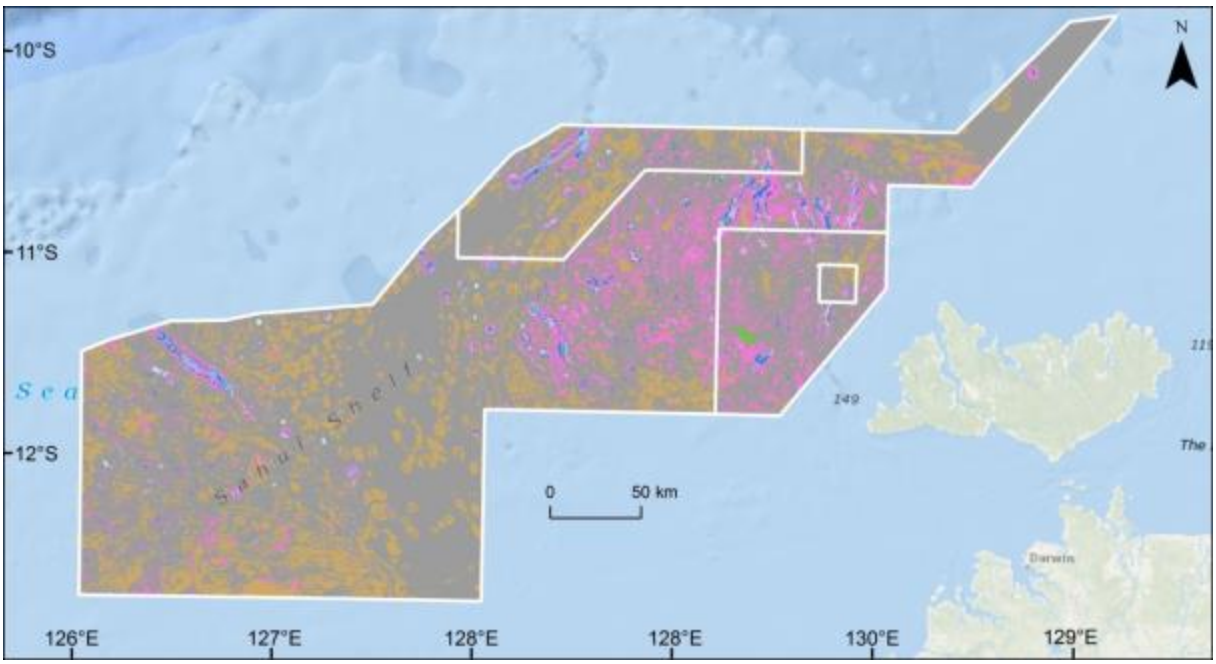

Figure 3: Predicted benthic habitat map of the Oceanic Shoals CMR (see Fig 4 for legend)

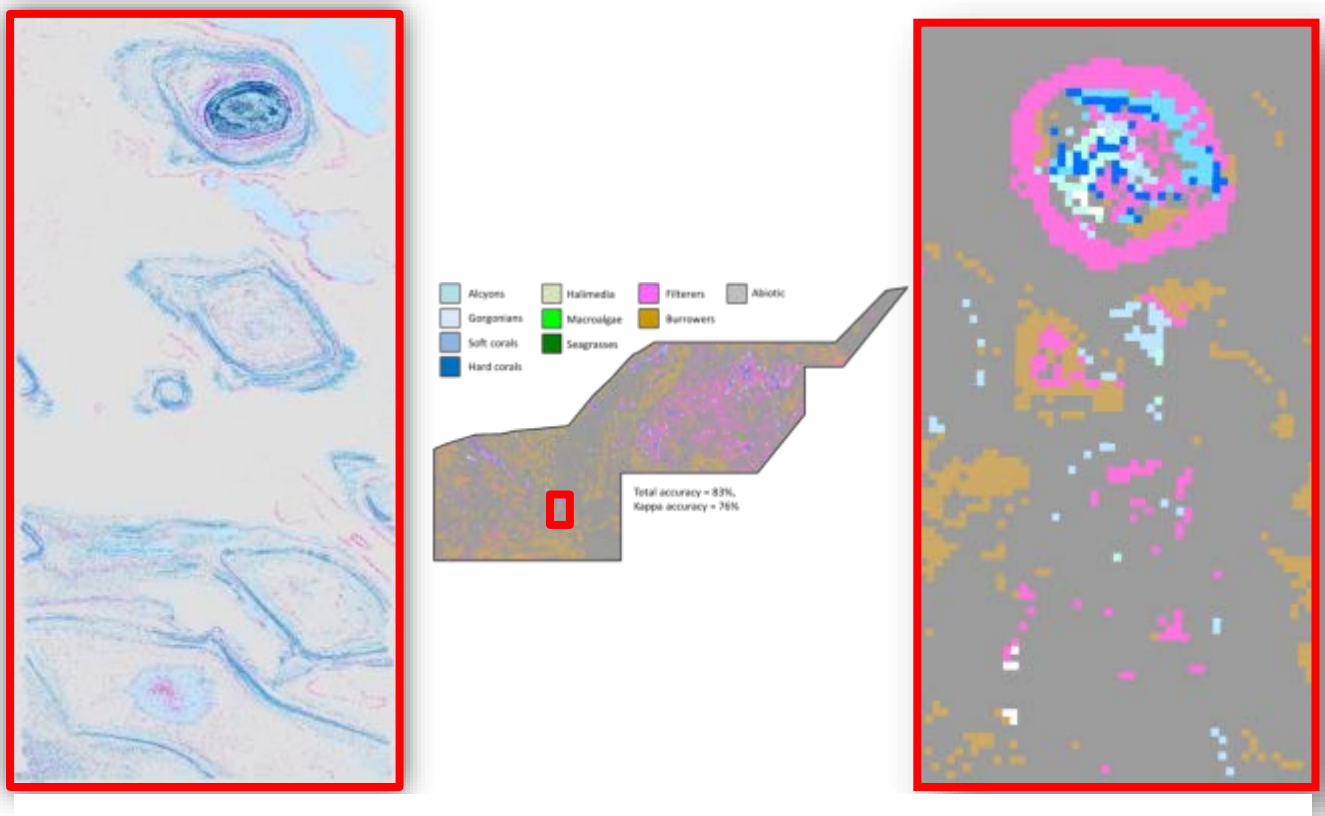

Figure 4: Extending from fine-scale model (left) to coarse-scale (right) – an example from the Oceanic Shoals CMR.

In GA, spatial predictive models were developed to predict the seabed substrate of four study areas on the eastern side of the Oceanic Shoals CMR (Figure 5) into four hardness classes (Figure 6). These seabed hardness classes are a potentially good proxy of benthic communities. The prediction indicates a strong agreement between observed and predicted seabed hardness classes for 140 sample locations with ~90% validation accuracy.

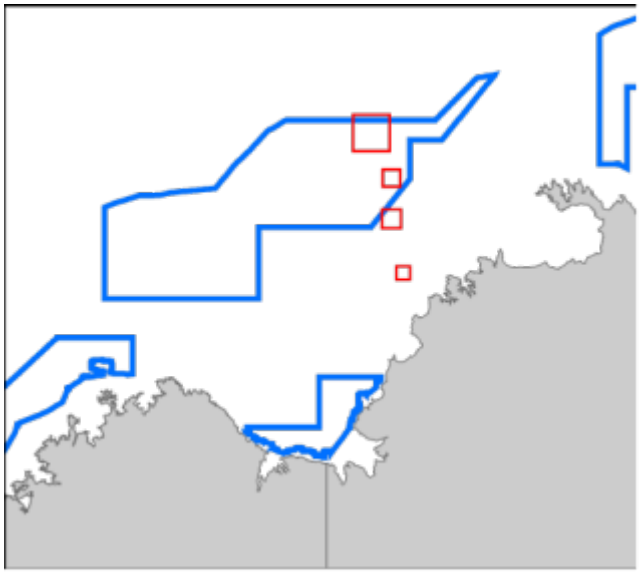

Figure 5: The four study areas that intersect with the eastern Oceanic Shoals CMR and carbonate banks and terraces of the Van Diemen Rise KEF.

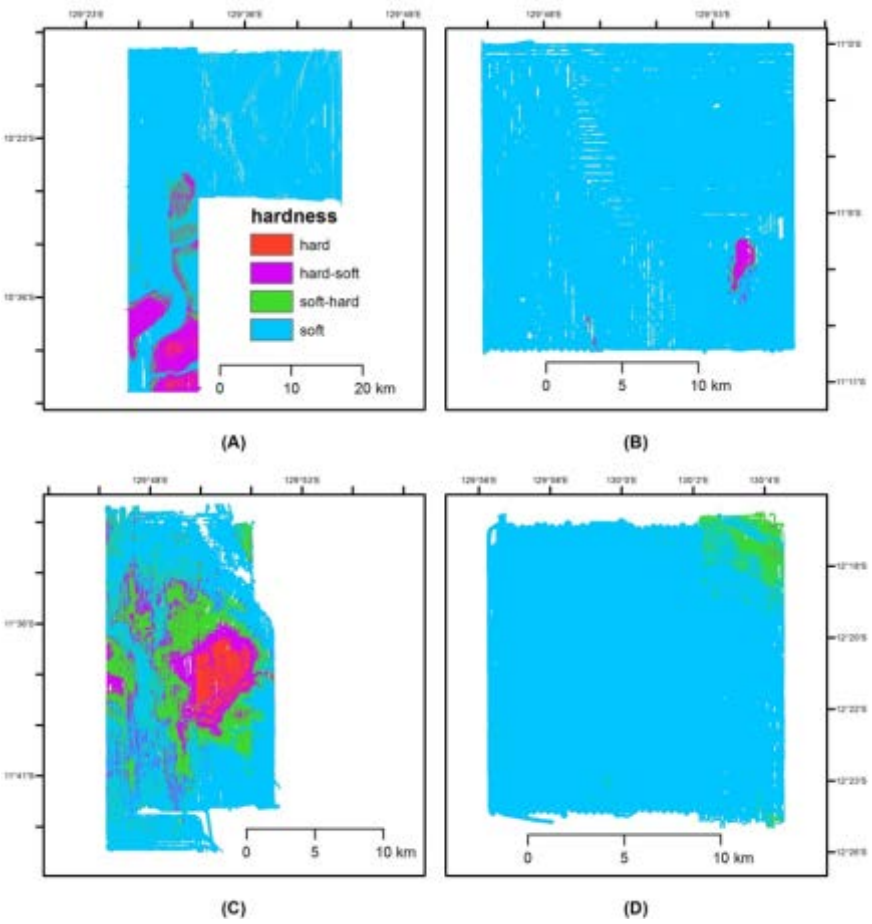

Figure 6: Seabed hardness predictions of the four study areas

In UWA, pelagic diversity (e.g., species richness) of the Oceanic Shoals CMR was predicted using several predictive modelling methods (Figure 7). The predictive modelling was also able to generate a spatial distribution of prediction uncertainty. Encouragingly, the best performing model was able to explain 69.8% of deviance.

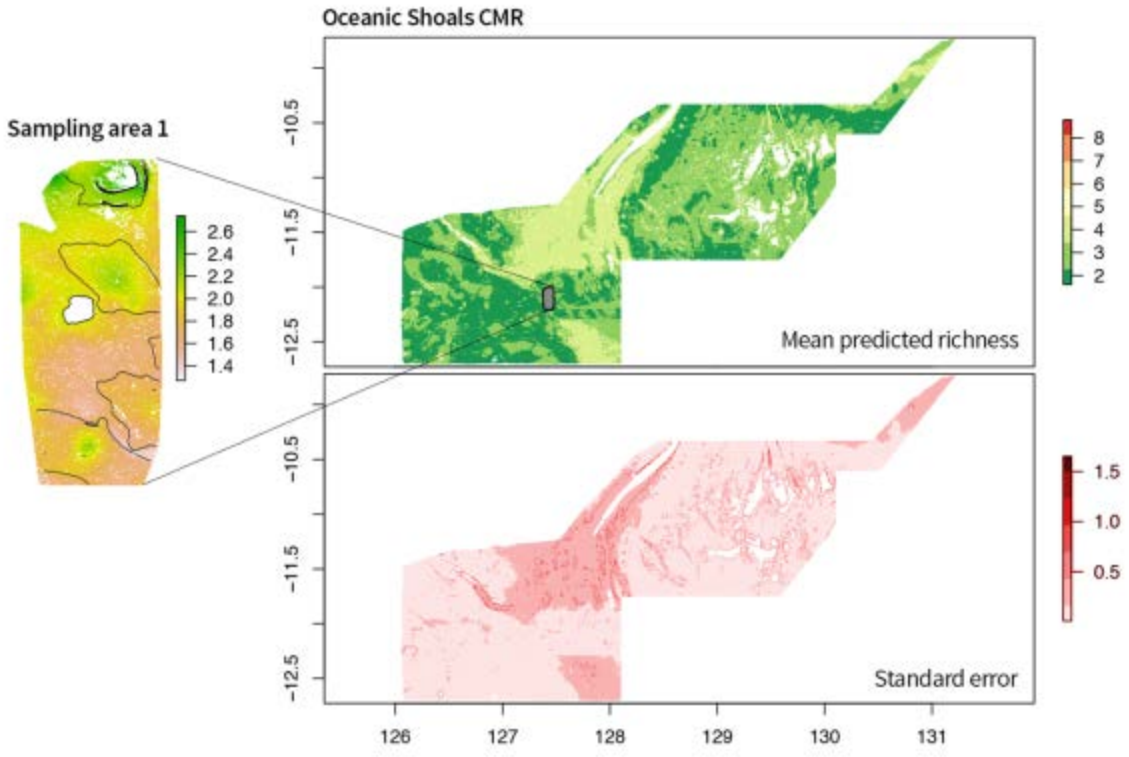

Figure 7: Pelagic diversity prediction of the Oceanic Shoals CMR and the prediction uncertainty

2.2 NESP Project D2 - Standard operating procedures (SOPs) for survey design, condition assessment and trend detection

Project D2 is a collaboration between CSIRO, UTas, AIMS, GA and UWA to develop Standard Operating Procedures (SOPs) for survey design, condition assessment and trend detection. Monitoring is the tool for objective knowledge. It is more than a series of surveys. Critically, these surveys must be coherent and standardised in order for trend detection to be valid. Without standardisation, data may not be comparable through time and space. In the worst case, no information of status and trends would be available for ecosystem understanding. In moderate case, information of status and trends needs to rely on interpretations of data resting on strong modelling assumptions. Project D2 has developed a conceptual model of the work flow involved with marine surveys, incorporating SOPs as shown in Figure 8. In 2015-16, this project developed an R-package to address one component of this conceptual model – Where/When to Sample. The R-package is based on generalised additive models to account for not only randomization but also autocorrelation. An example output of this R-package is shown in Figure 9. Progress has also been made in developing field manuals of various survey gears. Networks of field experts have been formed to develop field manuals for MBES, AUV, Towed Video, Benthic BRUV, Pelagic BRUV, Sled/Trawl, and Grab/Boxcore. A draft template of field manual has been designed to facilitate the manual development.

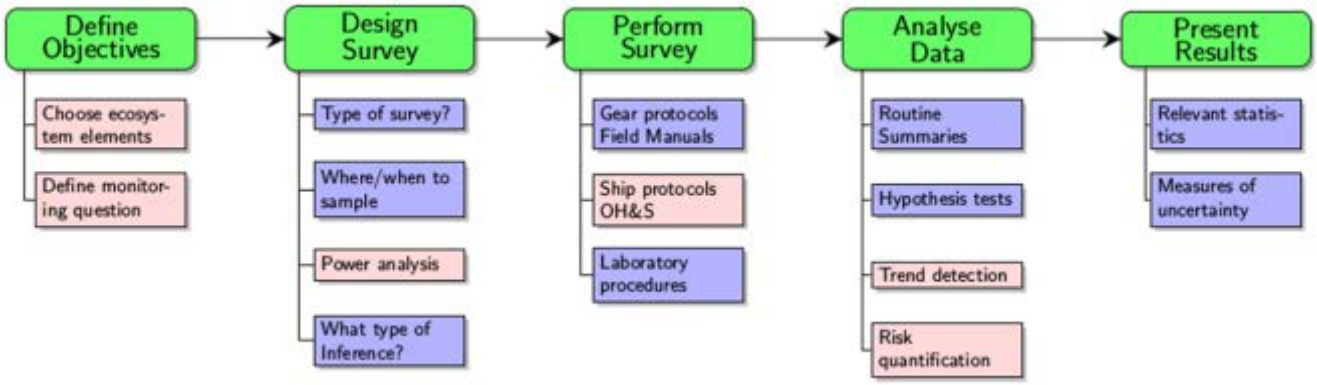

Figure 8: A conceptual model of marine survey work flow, incorporating SOPs

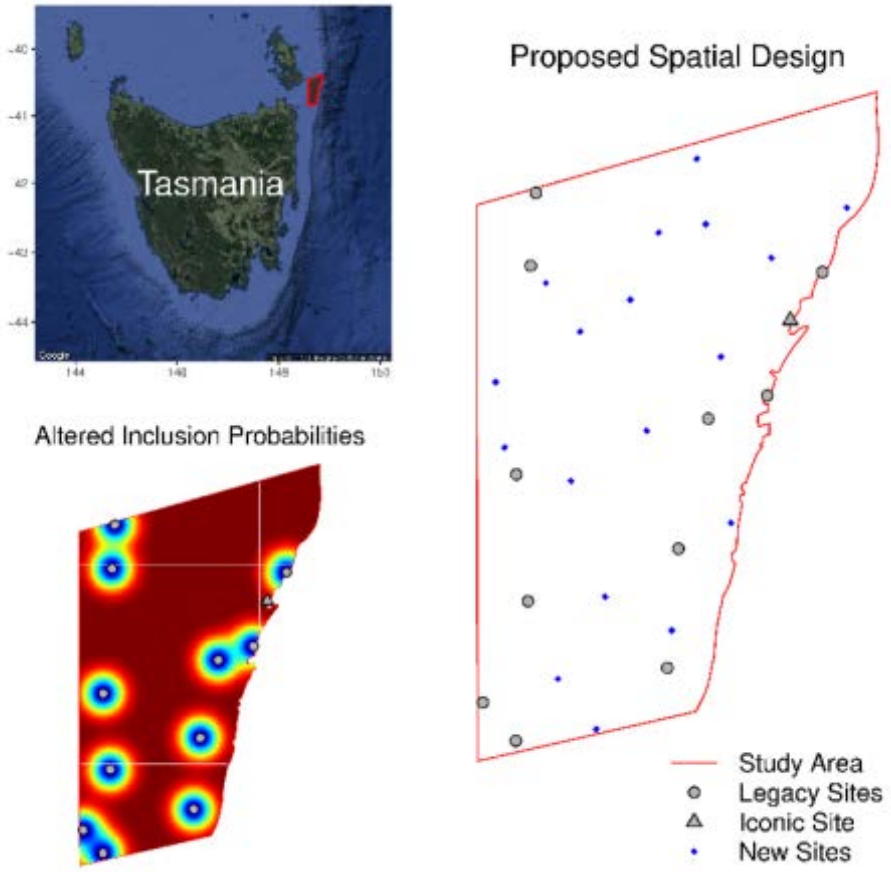

Figure 9: An example output of the R-package to indicate where/when to sample

2.3 NESP Project D3 - Preparing for, and implementing monitoring of CMRs and the status of marine biodiversity assets on the continental shelf

NESP Project D3 is collaboration between UTAS, GA, NSW OEH, CSIRO and UWA to evaluate the status of reef habitats on the continental shelf. This project has five components:

- national collation of shelf bathymetric and habitat mapping for national estate management, gap analysis, revision of shelf reef KEF understanding;
- development of a reef geomorphological classification scheme for shelf waters of Australia;
- applying collated mapping products from shelf waters to update knowledge of features and mapped extent within CMRs nationally, and enhanced description of biological and habitat features of case study CMRs in temperate waters;
- ARMADA-Refinement of a spatial data discovery tool to assist spatial management of CMRs and KEFs, and;
- Discovery surveys in the Hunter CMR shelf waters – new mapping to underpin understanding and future biological monitoring programs.

Up to now, the project has delivered a science workshop report (Lucieer et al., 2016), a shelf reef mapping and gap identification report (Lucieer et al. 2017) and a reef geomorphological classification scheme report (Nichol et al., 2016). A draft report updating the current knowledge status of Australia's temperate-water CMRs is also approaching completion (Monk et al., 2017). The current progress and achievements of the above five tasks were presented at this workshop and are summarised below.

2.3.1 Collation of shelf bathymetry mapping

This task was to collate existing shelf mapping data from various sources and to identify reef coverage within this and describe data gaps for Australia's continental shelf. Government (Commonwealth and States) and universities represent two major sources of the collated data. In summary, only 15% of Australian shelf waters (0-160m) have been mapped. The RAN/AHO represents the largest single data holding (12% out of 15%). NSW has mapped the largest proportion of their state waters (27%). The maps of the reef-like habitats on the continental shelf have been classified into four tiers based on the data quality. The tier 1 reef habitat maps (n = 51) are highest quality based on very high resolution multibeam data with robust mapping methods. They were obtained from GA, UTas, UWA, NSW OEH, SA DEWNR, NTG and Deakin University. An example of a tier 1 map is shown in Figure 10. The tier 2 maps are based on CSIRO multibeam data; while, the tiers 3 and 4 maps include data extracted from a bathymetric model produced by RAN/AHO data. All 70 collated datasets are discoverable on AODN.

The total mapping areas against each state and territory are summarised in Table 3, which indicate that only about 3.5% of Australian shelf waters have been mapped in tiers 1 and 2. Within the mapped areas, 25% of the total area is reef-like habitat. The greatest area of these reef-like habitats are within WA (31% of map coverage) and QLD (29%), respectively. The collated mapping data against each of the 48 shelf CMRs and the four-tier mapping outputs

will be published through SeaMap Australia to be publicly released this July at the AMSA 2017 conference. Collated datasets are described in the final report of this project (Lucieer et al. 2017) which contains links to metadata records of each individual dataset, many of which link further to the actual mapping data held by project partner agencies. Overall, the project significantly enhanced data discovery in this area, and significantly assisted in the process of making many of these datasets publically available through online resources.

Table 3 – Bathymetry data coverage listed by data type (Tier) and State.

STATE	Total area of shelf (Km^2)	Tier 1 (Km^2)	Tier 2 (Km^2)	Tier 3 (Km^2)	Total area mapped	Mapped area as % of total area
VIC	77500.00	4935.07	1218.36	3091.58	9245.01	11.93%
WA	698275.00	4757.78	20295.21	35924.40	60977.39	8.73%
TAS	104867.00	4856.44	8904.37	3328.08	17088.89	16.30%
SA	223780.00	1546.48	4975.91	16204.75	22727.14	10.16%
NT	404612.00	2134.20	6177.88	63314.18	71626.26	17.70%
QLD	601734.00	6.47	6445.09	128671.49	135123.05	22.46%
NSW	37372.00	3598.65	4371.39	2158.72	10128.76	27.10%
Total area (Km^2)	2148140.00	21835.09	52388.21	252693.20	326916.50	
Total area as % of survey type		1.02%	2.44%	11.76%	15.22%	

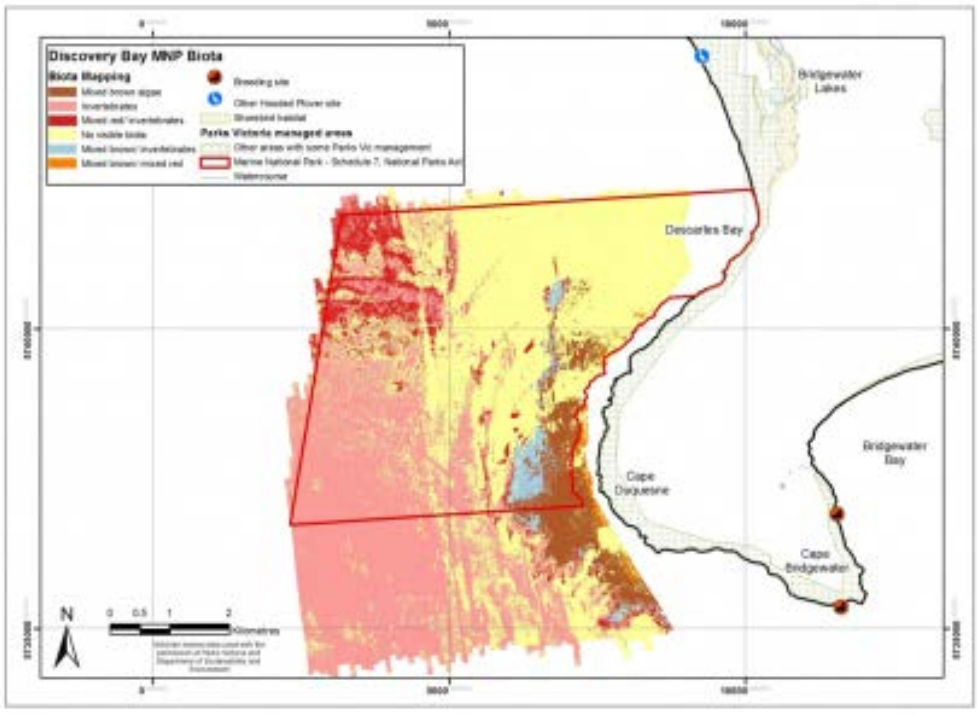

Figure 10: An example of tier 1 reef habitat map

2.3.2 Geomorphological Classification of Reefs

Reefs have been identified as KEFs in marine bioregional plans as potential surrogates of biodiversity. We require a common language (standard) to describe the reef structure. This task developed a classification scheme to describe the form, location, environmental setting and origin of a reef. The scheme (Figure 11) is scale independent and links to the following three existing schemas: coastal & marine ecological classification standard (CMECS), international hydrographic organisation undersea feature names, and national benthic bioregionalisation. As shown in Figure 11, the scheme is non-hierarchical and classified into eight categories: Origin, Ocean Climate Zone, Shelf Zone, Geofeature, Relief, Slope, Rugosity and Substrate. These eight categories describe both broad environmental settings and fine details of reef morphological measures where the quality of the data enables. A real-world example of reef classification based on the geomorphological scheme is given in Figure 12 and Table 4.

Figure 11: The reef geomorphological classification scheme (see Nichol et al. 2016)

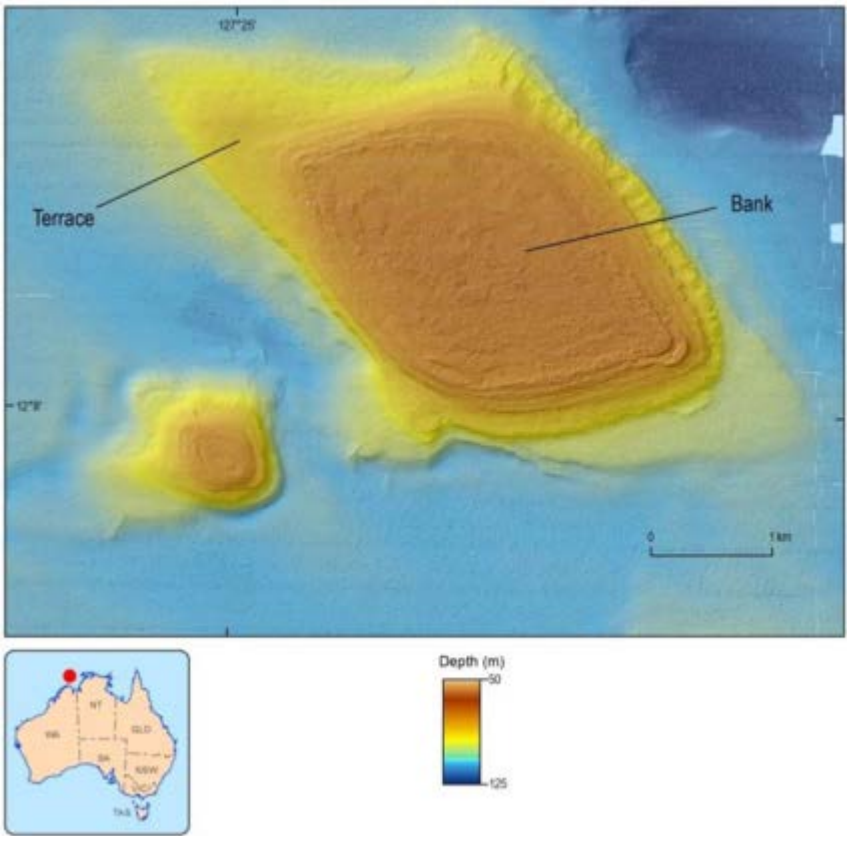

Figure 12: An example of reef morphological classification; the categories are described in Table 4.

Table 4: Reef morphological classification of Figure 12

Origin	Climate Region	Shelf Zone	Geofeature	Relief	Slope	Rugosity	Substrate	Rock Lithology
Biogenic	Tropical	Outer Shelf	Bank	Low to Medium[1]	Flat[2]	Very Low[3]	Rock	Indet
Biogenic	Tropical	Outer Shelf	Terrace	Low	Flat	Very Low	Rock	Indet

2.3.3 The biological and reef-habitat features of Australia's temperate-water CMRs

This task was to collate shelf mapping products to update knowledge of temperate reef features and their mapped extent within CMRs nationally, with a focus on habitats and biological characteristics. The biological data used in this inventory analysis include data collected by IMOS AUV, BRUVs, sled, grab and STV. The physical data include geomorphological feature layers and bathymetry data (from multibeam and other bathymetry sources). For example, in Flinders CMR, 17% of its area has been mapped with multibeam sonar (140 km^2) with about 4km^2 of this area identified as reef habitat (Figure 13). The STV data from CSIRO indicate that Bryozoa is the most prevalent sessile biota, followed by sponges. According to the BRUVs data, the fish species of *Nemadactylus macropterus* is the

most abundant. In addition, the IMOS AUV data indicates that the most prevalent communities of Bryozoa/Hydroid/Cnidaria Matrix occupy ~3.5% of continuous AUV patch (area=9km^2).

In summary, biological sampling of temperate reefs is lacking in Bass Strait CMRs (Apollo, Beagle, Boags, Franklin, Zeehan), the SA CMRs (Great Australian Bight, Kangaroo Is., Murat, Murray, Western Eyre) and the WA CMRs (Bremer, Eastern Recherche, South-west Corner, Twilight). Indeed, only 2% of the seabed on continental shelf sections of the CMRs has been mapped by MBES. The Lord Howe, Cod Grounds, Flinders and Jurien CMRs are the most extensively mapped by MBES (10-90%); while, Boags, Central Eastern and Carter Island CMRs have not been mapped by any multibeam survey.

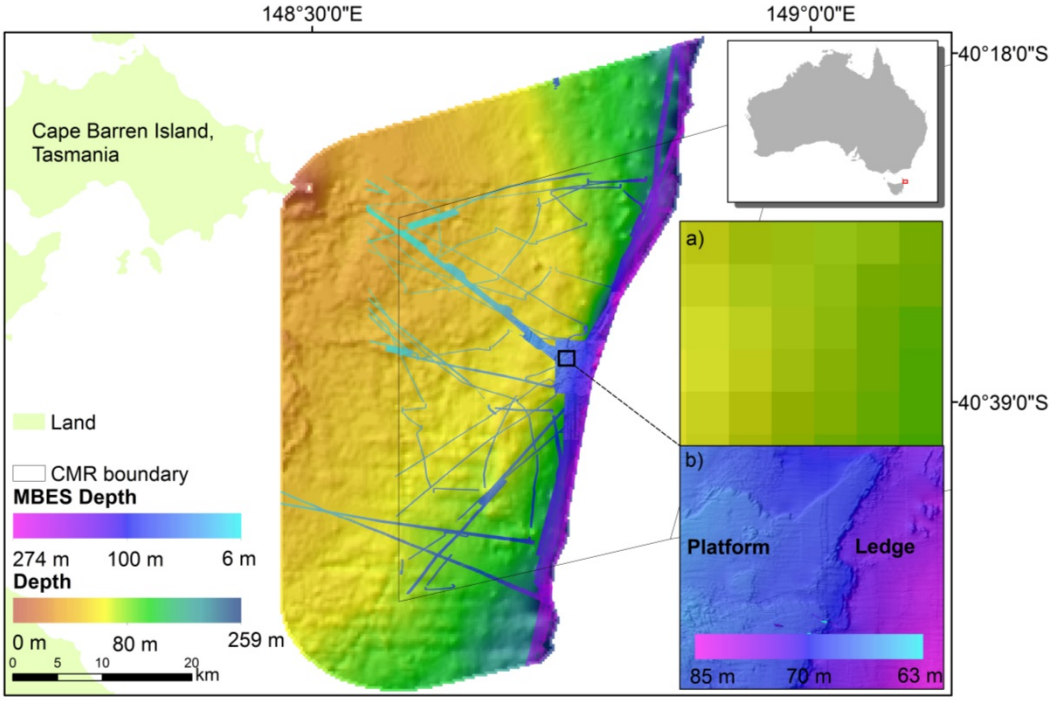

Figure13: Bathymetry mapping of the Flinders CMR

2.3.4 ARMADA

Australian Region Marine Data Aggregation (ARMADA) was developed to address a key data discovery issue. It has been designed to aggregate at a high level the spatial and temporal elements of the underlying data accessed from WFS services at organisations that host marine data and then map this within KEFs and CMRs. To avoid the issue with spatial extents published in metadata, ARMADA reads the WFS directly from the data providers, stores the data, aggregates them, and displays content within KEFs and CMRs. An example search result for the Freycinet CMR is shown in Figure 14. The time-series plot for different data/gear types was also generated (Figure 15).

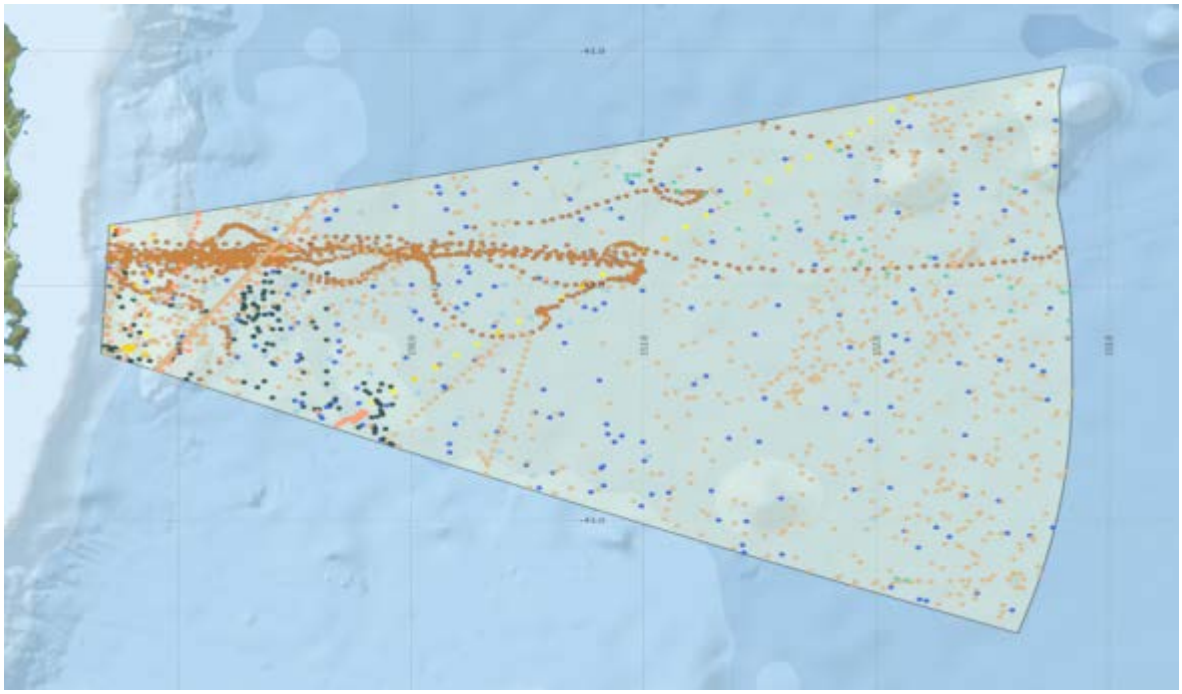

Figure 14: In-situ data located within the Freycinet CMR; obtained from the ARMADA search; different colours represent different gear types

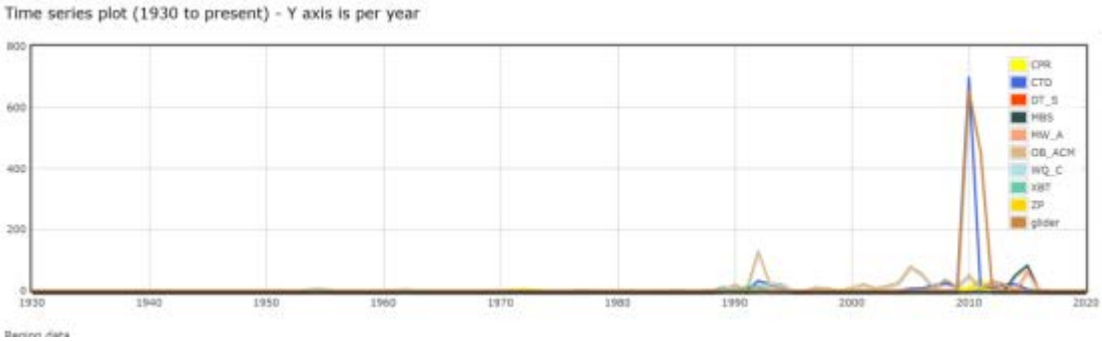

Figure 15: An example time series plot for the ARMADA search in the Freycinet CMR

2.3.5 Discovery survey in the Hunter CMR

This task used NSW OEH's survey vessel to extend multibeam sonar mapping in the Hunter CMR shelf waters to underpin understanding of seabed habitats and inform future biological monitoring programs (Davies et al. 2016). Based on the analysis of the existing multibeam data collected by NSW OEH and reprocessed multibeam data from CSIRO's Southern Surveyor surveys, around 90 possible reef locations were identified in the Hunter CMR (Figure 16). Based on this information, three new survey sites within the Hunter CMR were selected and mapped by multibeam sonar (Figure 17). The new bathymetry surveys indicate that:

- Extensive reef systems exist in depths of 70-90m, not far from state waters as well as further offshore in depths of 110-120m;

- It is highly probable that sparse low lying reefs also exist across deeper areas of the shelf;

- Nearshore reefs may have connectivity with important habitats for key vulnerable species of sharks (e.g., Grey Nurse Sharks and White Sharks) and possibly commercially important species such as Eastern Rock Lobster.

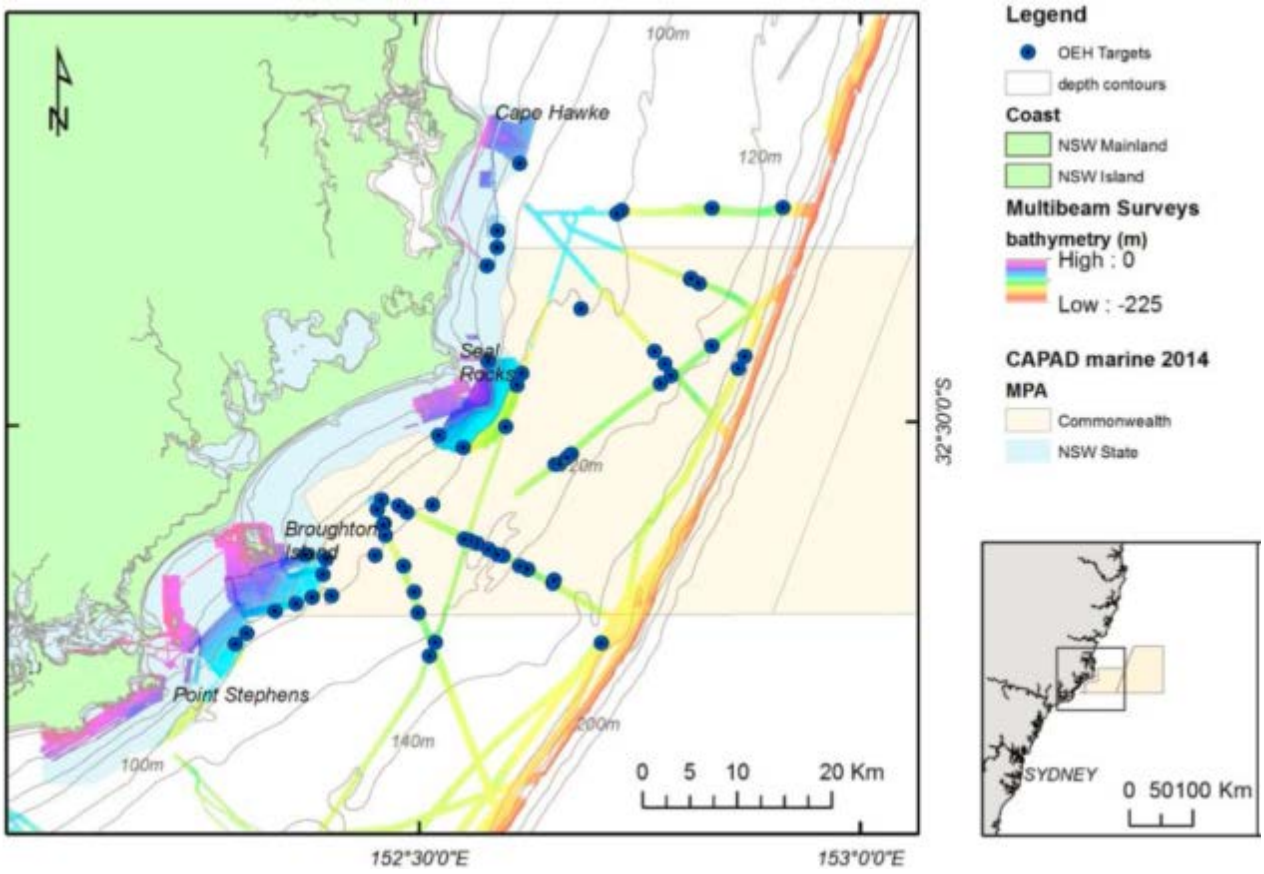

Figure 16: Existing MBES coverage and the possible reef locations, within and near the Hunter CMR

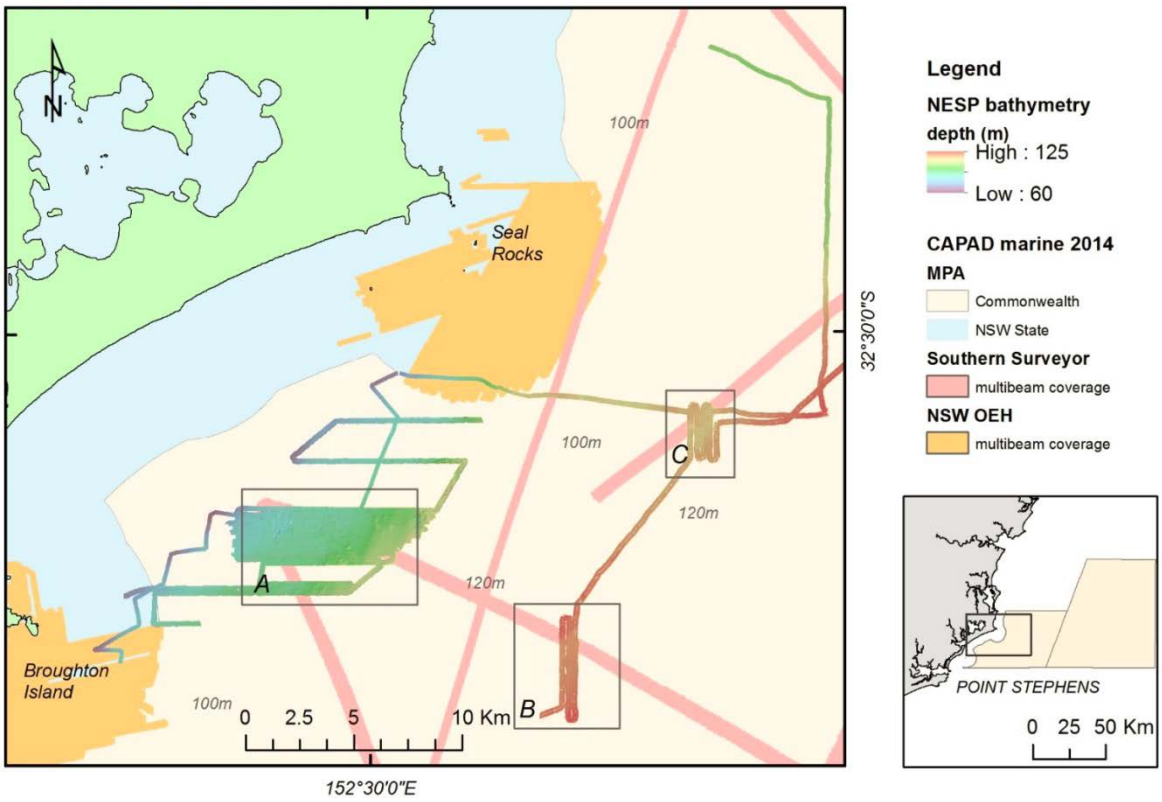

Figure 17: New MBES mapping in areas A, B, C within the Hunter CMR

2.4 NESP Project D4 - Expanding our spatial knowledge of marine biodiversity to support future best-practice reviews.

NESP Project D4 is mainly undertaken by Museum of Victoria. This project aims to fill data gaps and evaluate methods relevant to the ongoing spatial management of seafloor biota across the Australian marine domain. The objective of the project is to prepare Australia, State and Territory governments for future best-practice reviews of Australia's marine bioregionalisation that can be used to improve marine spatial planning and management initiatives. The project will incorporate results from field surveys to unexplored offshore areas of Australia's marine domain and communicate biodiversity values of the CMR network to the Australian public. There are three tasks in this project:

- Voyage of Discovery,
- Evaluation of Phylodiversity, and
- Development of biogeographic methods.

The current progress and achievements of NESP Project D4 presented at this workshop are summarised below.

A voyage of discovery to the abyssal habitats along the eastern margin of Australia will be undertaken during May-June 2017 using MNF's RV Investigator (Figure 18). The expedition will deploy a range of modern marine survey gear to collect multibeam sonar, mid-water

acoustics, isotopes and a range of biological benthic and pelagic data. The survey will be conducted between 2500 and 4000m water depths at intervals of 1.5^{o} latitude along the eastern margin from southeast QLD to northeast Tasmania. The expedition will also produce media releases, YouTube videos and live school stream as communication/education products.

A study to evaluate Australia's phylodiversity has been completed. The study found that the tropical upper slope (200-1000m) is the "rainforest" of marine biodiversity (Figure 19). The data has been delivered to ANHAT. A paper based on the study results is in draft form.

It has been recognised that the method used to generate the current Australian bioregionalisation scheme (IMCRA v4) has some issues including use of mixed biodiversity data that produced crisp boundaries that are highly unlikely, and has not considered the importance of protecting endemic species-poor areas.

To address these issues for future bioregionalisation, this project wants to develop a statistical model-based biogeography method. To this aim, a zonation global "pilot" study has been completed (Figure 20). The zonation produced a spatial priority ranking across a landscape based on mapped biodiversity.

Figure 18: The survey design of the abyssal expedition (May 15-June 16th 2017

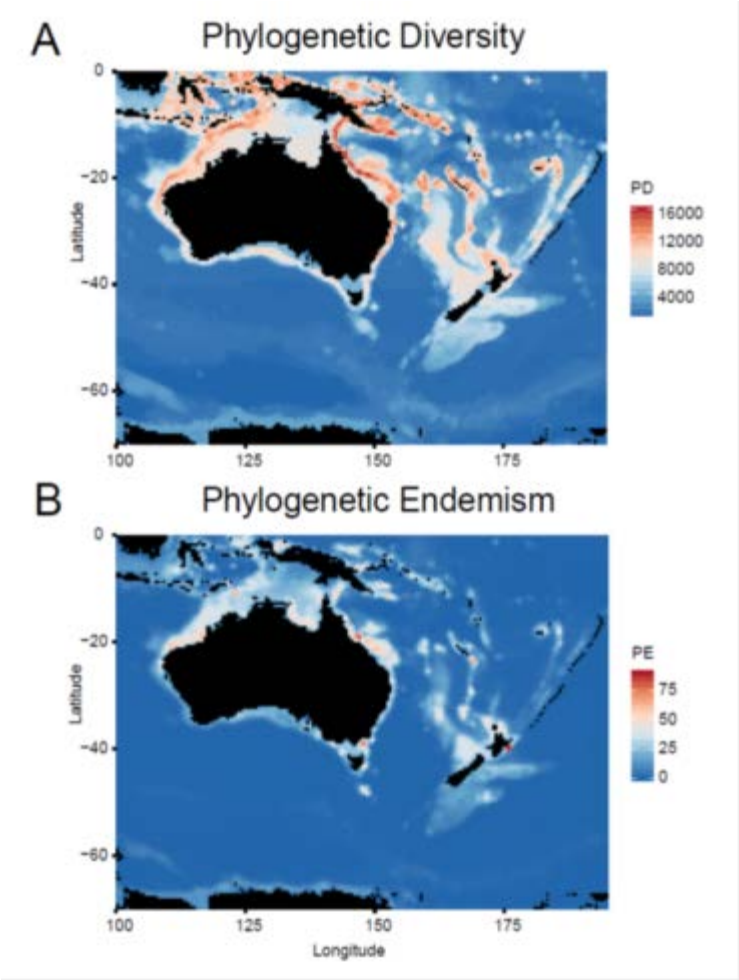

Figure 19: Australia's phylogenetic diversity and endemism

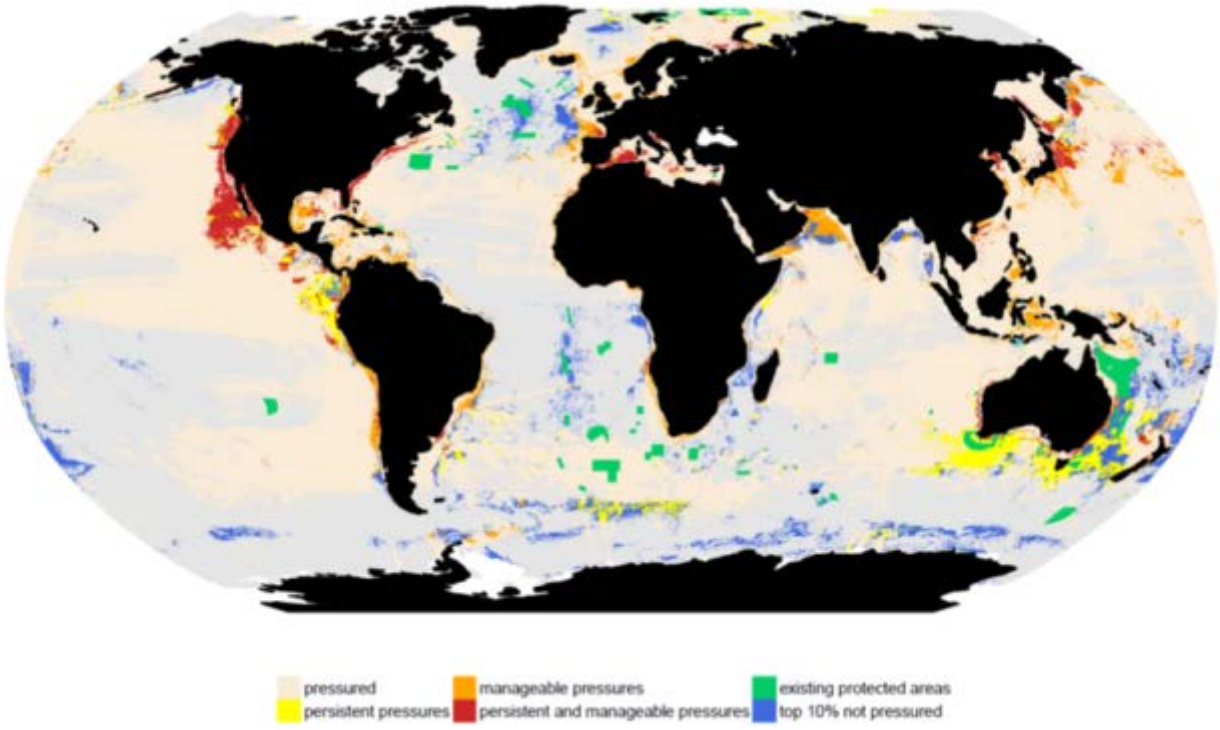

Figure 20: The global biogeography zonation

3. FUTURE DIRECTIONS IN 2017:

Each of the Theme D projects expanded on the work program being undertaken through 2017 and planned in general for 2018 onwards (with that being a specific topic of discussion for D1 and D3 on day 2 of the workshop).

For D1 the major focus during 2017 will be on supporting the development of an MPA eAtlas that Parks Australia has commissioned to inform CMR management. This essentially builds on the successful development of the NW eAtlas. At this stage the atlas will initially be populated with information from 12 or so representative CMRs around Australia during 2017. The atlas is essentially a web portal based around an atlas framework developed by AIMS that displays maps, videos, models etc to provide an overview of work undertaken within an area. It links with other programs (e.g. Fishmap) to display data. There is a significant time input required to add data, so the solution is to link to programs that do this more effectively.

For D2 the focus during 2017 is development of a range of standard operating protocols (SOPs) to underpin routine monitoring of CMRs in shelf waters using nationally agreed tools, including AUVs, BRUVs, towed video, benthic trawls, Multibeam sonar. Despite the CMR focus, these protocols are equally applicable to any form of survey in shelf waters, including oil and gas EIS and exploration studies, so can form the basis of guidance to companies and consultants about minimum standards for data acquisition and sharing. The development of SOPs involves establishing a number of working groups including representatives from all interested parties around Australia. It is proposed to have the SOPs in place by the end of 2017 to underpin their use in future CMR inventory and monitoring programs.

For D3 the focus during 2017 is in preparing for new surveys in 2018 onwards, and establishing national networks of researchers to facilitate development of an integrated monitoring program based around tools such as BRUVS, AUVs, and multibeam sonar. This includes supporting the development of national databases to store and share data from these tools, and development of two papers (BRUV and AUV based) around national and regional scale reporting into SOE based on agreed indicator metrics from these tools. In addition, the project will facilitate the establishment of a national MPA/CMR science/management forum to discuss key issues in this field, and share experience between state and commonwealth agencies.

For D4 the focus during 2017 is on completing a successful deep-water survey and inventory of the fauna of CMRs on Australia's eastern seaboard based on RV Investigator and post-survey processing of the acquired collections. This work continues the central focus of D4 in progressing opportunities to further our understanding of the biological assets of the deep water (slope, seamount and abyssal plains) areas of the commonwealth estate that are otherwise difficult to access by vessels other than the RV Investigator.

4. STATE AND RELATED PROGRAMS THAT INFORM MONITORING AND MANAGEMENT

NSW: Alan Jordan gave an overview of NSW MPA baseline and monitoring, including lessons learnt, past, present, and future approaches to methods used, evaluation, refinement, integration with adaptive management, and potential for integration into national (and CMR) monitoring programs. This included the importance of an extensive mapping program to build knowledge of the distribution of habitats within the MPA network and how

these are distributed with respect to zoning within MPAs and to what extent they are representative of regional habitat distribution. This has been invaluable in both planning monitoring programs as well as in ongoing reviews of MPA zoning, so strongly informs management decisions. Aspects of monitoring, e.g. dive surveys and the BRUV programs, provide state-wide coverage throughout the MPA network and are based on SOPS used in other jurisdictions. In some locations, such as MPAs adjacent to the Hunter CMR and CMRs at the Solitary Islands, or Lord Howe Island, there is opportunity to use such SOPs in collaborative, surveys that integrate with the CMR network.

Two data visualisation projects that readily fit into the survey and monitoring framework (inc eAtlas development) are SeaMap Australia and FishMap.

SEAMAP AUSTRALIA: Vanessa Lucieer gave an overview of SeaMap Australia, a tool being developed by IMAS/AODN to visualise the national mapping data collated by the D3 project, in addition to inshore datasets on seagrass and saltmarsh habitats that were not part of the D3 brief. This tool will be available from July 2017, enabling public access to a wide range of maps generated from state and commonwealth datasets. As part of the process, a vocabulary of classification labels has been developed to assist in labelling of mapped features in coastal and shelf waters. Maps from this tool could/should be able to be readily harvested into the MPA eAtlas project.

FISHMAP: Daniel Gledhill gave an overview of the FishMap project that allows spatial visualisation of the distribution of fish species in Australian waters based on a wide range of data sources. When completed, this tool will allow live updates of known fish species and assemblages within areas such as CMRs/KEFs, and be able to feed directly to other tools such as the MPA eAtlas.

RIMREP: In the absence of representatives from GBRMPA, Neville Barrett gave an overview if the RIMREP framework that GBRMPA and AIMS have invested a significant amount of energy over the past few years in developing, to better integrate management and monitoring frameworks. This coordinated and integrated monitoring, modelling and reporting program for the Reef and its adjacent catchment is designed to track progress towards targets and objectives of the Reef 2050 Plan, under the plan's seven themes. This will be a key input to assessing the effectiveness of the plan. Under the framework, there was no move to add new monitoring programs, but rather, a move to focus on those that were most informative for management, and to better integrate programs with each other and management. The initiative is based around a DIPSR (Driver-Pressure-Impact-Response) framework, which helps to more closely align monitoring programs with management needs.

5. GENERAL DISCUSSION, END OF DAY 1:

Key points from the general discussion at the end of the first day were that

- The work undertaken to date, and planned for the next year onwards, was very much on target with the needs that DOEE has identified previously, so overall Parks Australia in particular were very happy with the direction taken and outputs to date.

- The Social and economic area is a gap that requires further work. It was discussed and recognised that the previous NESP Hub had tried to engage in this area with little departmental traction. Some of this skillset had been lost due to staff movements, however, there were some future opportunities that could be explored.

- There was a need for pressures information and a decision tool to help inform field work priorities, and to work closely with Themes A & C to incorporate information generated from their programs into prioritisation of future survey locations and methods.

- In response to the RIMREP presentation and the incorporation of DIPSR frameworks into several state-based monitoring/management programs, there was a clear need to ensure the CMR space was also developing a similar mechanism to link/integrate monitoring effort with management responses.

- The interplay between pressures and values, particularly those values identified from management plans, should be drivers in the prioritisation of future surveys.

- KEFs and BIAs are also very important tools used in a wide range of applications in the management of the Commonwealth marine estate in general, so while monitoring programs, SOPs, eAtlas etc are focussed on CMRs, wherever possible, this should also incorporate any intersection with KEF's and BIA's into survey planning.

- Very important to make sure research presented in reporting outputs is integrated/presented in ways readily digested by time-poor management for rapid decision making.

6. WORKSHOP DAY 2

The second day of the workshop involved detailed discussions on the future research directions of projects D1 and D3 within Theme D. The overall focus of D1 is on improving data accessibility and visualisation by end users, including management, while the focus of D3 is on developing and implementing a national CMR monitoring program using SOPs that are integrated into national reporting frameworks. The day was divided relatively evenly between each of these themes, and guided in part by a detailed introduction of the research needs of Parks Australia.

6.1 PARKS AUSTRALIA RESEARCH PRIORITIES

The second day of the workshop began by an overview of the research priorities of Parks Australia.

Parks Australia identified the need to demonstrate the difference science can make for management, communication and to support adaptive management. Parks Australia's science strategies include identifying relative conservation values and relative pressures, and

discovery of environmental assets within CMRs. At the workshop, Parks Australia presented a research priorities table (Table 5). The table identifies the following types of research products that were considered as priorities for Parks Australia:

- Bathymetry (maps)
- Habitat maps (some detailed such as reefs, others broader-scale polygons)
- Habitat coverage estimates
- Application of SOE data and indicators to CMRs
- Integration and analysis of biological data (e.g. Reef Life Survey), pressures, climate/other models
- Forecasting using pressures data
- Developing indicators for pressures and uses
- Collation of existing knowledge and information (e.g. SOPs)
- Fish populations/assemblages and recreational fishing effort
- Coral reef health
- Sponge assemblages and distributions

An indication of priority CMRs and locations within CMRs are also listed in Table 5 to give some guidance of where information is currently required. In addition, Parks Australia identified key management and research questions, and potential outputs and outcomes from research that are relevant and useful for the management of the CMRs. In general, discovery science will still be big for the next decade within CMRs, despite the need for more focussed research as well. More broadly within DOEE there is a need to incorporate research on BIAs and KEFs wherever possible. KEFs are used by the department (and NOPSEMA) and there is a need to keep them current and build on them. If we have new data that is of use to improving KEFs and BIAs then it is of additional value and should be used to do so. However, there is no intention to identify new KEFs in the near future.

Overall, science is only one component of CMR management, with a range of other programs including compliance, education, management, permitting, tourism and visitation, and direct actions such as oil spill responses. All have competing funding needs. For science, there is progress towards a document that identifies science needs. It will include research, monitoring and communication, including fostering science through a collaborative approach and partnerships. One identified need however is an atlas to make information readily available for decision making. This was outlined in detail by PA in the following section.

Before the atlas was discussed, a series of questions were raised and discussed concerning these research priorities at the workshop. They are listed below in no particular order:

- Concerning data on pressures, biology, etc can we possibly use Rick Smiths SOE as a template? Noted that Tim Lynch has contacted every state for fishing pressure for SOE.
- Is a CMR risk assessment proposed? Pressures don't always equal risks.
- An indication of costs for gear described in SOPs is desirable (but noted as beyond scope for D2 I 2017), and an indication of the information provided by various sampling/observational tools. Noted the Monitoring Blueprint partially addresses this.
- Don't forget BIA and KEFs. KEFs are used by the department (and NOPSEMA). We need to keep information current and build on them. Require new data that is of use

to improving KEF and BIA knowledge. But no intention to identify new KEFs in the near future. Not enough bandwidth. Certainly on the radar for the future- post CMR management plans, etc. (Amelia Tandy, DOEE)

- Do we need uncertainty maps for the detailed bathymetry data of the showcase CMRs?
- Bathymetry maps for all CMRS, even at coarse resolution if all that is available would be useful for Parks Australia.
- In the priority Cod Grounds CMR, NSW OEH may have some data on bathymetry, habitat, species and substrata.
- For Elizabeth and Middleton Reefs there is not much existing data (some coarse bathymetry data only); but we can start with satellite images.
- We need to scope projects on building bathymetry in off-shelf (deep water) key areas.
- What is in a habitat map? Is it the type and extent of biological communities or seabed form, or both?
- Mix of coarse and detail habitat mapping is OK for Parks Australia use
- We need to use consistent terminology and standards for habitat mapping. Habitat mapping can be broad at start, with higher detail later.
- We can use CATAMI, SeaMap and Geoform terminology for habitat mapping.
- Can we duplicate what was done in D3 for shelf in deep water CMRs? If so, what is the reasonable timeframe?
- Is the discussion on the synthesis of coral bleaching detection/monitoring methods a NESP responsibility or task? Perhaps we need to talk with IMOS. Is there national bleaching coverage on the radar for both KEFs and CMRs?
- We need to add cyclone as pressure.
- We need to follow up with Dave Peel about ship-strike data as one of the pressure indicators.
- Social and economic indicators. NERP data are being analysed by Sarah Jennings (UTAS) for social indicators (Nic Bax). Can be done with Terry Walshe, etc? What about a SOP for social? Nic Bax indicated that we are rebuilding this capability. Sarah Jennings and colleagues are running an FRDC project that is looking at social indicators. Tim Langlois has a PhD student that has focussed on this from Recreational Fishing angle and may have done a lot of ground work already.
- Recreational Fishing. Are there surrogates rather than doing Kreel surveys?
- Perhaps we should be targeting potential flash points for monitoring (e.g. recreational fishing).
- NESP can produce an impact of fishing pressure from Rick and GEdgar's RLS data. In a longer term we need to do more, and use potential FRDC funding. Alternatively, Tim L and Russ B can do for Ningaloo as a case study.
- Commercial fishing remains an issue, but beyond scope of D1.
- Can conditions be put on people who fish in CMRs to report catch?
- DOEE indicated that this is not ideal as extra responsibility on fishers which may not be taken up.
- Coral reef health issue will be covered by RLS/SOE discussions.
- What about connectivity? How about we target connectivity of corals in CMRs with coral, excluding GBR, e.g. Ningaloo to Lord Howe? What kind of connectivity are we talking about? Sources and sinks from oceanographic data- species info is very expensive compared to genetics.
- List of sponges and abundance distribution within CMRs (any reserve) would be very useful for Parks Australia.

- Parks Australia is interested in monitoring the effectiveness across zones in CMRs, but this is a longer-term priority to be addressed in future.

6.2 CMR Atlas

Parks Australia has chosen the eAtlas platform as the tool for communicating the science that underpins CMR management. They are developing the atlas independent from NESP. AIMS will be building and maintaining the atlas based on the existing eAtlas infrastructure. It will be an interactive mapping portal and website called the Australian Marine Parks Science Atlas. The Atlas will be designed to **communicate** the science and research underpinning Australian Marine Parks and assist with **discovery** of science relevant to CMRs. The initial phase of the development of the atlas will focus on making available the science that informed the current CMR boundaries and management plans.

While the development of the AMP Science Atlas sits outside of NESP Theme D, there is an expectation from Parks Australia that any new science discoveries and information that arise from all NESP projects will be uploaded into the eAtlas to ensure accessibility to managers and the public. For example, Parks indicated that it would be appropriate for new bathymetry data to be able to link to the atlas so it is always up to date. They also want to develop a specific vocabulary for this task so that the information is better organised and described.

Although the AMP Science sits outside NESP, NESP projects will need to provide new information and materials for the AMP Science Atlas. Within Theme D, this would include outputs from any new field surveys, mapping or models. For Project D1, planned data syntheses can also be made available through the AMP Science Atlas, as well as exploring options for linking information from other databases into the eAtlas. . The discussion points around the CMR Atlas are listed below:

- Linking of the Hydroid (linked open marine data) search tool to the CMR Atlas (noted as technically possible; GA and AIMS to progress in D1), likewise ARMADA, developed by the Hub (CSIRO) may be able to identify datasets spatially within the CMRs for this.
- In the next six months, CMR Atlas will focus on a small set of pilot CMRs (12?) and contain existing work within CMRs, including videos, maps, etc of some key CMRs. Beyond next 6 months, CMR Atlas will continue to include existing data, and update with current work. CMR Atlas needs to be kept up to date by researchers providing science communication outputs into the Atlas.
- The CMR Atlas team is intending on publishing guidance on what works, format wise, for atlas. There is also a need to develop CMR vocabulary.
- How do we deal with CMRs with little/no data?
- Parks Australia will proclamation text and potentially some other policy info for CMR Atlas.
- CMR Atlas needs to establish standards/guidelines for content
- Parks Australia has commissioned a literature review of all docs in CMRs (undertaken by JCU).
- Parks Australia wants management–ready products and communication, not data.
- Existing maps from D3 should be used for CMR Atlas.
- Who is going to resource this now and into the future?

- Need to link Atlas aim with the key assets, etc
- PA can give proclamation, and potentially some background on the features the reserves were identified as having.
- Need to overcome who/how writes what with descriptions. Need standards/guidelines
- Data on pressures, biology, etc - possibly use Rick Smiths SOE as a template?
- Is a risk assessment proposed and able to be incorporated into the atlas?- pressure don't always = risks
- Incorporation of KEF/BIA information is important for these maps

6.3 Project D1

The discussion focussed broadly on the research needs of PA and how the hub projects D1 and D3 in particular could assist in meeting these needs. . The D1 discussions were structured around Table 5 (PA's research priorities) and explored the types of data synthesis products that could be developed to meet each of these needs in the priority CMRs. The possible focus on each of these areas was discussed sequentially and essentially reflect where hub partners are able to meet specific needs of the Atlas through contributions to Project D1. Project D1 will use the information in Table 5 to inform their work plan for 2017/18 in order to target appropriate research and synthesis to meet PA priorities.

Overall, key discussion points during this session were:

What values exist and why do we care about CMRs? How can these be captured and made accessible?
Parks Australia need to have information available that explains the reasoning behind boundaries and zone activities
List social/economic benefits?
How to fill bathymetry gaps in survey data-> fill with other RS data?
Capacity/limitations to map the distribution of habitats in the CMR? Including substratum/sediments
Mapping:
Existing maps from Project D3 (shelf) can be uploaded onto the AMP Atlas
Detailed bathy can be generated for many priority CMRs
(bathy maps for all cmrs - at coarse)
Some priority areas have good data for synthesis and upload to the AMP Atlas e.g. Cod grounds – bathy, habitat, species, substrata, others don't, e.g. Elizabeth/ Middleton- coarse data only
A scoping project could be undertaken on building bathy in off shelf (deep water) key areas
The atlas has a national focus
Define clearly what is a habitat map- type and extent of biology/habitat?
Mix of coarse and detail habitat mapping - ok
Sites:
Potential areas with good data are: (But provide a list of where we have data so final cmrs can be selected)
Cod grounds, Solitary, Osprey, Mermaid, Ashmore, Kimberley
Habitat maps need consistent terminology and standards
Can be broad at start- with higher detail later
Use CATAMI, seamap and geoform terminology
Action: Can we duplicate what was done in D3 for deep water CMR- time?

Extent/cover estimates of habitats: D3 will look at this
Synthesis of coral bleaching detection/monitoring methods - for discussion…is this NESP? Perhaps we need to talk with IMOS- is there national bleaching coverage on the radar? For both KEF and CMRs

Pressures- Need to add cyclone.
Ship strike data from Dave Peel?
Social and economic indicators- NERP data being analysed by Sarah Jennings (UTAS) for social indicators…Can be done with Terry Walshe, etc?
What about a SOP for social? N Bax- yes we are rebuilding this capability. GRBMPA, states, etc has done a chunk of this. Perhaps we should add this to the CMR/MPA forum discussion where we get parties into the one room for discussion.
Sarah Jennings and colleagues are running a FRDC project that is looking at social indicators. These may be useful
Tim Langlois has a PhD student that has focussed on this and may have done a lot of ground work already.
Rec fishing pressure: Are there surrogates rather than doing Kreel surveys?
Action: NESP can produce an impact of fishing pressure from Rick and GEdgar RLS data. Longer term we need to do over longer term- potential FRDC. Alternatively, Tim L and Russ B can do for Ningaloo as a case study.
Commercial fishing remains an issue, but beyond scope of D
What about connectivity? How about we target connectivity of corals? CMRs with coral excluding GBR. i.e. Ningaloo to Lord Howe.
Sponges: List of sponges and abundance distribution within CMRs (any reserve).

6.4 Project D3

Discussion of surveys to support CMR monitoring

- The afternoon discussion on prioritisation of future CMR surveys focussed initially on identifying a range of core drivers for surveys and the importance of making these clear, that surveys are not just for the sake of undertaking surveys. A range of key issues were discussed (listed below), including where some of these priorities may be within the list provided by PA in Table 5.

Key discussion points and agreed drivers of survey priorities:

- Parks Australia noted that the Zoning Review process shouldn't be a hold up for Hub CMR work. Although surveys shouldn't make assumptions at this stage about actual management plans (zoning within CMRs) other than in the SE network where these are already in place.
- Why are we doing surveys/monitoring:
    - Demonstrate that we can integrate data into a national framework
    - Demonstrate an effective path forward: a standardised consistent survey approach, able to be rolled out nationally, cost-effectively

  - Applying the SOPs and working within limits of targeted sampling platforms (e.g. AUV, BRUVs)
  - Reporting into SOE
  - Discovery that doubles as a baseline
  - Model validation
  - Filling biogeographic gaps- national gaps.
  - Representation of CMR management regions
  - Meeting DOEE needs such as SE CMR ten year plan
  - Testing CMR effects, protection, zoning- effectiveness of management actions
  - Deposit of biological specimens in registered organisations
  - Public engagement- goes both ways- science making a difference
  - Align/engage with States work.
  - Have potential to leverage MPA/CMR work.
  - Deposit biological specimens in registered organisations

- Why are particular CMRs on the DOEE priority list? DOEE to provide Criteria.
- Drivers for surveys to be better defined. Vessel Access is a key issue; States abilities- need to know their work agenda- capabilities to develop joint surveys.
- Have a discussion with AHO as a potential survey co-investor to combine targets.

Following the discussion of overarching priorities, discussion/decision of actual locations for initial surveys was deferred, with this process to be undertaken via an EOI between hub partners to be undertaken during May, incorporating a range of potential surveys to be undertaken between 2018-20. The Hub RLT and steering committee would then work through these to decide which proposals to develop further for the 2018 and onwards workplans. The proposed approach to develop these EOIs is initially for each partner organisation to work within and between organisations to flag the areas of most interest and sent them as lists, with justification and/or shapefiles. The intent is that EOIs are as collaborative as possible between partners, engaging core Theme D staff where possible and meeting the key criteria listed above, to the fullest extent possible. In general, the proposed survey areas should match Parks Australia's priorities listed in Table 5.

Table 5 – Parks Australia Research Priorities for CMRs

Type of research	Location	Management or research question	Data / analysis required	Potential outcomes and outputs	Management relevance / outputs
Bathymetry data & maps	All CMRs. Particularly Ashmore Reef, Osprey Reef, Coringa-Herald, Lihou, Mermaid, Ningaloo, Cod Grounds, Elizabeth and Middleton, Solitary Islands, Huon seamount, Perth canyon, Cartier Reef, Gulf of Carpentaria, Norfolk Island nearshore waters	What do reasonable resolution maps of our reserves look like?	Either reanalysis of existing bathymetry or collection of new data where there are key gaps	Higher resolution maps in CVA and on website	Comms, planning for field activities (incl research), combining with other data layers to better understand ecosystems in CMRs
Habitat maps	Particularly Ashmore Reef, Osprey Reef, Coringa-Herald, Lihou, Mermaid, Ningaloo, Kimberley, Dampier, Roebuck Bay, Eighty Mile Beach, Cod Grounds, Elizabeth and Middleton, Solitary Islands, Huon seamount, Perth canyon, Cartier Reef, Gulf of Carpentaria, Norfolk Island nearshore waters (and any other areas available), Twilight, Murat,	What sort and how much of different habitats and communities can we expect to find in our reserves?	Predicted versus actual?? In field data / bathymetry / satellite imagery / modelling?	Maps of predicted or actual habitat within specific locations or interest	Comms, planning for field activities (incl research), combining with other data layers to better understand ecosystems in CMRs

Type of research	Location	Management or research question	Data / analysis required	Potential outcomes and outputs	Management relevance / outputs
Habitat coverage estimates	Kimberley, Gulf of Carpentaria, Huon, Freycinet rec use zone	What's in our reserves?	Similar to NERP Geographe Bay	Report, % cover of habitats	Comms, planning for field activities (incl research), combining with other data layers to better understand ecosystems in CMRs
Application of SOE data and indicators to CMRs	All CMRs where data is available	What does the work done for the SOE data sets tell us about how our CMRs are doing on a regional / national scale; where is particular data paucity?	Utilising the work in– comparing / combining different biological datasets to apply to CMR management context	Use of consistent national indicators for ecosystem health reporting / monitoring; U nderstanding "state" or condition of our reserves or locations / habitats within reserves	Comms, reporting, managemen t actions, compliance risk assessment, ongoing monitoring
Integration and analysis of biological data (RLS / AIMS / CSIRO/JCU) pre ssures data and climate/other mo dels	Coral Sea, North, North-west, Temperate East Networks	What can existing information tell us about current and future risk of bleaching to tropical coral Reefs?		Reporting on condition of parks, inform resilience effects of reserves,	Inform investment in research and monitoring; inform other managemen t options (eg activities and compliance)
Forecasting using pressures data	All	What are the key risks from known pressures and threats to each Network and the Coral Sea?	Model predicted risks of uses and pressures into the future in CMRs		Inform compliance risk assessment, managemen t of activities in reserves and investment in research and monitoring

Type of research	Location	Management or research question	Data / analysis required	Potential outcomes and outputs	Management relevance / outputs
Developing indicators for pressure / uses	All	What are the best ecological, economic or social indicators to detect the highest risks?	??		Inform compliance risk assessment, management of activities in reserves and investment in research and monitoring
Collation of existing knowledge and information	All	What type of techniques are available to monitor our reserves, what type of information do they provide and how expensive are they?			Inform future research and monitoring investment to support management
Fish populations/assemblages & Recreational fishing effort	NW – Ningaloo	What is the impact of recreational fishing on demersal fish communities?	Recreational fishing surveys	Report on the impact of recreational fishing on demersal fish communities	Inform management of activities (conditions on authorisations)
Coral reef health	NW - Ningaloo, Kimberley, Mermaid, Ashmore, Cartier	What is the impact of coral bleaching on reef communities?	Reef surveys	Report on the impact of bleaching events	Inform understanding of the impacts of bleaching and resilience to bleaching events

Type of research	Location	Management or research question	Data / analysis required	Potential outcomes and outputs	Management relevance / outputs
Sponge community distribution, abundance and biological role	NW - Dampier, Montebello, Eighty Mile Beach, Ningaloo	What is the distribution and abundance of communities within the reserves?	Sponge habitat mapping	Report on sponge habitats - distribution and abundance	Inform understanding sponge community distribution in the reserves

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APPENDIX A – LIST OF WORKSHOP PARTICIPANTS

NESP Marine Biodiversity Hub Researchers

- Neville Barrett (UTAS)
- Vanessa Lucieer (UTas)
- Jacquomo Monk (UTas)
- Graham Edgar (UTas)
- Nic Bax (UTAS)
- Paul Hedge (UTAS)
- Karen Miller (AIMS)
- Terry Walshe (AIMS)
- Marji Puotinen (AIMS)
- Keith Hayes (CSIRO)
- Scott Foster (CSIRO)
- Franzis Althaus (CSIRO)
- David Watts (CSIRO)
- Brendan Brooke (GA)
- Rachel Przeslawski (GA)
- Scott Nichol (GA)
- Zhi Huang (GA)
- Rachel Nanson (GA)
- Andrew Carroll (GA)
- Timothy Langlois (UWA)
- Alan Jordan (Primary Industries, NSW)
- Peter Davies (Environment, NSW)
- Tim O'Hara (Museum Victoria)
- Ryan Downie (CSIRO)
- Kim Pickard (GA)
- Rachael Nansen (GA)
- Russ Babcock (CSIRO)
-

Research users - Parks Australia and the Department of the Environment and Energy

- Jason Mundy (Parks Australia)
- John Lloyd (Parks Australia)
- Bianca Priest (Parks Australia)
- Amanda Parr (Parks Australia)
- Andrew Coleman (Parks Australia)
- Samantha Fox (Parks Australia)
- Andrew Read (Parks Australia)
- Carolyn Armstrong (DOEE - Science Division, ERIN)
- Amelia Tandy (DOEE - Wildlife, Heritage and Marine Division, Domestic Policy)
- Scott Laidlaw (DOEE – Science Division, NESP)
- Jillian Grayson (DOEE, Marine Division)
- Jeremy Smith (DOEE, Parks Australia)
- Ben Roundnew, DOEE, EEM)

Other Stakeholders

- Stan Lui (Hub Steering Committee/ Torres Strait Regional Authority)
- Ana Lara-Lopez (IMOS)

- Tim Moltmann (IMOS)
- Sebastien Mancini (AODN)
- Emma Flukes (AODN)
- Michelle Grady (Pew Foundation)
- Eric Appleyard (AFMA)
- Daniel Gledhill (CSIRO, FishMap project)

APPENDIX B – WORKSHOP AGENDA

Monday 27 March 2017

Day 1 objective: To develop a shared understanding of the research achievements and future directions for Theme D.

A focus of the Theme is championing a science-based approach to develop marine baselines and monitoring to inform national environmental reporting commitments and in particular those for managing the network of Commonwealth Marine Reserves.

Time	Topic	Presenters
9.00	Introduction and context	Neville Barrett
9.15	PA: Key questions for baseline and monitoring of CMRs, and science in the reserves outside of the Hub. Inc update on management plans and timing. Importance of links to information needs and potential Hun research/products.	Jason Mundy (DOEE)- presentation Amanda Parr (DOEE)- presentation
9.45	Project D1 - National data collation, synthesis and visualisation to support sustainable use, management and monitoring of marine assets. Including development of an e-atlas. (1) Overview of Project D1 Objectives for 2015/16 (Karen Miller, AIMS) (2) NW Atlas (Marji Puotinen, AIMS) (3) Gap Analysis Intro/Rationale (Marji Puotinen, AIMS) (4) Gap Analysis – Physical data sets (Zhi Huang, GA) (5) Gap Analysis – Biological data sets (Marji Puotinen, AIMS) (6) Synthesis of knowledge – Ancient Coastline KEF (Jessica Meeuwig, UWA) (7) Predictive modelling for the Oceanic Shoals CMR (8) Benthic habitats (Marji Puotinen, AIMS) (9) Pelagic Fish (Jessica Meeuwig, UWA) Substrates (Zhi Huang, GA) (10) Overview of planned work for 2017 onwards (Scott Nichol, GA)	–5 minutes per speaker
10.30	Discussion (including research user and stakeholder input)	Neville Barrett facilitating- open discussion
10.45	Morning tea	

Time	Topic	Presenters
11.05	Project D2 - Standard operating procedures (SOPs) for survey design, condition assessment and trend detection. Part 1. Overview of the project and work completed to date under NESP.	Scott Foster (CSIRO)- presentation
11.25	Project D2-Part 2. Proposed work for 2017 onwards, including initial prioritisation of SOPs for national programs.	Rachel Przeslawski (GA)- presentation Scott Foster (CSIRO)- presentation
11.40	Discussion (including research user and stakeholder input)	Neville Barrett facilitating- open discussion
12.00	Project D3 - Preparing for and implementing monitoring of CMRs and the status of marine biodiversity assets on the continental shelf. Part 1. Work completed to date. (1) Overview- 5 mins. Neville Barrett (IMAS) (2) Collation of all known shelf mapping products/ bathymetry for improved national understanding- with a focus on updating reef KEF distribution -10 min. Vanessa Lucieer (IMAS)- presentation (3) A reef geomorphological classification scheme for shelf waters of Australia. 10 min Scott Nichol (GA) -presentation (4) Applying collated mapping products from shelf waters to update knowledge of features and mapped extent (and gaps!) within CMRs nationally, and enhanced description of biological and habitat features of case study CMRs in temperate waters. 10 min Jacquomo Monk.-presentation (5) Discovery surveys in the Hunter CMR shelf waters – New mapping to underpin understanding and future biological monitoring programs – Peter Davies (NSW OEH)- presentation	
12.45	Lunch	
1.30	Project D3 – continuing: (6) ARMADA- Development of a spatial data discovery tool to assist spatial management (e.g. CMRs and KEFs) and its availability as part of the national data infrastructure. 10 min David Watts (CSIRO)-presentation (7) Summary, and integration with future work (e.g. D1 products), and survey prioritisation. 5 min Neville Barrett – presentation.	
1.45	Project D3. Part 2- Planned focus in 2017 onwards. Including adoption of integrated national monitoring and mapping approaches and related databases, building MPA researcher/manager networks, planning for, and prioritisation of future CMR surveys-as case studies and for model validation.	Neville Barrett- presentation
2.00	Discussion (including research user and stakeholder input)	Neville Barrett facilitating-open discussion

Time	Topic	Presenters
2.15	Project D4 - Expanding our spatial knowledge of marine biodiversity to support future best-practice reviews- Work to data, future work planned including the upcoming MNF voyage examining deep water fauna of eastern seaboard CMRs.	Tim O'Hara (MOV)-presentation
2.40	Project D4 discussion	Neville Barrett facilitating-open discussion
3.00	Afternoon tea	
3.20	An overview of NSW and Vic MPA baseline and monitoring, lessons, past, present, and future approaches to methods used, evaluation, refinement, integration with adaptive management, and potential for integration into national (and CMR) monitoring programs.	Alan Jordan (DPI, NSW)-presentation Lawrence Ferns (Vic)-presentation
3.40	Hub-related data visualisation products. SeaMap Australia and FishMap – status, products and future plans	Vanessa Lucieer (SeaMap project)-presentation Dan Gledhill (CSIRO)-presentation
4.10	RIMREP: developing approaches and capacity for sustained observation and monitoring in the GBR, and links with a nationally integrated monitoring program for CMRs.	TBA.
4.30	General Discussion and reflections on Hub Strategic Plan	Neville Barrett facilitating-open discussion
5.00	Meeting close	
5.00-6.00	Note takers to collate meeting notes	

Tuesday 28 March 2017

Day 2 objective:

1. To clarify the proposed approaches and refine priorities for collation and synthesis of relevant national data for inclusion in the CMR Science Atlas.
2. To develop a shared understanding about options and priorities for a science-based approach to develop national marine baselines and monitoring for CMRs.

Time	Topic	Presenters
9.00	Introduction and reflection on Day 1	Neville Barrett/Brendan Brooke
9.15	Parks Australia overview of (1) information priorities and data access products (2) science related information management projects	Amanda Parr-Presentation Andrew Coleman
9.30	Project D1 - The MPA Science Atlas and related initiatives: an overview of its purpose and user-scenarios	Karen Miller and Amanda Parr (An informal discussion)
10.00	Project D1 - priorities for national data collation and synthesis: and priority use to inform specific regional needs. Including review of data options for input to CMR Atlas e.g.: • Bathymetry • Seabed substrate (point observations) • Geomorphic features • Ecological data • Sea surface temp, suspended sediment, Chl-a Fish Priorities for network/reserve data and synthesis: review of options (e.g. Kimberley, Gascoyne, one other)	Karen Miller, Scott Nichol and Amanda Parr (An informal discussion)
10.30	Morning tea	
11.00	Data collation and synthesis continued:	
11.30	National data collation and visualisation: Identification of priority datasets to contribute to related initiatives e.g.: • eAtlas/NW Atlas • ARMADA • AODN portal • ALA Fishmap • NationalMaps • SeaMap Australia • Deep Reef Explorer	Karen Miller and Amanda Parr (An informal discussion)
12.30	Project D1 - A shared timeline - Product delivery and engagement for national collation and synthesis	Karen Miller and Amanda Parr (An informal discussion)
1.00	Lunch	
1.45	An overview of CMR science needs.	Amanda Parr

Time	Topic	Presenters
2.00	Project D3 – CMR baselines and monitoring – links with other initiatives (e.g. KEF monitoring, state monitoring, EEM, MNSP, AHO, WAMSI, IMOS, etc)	Neville Barrett and Amanda Parr
2.30	Project D3 – Data gap analysis for CMR baselines and monitoring, including overview of current mapping gaps available from the earlier D3 mapping collation work.	Neville Barrett and Amanda Parr (An informal discussion)
3.30	Afternoon tea	
3.00	Project D3 – Gap analysis for CMR baselines and monitoring	As above
4.00	Project D3 – Prioritising areas and partnerships for CMR baselines and monitoring	As Above
5.00	Meeting close	
5.00-6.00	Workshop note takers to collate notes.	

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