Marine Biodiversity Hub

National Environmental Science Programme

Scientific Workshop Report (9-10 September 2015)

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NESP Project D1: Developing a toolbox of predictive models for the monitoring and management of KEFs and CMRs in the North and North-west regions

Milestone Report - 23 December 2015

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Important Disclaimer

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EXECUTIVE SUMMARY

A scientific workshop for NESP Project D1 'Developing a toolbox of predictive models for the monitoring and management of KEFs and CMRs in the North and North-west regions' was held at Geoscience Australia 9-10 September 2015. The objectives of the workshop were to discuss future research priorities for the North and North-West regions and to define current knowledge gaps by consolidating existing datasets from AIMS, GA and UWA. Several robust datasets for the North and North-West region were identified which may be used to validate, refine, or extend existing models, particularly in the Oceanic Shoals CMR and along the North-west coastline, including the Kimberley CMR. There are still large regions for which very little scientific information exists, notably the Argo Rowley Terrace CMR and other deep-sea areas. However, when balanced against stakeholder interests and marine management priorities, data-poor CMRs closer to the coast such as the Kimberley and 80 Mile Beach CMRs are the most likely candidates for future research.

1. WORKSHOP OBJECTIVES & STRUCTURE

The primary objectives of the workshop were to consolidate existing datasets, to identify data gaps, and to discuss future research opportunities to better understand marine ecosystems in the North and North-West regions. The first day included a series of presentations by workshop participants from GA, UWA, and AIMS, which provided overviews of recent research in the North and North-West regions. These presentations and associated discussions focussed on the description of existing datasets and models and the discussion of ways in which they may be refined or incorporated into future research under Project D1 (Section 2), as well as an introduction to the North-West Atlas, an online resource managed by AIMS (Section 3). The second day of the workshop included a qualitative gap analysis (Section 4), as well as discussions about potential future research directions and deliverables based on these gaps (Section 5) and challenges associated with the potential research activities (Section 6).

2. EXISTING DATASETS AND MODELS FOR N AND NW REGIONS

2.1 Megafauna

Several models based on distribution, abundance, diversity and migratory pathways exist for megafauna in the North and North-West region. These are summarised below.

2.1.1 Seas Around Us Project (SAUP)

The Seas Around Us Project (SAUP, Bouchet et al. Submitted) model links the abundance of commercially important species of pelagic fish to several environmental and habitat characteristics, including the distribution and attributes of large seabed features (e.g. submarine canyons, as per the revised canyon classification scheme produced under NERP). Data stem from historical fishing records compiled by the University of British Columbia's Sea Around Us Project (http://www.seaaroundus.org/) and are available as tonnage summaries for each of 912 grid cells covering the western part of the Australian exclusive economic zone (i.e. EEZ adjacent to the state of WA) at a resolution of 0.5 x 0.5 decimal degree, over a ten-year period (1997-2006). The catch consists primarily of tuna and mackerel species (ca. 75% of total catch) and has been standardised to account for gear selectivity and temporal effects. The model currently allows the mapping and identification of important pelagic fish areas ("hotspots", Figure 1). Future directions may include refining the model to explore the relationship between pelagic species and other selected KEFs such as ancient coastlines, as well as adapting the model to deliver similar outputs for demersal species.

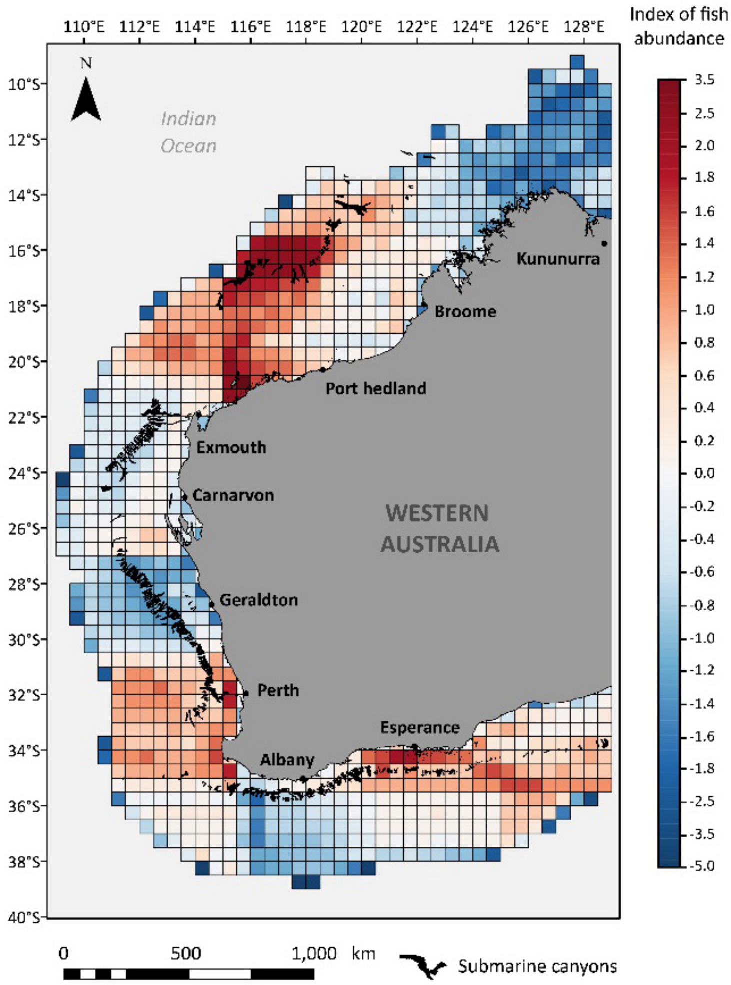

Figure 1: Relative pelagic fish abundance inferred from the SAUP model.

2.1.2 Oceanic Shoals Pelagic Diversity Model

The Oceanic Shoals Pelagic Diversity Model (Bouchet et al. In prep.) relates the richness of pelagic vertebrate assemblages to seafloor variability, including the distance to key features such as submerged carbonate banks. The model was developed from visual observations of oceanic sharks, fishes, turtles and marine mammals made using midwater baited remote video systems (stereo-BRUVS) during the NERP Theme 4 marine survey of the Oceanic Shoals Commonwealth Marine Reserve (Sept – Oct 2012). Data are available as species counts (corrected for individual abundance) for each of 116 sites spread across three sampling areas of approximately 165 km^2 in size. The model identifies associations between large megafauna and static habitats, and future upscaling may provide regional predictions of marine vertebrate diversity throughout the CMR based on a coarser-resolution (250 m) national bathymetry grid.

2.1.3 Migration Models for Flatback Turtles

Flatback turtles were satellite tracked from the Lacepede Islands (WA), and Bayesian state-space models were implemented to account for observation error and infer the behaviour of the animal that underlies the track (transiting or residency). Since residency can be related to nesting or foraging which are typically separated by a transit, it is possible to objectively identify the inter-nesting phase, the transit phase, and the foraging phase from the tracking data. Kernel density estimation was used to calculate the spatial and temporal extent of each of these important components of turtle life history in the Pilbara and Kimberley region (Figure 2). Future research opportunities linked to this data include the addition of other flatback turtle datasets from Cape Lambert, Barrow Island and Port Hedland in similar models to map the spatial and temporal extent of the biologically important areas (BIAs), as well as describing relationships between the animals and habitat features (e.g. carbonate banks KEF, ancient coastline KEF). Preliminary data suggest that foraging is focussed on the carbonate banks, and the transit to foraging grounds appears to be influenced by tidal fronts and might also be associated with ancient coastline.

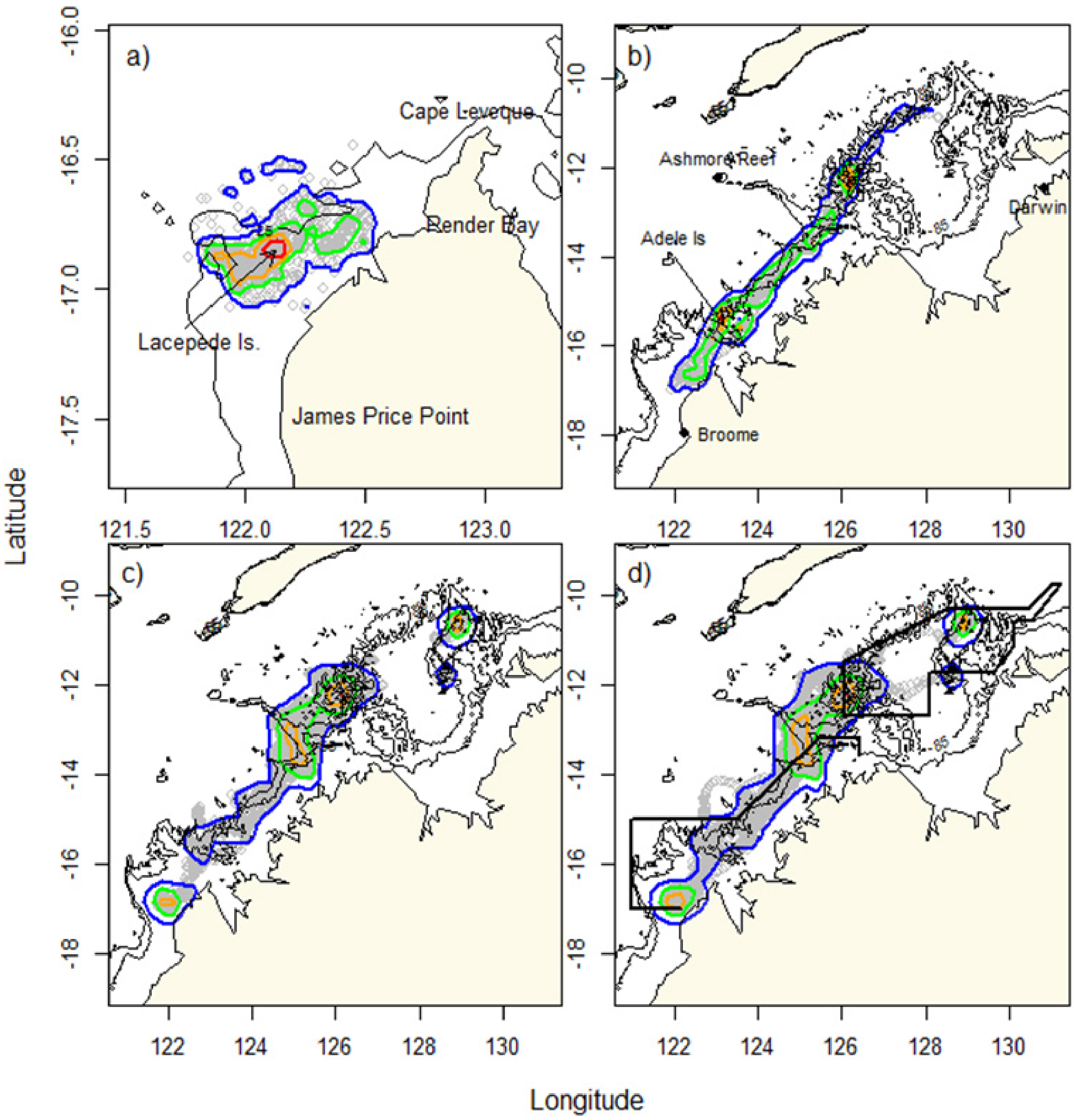

Figure 2: State-space model position estimates (grey open circles) for flatback turtles from the Lacepede Islands showing the 25% (red), 50% (orange), 75% (green) and 95% (blue) kernel utilisation distribution for all turtles during: a) the nesting season, showing the 25 m depth contour in black; b) the outward transit; c) foraging and; d) all phases combined. Also shown in thick black lines are two Commonwealth Marine Reserves; the Oceanic Shoals (top) and Kimberley (bottom). Black contours on maps b, c and d show the 65 m and 85 m depth contours

2.1.4 Spatial Models for Humpback Whales

Spatial models for humpback whales are being developed under a WAMSI-funded project using aerial and vessel survey data collected over two decades (1990s and 2000s) and satellite tracking data for 23 animals in the Kimberley region. All existing data has been amassed and will be used to develop spatial-distance sampling and species distribution models of humpback whale distribution, abundance and habitat use. As with turtle migration models, future priorities may also include mapping biologically important areas (BIAs) (e.g. areas important for calves) and investigating relationships with KEFs. An important data gap for humpback whales is understanding the importance of 80 Mile Beach as a resting area; limited satellite tracking data suggest they rest here for short periods.

2.1.5 Other Megafauna Models

Various other models are being developed at the University of Western Australia across different megafauna species and ecosystems of regional importance. These include benthic fish diversity at Ningaloo Reef (diver-based video, Sequeira et al. In press), juvenile shark distribution between NW Cape and the Timor Sea (BRUVS, Oh et al. Submitted), shark abundance and diversity across tropical Australia (BRUVs), humpback whales in Exmouth Gulf (aerial surveys, Braithwaite 2014), and snubfin dolphin abundance in Roebuck Bay (vessel-based surveys, Raudino et al. In prep.). These additional models may be synthesised and uploaded as relevant spatial layers into the Northwest Atlas web portal to support information discovery and sharing, in liaison with industry and science partners.

2.2 Invertebrates

Several datasets and associated models of marine invertebrates exist at a regional scale (tens of kilometres) for the North and North-West.

2.2.1 Sponge assemblages - Oceanic Shoals CMR

Species-level identifications are available for all sponges collected by benthic sleds on collaborative surveys between AIMS and GA to the Joseph Bonaparte Gulf and Timor Sea, overlapping the Oceanic Shoals CMR (surveys SOL4934, SOL5117, SOL5650, and SS2012t07). Sponges were identified by a taxonomist at the Museum and Art Gallery of Northern Australia (Belinda Alvarez), and an associated matrix of 348 species was produced from 86 sampling sites to analyse ecological patterns of sponge assemblages. Results supported the listing of carbonate banks in the CMR as a KEF, although large variations exist in sponge assemblages among individual banks (Przeslawski et al. 2014, 2015). Future research could investigate processes and environmental drivers that regulate sponges and other habitat-forming invertebrates within and among these banks, although this would require more data to be collected through future surveys or acquisition of currently inaccessible data (e.g. industry data).

2.2.2 Sponge species richness model - Oceanic Shoals CMR

Using sponge species richness derived from the identifications detailed in Section 2.2.1, a range of predictive models were developed using random forests, generalised linear models, and their hybrid methods. The spatial distribution of sponge richness was predicted using the most accurate model, which confirmed that the relationship between sponge species richness and environmental variables is non-linear and that hard substrate is associated with high species numbers. Results will also help inform future model development in this region by facilitating specific recommendations for model input parameters and methodology. Future research incorporating more data points would help further refine the model and extrapolate to other regions.

2.2.3 Infaunal assemblages - Gascoyne and Oceanic Shoals CMRs

Species-level identifications are available for all polychaetes collected by grabs on surveys to the Joseph Bonaparte Gulf and Timor Sea, overlapping the Oceanic Shoals CMR (surveys SOL4934, SOL5117, SOL5650, and SOL5463) and the collaborative AIMS and GA survey to Carnarvon Shelf, overlapping the Gascoyne CMR (SOL4769). Infauna from SOL4769 was identified by an ecologist (Matt McArthur), and those from the other surveys were identified by a taxonomist at the Museum and Art Gallery of Northern Australia (Chris Glasby). Results from the Gascoyne CMR showed significant spatial variation, but weak relationships between infauna and sediment composition and depth (Przeslawski et al. 2013). For the Oceanic Shoals CMR, an associated matrix of over 260 species is now being produced from over 100 sampling sites to analyse ecological patterns of infaunal assemblages. Future research priorities will include the analysis and publication of the Oceanic Shoals polychaete data. In addition, the processes and environmental drivers that regulate epifauna such as sponges (Section 2.2.1) and infauna could be compared, and the biological specimens associated with this dataset could be used for genetic analysis to validate, refine or expand upon the 4-D connectivity model described in Section 2.3.

2.2.4 Spatial distribution datasets and models of habitat and species

AIMS and its partners have been collecting data and developing habitat and species distribution models for benthos and demersal fish at range of spatial and temporal scales (e.g. from individual reefs to the entire NW Shelf) over the past 15 years. The major objectives beyond habitat prediction are to develop an improved understanding of ecosystem processes and to facilitate decision support. These models have been constructed using data from a broad range of remote sensing technologies, including passive satellite sensors for shallow water communities, activate sensor airborne Lidar, acoustic single- and multi-beam datasets (including multiscale geomorphic derivatives), with validation using infield image measurements (towed video, benthic sled sampling and BRUVs). Relationships between physical and biological parameters are modelled using a range of methods which are selected based on available data and modelling objectives (e.g. ecological interpretation, predication accuracy, or spatial interpolation). These include techniques such as general additive mixed models, machine learning techniques (assembler methods, boosted regression trees, aggregated boosted trees and random forests), clustering algorithms (K-means, support vector machines and naïve Bayes methods) and spatial autocorrelation methods (kriging, triangulation network models, thin-plate spline interpolation and geographically weighted regression). Outputs from predictive habitat models include probability of occurrence maps of demersal fish abundance and biodiversity, habitat maps based on combined benthic probability models, estimates of model accuracy and details of links between physical variables and biota (commonly interpreted using partial response plots/maps).

A number of example spatial models covering the area offshore from the Kimberley CMR were shown as part of the workshop. Model outputs for some of the offshore banks and shoals (carbonate mounds) are also available on the Northwest Atlas.

2.3 Connectivity

An individual-based dispersal model was used to simulate the movement of marine larvae in four dimensions (3D space over time) for the entire Australian Exclusive Economic Zone, excluding external territories (Kool and Nichol 2015). The model simulates the interactions of large numbers of individuals with their environment and one another, allowing the study of their collective behaviour. Individual-based modelling is a powerful means of modelling complex environments, and has been used in economic and financial analysis (e.g. stock markets) as well as for environmental management. The model uses three-dimensional ocean currents generated from real-world observations together with known larval behaviour to develop maps of the expected flow patterns of marine larvae using brittle stars as a model species. The computations were carried out using Australia's national supercomputer at the ANU, involving billions of simulated larvae and trillions of calculations. This information can now be used to evaluate the degree to which different marine areas are connected with one another in three dimensions, where the results can be partitioned or grouped on the basis of geography (e.g. marine reserve, key ecological feature or arbitrary volume) and time (e.g. year or season) (Figure 3). Results will help inform management decisions by detecting interdependent areas, pinpointing critical linkages, identifying exchanges between marine regions, locating areas where conservation spill-over benefits might occur, and investigating potential pathways by which invasive species might spread. Future priorities include determining if the dispersal model will be able to identify dispersal 'corridors' among marine reserves and investigating the degree to which oceanographic current structure coincides with geomorphic features (e.g. palaeo shorelines) and migratory routes of megafauna (e.g. turtles, whale sharks).

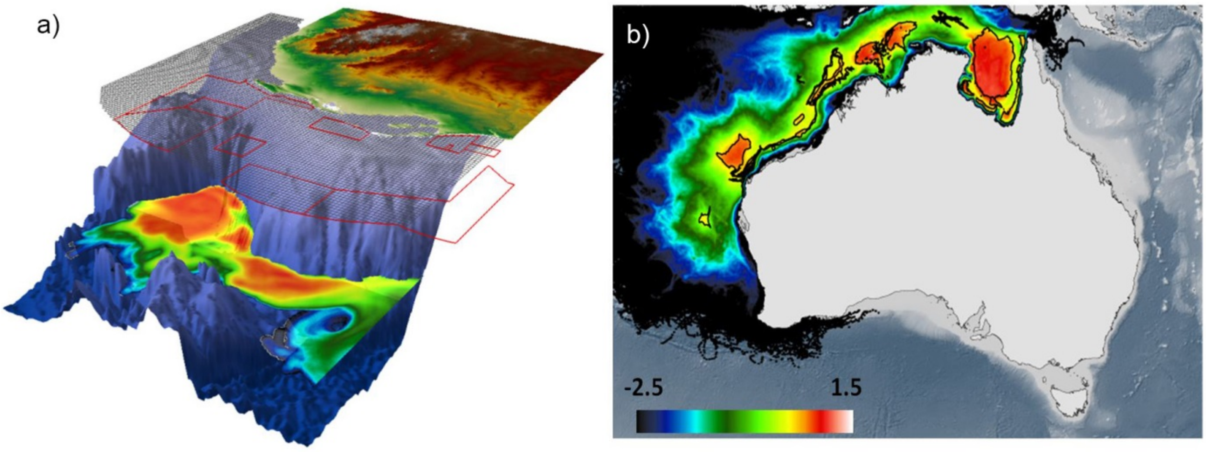

Figure 3: Outputs from the 4-D individual-based dispersal model for the North and North-West region, showing: a) Sample dispersal near the Gascoyne Commonwealth Marine Reserve (Cape Range Canyon and Carnarvon Canyon), WA as a dispersal probability surface at 3000-3500m depth, integrated over 2009-01-01 to 2009-12-31 and; b) connectivity among KEFs using Log10 particle densities for a 12 km radius around a 1 km cell, released from Key Ecological Features, integrated over January 2009 through December 2012 and over all depths. Red lines indicate CMR boundaries.

2.4 Environmental Data

There is a substantial number of marine environmental datasets covering the North and North-West regions (Appendix C). These datasets were generated from different sources and describe different aspects of the marine physical environment. In summary, these datasets include:

- *Bathymetry and derived products*: The current version (2009) of Australian Bathymetry data was constructed from a variety sources including multibeam, single beam and satellite imageries. A range of derivatives were later generated to describe the geomorphology of the seabed. A recently published national multibeam bathymetry dataset also has some coverage in these regions.

- *Seabed sediments*: The sediment grain size parameters were generated from GA's MARS database using spatial prediction techniques (Li et al. 2012).
- *Seabed disturbance*: The Geomacs variables are the outputs of Geomacs model which estimates the bed shear stress on the continental shelf (Hughes et al. 2010).
- *Sea surface water quality*: The MODIS water quality variables were obtained from MODIS imageries using NASA's SeaDAS image processing software.
- *Submarine canyons*: The submarine canyon layer was the result of a submarine canyon mapping (Huang et al. 2014).
- *Connectivity/Dispersal variables*: Outputs of the 4-D connectivity model (Kool and Nichol 2015) (Section 2.3), incorporating BRAN3.5 oceanographic variables extracted from the Bluelink ReANalysis data.
- *CARS variables*: CARS 2006 data, describing the chemical and physical properties of the bottom water.
- *Atmospheric and Climate layers*: Obtained from BOM database and a global environmental dataset.

Appendix C lists the basic characteristics of these marine environmental datasets. The detailed metadata of most of these datasets can be found in Huang et al. (2010, 2013).

In addition, in recent years, GA in collaboration with AIMS and other organisations has conducted several surveys in the North and North-West regions (Figure 4). The surveyed areas include Carnarvon Shelf (2008), Bonaparte (2009, 2010), Oceanic Shoals (2012), and Browse and Petrel areas (2012, 2013, 2014). These surveys have deployed a range of gear (e.g., multibeam, towed video, sediment grab, benthic sled, etc.), and as a result, have generated high quality environmental and biological datasets as listed in Appendix D.

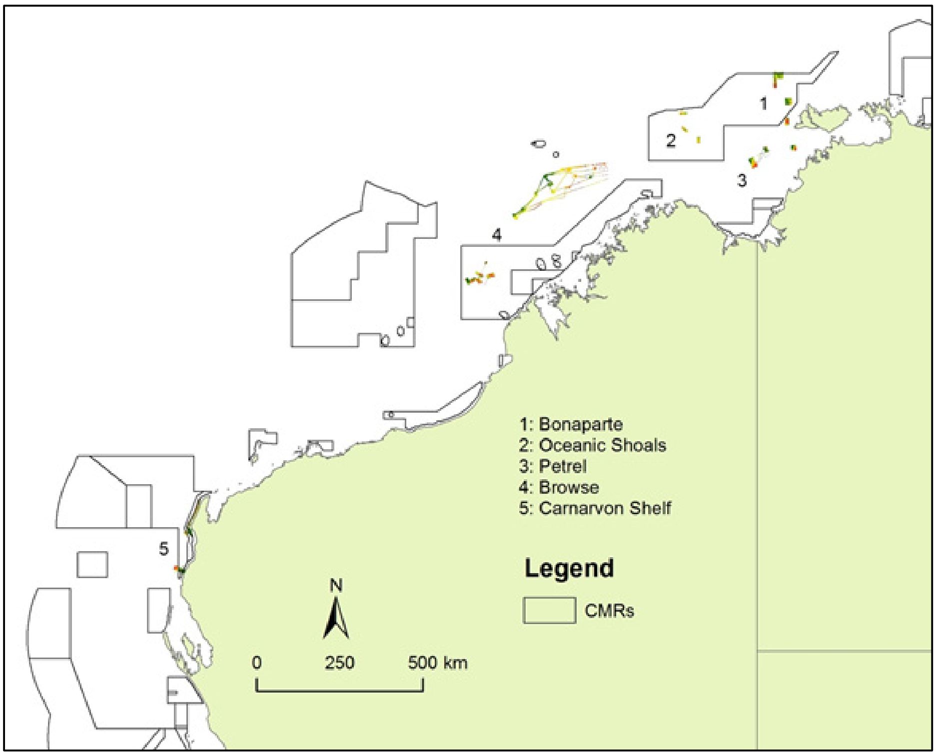

Figure 4: Location of CMRs and GA marine surveys that collected marine environmental data 2009-2015.

AIMS, in collaboration with industry partners, has also amassed considerable biological and environmental data across the NW Shelf over the past 20 years, including data on benthos, demersal fish and multibeam data (Figure 5)

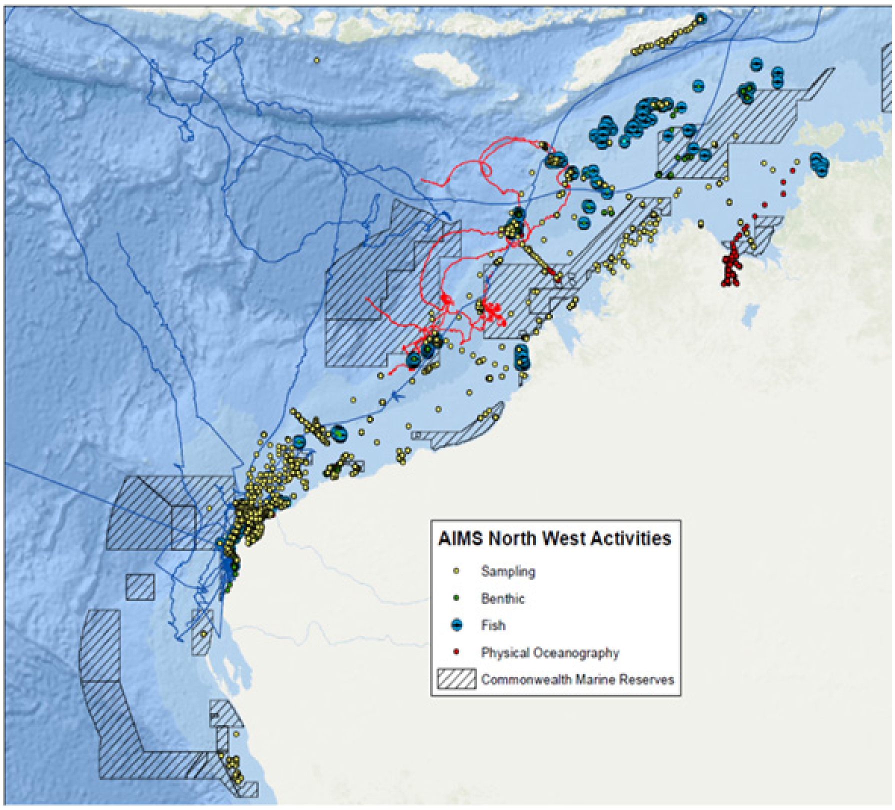

Figure 5. Summary of AIMS activities in the NW Shelf (up to 2014) including details of the types of data collected. Notably most data is from areas outside of the CMRs, highlighting an important data gap.

2.5 Other Data

There are other biological and environmental data available for the North and North-West region from industry surveys and associated environmental impact assessments, but much of this is not publicly accessible. The developing IGEMS initiative may make it possible for these data to be made more easily accessible, and Hub partners (e.g. AIMS) may be able to facilitate access to such data, but their suitability for the purposes of NESP Project D1 needs to be investigated further.

3. EXISTING DATA RESOURCES FOR N AND NW REGIONS

3.1.1 North West Atlas

The North West Atlas (http://northwestatlas.org) is a web portal that was created in response to the need for more comprehensive and accessible information on environmental and socio-economic data on the greater Northwest region. It provides the infrastructure and tools to promote the free and open exchange of information to support science, policy making and public understanding of the greater Northwest region. In addition to e-Atlas projects for the Great Barrier Reef and the Ningaloo Atlas, the North West Atlas includes spatial data, model outputs, and map products from a range of projects including from the Marine Biodiversity Hub (CERF and NERP programs). .

The North West Atlas will be the key information repository for the NW region providing:

- Access to data for informed decision making.
- An overview of work done in the region.
- A user friendly site to engage the public.

North West Atlas content is discoverable through search tools for datasets and projects, as well as functions to evaluate and attribute value to spatial datasets in order to determine if they are fit for purpose. The North West Atlas also allows the investigation of spatial relationships between different datasets, and data can be brought into other GIS software systems for further analysis or made available for download.

The North West Atlas will be an important repository for data and models from NESP Project D1, and outputs related to its web delivery services have been identified for subsequent years (Section 5)

3.1.2 Atlas of Living Australia

Species presence data is available at a national scale from the Atlas of Living Australia (ALA) (www.ala.org.au). The ALA is a portal that harvests species records from museums and other institutions to allow regional searches and data analysis.

4. DATA GAP ANALYSIS

Data and models exist over some areas in the North and North-West (Section 2), but there are limitations with respect to depth, substrate types, and supporting validation data. During the workshop, GIS files representing existing data locations were combined from AIMS, UWA, GA, and CSIRO into a single map in order for participants to identify major spatial and data gaps. One of the key conclusions from this qualitative gap analysis was that most data for the NW exists from outside CMRs, and there is also little quantitative data from KEFs in the NW Region, especially the Ancient Coastline KEF (e.g. Figure 5). A kernel-based hotspot analysis undertaken prior to the workshop showed potential to extend existing models (Section 2.2.4) into other areas including CMRs and KEFs, particularly those areas where there exists empirical data in adjacent or similar habitats. The best candidate areas based on scientific data that would likely produce the most robust models would be in the North-west marine region, for example the Kimberley and Oceanic Shoals CMRs as well as the Eighty Mile Beach and Gascoyne CMRs. However, extension of existing models into new areas would need to be validated with targeted field data collection in order to provide confidence intervals associated with model outputs.

One particularly data-poor area is the Argo-Rowley Terrace CMR which includes a diversity of deep water habitats (abyssal plains, canyons, terraces), but there is probably insufficient empirical data in this or other similar habitats to confidently model diversity without additional field surveys. The importance of filling knowledge gap in the Argo Rowley Terrace would need to be established with stakeholders before considering this as a target for research, as it is likely to be logistically difficult and expensive to collect data in such a deep and remote region.

5. FUTURE DIRECTIONS & DELIVERABLES

From a scientific perspective, workshop participants agreed that the areas that could be most easily and accurately modelled would be those adjacent to, or in similar habitats to, areas for which datasets exist (e.g Kimberley CMR). As such, four key areas for the future direction of Project D1 were identified that will ultimately input into prioritisation processes with end users as part of the planned D1 Stakeholder workshop to be held in early 2016:

- Synthesise new datasets and incorporate new information into existing models
- Establish values and baseline data for target CMRs
- Refine and update key KEF descriptions
- Provide resources for regulators and industry

Each of these is expanded upon below.

5.1.1 Synthesise new datasets and extract new information to underpin modelling

Through the workshop process, many recently acquired datasets were identified that had yet to be utilised in any of the predictive modelling described (Section 2) as well as a number of surveys that were scheduled in the coming six months that would generate data relevant to understanding and predicting biodiversity in the North and NW. These include:

- Bonaparte Gulf (Multibeam, BRUVs, towvid, seabed hardness predictions)
- Margaret Harries Bank (Multibeam, BRUVs, towvid)
- Kimberley including offshore turtle feeding areas (Multibeam, Towvid, sediments, biodiversity)
- New Montara area shoals (from Falkor trip – multibeam, single beam, ROV, in-water measurements)
- Emergent reefs/hard coral models
- Shark Bay (Towvid and BRUVS)
- LIDAR – Oceanic Shoals to 40m
- Whales from Space (uses high resolution (30 cm) satellite imagery (Worldview 3) to monitor humpback whale populations)
- Wallaby Plateau (multibeam, sediments, biodiversity)
- Darwin Harbour (multibeam, towvid, sediments)
- O&G industry data through IGEMS
- Infauna and polychaete data from previous NERP surveys in the Oceanic Shoals CMR

In order to fully meet the priorities listed below, these datasets must be synthesised such that data gaps can be identified and spatial and ecological patterns can be further assessed. Any future synthesis and modelling should include these new data, where possible.

5.1.2 Establish values and baseline data for CMRs

The Department of the Environment has already indicated through the NESP MPA Workshop (held August 2015) that obtaining baseline data and values for CMRs is important for the effective management of CMRs. In the North and North-West, existing and future models can predict the nature and distribution of biodiversity, particularly regarding benthic ecosystems in the Kimberley and Oceanic Shoals CMRs and migratory megafauna in the 80 Mile Beach and Kimberley CMRs. Existing datasets and models can be applied to a more process-oriented approach to identify environmental drivers that generate patterns. For example, ocean currents and topography may interact to affect the spatial and temporal activity of migratory megafauna along the North-West coast.

5.1.3 Refine and update KEF descriptions

Since the designation of Key Ecological Features in 2007, much more data have been collected and analysed through the NERP Hub and other research programs. These data and associated models can now be synthesised to refine and update KEF descriptions and values. Hypotheses stemming from NERP data can also be developed to investigate existing and potentially new KEFs (e.g. ancient coastlines as a migratory pathway, hotspots at canyon heads).

5.1.4 Provide resources for managers, regulators and industry

Although the workshop focus was on scientific objectives, the need to make such work relevant and accessible to regulators and industry was at the forefront of discussions. The priority research needs for stakeholders in the North and NW will be established through the Project D1 Stakeholder Workshop to be held in early 2016. However, outputs from the research proposed during the scientific workshop that will be of direct relevance for stakeholders include the following:

- Identification of Biologically Important Areas (BIAs) used for feeding, breeding, and transit;
- Interactive risk maps with cyclone and wave impact, shipping movement, sound exposure;
- Data and model delivery via the North West Atlas;
- Indigenous engagement regarding the awareness of CMR management and values;
- New and refined conceptual models for biophysical processes of CMRs and KEFs;
- An updated description of North and North-West KEFs which would be delivered via the North West Atlas; and
- Guidance for monitoring which would involve informing sampling design and identification of monitoring priority areas.

Importantly, by making scientific data and synthesis products available on the North West Atlas this information will become readily accessible to stakeholders and will enable public engagement in the marine values of the North and NW. This approach has been proven, for example, through the Ningaloo Atlas, which is often used as a source of information by industry in compiling environmental assessment decision support protocols, informing pre-approval surveys, developing models that guide post-approval activities, and forming interactive risk maps.

6. OUTCOMES AND OPPORTUNITIES

The synthesis and analysis of datasets describing benthic and pelagic biodiversity in the North and North-west marine regions will inform future prioritisation of research to support management and monitoring of CMRs and KEFs in these regions. A key opportunity as part of this prioritisation process will be to use the data synthesis to identify areas that require better descriptions of biodiversity values, through additional data acquisition and model validation achieved by field, lab and desktop studies. Importantly, the consideration of priority areas for future research will extend beyond the initial work of Project D1 to include research findings from Project D3 – 'Shelf reefs', Project C1 – 'Pressures', and other NESP projects where relevant.

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APPENDIX A – LIST OF WORKSHOP PARTICIPANTS

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APPENDIX B – WORKSHOP AGENDA

NESP MARINE BIODIVERSITY HUB – SCIENCE WORKSHOP

Project D1: “Developing a Toolbox of Predictive Models for the Monitoring and Management of KEFs and CMRs in the North and North-west regions”

9th & 10th September, 2015

Room 4.105 (Wed) & 3D Viz Lab (Thurs), Geoscience Australia, Canberra

DAY 1 – Wednesday 9th September, 2015

9:00am	Coffee & Tea Available (Café Rocco, Ground Floor)
9:30am	Introduction & overview of project and workshop objectives (Karen Miller/Scott Nichol) [Copy of NESP Round 1 Project Proposal circulated to group]
9:45am	Summary of Existing Model – Large-scale Connectivity (Johnathan Kool, GA)
10:15am	Summary of Existing Model – Pelagic Hotspots (Phil Bouchet, UWA)
10:45am	Morning Tea
11:15am	Summary of Existing Models –Benthic Habitats (Ben Radford, AIMS; Jin Li, GA)
12:00am	Summary of Existing Model –Megafauna (Michele Thums, AIMS)
12:30pm	Lunch
1:30pm	NW Atlas (Ben Radford)
2:00pm	Identification of new data sets that can inform future model development and integration of these to NW Atlas (Zhi Huang and others)
3:00pm	Afternoon Tea
3:30pm	Project objectives and deliverables for 2015– understanding how we plan to achieve these (Karen Miller/Scott Nichol)
5:00pm	Meeting close
7:00pm	Workshop Dinner [Rubicon Restaurant - 6a Barker St, Griffith ACT 2603]

DAY 2 – Thursday 10th September, 2015

9:00am	Coffee & Tea Available (Café Rocco, Ground Floor)
9:30am	Introduction & overview of the day's objectives (Karen Miller/Scott Nichol)
9:45am	Where to next – stakeholder context and links with decision support (Terry Walshe)
10:15am	Gap Analysis – reviewing what we already know and identifying what we'd like to know from a science perspective**
10:45am	Morning Tea
11:15am	Gap Analysis – reviewing what we already know and identifying what we'd like to know from a science perspective continued
12:00pm	Where to next – identifying key science questions and broad direction of NESP NW Project for Round 2 Proposal
12:45pm	Lunch
1:30pm	Where to next – fleshing out the scope of the future NESP NW Project for Round 2 Proposal
3:00pm	Afternoon Tea
3:30pm	Where to next – planning and delegation of tasks for development of Round 2 proposal
5:00pm	Meeting close

** Participants requested to bring summary information about nature and locations of existing data for formal gap analysis

APPENDIX C – NATIONAL AND REGIONAL MARINE ENVIRONMENTAL DATASETS

Group	Name	Format	Spatial Coverage	Spatial Resolution	Temporal Coverage	Custodian
Bathymetry and derivatives	Australian Bathymetry	Raster	National - EEZ	0.0025dd		GA
	Topographic Aspect	Raster	National - EEZ	0.0025dd		GA
	Topographic Slope	Raster	National - EEZ	0.0025dd		GA
	Topographic Relief	Raster	National - EEZ	0.0025dd		GA
	Topographic Rugosity	Raster	National - EEZ	0.0025dd		GA
	National Multibeam Bathymetry	Raster	National - variable	50m		GA
	Geomorphic features	Vector - Polygon	National - EEZ			GA
Sediment parameters	%Gravel	Raster	N and NW	0.0025dd		GA
	%Mud	Raster	N and NW	0.0025dd		GA
	%Sand	Raster	N and NW	0.0025dd		GA
MODIS Water Quality	SST	Raster	National - EEZ	0.01dd	monthly, 2002-2014	GA
	Chlorophyll a	Raster	National - EEZ	0.01dd	monthly, 2002-2014	GA
	Coloured Dissolved Organic Matter	Raster	National - EEZ	0.01dd	monthly, 2009-2011	GA
	Total Suspended Sediment	Raster	National - EEZ	0.01dd	monthly, 2009-2011	GA
	K490	Raster	National - EEZ	0.01dd	monthly, 2009-2011	GA
	Euphotic Depth	Raster	National - EEZ	0.01dd	monthly, 2009-2011	GA

Group	Name	Format	Spatial Coverage	Spatial Resolution	Temporal Coverage	Custodian
Geomacs outputs	25th Quartile	Raster	National - CS	0.1dd		GA
	50th Quartile	Raster	National - CS	0.1dd		GA
	75th Quartile	Raster	National - CS	0.1dd		GA
	Trimmed Mean	Raster	National - CS	0.1dd		GA
	Geometric Mean	Raster	National - CS	0.1dd		GA
	Ratio	Raster	National - CS	0.1dd		GA
	Percentage Exceedance	Raster	National - CS	0.1dd		GA
	Percentage of time the Shields Parameter Exceeds 0.25	Raster	National - CS	0.1dd		GA
	The Integrated Shields Parameter Exceeding 0.25 Divided by the Integrated Total Shields Parameter	Raster	National - CS	0.1dd		GA
	Average Time between Events When the Shields Parameter Exceeds 0.25 Based on a PAT Analysis	Raster	National - CS	0.1dd		GA
	Ecological Disturbance Index	Raster	National - CS	0.1dd		GA
Canyon	National Submarine Canyons	Vector - Polygon	National - EEZ			GA
Connectivity and Dispersal	Particle Tracks	Vector - Polyline	National - EEZ			GA
	Dispersal Surface	Raster	National - EEZ	0.08dd	variable	GA
	Source Capability	Raster	National - EEZ		variable	GA
	Sink Capability	Raster	National - EEZ		variable	GA
	Total Activity	Raster	National - EEZ		variable	GA
	Net Activity	Raster	National - EEZ		variable	GA

Group	Name	Format	Spatial Coverage	Spatial Resolution	Temporal Coverage	Custodian
BRAN3.5	East-West Current Velocity	Raster	National - EEZ	0.1 dd	monthly, 2007-2012	GA
	North-South Current Velocity	Raster	National - EEZ	0.1 dd	monthly, 2007-2012	GA
	Vertical Velocity	Raster	National - EEZ	0.1 dd	monthly, 2007-2012	GA
	Upwelling at Bottom	Raster	National - EEZ	0.1 dd	monthly, 2007-2012	GA
	Upwelling to Euphotic Depth	Raster	National - EEZ	0.1 dd	monthly, 2007-2012	GA
	Upwelling to Mixed Layer Depth	Raster	National - EEZ	0.1 dd	monthly, 2007-2012	GA
CARS 2006	Bottom Nitrate	Raster	National - EEZ	0.01dd		CSIRO
	Bottom Oxygen	Raster	National - EEZ	0.01dd		CSIRO
	Bottom Salinity	Raster	National - EEZ	0.01dd		CSIRO
	Bottom Silicate	Raster	National - EEZ	0.01dd		CSIRO
	Bottom Phosphate	Raster	National - EEZ	0.01dd		CSIRO
	Bottom Temperature	Raster	National - EEZ	0.01dd		CSIRO
Atmospheric and Climate	Tropical Cyclone Tracks	Vector - Polyline	National			BOM
	Calcite	Raster	National	~9km		Ghent University
	Could Mean	Raster	National	~9km		Ghent University
	Cloud Minimum	Raster	National	~9km		Ghent University
	Cloud Maximum	Raster	National	~9km		Ghent University
	pH	Raster	National	~9km		Ghent University

APPENDIX D – GA SURVEY MARINE DATASETS

Location	Name	Format	Spatial Coverage	Spatial Resolution
Oceanic Shoals	Bathymetry	Raster	4 Areas	2m
	Backscatter	Raster	4 Areas	2m
	BRUV	Vector - Point	4 Areas	
	SISSTAS	Vector - Point	4 Areas	
	Benthic Sled	Vector - Point	4 Areas	
	Towed Video	Vector - Point	4 Areas	
	Sediment Grain Size	Vector - Point	4 Areas	
	Sediment Geochemistry	Vector - Point	4 Areas	
	Sediment Infauna	Vector - Point	4 Areas	
	Geomorphic Features	Vector - Polygon	4 Areas	
Bonaparte	Bathymetry	Raster	4 Areas	10m
	Backscatter	Raster	4 Areas	10m
	Sediment Grain Size	Vector - Point	4 Areas	
	Sediment Geochemistry	Vector - Point	4 Areas	
	Sediment Infauna	Vector - Point	4 Areas	
	Towed Video	Vector - Point	4 Areas	
	Benthic Sled	Vector - Point	4 Areas	
Carnarvon Shelf	Bathymetry	Raster	3 Areas	3m
	Backscatter	Raster	3 Areas	3m
	Sediment Grain Size	Vector - Point	3 Areas	
	Sediment Infauna	Vector - Point	3 Areas	
Browse and Petrel	Bathymetry	Raster		2m
	Backscatter	Raster		2m

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