National Environmental Science Program

Marine and Coastal Hub research plan 2021 – Attachment B project plans

Project 1.1 – Scoping Study: Protected Places Mission

Project description

Project summary

To develop the Protected Places Mission, its activities and outcomes, the Mission Co-Leads will engage in a scoping project. The project will engage with relevant stakeholders, researchers and research providers, including relevant DAWE sections, to co-design a research plan for the Mission over the duration of the Hub. The workshops and engagement process will develop the Mission focus areas, vision, activities, indicators, and outcomes from the Mission, and will identify Mission specific research needs for the near term. Outputs include a set of priority co-designed project proposals for submission in the subsequent annual research plans of all four Hubs and an overall Strategic Plan for this Mission.

Project description

The Protected Places Mission Co-Leads will develop a research plan (using program logic) that describes the activities, outputs and outcomes from the Protected Places Mission, in collaboration with relevant stakeholders in DAWE. The research plan will be informed by discussions with research providers to ensure that appropriate capability can be identified to complete the activities and produce the outputs. The discussions will target terrestrial and marine protected areas including Reserves, National Parks, World Heritage Areas, and Ramsar sites, and consult with sections of DAWE responsible for the management of each of these protected places. These protected places will be contextualised within the broader landscape scale to ensure that threats and opportunities are clearly articulated. Further discussions will be held with Indigenous stakeholders to cover the Indigenous protected places estate.

Methodology

The scoping project will run a series of facilitated workshops and direct engagements with stakeholders to develop the research plan for the Protected Places Mission. We envisage multistakeholder workshops, with participants from science, government and traditional owners held in Canberra, Darwin and Perth to identify vision, research priorities, activities and outputs in each of the protected places. The mission co-Leads will also hold direct consultations with GBRMPA (Townsville) and Parks Australia (Hobart) and with relevant sections in Canberra in parallel with the workshops.

Within DAWE we plan to engage, either through workshops or direct consultation

- Parks Australia
- GBRMPA
- Reef Branch
- Heritage Branch
- Protected Species and Communities Branch
- Supervising Scientist Branch
- Environment Protection Reform Branch
- Wetlands section
- Environmental Biosecurity Office
- Monitoring, Evaluation, Reporting and Improvement Section, MERI Program Delivery Branch

- Bushfire Recovery Programs Branch
- NRM Groups
- Landcare Organisations

We will engage with additional areas as they are identified as needing to contribute to the mission.

We will also ensure that we will continually engage with the other Hubs and Missions through our regular collaboration mechanisms. The draft Protected Places work program will be committed for comment across the NESP2 system. This will ensure synergy and added value from the Mission for the NESP2. As the plan develops, we will identify where the interests of DAWE overlap with other stakeholders (eg NOPSEMA, AFMA, e-NGOs, States, NRM bodies) and engage in consultations with them to identify complementary outcomes.

Prior to the consultation process a document will be produced and provided to consultees. The document will include a precis of the relevant governing legislation and policies and agreements that apply to protected places and a summary of key challenges to regulators.

In developing the work program the Mission focus areas

The mission focus areas identified in the current priorities cover 5 main areas. Preliminary mission focus areas were developed by the Mission co-leads through informal consultations with stakeholders and scientists. These will be discussed and refined through the consultation process.

1. Supporting the management of Australia's protected places by building capacity of Indigenous communities and organisations to determine, lead and disseminate science to support protected place management. This would include the integration of indigenous and western knowledge. Thus, ensuring they benefit from protected places, including protection of social and cultural values, training and employment.

2. Building capacity for consistent, standards-based approaches to collecting, analysing, managing and reporting social, economic and environmental data to identify the key drivers of resilient populations and ecosystems in protected places, particularly climate change and impacts from multiple drivers.

3. Improving the governance of Australia's protected areas by reviewing approaches to monitoring, evaluation, reporting and improvement (MERI) in Australia to identify best practice and highlighting opportunities to develop complementary approaches between programs and across land sea/nexus.

4. Development of cost-effective methods and strategies to monitor the status and trends of biodiversity, cultural, indigenous, and heritage values.

5. Restoration of landscapes/seascapes within protected places and build the adaptation capacity and resilience to climate change of protected places across the Australian land, sea and coastal jurisdiction (in collaboration with the Climate Adaptation Mission).

The ability of the Mission co-leaders to provide targeted advice on delivery of scientific support for Australia to inform specific advice on short-term problems and in meeting obligations and reporting for Protected Area related international treaties & agreements (e.g., CBD, CITES, CMS, UNEP, BBNJ) will also be discussed with the relevant sections.

Roles

Because of the skill sets of the two Mission Co-Leads there will be a breakdown of tasks with Dr Piers Dunstan taking responsibility for the marine projects and Professor Iain Gordon having responsibility

for those in the coastal and terrestrial systems. The overall responsibility for the project will be Professor Iain Gordon.

Output.

A detailed research plan on protected place management that identifies the short-term research needs that need to be prioritised and the long-term goals that will be met over the 6 years of NESP funding. The plan will describe the vision, mission focus areas, activities, indicators and outcomes This will be delivered as a 2 year Operational Plan, 6 year Strategic plan and a Mission Engagement Plan. The update frequency for the plans will be determined in consultation with the Department, but it is anticipated that the Operational plan will be updated annually and the Strategic plan after 3 years.

Links to Other Projects

The Mission scoping project is intended to draw on the outputs of the MAC Hub scoping projects. In some cases, mission co-leads are explicitly engaged with the projects. Through the scoping project, Mission co-leads will identify & engage with appropriate projects where mission need, and outputs are identified.

Project 1.2 – Scoping study: National Areas of Interest for Seabed Mapping, Characterisation and Biodiversity Assessment.

- Piers Dunstan is working with project leaders on the development of the project & will be an active participant.

Project 1.3 – Support for Parks Australia's Monitoring, Evaluation, Reporting and Improvement System for Australian Marine Parks

- Piers Dunstan is leading the project and working closely with Parks Australia to ensure that the future needs of MERI – both marine and terrestrial are integrated into the Mission research plan. Iain Gordon will increase involvement as MERI moves towards a terrestrial phase.

Project 1.17 – Scoping study: a national approach to socio-economic values of the marine environment

- Iain Gordon and Piers Dunstan will engage with the project to ensure that the outlines of research proposals and the identified set of socioeconomic research priorities across the three themes (valuing nature, planning for multiple values, implementing for success) can be integrated into the mission.

Project 1.20 - Scoping Study: Marine and Coastal Threatened Species and Communities

- Iain Gordon & Piers Dunstan will engage with the project and are in close communication with the Helene Marsh to ensure that the missions are coordinated.

Project 1.29 – Scoping Study: New Approaches to Marine Monitoring

- Iain Gordon and Piers Dunstan will engage with the project to ensure that potential monitoring methods that could be used in Protected Places are identified and integrated into the mission objectives where appropriate.

Project 1.31 – Scoping Study: Indigenous Leaders Environmental Research Network

- Iain Gordon and Piers Dunstan will engage with the project to ensure that the mission is linked to the MCH process for indigenous engagement.

Indigenous consultation and Engagement

This a Category 2 (Indigenous Partnerships Strategy) project. The Protected Places Mission will adopt the Marine and Coast Hub's Indigenous Engagement Partnerships Strategy (IPS) and will operate under the NESP Indigenous Partnerships Principles. This will ensure research leaders actively consider opportunities for the Engagement of Traditional Owners in projects from the inception stage, throughout the project's life and beyond. Research project leaders are expected to have identified, consulted and negotiated with, and received consent from Indigenous peoples for effective Engagement with Traditional Owner groups prior to submission of research project proposals. Any data collected will be treated consistent with the Hub Data Management Strategy.

The Mission will work with the Marine & Coastal Hub to facilitate appropriate participation by Indigenous groups when undertaking research activities. In conjunction with project objectives, Indigenous knowledge systems and processes must be respected. Indigenous participation, as collaborators, is to be encouraged, acknowledged and remunerated. Indigenous employment should, where possible, be undertaken through organisations that have appropriate institutional arrangements.

To facilitate appropriate participation in research projects, researchers will be encouraged to develop and demonstrate an appreciation of the diversity of Indigenous peoples, their different languages, cultures, histories and perspectives. Direct involvement as collaborators, co-authors, co-researchers and employees is often the most effective means of incorporating Indigenous perspectives in research activity. Project leaders and teams will need to understand differing types of participation are likely to require different pay rates, for example, technical assistance, consultation, liaison, translation, expertise in ecological and cultural knowledge. Indigenous Engagement and participation must be budgeted into the life of the project.

Partner institutions will also be encouraged to support employment pathways by providing professional development opportunities and capacity building for Indigenous people. This would include opportunities for doctoral, postdoctoral and graduate programs within the institution. Indigenous natural resource management service providers will be given the opportunity through partnership with research projects to enhance and improve the community's capacity to monitor natural environmental assets within their sea country. This can be achieved through operational training to upskill a range of indigenous natural resource management service providers and the integration of Indigenous Ecological Knowledge (IEK) with western science.

Location of research

The majority of the work for the scoping study will occur in Hobart and Townsville, with workshops proposed for Darwin, Perth and Canberra (Covid pending). This scoping study is planning a set of activities, in future years, that will include local, regional and national scales. The Mission's general approach will involve local/regional studies and trials that are developed from the outset with an understanding or how they can be scaled-up or transferred to other regions, or as appropriate, nationally, through a network of local/regional studies. The choice of locations is a key outcome from the scoping and co-design process and will be determined in consultation with relevant research leaders and from all four Hubs, identified by their mission champions, which includes a review of the most appropriate locations to trial regional approaches.

Project 1.2 - Scoping Study: National Areas of Interest for Seabed Mapping, Characterisation and Biodiversity Assessment

Project description

Project summary

The project aims to assist the planning and prioritisation of marine surveys (both physical and biological) by scoping a prioritisation framework and web tool. Focused workshops and targeted engagements with seabed mapping organisations will ensure the framework meets the needs of the Marine and Coastal Hub, key end users such as Parks Australia, and the wider seabed mapping and biodiversity management community. Adoption and adaption of the AusSeabed Survey Coordination Tool will facilitate the development of an interim national areas of interest product to inform future survey planning. This product will support the needs of Parks Australia network Science Plans and consideration of information needs for Indigenous Protected Areas within Sea Country.

Project description

Seabed and marine biodiversity data are time-consuming and costly to collect, so it is imperative that acquisition is focused on areas that align with end user priorities. However, understanding the value that different stakeholders place on seabed and biodiversity data is currently difficult to determine, with the risk that marine survey planning may not always be based on the most comprehensive information. Here we define seabed mapping surveys to encompass activities that map and characterise the seabed, specifically its physical properties (depth, morphology, substrate type) and associated biological communities (benthic and demersal habitats). The National Areas of Interest project will therefore deliver to the planning requirements for seabed mapping and characterisation to establish baselines, and to design biodiversity assessment and monitoring surveys.

The project aims to facilitate the marine survey planning process by establishing a community-endorsed value framework and set of metadata attributes that can be used to identify areas of common interest. Stakeholders will be able to update their areas of interest through the existing AusSeabed Survey Coordination tool that will feed changes across to the AusSeabed portal in real time and allow for distribution to other portals. The project will also develop a plan to sustainably manage the ongoing collation of areas of interest that will allow nationally funded programs such as the NESP2 Marine and Coastal Hub (MCH) and the Hydroscheme Industry Partnership Program (HIPP), to investigate the value of registered areas of interest, identify where the greatest need for data is, and where collaborative opportunities may exist. It also presents an opportunity to build the capacity for the MCH and the Marine National Facility (MNF) to leverage the existing HIPP process for collaborative seabed mapping within areas of common interest. This aligns with MNF's strategic goal of increasing the reach and impact of voyages undertaken on the Facility's vessel, by providing information on national mapping priorities to voyage proponents, planners and participants.

The task of guiding future benthic biodiversity surveys and ongoing monitoring priorities within the Australian marine estate is somewhat more complex than guiding physical mapping priorities. There are a wide range of stakeholders with an equally wide range of information needs, and it is important that the MCH determines the main drivers of survey priorities over the life of the program to ensure core stakeholder needs are adequately addressed. Such guidance is also needed by the wider

research community and the major infrastructure providers that underpin this process, including the Integrated Marine Observing System (IMOS) and the research institutions with mapping interests and capabilities. Priorities within the MCH will be guided by the Parks Australia Science Plans, as well as by their regional management process for identifying priority areas for initial mapping characterisation and biodiversity description. However, there may be a wider need to understand biodiversity values outside of the reserve network to underpin conservation and extractive industry values and needs, and these need to be adequately captured in a prioritisation process. In sum, the project will complement the AusSeabed Survey Coordination Tool by developing a prioritisation process and initial indication of future survey priorities for both physical and biologically focussed discovery and monitoring within Australia's EEZ.

How the research will be undertaken, including what is in and out of scope

This project is national in scope, addressing the information needs to support management of all marine regions and spanning State and Commonwealth waters. The project will also consider the scoping of seabed mapping and biodiversity information needs within Australian Antarctic Territory. To achieve this broad agenda, the project will undertake consultation through a series of workshops and targeted engagements with partners and end-users in the AusSeabed and Marine and Coastal Hub communities, underpinned by desktop reviews and research into best practice survey planning.

The following is in-scope for this project:

- Desktop research of existing value prioritisation frameworks and associated metadata that are used to classify and prioritise "areas of interest" for seabed physical and biodiversity data collection (including the earlier NESP Marine Biodiversity Hub survey prioritisation framework).

- Workshop 1: A cross-sector activity-based workshop involving key marine data users and collectors across government, industry and academia to develop a prototype value prioritisation framework and establish required metadata for spatial representation (taking into account existing solutions).

- Repurposing of the AusSeabed Survey Coordination Tool (National Priority Areas service) to ingest spatial data and interoperability serve physical and biodiversity mapping priorities as spatial layers on national portals, such as the Australian Ocean Data Network (AODN) and MNF MAPS, (the CSIRO online application and voyage planning portal).

- Training sessions with the wider community to teach them how to deliver areas of interest through the AusSeabed Survey Coordination Tool

- Workshop 2: A community workshop session to review submitted areas of interest and refine the prototype prioritisation framework

- Workshop 3: A closed workshop with key MCH partners and Parks Australia to apply the prototype prioritisation framework to the Parks Australia areas of interest and help inform the forward planning for surveys within the MCH.

- A progress report to deliver updates on workshop outcomes and recommendations in December and a Final report communicating achievements and recommended next steps.

The following is out of scope for this project:

Software development of a multi-criteria assessment (MCA) prioritisation web tool.

Pressures, specifically climate change scenarios (e.g. sea surface temperature trends), as a spatial layer to inform the prioritisation framework.

Portal functionality to view separate maps of areas of interest for: bathymetry/backscatter; Ground truthing and validation; and comprehensive biological surveys will not be developed during this iteration of the project due to limited funding, time and resources. However, this work will be scoped

and a suggestion for delivery of this functionality will be made in the recommendations section of the final report.

Details of related prior research

Currently, a national map of federal and state government priorities exists on the AusSeabed portal. This map has proved useful to Parks Australia, the Australian Hydrographic office, the MNF and the Schmidt Ocean Institute in helping identify regions of higher value for seabed mapping and characterisation. However, this map is limited in that it does not represent the interests of the broader seabed community (for example biodiversity), and it presents an organisationally determined priority, not the combined value of mapping surveys as defined above, in different areas. The map is also a rudimentary and (now) dated spatial representation with limited interactive capacity. The opportunity exists, therefore, to update and broaden the stakeholder representation through scoping a National Areas of Interest framework that can be used to capture and prioritise physical seabed mapping, ground-truthing and validation.

There is no similar priority map for associated biodiversity inventory or monitoring programs, hence the need to develop an appropriate process and overall guidance. The recently completed NESP Marine Biodiversity Hub did run a survey prioritisation process for the planning of Australian Marine Park survey locations and survey techniques (SOPs), including prioritisation of proposed SOPs for national uptake in the survey process. This involved significant consultation with Parks Australia, a wider stakeholder workshop and establishment of a prioritisation framework that included adequate spatial representation nationally, filling major spatial knowledge gaps, engagement of regional research providers and linkage with national research programs, databases and data portals. This project will therefore build on this earlier work.

How the project links to other research and/or the work of other hubs.

The project will link to the research undertaken to develop the AMP MERI system led by Parks Australia and the NESP Marine Biodiversity Hub. Developed initially as a pilot for the South-east Network of Australian Marine Parks, the MERI system identifies and defines the natural values for marine parks and is being extended to other networks as a NESP2 bridging project. This NESP2 project provides the opportunity to integrate these AMP natural values into the National Areas of Interest framework for future proposed surveys.

The project links to a range of national monitoring and biodiversity description initiatives, such as the IMOS Automated Underwater Vehicle-based benthic monitoring program, the national Baited Remote Underwater Video working group, and the AODN reef monitoring database, all of which provide SOP-based data into nationally integrated monitoring programs and State of the Environment reporting. More broadly, the project will also aim to link to the recent work of the National Marine Science Committee Working Group on Marine Baselines and Monitoring. In particular, the working group has identified a range of drivers and characteristics of a national program for establishing baselines and monitoring that will be used to guide this MCH project.

The Marine National Facility will use outcomes from this project to bring priority-informed work within MNF (such as partnerships which already exist with Parks Australia, Geoscience Australia and state Heritage programs) under a single strategic banner, and thereby provide greater transparency, collaboration and input to the voyage application, planning and delivery process. In particular, the project will support researchers develop proposals that link to the new Streams of Access under the MNF 2030 Strategy. In addition, MNF seek to maximise impact from the Facility by undertaking opportunistic seabed data collection when possible. However, prioritising this work is currently undertaken in an ad hoc manner and would benefit from a transparent mechanism to inform researchers of priority areas for mapping.

The interim National Areas of Interest map developed as a product of this process also offers value to the *De-risking Investment in the North* project led by James Cook University by providing a process to facilitate stakeholders in identifying the type and location of data required to address knowledge gaps

currently preventing investment. The prioritisation framework aspect of this project could then be applied by State Government agencies to help maximise the impact of data and focus collection efforts and by AIMS who could use the map to help deliver opportunistic mapping and data collection when opportunities on voyages/transits present themselves.

Summary of how it is expected that the research will be applied to inform decision-making and on-ground action.

The National Areas of Interest map developed in this project will allow industry, non-government organisations, academic institutions, state and federal government agencies and national marine programs, including the NESP Marine and Coastal Hub, MNF and HIPP, to understand the range of values associated with the unmapped and data poor regions of Australia's marine estate. By doing so, this work will empower the decision makers within these organisations and program bodies to identify the highest value areas requiring data collection and focus efforts accordingly.

It is intended that the National Areas of Interest map will include tangible, qualitative and quantitative environmental, economic, and social value scores attributed in the metadata. This will allow for cross-organisational value comparison to identify geographic areas where multiple stakeholders have shared interest, thereby maximising the return on investment in future marine surveys.

The planning and prioritisation framework proposed here is completely focussed on informing decision-making (i.e. where are the national biodiversity/monitoring priority areas) and on-ground actions (i.e. the undertaking of actual surveys, their location and the sampling methods used). Primarily, this will guide the MCH's survey focus over the next five years, with significant guidance from the Parks Australia MERI project and regional AMP network discovery priorities. It is likely that the structured approach taken here may in turn help to inform the MERI process and the underpinning prior knowledge around values needed to inform establishment of any initial monitoring.

Software support beyond the life of the project

The software development work proposed is minimal and is based on adaption and adoption of a service already maintained by Geoscience Australia—the AusSeabed Survey Coordination Tool. It is expected that this and the National Areas of Interest functionality will continue into the future.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

The project leaders will work with the NESP2 Marine and Coastal Hub Indigenous Facilitator and Knowledge Brokers to identify opportunities for respectful Indigenous participation in this project. For example, regional native title representative bodies could participate in scoping activities designed to identify knowledge needs and interests.

Location of research

This is a desktop project that will be led by Geoscience Australia, CSIRO, and UTAS with input from project partners and end-users via online workshops and face-to-face meetings (where possible).

The project is national in scale and is intended to have application to future marine (physical and biological) survey planning across the Australian marine estate, including Australian Antarctic Territory.

Project 1.3 – Support for Parks Australia's Monitoring, Evaluation, Reporting and Improvement System for Australian Marine Parks

Project description

Project summary

This project aims to continue scientific support for developing the Monitoring, Evaluation, Reporting and Improvement (MERI) system for Australian Marine Parks (AMPs). Specifically, it will provide a major input to the development of Science Plans for the AMP networks and Coral Sea Marine Park (CSMP). This project builds on the achievements of pilot research conducted through the SS2 and D7 projects as part of NESP1, which designed and implemented a fit-for-purpose approach to identify monitoring priorities for natural values and pressures for the South-east Marine Parks Network.

The project team will provide the scientific and technical information, and advice, to apply the tools and approaches from SS2 and D7 to the remaining AMP Networks and the CSMP to support development of the remaining Science Plans. The team will collate and analyse environmental and human use-data, and produce reports and data and mapping products, for each of the four remaining networks and the CSMP. The key outputs and reports will identify the monitoring priorities in each Network and the CSMP and help to identify key knowledge gaps to help inform research priorities.

Project description

Parks Australia is currently developing:

•   An AMP Monitoring, Evaluation, Reporting and Improvement (MERI) system to support evidence based adaptive management of AMPs.

•   Science Plans that identify research and monitoring priorities for all the AMP Networks and the Coral Sea Marine Park (CSMP). These Plans set out priorities for AMP Networks that are consistent with the Parks Australia MERI system and national AMP marine science program objectives and principles.

This project will support Parks Australia to develop the MERI system and Network Science Plans for the Australian Marine Parks. It will do so by providing Parks Australia with the scientific and technical information, and advice, necessary to establish monitoring priorities for natural values and pressures in the South-west, North-west, North, and Temperate East Marine Park Networks, and for the CSMP.

This project will utilise the Marine and Coastal Hub's (former Marine Biodiversity Hub) previous work to contribute to the development of AMP Network Science Plans with a focus on natural values and pressures. Previous work by the Marine and Coastal Hub (former Marine Biodiversity Hub) project D6 will inform the social and economic benefits. Future work will be required to identify research and monitoring priorities for cultural values, but improvements in understanding of cultural values and in Indigenous engagement are required before this step can proceed. Cultural values research and monitoring priorities will therefore be progressively incorporated into Science Plans as they become available.

In 2020 Parks Australia and the project team, as part of the NESP SS2 and D7 projects, developed a process for identifying monitoring priorities for natural values and pressures (Figure 1) that could be

replicated across all networks and piloted the process for the South-east Marine Park Network. The process was comprehensively documented in a NESP report; Designing a targeted monitoring program to support evidence-based management of Australian Marine Parks - A pilot in the South-east Marine Parks Network. This project will repeat this process developed for the South-east Network for the remaining Networks and CSMP. It will also take steps to address recommendations in the NESP SS2/D7 report.
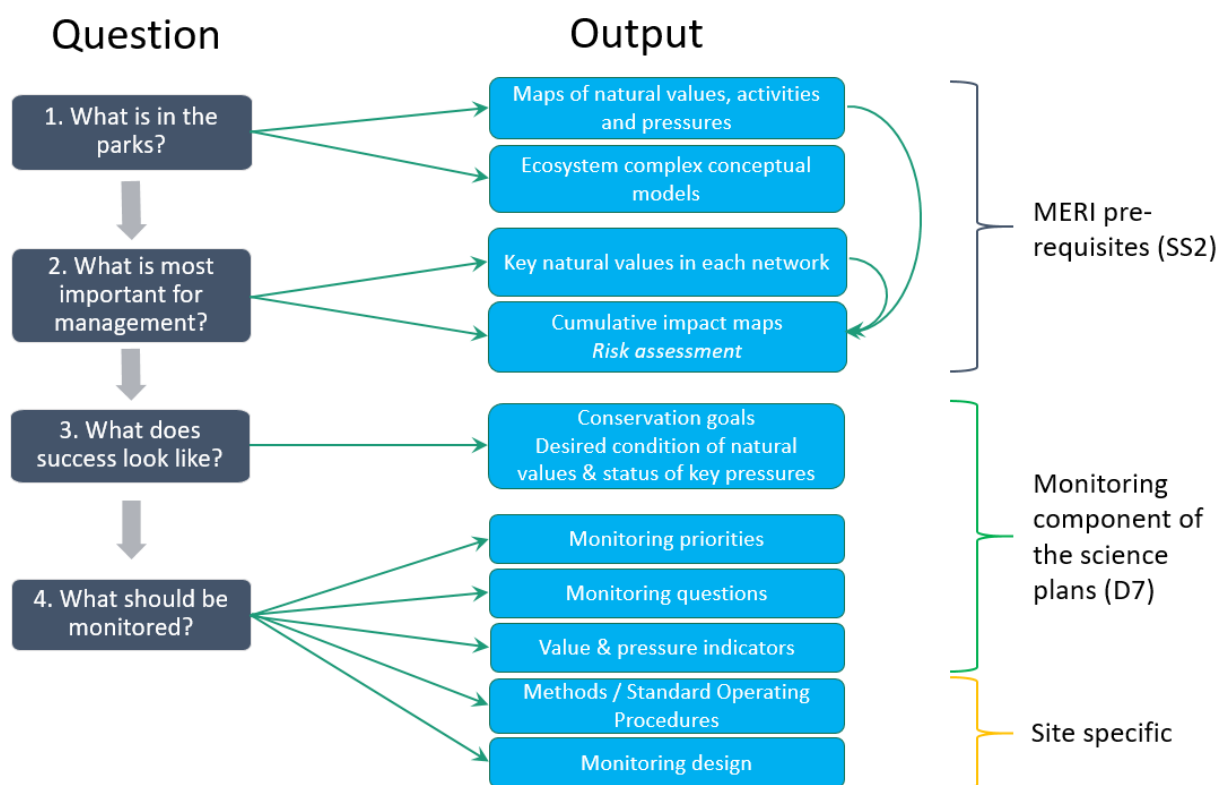

Figure 1: An overview of the key questions and elements considered in the process of identifying monitoring priorities for natural values and pressures, forming the basis of the monitoring section of the AMP Science Plans. *Note that site 'specific details' are out of scope for this project.*

Key tasks for this project include:

1. Describing what is in parks.

    a. Reviewing updated ecosystem conceptual models (situation analyses) to ensure they are tailored to each of the AMP networks and CSMP.

    b. Updating the habitat model (informed by the national reef model) using multibeam mapping data and habitat observations from underwater imagery and video to validate the model.

    c. Updating activity GIS/map layers for the period 2013-18 where possible (i.e. 5 years immediately prior to management plans coming into effect on 1 July 2018). The PL will work with the Climate Adaptation Mission Leader to ensure that the relevant climate data is used.

2. What's important for management.

a. Identify Key Natural Values (KNVs) using agreed criteria based on the CBD EBSA criteria. Where other information is available (eg RAMSAR) this will be integrated into KNV descriptions (eg Elizabeth and Middleton Reefs)

b. Undertake a vulnerability assessment of ecosystem components to determine cumulative impacts on natural values and updating as necessary following review of missing data. Consider options for assessing risk to key natural values.

3. What success looks like.

a. Provide advice and feedback on SMART conservation goals for relevant natural values and pressures, including where possible advice on current and desired condition (depending on management levers available to Parks Australia).

4. What should be monitored.

b. Provide expert advice on monitoring priorities and key knowledge gaps to help inform research priorities (including inventory).

c. Provide advice on targeted monitoring questions for each of the monitoring priorities.

d. Provide advice on potential indicators for natural values and pressures identified as monitoring priorities.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study requiring deep engagement with the agency that has responsibility for managing Australian Marine Parks (i.e. the knowledge generated in this project is primarily targeted to meet the needs of Parks Australia). Category 3 projects communicate and share results with relevant Indigenous organisations.

Progress to develop and implement the MERI System is the responsibility of Parks Australia. Further work, outside the scope of this project, will be undertaken to establish how the MERI System will support adaptive management, including identification and monitoring of cultural and heritage values and the social, cultural and economic benefits of AMPs. The MERI System will include components that are of direct relevance to Australian Aboriginal and Torres Strait Islanders. Parks Australia have an Indigenous engagement program and established regional advisory committees for AMP networks to include stakeholders and Indigenous peoples in park management. The project team will work closely with Parks Australia to ensure the scope, progress and findings of this research are clearly communicated to all Indigenous members of the relevant regional advisory committees for AMPs.

Location of research

The desktop research will be conducted in Hobart, Perth and Townsville. There are no planned on-ground actions other than project meetings in Hobart and meetings (pending COVID travel restrictions) at locations likely to include Sydney, Perth, Darwin and Cairns or Townsville.

Project 1.4 – Characterising values and identifying indicators and metrics of fish and benthic assemblages within the Capes region of the South-west Corner Marine Park

Project description

Project summary

Inventory surveys of Australian Marine Parks (AMPs) provide a broad description of the natural assets that exist in Commonwealth waters. These data can be further explored to identify biological indicators and metrics to cost-effectively monitor the AMPs and inform the AMP Monitoring Evaluation Reporting and Improvement (MERI) system. This project will use fish and seafloor imagery obtained from the recent inventory survey in the Capes region of the South-west Corner Marine Park to identify important natural values and indicators of fish and benthic assemblages relevant to park management and the AMP MERI system.

Project description

AMPs help to conserve marine habitats and the marine species that live within and rely on these habitats. The characterisation of key natural values and the identification of reliable indicators of the status of marine ecosystems are essential for park managers to cost-effectively monitor natural assets and ensure their adequate protection. Hence, there is a need to identify the best direct and indirect indicators of biodiversity and ecosystem status for monitoring marine parks that will effectively inform the park management and the AMP MERI system.

The South-west Corner Marine Park is one of 14 parks in the South-west Marine Parks Network. The park is the largest in the network, extending from offshore Cape Naturaliste around south-west Australia to offshore Esperance covering an area of 271,833 km². As part of the Marine Biodiversity Hub Project D3, 'Implementing monitoring of AMPs and the status of marine biodiversity assets on the continental shelf', a survey of the Capes region of South-west Corner Marine Park was conducted in collaboration between the University of Western Australia (UWA), Geoscience Australia (GA), the Institute for Marine and Antarctic Studies (University of Tasmania) and the IMOS Autonomous Underwater Vehicle (AUV) facility. The survey focused on continental shelf habitats within the National Park Zone and adjacent Special Purpose Zone (Mining Exclusion), offshore from the Cape Mentelle to Cape Freycinet coastline of southwest Western Australia. The purpose of this survey was to apply standardised methods of data collection to build the baseline inventory of reef habitat at these locations that would be used to support ongoing monitoring of South-west Corner Marine Park.

The prioritisation of the Capes region within South-west Corner Marine Park (SwCMP), and methods used, is based on (1) the need for additional baseline/monitoring within the South-west Network as part of the current 10 year management plan; (2) known significant pressures, including recreational fishing (line) on discrete shelf reefs, (3) need for baseline biological data (except for limited BRUV drops there was virtually no pre-existing quantitative knowledge of the presence/distribution of biota within the SwCMP (4) potential for SOE reporting based on condition of targeted fish stocks (including recreational species) and habitats, and climate-related shifts in benthic species distributions; (5)

significant alignment with state interest, including adjacent (conjoining) State Marine Park monitoring programs in Western Australia (Ngari Capes Marine Park); (7) potential for alignment with existing BRUV monitoring programs with the State MP; (8) adjacent to existing survey in the Geographe Marine Park that provides a template for the survey methods to be used; (9) potential for engagement with the Traditional Owners in the region to inform and improve biodiversity surveys with an understanding of connection to country, including areas that are now below sea level, and marine resources.

Initial exploration of biodiversity data from this survey of the South-west Corner Marine Park found diverse and extensive fish assemblages and benthic communities. However, the imagery obtained from drop camera and AUV surveys remains to be annotated and the data from these and from completed Baited Remote Underwater Stereo-Video (stereo-BRUV) need to be further explored to better characterise biotic communities and establish inventories of natural values and potential indicators and metrics of benthic and fish assemblage status in the region. As such, in this project we propose to:

- Annotate AUV and drop camera imagery following NESP MBH Field Manuals and finalise annotations of stereo-BRUV (Figure 1, and Table 1).
- Further identify and describe the inventory of fish and benthic biodiversity from both stereo-BRUV and benthic imagery to determine key natural values in the South-west Corner Marine Park.
- Test the applicability of indicators and metrics of fish and benthic assemblages in South-west Corner Marine Park to inform AMP MERI system.
- Classify geo features from fine scale multibeam data to define areas of potential reef habitat within the survey area of the National Park Zone and Special Purpose (Mining Exclusion) Zone.
- Further develop science communication products, in collaboration with Parks Australia, to build upon the previous voyage communication plans and eco-narratives.

The outcomes of this project will directly contribute to the 10-year outcomes sought in the marine science section of the 'South-west Corner Marine Park Network Management Plan 2018' and deliver to the science program needs identified in the 'South-west Network foundational Implementation Plan 2018-2022'. As such, the outcomes will increase understanding of the natural values and pressures, improve the understanding of the effectiveness of marine park management in protecting the park's values and assets, and provide baseline information to improve decision-making processes.
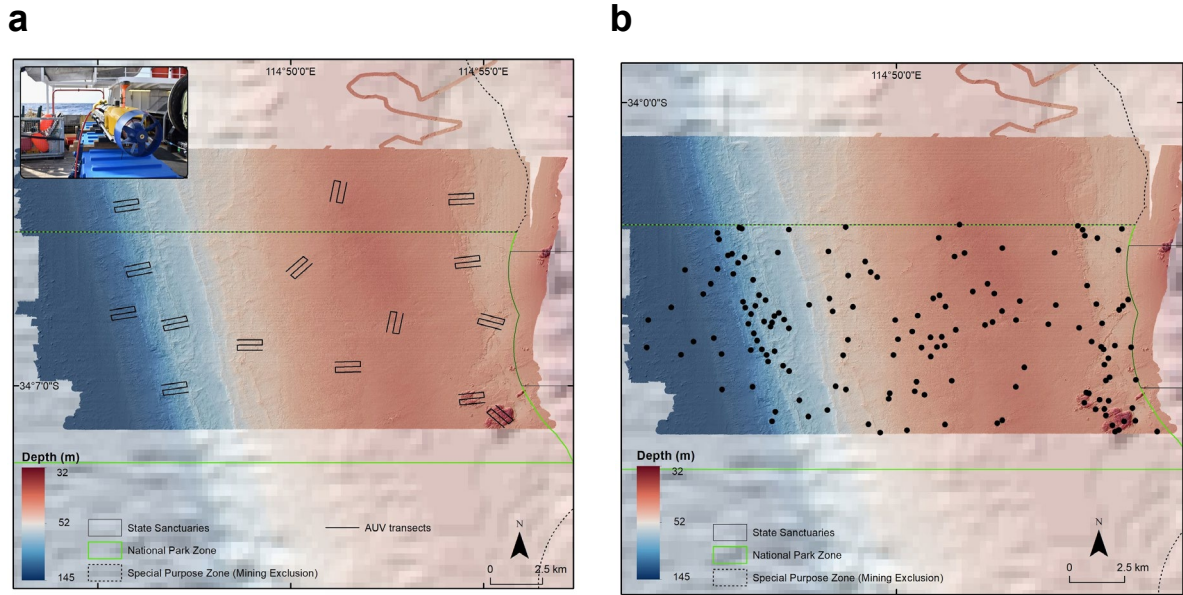
a

b

Figure 1. Locations of a) AUV transects, and b) drop camera deployments surveyed and to be annotated. Also showing the area of fine scale seabed mapping to be analysed for classification of geo features.

Table 1. Summary of the data collected and processed

Methods	Area / No. samples	% of samples processed / annotated	Planned repository once complete
Bathymetry	NP and SP Zones	85	AusSeabed
stereo-BRUV	284	95	GlobalArchive
Drop camera	418	0	Squidle+ / UMI
AUV	15 transects	0	Squidle+ / UMI

NP =National Park Zone and SP = Special Purpose Zone (Mining Exclusion)

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

The results of the project will be communicated with the relevant Indigenous organisations, including the Undalup Association Inc and the South West Aboriginal Land and Sea Corporation (SWALSC). This project will build on the previous research project funded by the NESP Marine Biodiversity Hub (Project D3 – South-west Corner AMP survey) by using existing relationships and communication mechanisms developed in consultation with Parks Australia, SWALSC and Undalup Association. The

project team will work collaboratively with Parks Australia and relevant Indigenous groups to develop a shared understanding about the project objectives and its findings.

Location of research

Data comes from the previous MBH inventory surveys of the Capes region of the South-west Corner Marine Park, all data has already been collected in the field. The outputs of this project will be specific to this regional dataset.

The desktop annotation and analysis in this study will be conducted at:

- UWA, Perth, Western Australia
- UTas, Hobart, Tasmania
- GeoScience Australia (GA), Canberra, ACT

Project 1.5: Scoping Study: Identify knowledge gaps and solutions for extent mapping of Australian marine and coastal wetlands

Project description

Project summary

Marine and coastal wetlands provide extensive ecosystem services to Australia, and a comprehensive inventory is required for effective conservation and protection. This project will identify key knowledge and inventory gaps and determine solutions to progress a consolidated inventory within the context of a wider review of national mapping capacity for wetlands. Gaps and solutions will be identified through targeted surveys and workshops with end-users and researchers following a review of relevant data and literature. A summary of the status of mapping habitat attributes and services such as blue carbon, coastal protection and shorebird habitat will be produced. The outcome will be identified prioritisation for future investment to fill knowledge gaps.

Project description

Problem statement

The management of human impacts on marine and coastal wetlands in Australia is hampered by the lack of a consolidated, comprehensive and current wetland inventory. Coastal wetland extent and distribution is at present only partly mapped, and with different methodologies and resolution for sections of coastline in different jurisdictions. Gaps in existing mapping prevent rigorous analyses of historical changes in extent, and predictive modelling of potential future changes in distribution. They also make it difficult to provide practical, on-ground management advice to avoid or minimise impacts on wetlands from proposed new developments and activities. There is a need to develop capacity and integration across all wetland mapping in Australia, and this project will help to achieve that for marine and coastal habitats.

Description of research

The project aims to identify knowledge and mapping gaps for marine and coastal wetlands and provides solution pathways to filling those gaps. This will be achieved by analysing how end-user needs intersect with mapping methods and capacity.

User needs. User needs will be determined through broad involvement of practitioners and scientists using a survey, interviews, and workshops. An on-line questionnaire will be widely disseminated to relevant Australian agencies and research institutions and will be followed by targeted interviews following up specific topics with a select sub-set of survey participants. Virtual workshops will bring together conservation practitioners and agency representatives to further elicit needs and gaps in the wetland inventory. The focus will be on intertidal and shallow subtidal coastal wetlands, including the major habitats of seagrass, mangrove, and saltmarsh, as well as habitats that to date have been overlooked, such as sand and mud flats, and algal and rubble beds. We will incorporate mapping of attributes and service provision, incorporating new possibilities in mapping for benefits from blue carbon, coastal protection, fisheries production and shorebird usage.

Methods and solutions. The project will identify efficient pathways to filling mapping gaps and ultimately completing the inventory of Australia's marine and coastal wetlands using a literature

review of the latest methods available and a focussed workshop. The review will draw on recent international developments in satellite image processing and analysis, as well as current projects in Australian research institutions, including Geoscience Australia. A virtual workshop will bring together experts in wetland mapping to debate findings of the review and help to determine effective and efficient mapping methods to complete an Australian inventory of marine and coastal wetlands.

Project scope

Project scope includes intertidal and shallow subtidal wetland habitats: the major vegetated coastal habitats of seagrass, mangrove, and saltmarsh, as well as habitats that have received less attention to date, such as sand and mud flats, and algal and rubble beds. Mapping of shallow water kelp beds will be included via liaison with other NESP projects. Spatially the focus will be waters south of Tropic of Capricorn, including southern QLD, NSW, VIC, TAS, SA, southern WA, and relevant Australian external territories. Findings will be integrated with those from northern waters for particular purposes, including bioregional analysis and for practical use by Parks Australia. Guidance for future work will be integrated with outcomes from existing and planned wetland mapping in northern Australian led by Nathan Waltham from JCU. Some users have an interest in including coastal freshwater wetlands, and we will take advice on whether and how to include those from experts including Michele Burford and Fernanda Adame (Griffith University). While the project will not directly address environmental accounting of wetlands, the improved wetlands inventory will help to form a stronger basis for future environmental accounting projects.

Related prior research / links to other hubs

Previous research. The starting point for this project relies on many previous projects developing methods for wetland mapping, including NESP-supported projects such as SeaMap Australia.

DAWE consultancy (Auricht Consulting). This proposal builds synergistically on the current consultancy providing a scan of wetland mapping capacity and gaps across agencies for Australian wetlands more broadly. Project participants will attend a workshop in July 2021, as a springboard for deeper analysis of weaknesses and opportunities specifically for coastal and marine wetlands.

Blue Carbon: a) Methodology Determination by Clean Energy Regulator - Prior to and during the project we will incorporate advice from departmental experts; b) MC NESP project 1.15. Liaise with leading scientists in blue carbon, e.g. Catherine Lovelock (UQ), and wetland regeneration, Will Glamore (UNSW).

De-risking Northern Australia. Integration with outcomes from existing and planned wetland mapping in northern Australia will be ensured through liaison between project leaders Rod Connolly and Nathan Waltham (JCU). The focus of current project remains southern waters, but where appropriate will include findings from northern waters, e.g. for Parks Australia purposes, and bioregional analyses.

RAMSAR. We will incorporate current RAMSAR initiatives through discussions with Alex Tomlinson (DAWE), Max Finlayson (Australian rep), and state leaders such as Mike Ronan in QLD.

Digital Earth Australia, Geoscience Australia. Incorporation of the needs of this research program, a major end-user of a consolidated wetlands inventory, will be ensured through participation of Leo Lynburner on the project.

Coastal freshwater wetlands. Prior to and during the project we will take advice on inclusion of coastal freshwater wetlands from Michele Burford and Fernanda Adame (both Griffith Uni).

State agencies. Prior to and during the project we will liaise with state agencies across QLD, NSW, VIC, TAS, SA, and WA to ensure broad representation of capacity and user needs.

Resilient Landscape NESP Hub. We will involve any relevant research projects in the early stages of the Resilient Landscapes hub.

Environmental Accounting. While this project will not directly address environmental accounting of wetlands, in helping to improve the wetlands inventory it will make future environmental accounting projects more achievable.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

The project leaders will work with the NESP2 Marine and Coastal Hub Indigenous Facilitator and Knowledge Brokers to identify opportunities for respectful Indigenous participation in this project and communication of the research findings. For example, the review on knowledge gaps and report on future directions can consider Indigenous land tenure/ownership/native title/Indigenous protected areas/sacred places. Similarly, a fact sheet could be prepared to communicate the findings of the review to native title representative bodies.

Location of research

The study is based on a review of inventory mapping capacity for coastal and marine wetlands. There is no field component in a particular location. Workshops will be virtual, based in multiple locations including Gold Coast (QLD) and Adelaide (S Aust).

The outputs from the project will impact on marine and coastal wetland mapping across southern Australia.

Project 1.6 – A roadmap for coordinated landscape-scale coastal and marine ecosystem restoration

Project description

Project summary

This project aims to develop a roadmap to guide research and investment into landscape-scale coastal and marine restoration. The project brings together interdisciplinary expertise in coastal engineering, decision theory, marine ecology, modelling and ecosystem services to examine decision support needs and opportunities to restore coastal marine ecosystems at scale. The research will focus on the ecosystem services of coastal protection and climate resilience with the recognition that this Nature-based Solution (NbS) approach provides co-benefits such as biodiversity, fisheries production, carbon sequestration, and nutrient cycling. The research will be accomplished through surveys and workshops/meetings with input from key end user groups in industry, NGO, Indigenous and Governmental organisations.

Project description

This project **aims** to apply the lens of structured decision making to articulate a vision for the development of coordinated landscape scale coastal and marine restoration in Australia. Structured decision making is an approach for careful and organized analysis of natural resource management decisions which is based on the fields of decision theory and risk analysis. The research will focus on restoration of coastal and marine ecosystems, such as mangroves, marshes, oysters, coral reefs, seagrass and kelp, to provide the ecosystem service of coastal defence as a "Nature-based Solution (NbS)" to mitigate against the impacts of climate change on coastal areas. Focus on this ecosystem services allows us to bring technical expertise in coastal processes to the working group, but the overall approach will be applicable and transferable to other ecosystem services and benefits from restoration.

Large-scale restoration is necessary and is prominent in high level declarations such as CITES, the UN Sustainable Development Goals (2030), and UN Decade of Ocean Science for Sustainable Development (2020-2031). Marine restoration projects in Australia, as in most countries, have typically been small scale, experimental, and lacking coordination. In contrast, a national scale approach to NbS for shoreline protection was applied successfully in Bangladesh, where coordinated efforts at restoration and afforestation of 195,000 ha of mangroves was employed starting in the 1960's to mitigate erosion. Uncoordinated approaches to restoration can result in inefficient use of resources with poor social and environmental outcomes, such as lack of confidence and support for restoration, or low delivery of ecosystem services. At present, there is currently little long-term planning in terms of what is possible now or in future as shifts in climate and environmental conditions become unsuitable for the present-day ecosystems and species.

Recent investment by the Commonwealth Government into coastal marine restoration research and practice hints that larger scale restoration programs to achieve societal and environmental objectives are feasibly on the horizon. For instance, the $130 million Reef Recovery and Adaptation Program for research and development on coral restoration on the GBR, and the $20 million Reef Builder program to build shellfish reefs at 13 sites nationally. Building on these programs, a roadmap is required to inform large-scale, coordinated, climate smart landscape scale restoration which provides measurable benefits to the environment and society.

Structured decision making has been used extensively in the discipline of Conservation Science to make evidence-based and cost-effective decisions, such as the implementation of the Commonwealth

Marine Protected Area network. Structured decision support models have several common features: 1) clearly stated objectives; 2) fixed budget and timeline; 3) realistic model(s) of the system, and 4) estimates of the costs, benefits, and feasibility of different actions.

This project is linked to the Australian Coastal Restoration Network. It builds on the knowledge developed in several previous NESP projects, including Marine Biodiversity Hub Project E5 - The role of restoration in conserving matters of national environmental significance; National Centre for Coasts and Climate Project 5.9: Natural habitats for coastal protection and carbon sequestration; and NESP TWQ Project 3.3.2 Science evaluation of coastal wetland restoration in Great Barrier Reef catchments. Members of our team recently pioneered prototype models of decision support for coastal marine restoration by developing resource allocation models to underpin decision making in seagrass (Saunders et al. 2017 Plos Biol) and mangrove (Possingham et al. 2016 Plos Biol) restoration.

The proposed research aligns with the Marine and Coastal Hub theme of Ecosystem Restoration and Protection. There are cross theme links, particularly to People and Sustainable Use (by supporting decision making for climate adaptation) and Informing Policy and Decision Making (by translating biophysical science into policy-ready decision science frameworks). Through the focus on evidence-based science to support decision making for coastal climate resilience we envision cross hub collaborations with all three other Hubs (Resilient Landscapes, Climate Systems, and Sustainable Communities and Waste), particularly as the results of this first project mature and become socialised among our national networks of practitioners, managers and policy planners, NGO, Indigenous and academics.

The research will position restoration practitioners and decision makers with better knowledge to expand restoration efforts in the right locations and in ways that maximise return on investment. It will highlight current gaps in critical data availability (for instance, spatial and time series data on water clarity in shallow nearshore coastal zones) which may be required to make effective decisions around coastal marine restoration, thus pointing towards opportunities for strategic monitoring efforts. The research will consider how climate change may impact coastal marine ecosystems and influence their ability to provide shoreline protection, thus giving practitioners and decision makers frameworks for commencing climate-proof restoration strategies.

Description of research

The proposed research will bring together experts in decision science, modelling, restoration, engineering, and coastal Nature-based Solutions. Through in person (COVID permitting) and virtual workshops the project team and key end users will articulate a conceptual model of how structured decision models can be developed and used to guide the implementation of landscape-scale restoration in marine habitats over multiple spatial scales and what challenges exist to the success of such efforts (such as cross-jurisdictional policy differences).

The project will consist of three components. 1) Design and dissemination of a national scale survey distributed through our networks of restoration practitioners and decision makers that will elicit information on how decisions are currently made, how research could help that decision making be improved, and what is needed to achieve landscape scale coastal restoration. 2) A project workshop to discuss how to and what data will be required to apply principles of structured decision making to landscape scale coastal marine restoration for shoreline protection and coastal resilience; 3) A targeted approach to Indigenous Engagement achieved through in person or virtual meetings.

The research will involve addressing questions such as "what information is currently used to inform decision making in coastal restoration", and "what do we want to achieve in restoration?"; deciding on what the minimal level of complexity that would be acceptable in a model of a restoration system, and identifying suitable candidate systems, models, and data availability required to address those objectives. Both active and passive restoration actions will be considered, as well as 'hybrid' approaches to factor in natural ecosystems into urban or industrialised areas. Consideration will be given to the role of restoration in Australian Marine Parks and other assets such as Ramsar sites. The research will be grounded in established international frameworks such as the Society for Ecological

Restoration "International Principles & Standards for the Practice of Ecological Restoration" and the IUNC "Guidance for using the IUCN Global Standard for Nature-based Solutions.

Out of scope activities will include: Completion of decision support models or tools; Explicit consideration of other benefits of coastal marine restoration, such as biodiversity, fisheries habitat, carbon sequestration, water filtration, or social benefits (although it is recognised that restoration provides these benefits, and that the basic framework outlined in the proposed could be applied to achieve these values); and Field data collection of biophysical data.

Indigenous consultation and engagement

This a Category 3 (Indigenous Partnerships Strategy) project. Coastal ecosystems such as oyster reefs were a significant component of many east coast cultures, with oyster aquaculture dating back 9,000 years in Australia. Indigenous engagement on landscape scale restoration will be led by Mibu Fischer. Mibu is a Quandamooka woman and leads indigenous engagement research in CSIRO. In consultation with NESP, we will commence discussions with Indigenous groups with the aim of developing collaborations and relationship building. This will consist of face to face and/or virtual meetings (pending COVID) to identify opportunities for collaboration early in the process. Funds have been budgeted in to compensate participants for their time and knowledge sharing.

Some groundwork exists for engagement with Indigenous groups related to coastal and marine restoration. For example, In November 2016, McLeod and colleagues held a workshop on Bribie Island with 21 Traditional Owners from Australia and New Zealand. They identified that "By co-designing and co-managing restoration projects, with a particular focus on local outcomes and employment opportunities, Traditional Owners and scientists can work together to develop projects and programmes, which encourages mutually beneficial outcomes" (McLeod et al 2018 Ecological Management and Restoration). As the restoration economy grows in Australia and more Indigenous groups get native title over the land and sea country, employment and economic opportunities will increase for local communities.

We intend to follow in the guidelines developed in the Our Knowledge, Our Way Guidelines from CSIRO and The North Australian Indigenous Land and Sea Management Alliance Ltd (NAILSMA). The proposed research will follow the advice in the Hub's Indigenous Partnerships Strategy when it is available. We will consider opportunity for co-authorship, capacity building/training, Indigenous employment, how Indigenous Cultural and Intellectual Property (ICIP) and Traditional knowledge will be managed, accordingly. We will also keep our Indigenous partners updated on progress of this project with monthly emails.

Location of research

The project is national in scale. We have representatives on the project team and end users from five states (QLD, NSW, VIC, Tas, ACT) and from the Commonwealth Government. There will be an information collection and compilation component which will occur by delivering surveys electronically via: 1) the Australian Coastal Restoration Network mail list, and 2) a network of NbS practitioners nationally, recently brought together by Swearer and Morris for the recent NESP Coastal Hub.

Our research end users at present represent different levels of Government and industry in SE Qld, and the project leads are based in Qld, therefore it is likely that there will be some emphasis on SE Qld in particular as a case study site. However, we intend to engage with potential research end users nationally.

In person meeting with Indigenous partners are proposed to take place in SE Qld, as this is where our Indigenous Engagement team member (Mibu Fisher) has the strongest ties and where the project lead and funded team members are based.

One workshop for the project team is budgeted which is proposed to take place at North Stradbroke Island, SE Qld. There is no science field work proposed.

Project 1.7 – Towards a consolidated and open-science framework for restoration monitoring

Project description

Project summary

Coastal habitat restoration is scaling up rapidly in Australia and covers a range of habitats including oyster reefs, seagrass meadows, mangrove forests, kelp forests, and saltmarshes. Every restoration project includes some attempt at monitoring outcomes but currently these are piecemeal, uncoordinated, often poorly funded, and rarely follow Open Science protocols. Previous NESP-funded projects have improved understanding of the ecology and service provision of threatened ecosystems and established targets for repair based on reference conditions (e.g. Marine Biodiversity project B4). They have also established an extensive database of marine and coastal restoration projects (ARCN: project E5), and have supported the development of monitoring, evaluation, reporting and improvement systems (MERI) for various sectors or projects. By combining the knowledge of all Australian researchers undertaking monitoring of restoration projects, across multiple habitats, this project will build upon these previous projects to synthesise the approaches for monitoring of habitat restoration. It will also explore integration of new technologies, such as automation, artificial intelligence, and eDNA, within the monitoring framework to improve efficiency and cost-effectiveness. The primary output will be a co-ordinated and open-science framework for restoration monitoring across projects, scales and habitats, that integrates clearly articulated hypotheses to determine the goals for restoration. This framework will streamline development of future restoration projects and ensure that maximum value from monitoring activities is achieved.

Project description

Problem statement

There is currently a surge in interest in marine and coastal restoration within Australia, with a significant number of projects underway and many more planned. The projects are undertaken by a range of NGOs, government agencies, and community groups, and vary in scale, objectives and resourcing. Current methods for monitoring restoration progress and success vary enormously, with low uptake of technological advances that promote efficiency and comprehensiveness, and large differences in approaches among habitats. Additionally, projects often focus on monitoring of ecological objectives independently of assessing progress towards any socio-economic, engineering (e.g. shoreline stabilisation) or educational and/or cultural goals. What is lacking is a coordinated, open-science approach to monitoring, that standardises data formats, allows trade-offs or synergies between ecological, socio-economic and cultural benefits to be explored, and facilitates cross-project comparisons and benchmarking. Monitoring can be substantially improved with a standardised toolkit of monitoring techniques tailored to address different desired restoration outcomes and available resources for monitoring, including ecological, physical, economic, social, and cultural. Ideally, this toolkit would enable incorporation of adaptive management protocols to facilitate evolution of monitoring strategies across the sector as knowledge develops.

Description of research

The project will begin by identifying a database of restoration practitioners (building upon the existing ACRN database), researchers, and partners. The following research activities will then be conducted:

- Literature review of strategies that have been implemented globally to monitor progress towards ecological, socio-economic, engineering and cultural goals of restoration. This will especially focus on new and emerging technologies (including eDNA, artificial intelligence, remote sensing, drone technology, geo-tagging, app-based surveys), automation, whole-of-ecosystem (rather than taxon-specific) approaches, the use of citizen science, the integration of cultural monitoring, and temporal continuity. The review will build on existing monitoring protocols (e.g. the Society for Ecological Restoration's generic principles and standards guide) to determine what variables might be monitored as a starting point, and provide the framework for workshop discussions about best-practice monitoring.
- Stakeholder engagement by targeted interview-style and online surveys of restoration practitioners, scientists and partners (including indigenous ranger groups), to first define the goals for restoration and then to identify key elements of current monitoring programs, current data handling and reporting practices, access to equipment and resources (e.g. funding), and key constraints and challenges to obtaining meaningful results. These data will be analysed with the results of the literature review and used to produce a draft best-practice toolkit.
- A workshop will be held for all participants (hybrid mode) to critically assess the drafted best-practice toolkit in the context of current monitoring programs, gaps and challenges, data availability and adoption of new technologies. This will include monitoring of ecological metrics as well as engineering, social, economic, educational and cultural impacts. Participants will identify monitoring goals and protocols applicable across restoration projects to facilitate comparison and benchmarking across projects, based upon desired restoration outcomes.

These activities will lead to the development of a guidelines document (best-practice toolkit) for co-ordinated monitoring of restoration initiatives. The guidelines will link to the broader policy agenda regarding Nature-based solutions and will follow the guidance provided by IUCN. Findings will be used in the development of the DAWE EPBC Act listing assessment for Native Oyster Reefs as a threatened ecological community.

Statement of scope

Project scope includes review of global monitoring strategies, advanced monitoring technologies, and open-science frameworks. Monitoring strategies that are only relevant to terrestrial or freshwater river systems are out-of-scope, as are field trials of identified strategies.

Trial programs/case studies

A wide range of marine and coastal restoration projects are currently underway for a range of habitats, including seagrass, mangrove, saltmarsh, coral reef, and shellfish reef, and have monitoring programs associated with them. These will be utilised as case studies for this project. Examples include:

- A diversity of restoration activities underway in NSW, including those identified as benefits of priority actions under the NSW Marine Estate Management Strategy 2018–2028. The Strategy encompasses a ten-year Marine Integrated Monitoring Program (MIMP) to monitor conditions, benefits, measure the success in reducing the priority threats and to fill key knowledge gaps.
- Seagrass restoration projects underway in WA, South Australia, and Victoria (e.g. NESP E5; Operation Posidonia; Operation Crayweed), involving partnerships between recreational fishers (OzFish, RecFishWest), indigenous communities (Malgana Land and sea Rangers), and researchers (UWA, UNSW, SIMS).
- Citizen-scientist lead monitoring of aquatic restoration sites using BRUV/RUVs (e.g., OzFish).
- TNC-lead shellfish reef restoration projects Australia-wide.

Related prior research / links to other hubs

The project is designed to draw together practitioners from as many projects as possible to ensure benefits are widely applicable. It has linkages with other projects with common goals of restoration and nature-based solutions within the NESP Marine Biodiversity Hub. These projects are overlapping, but complementary. Named researchers on this proposal that will participate in the survey and workshops are also participants in other related NESP MACs projects, these personnel will facilitate cross-project communication. Project outputs will be directly provided to research leaders on these related projects.

The project will build on previous initiatives, including the ACRN database developed through project E5, the NMSC marine monitoring and baselines working group, the GBR Reef 2050 Integrated Monitoring and Reporting Program, and the Parks Australia Monitoring, Evaluation, Reporting and Improvement framework. The project has strong linkages to the NESP Marine Biodiversity Hub, in particular. The project will also benefit from prior research conducted by project participants. For example, use of eDNA has been trialled in Port Stephens and compared to traditional surveying techniques for monitoring fish assemblages associated with oyster reefs (Cole et al. 2021 *Environmental DNA*). Likewise, eDNA has shown promise for detection of oyster diversity and communities in estuaries (McDougall *et al.*, unpublished data). A second example is the use of automated detection for video monitoring; TNC are trialling automated detection and counting of fish in underwater videos from restored reefs, using Griffith's AI computer vision software. This is proposed to merge with citizen science data into a Reef Builder database. NSW DPI Fisheries are also developing methods for mapping mangrove and saltmarsh from aerial imagery captured by drones and multispectral cameras, and trialling machine learning and deep learning methods for mapping.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category three projects communicate and share results with relevant Indigenous organisations.

The project team will seek to engage relevant Indigenous organisations that can identify gaps and opportunities in relation to cultural monitoring. The two main engagement pathways are via NSW DPI's Aboriginal Fishing and Marine and Coastal Environments Branch, specifically the Initiative 4 team under the Marine Estate Management Strategy which aims to work with Aboriginal communities in the management of Sea Country to reduce threats and risks to Aboriginal cultural heritage, and indigenous contributions via the DAWE-led shellfish reef program.

Specifically, we aim to build upon the 'Seven pearls of wisdom: Advice from Traditional Owners to improve engagement of local Indigenous people in shellfish ecosystem restoration' (Marine Biodiversity NESP), particularly:

- early engagement
- co-design and co-management of projects
- sharing of knowledge
- consistency of engagement
- focus on local outcomes and employment opportunities

We will consult with several key Indigenous participants in the survey and at the workshops. Their engagement will provide opportunities to explore and develop capacity-building strategies for Indigenous people such as through the Indigenous Ranger program, to train for and lead delivery of

new monitoring technologies whilst also exploring options for delivering cultural monitoring techniques within a more traditional scientific based monitoring framework.

Location of research

The desktop component of the study will largely be performed by project participants at Griffith University (Nathan and Gold Coast) and NSW DPI Fisheries (Port Stephens). The participant workshop will be held at NSW DPI Fisheries, Port Stephens.

The outputs from the project will impact on coastal and marine restoration projects Australia-wide.

Project 1.8 – A national framework for improving seagrass restoration

Project description

Project summary

This project aims to generate a national experimental framework for seagrass restoration and act as a bridging project for ongoing seagrass restoration with indigenous and community groups. This project expects to enhance restoration success for seagrasses by incorporating key ecological knowledge gaps (such as below-ground soil processes) into restoration strategies. This project should provide significant benefits, such as 'road-map' for increasing restoration success, and the development of key strategic alliances to enhance restoration and management of seagrasses, and the ecosystem services, and economic and social benefits they provide.

Project description

Across Australia, the loss of >275,000 ha of seagrass meadows and associated ecosystem services – valued at AU$ 5.3 billion – has contributed to the long-term degradation of estuarine and coastal marine ecosystems. Restoration of seagrass is critical for improving the health and function of these ecosystems and sustaining coastal communities and industries that depend on them. This is **primarily because restoration practices are piecemeal and driven by local drivers and are generally not conducted at scales of seagrass loss. We will address this problem by bringing together scientists and key stakeholders to collate knowledge on seagrass ecology and restoration and generate a framework to scaling-up restoration nationally.** We will also build on ongoing restoration trials to test the proposed framework.

An in-person conference, to be held at the Sydney Institute of Marine Science, will bring together seagrass ecologists, environmental managers, Indigenous ranger groups and OzFish representatives from NSW, Tasmania, Victoria, South Australia and Western Australia to provide an update on current restoration projects in each state and to identify potential knowledge gaps and impediments to improving seagrass restoration outcomes and scaling up restoration efforts in Australia. Research directions to be discussed include the role of utilising seagrass-soil feedbacks and sediment microbes as tools to enhance restoration success, to engineer sites for increased success in recruitment and to scale up restoration with seed-based approaches using innovative community engagement activities to boost coastal stewardship and to increase the public's understanding of the importance of seagrass ecosystems. The workshop builds on the relationships PI Gribben and the Co-PIs have developed through two current ARC Linkage grants on oysters and seagrasses led by PI Gribben.

There are three restoration trials we wish to support to further develop, that will inform the knowledge exchange workshop and our recommendations to DAWE. These are: assessing sediment quality and manipulations (Gamay Rangers, UNSW); use of sediment filled hessian tubes for seed and seedling capture (Malgana Rangers, UWA), and: scaling up seed collection for seed-based restoration (Seeds for Snapper, OZFISH, UWA).

In NSW, naturally detached fragments of *Posidonia australis* will be planted in Foreshore beach in Botany Bay in collaboration with the Gamay Rangers, in an area where *P. australis* used to be abundant. Recent engineering works by the Port Authority of NSW have restored sediment stability and these trials will test the suitability of sediment manipulations for *P. australis* restoration, in preparation for scaling up these restoration efforts.

In WA, sediment filled hessian tubes (2.5m x 30 cm) have been trialled with some success for both *Amphibolis australis* seedlings and *P. australis* seeds in Shark Bay in 2020 (NESP E6). Continued funding is sought to scale up seagrass restoration using the sediment filled hessian tubes in Shark

Bay with the Malgana Land and Sea Rangers in 2021. Rather than transplanting shoots or fragments this project looks at increasing surface area of fibre to trap naturally produced seeds and seedlings and to reduce hydrodynamic forcing from waves.

Also in WA, a community-based program called "Seeds for Snapper" managed by RecFish West and Ozfish is in its 3rd year of operation. The program needs to scale up seed delivery and to do that needs to increase the number of seeds collected. Funding from Ozfish and NESP2 will allow preliminary trials with environmentally friendly otter trawling through flowering seagrass meadows. Seed-based restoration as opposed to shoot or fragment transplanting is more scalable to past and existing seagrass losses and if this program continues its successes, it will define the strategies and techniques for seed-based restoration.

Our team is among the first, globally, to provide critical experimental evidence for the importance of plant-sediment feedbacks controlling marine plant performance. We have manipulated whole sediment microbial communities in the seagrass *Zostera muelleri* to show that the presence of seagrass microbes inhibited growth of an invasive alga. Similarly, we demonstrated that sediment microbial communities growing under the long-lived *Amphibolis antarctica* respond to environmental gradients in salinity and phosphorus availability, suggesting that plant-sediment feedbacks play a role in the survival of *A. antarctica* in extreme environments. We have also experimentally manipulated the effect of continuous and fluctuating low light on the relationship between root exudation and the composition and function of the root microbiome in three co-occurring tropical seagrass species, *Halophila ovalis*, *Halodule uninervis* and *Cymodocea serrulate.*

The Malgana Land and Sea Rangers and restoration scientists at UWA have formed a partnership to use restoration to enhance the recovery of seagrass meadows in Gathaagudu, the Shark Bay World Heritage Site. In 2011 an extreme marine heatwave resulted in the loss of over 1,300 km^2 of seagrass meadows within the bay. Recovery has been slow, and a targeted restoration program may help to speed recovery. NESP E6 Seagrass Restoration in Shark Bay (2019-2020) has started innovating with seagrass restoration from seed, shoots and sand filled hessian tubes. We need to continue the learning into 2021 and continue the restoration program.

Our project builds on an ongoing collaboration with UNSW scientists and the Gamay Rangers (first urban Indigenous Ranger group in Australia) restore a local endangered seagrass, *Posidonia australis*, to Botany Bay. Our project aims to support enhanced success of restoration trials by incorporating plant-sediment feedbacks into restoration efforts.

This project will bring together practitioners and scientists to generate an update on the state of knowledge, knowledge gaps and critical next steps for seagrass restoration in Australia, providing a national framework to scale-up seagrass restoration efforts and enhance their success. Also, the outcomes of trials in sediment-plant feedbacks (Gamay Rangers), engineering high rates of natural recruitment of seeds and seedlings (Malgana Rangers) and scaling up seed delivery for seed-based restoration (OZFISH) will be reported on and potentially will form key strategies for further Seagrass Restoration research in NESP2. Direct engagement with our extensive group of national end-users (via the workshop and restoration trials) will ensure incorporation of key findings into environmental decision-making strategies/documents and their translation to on-ground action.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project essentially extends a category one project (funded under the NESP Marine Biodiversity Hub- project E6). Category one projects are co-designed with Indigenous people, organisations and communities. They respect Indigenous priorities and values and ensure Indigenous people have meaningful participation in the governance of the project. These projects work towards an application of caring for Country offering ways of interacting with nature for economic, social and cultural prosperity. Category 1 projects have the following elements: co-design the plan, collaborate on the work, and communicate the outcomes.

Our proposal includes Indigenous consultation and engagement with The Malgana Land and Sea Rangers (WA) and Gamay Rangers (NSW). Gamay Rangers - The Gamay Rangers, established in 2019, are the first urban Indigenous Ranger group in Australia. This project builds on an ongoing collaboration with UNSW scientists to protect and restore a local endangered ecological community (*Posidonia* australis). Malgana Land and Sea Rangers – The Malgana Land and Sea Rangers, established in 2019, support the Malgana Aboriginal Corporation, Indigenous custodians of Gathaagudu (Shark Bay). The Land and Sea Rangers were partners of the NESP E6 Seagrass Restoration project and will receive project funds to continue their experiments with hessian tubes and natural seed and seedling recruitment started in seagrass restoration projects in 2021 (NESP E6) and to bridge their restoration activities between NESP and NESP2.

Location of research

The project is national in scale. The workshop will be conducted at the Sydney Institute of Marine Science, Sydney. Onground restoration trails will be conducted in Shark Bay, Cockburn Sound and Owen Anchorage, Western Australia and Botany Bay, Sydney.

Project 1.9 – Quantifying the ecosystem services of the Great Southern Reef

Project description

Project summary

The Great Southern Reef (GSR) is an interconnected system of reefs dominated by kelp forests spanning over 8,000 km along southern Australia. It is a global hotspot for marine biodiversity and endemism, and one of the most productive ecosystems on Earth. Kelp forests, however, are diminishing and evidence-based management is hindered without accurate estimates of their contribution to society and the economy. In this project, we will systematically compile and synthesise existing data on the ecosystem values and services provided by the GSR, including market and non-market values. These assessments will be aligned with existing accounting standards to ensure compatibility with ongoing and future efforts.

Project description

Problem statement

The Great Southern Reef is here defined as the coastal interconnected system of kelp-dominated reefs between 0-50 m depth along southern Australia, spanning from Brunswick Heads (28.5°S) in northern NSW around the coastlines of Victoria, Tasmania, Southern Australia and Western Australia up to Kalbarri (27.7°S). Although the kelp *Ecklonia radiata* can be exceptionally found at depths of > 60 m in a few regions, this species is typically found in shallower reefs (< 30m), where most human attention and activity is also concentrated.
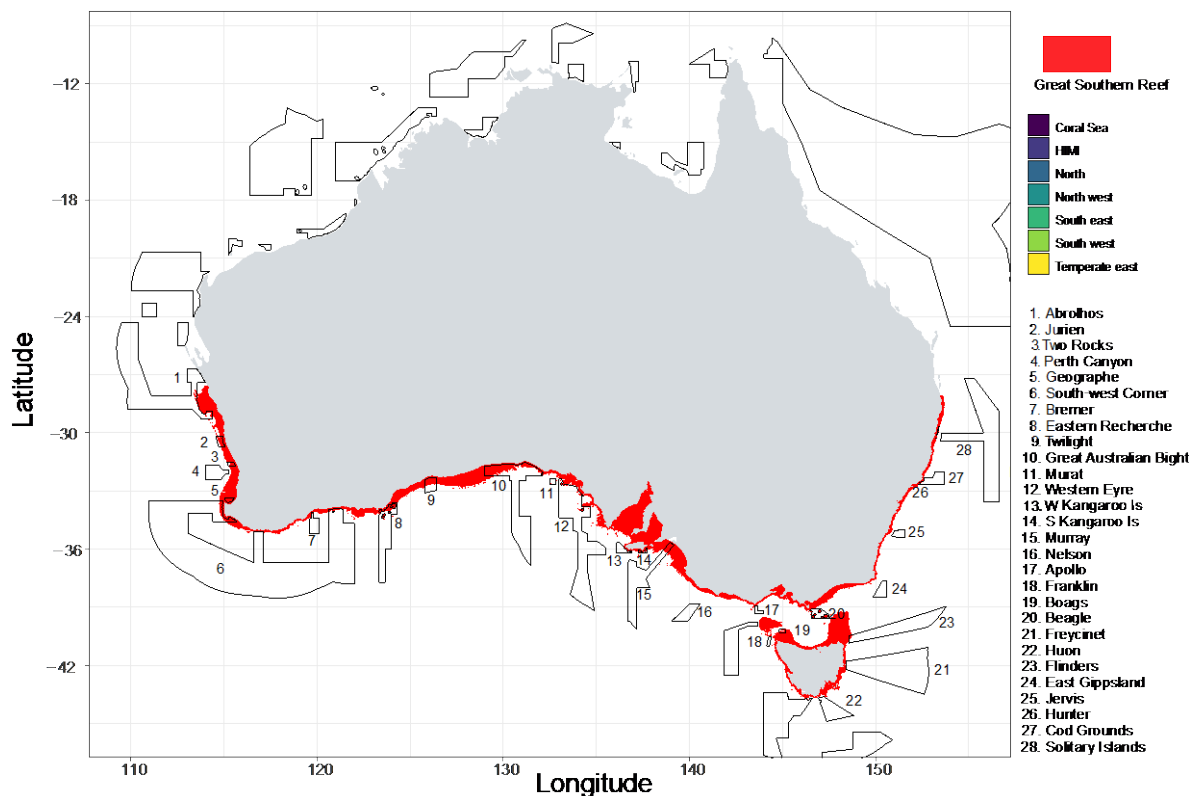

Fig. 1 Map of the Great Southern Reef out to 50m depth contour (red shading) and the overlap with the Australian Marine Parks. Overall, the Great Southern Reef overlaps with 17,930km^2 of Australia's

federal marine parks. This represents 9.7% of the total area of the Great Southern reef between 0-50m. Of the 23 parks that overlap with the Great Southern Reef, the Great Australian Bight (10) marine park covers approximately 7250 km^2 of the Great Southern Reef, South-west corner MP (6) covers 2458 km^2 and Twilight MP (9) covers 2105 km^2.

Ocean warming and marine heatwaves are causing the loss of kelp forests at alarming rates. In 2011 alone, 96,300 hectares of kelp forest were lost in Western Australia. Giant kelp forests are also listed as Endangered under the EPBC Act, following losses in Tasmania of 95% in area over the last few decades. Warm water species are moving south and transforming reefs, with major implications to local ecosystems. For example, long-spined sea-urchins have already caused the collapse of 15% of reefs in Tasmania and are projected to cause the degradation of 50% of reefs by 2030 at current rates. Further, human population growth along the GSR is increasing pressure on fish stocks, causing coastal runoff and eutrophication of reefs. Several protected species which occur in the Southern and Eastern Scalefish and Shark Fishery (SESSF) are also intimately associated with kelp, such as the Weedie Seadragon (*Phyllopteryx taeniolatus*) or the Leafy Seadragon (*Phycodurus eques*).

Significant knowledge gaps and data within the GSR hinder monitoring and evaluation of its ecosystems, and further limits an understanding of its importance to local communities and maritime sectors. This project will discern the state of knowledge and available biophysical data for kelp forests (i.e., extent and condition), and how these factors may determine the services these ecosystems provide. Biophysical data is foundational to both an understanding of trends (through an accounting approach) and other socio-economic assessments, including total economic value and welfare values.

Thus, evidence-based decision-making would be facilitated by measuring the services and benefits provided by the GSR, in evaluating progress towards management and policy targets. Quantifying and assessing ecosystem services provided by marine ecosystems is relevant in the context of the UN Decade of Ocean Sciences, achieving the UN Sustainable Development Goals, the growing the field of ocean accounting, and developing cost-benefit analyses to motivate restoration efforts.

Description of research

1. A list of all the provisioning, regulating and cultural services and values provided by Australia's GSR will be collated through initial desktop studies. This will include both direct and indirect uses as well as non-use values such as bequest and existence values.
2. The current state of knowledge of the ecosystem services provided by the Great Southern Reef will be identified, through systematic and critical review of literature and other sources.
3. All existing habitat mapping data along the GSR will be collated (including an assessment of condition, where available) and unmapped regions will be identified.
4. Datasets (spatial and non-spatial) pertaining to the related uses of ocean resources and human activities will be identified.
5. Economic values will be assessed using available market data for market-based services and benefit-transfer of 'willingness to pay' studies for non-market services.
6. Service and value data will be combined with habitat mapping data to produce a spatially explicit assessment of ecosystem services and potential benefits from the GSR.
7. The places where specific services and values have not been measured will be identified as knowledge gaps and become target areas for future research.
8. A workshop with stakeholders and end-users will take place to discuss findings and identify key knowledge gaps.
9. An inventory of data, with an assessment of quality and relevance, to services and values related to the GSR will be produced.
10. A report will be developed including a roadmap of future research priorities.

Related prior research

This project builds on >15 years of relevant research from experts in kelp ecology, environmental economics, and ocean accounting. From the ecology side, the team includes the leading researchers that established the notion of the Great Southern Reef as an entity composed of interconnected reefs

(Bennet & Wernberg), pioneering researchers on the drivers of kelp loss and the carbon capturing and sequestering potential of kelp forests (Wernberg, Bennett, Vergés, Filbee-Dexter), as well as leaders in science communication efforts raising awareness about this system (Vergés, Bennett, Wernberg).

From the environmental economics side, the team includes Rogers and Burton, experts in non-market valuation of marine ecosystem services and the integration of this data into resource prioritisation frameworks including benefit-cost analyses. They work extensively with decision makers across all tiers of government to develop highly applied economics research outputs. Rogers is Co-Director of the UWA Centre for Environmental Economics & Policy, 'Coasts & Communities' Theme Leader for the UWA Oceans Institute, and Economic & Social Theme Co-Lead for the Western Australian Marine Science Institution's Cockburn Sound Science Program.

With regards to Ocean Accounting, Milligan is Secretariat Director of the Global Oceans Account Partnership (GOAP), which supports the growing global community of practice including national governments, international organisations, and research institutes. The GOAP Secretariat (Milligan & Gacutan) is involved with the coordination of international pilot projects and dialogues, developing the [Technical Guidance on Ocean Accounting](#) and supporting documentation for decision-makers and account compilers. GOAP was a member of the team delivering the Geographe Bay Marine Park Ocean Account pilot (2020), in addition to the Samoa Tourism-Waste account (2021), both of which were commissioned by the Department of Agriculture, Water and Environment (DEWA). GOAP has ongoing dialogue with DEWA and provided in-kind support to Australia's delegation to the High-Level Panel for a Sustainable Ocean Economy (HLPO). In support of kelp accounting within Australia, GOAP commissioned an assessment of data needs and availability nationally, and a preliminary assessment of *Ecklonia radiata* ecosystem services within South Australia and Tasmania.

Links to other NESP hubs and application of research to inform decision-making and on-ground action

Our project will generate a synthesis of existing data and knowledge about the ecosystem services and values provided by the Great Southern Reef.
This will include preliminary accounts for the extent and condition of GSR ecosystems, and their benefits to society and the economy (measured in physical and, where practical, monetary terms) through flows of ecosystem services. The compilation of several accounts allows for the aggregation of information into decision-relevant statistics and indicators, which provide an understanding of the state of ecosystems, and changes over time.

A detailed understanding of the services provided by the kelp forests that underpin the GSR and their economic value will allow for better consideration about when and where to restore kelp forests and the expected services provided. Identification of knowledge gaps and key future research priorities will provide a base to develop strategies to improve management and restoration initiatives for the GSR in future NESP hub projects.

This project advances the concepts, definitions and methodologies underpinning environmental-economic accounting within the ocean domain. The ability to initiate a database of economic values, including market (financial) and non-market (social and environmental) values all standardised as comparable $ values, will be a first step towards enabling development of benefit-cost style decision support tools. Studies resulting from the opportunities identified within the workshops will be guided by a common framework (ocean accounting), providing data coherency across environmental, economic and social domains. The standardisation of data and use of a common conceptual framework facilitates scalability in compiling accounts for the GSR region and beyond. The tools developed will enable comparative assessments of restoration initiatives (both for the GSR and for other marine systems, e.g. seagrass meadows, saltmarshes, mangrove forests), that can establish economic viability and rank project alternatives to guide conservation and management resource allocation toward projects that generate the largest benefits for Australians.

The study also contributes to national efforts on ocean accounting, aligning with the Australian Government's strategy and [action plan for environmental-economic accounting](#) and recent commitment to develop [national ocean accounts](#) in line with HLPO commitments. Ocean accounts

provide a means to monitor the state of the environment, thus having direct relevance to marine park and environmental authorities, in identifying the efficiency of management interventions and evaluating progress towards conservation targets (as evidenced by the 2020 Geographe Bay pilot).

Accounts also support reporting needs, including State of the Environment, and Sustainable Development Goal reporting.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

The project team will work with the Hub's Indigenous facilitator with the view to seeking to engage with relevant Indigenous organisations. For example, Indigenous groups working in the management of Sea Country and in the development of new coastal business opportunities within the Great Southern Reef will be invited to participate in the workshop. This includes the Gamay Rangers, First Nation managers in the Sydney region, Djungga Corporation in the southern NSW coast and OzFish vice-president from the Eurobodalla Chapter (NSW). This builds on active and ongoing collaborations in NSW and new relationships with Indigenous representatives from other GSR states will be developed during the project.

Location of research

This project is regional in scale. As a desktop study, the research will be conducted across several research institutions within NSW (UNSW, Sydney), Western Australia (UWA), and Tasmania (UTAS). The research is subject to data availability, and will use **regional** case studies, conducted with **national** scalability in mind. The research subject matter, however, impacts all States and Territories with Australia's temperate reefs, namely Western Australia, South Australia, Victoria, Tasmania and New South Wales.

Project 1.10 – A national inventory of implemented nature-based solutions to mitigate coastal hazards

Project description

Project summary

This project aims to generate an online inventory of all current and planned on-ground actions by coastal land managers that have implemented a nature-based solution (NBS) to mitigate coastal hazards. The resulting inventory will be the first step in identifying best practice, which will inform the future development of detailed technical design guidelines for implementing different nature-based methods in Australia.

Project description

Climate change and continued population growth are accelerating the need for diverse solutions to coastal protection. Traditionally shorelines are armoured with conventional "hard" or "grey" engineering structures, which are non-adaptive and come with significant economic, environmental and social costs. While hard structures will continue to have a place in coastal protection, alternative methods that are more sustainable and climate-resilient should be more broadly adopted into the future where appropriate. Nature-based methods (through "soft" or "hybrid" techniques) have the potential to play important roles in climate adaptation and mitigation because of their ability to reduce the threats of coastal erosion and flooding and provide co-benefits such as carbon sequestration. One reason that nature-based methods have been underutilised in Australia is that decision-makers need clearer guidelines for when a soft, hybrid or hard coastal defence approach is most appropriate. This resulted in the recently published foundational guide (led by Morris and Swearer and delivered under ESCC Hub Project 5.9: Natural habitats for coastal protection and carbon sequestration) to inform the national use of nature-based methods for coastal hazard risk reduction[1]. In the process of producing these guidelines, the lack of a national inventory of coastal protection projects already using nature-based methods was identified by end-users as a priority to enable their wider adoption as an adaptation strategy in Australia.

To address this need, this project will undertake:

1. The development of an online survey and dissemination to state governments, NGOs, coastal councils, and other coastal Local Government Area (LGA) and Indigenous land managers throughout Australia[2].

2. A systematic review of the grey literature and peer-reviewed publications of on-ground NBSs implemented in Australia[2].

3. Follow-up targeted interviews with key organisations to fill in any data/knowledge gaps.

4. Data collation and integration into a technical report and made publicly available online via an interactive web application using the R package Shiny and hosted by the University of

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[1] https://nespclimate.com.au/wp-content/uploads/2021/05/Nature-Based-Methods_Final_05052021.pdf

[2] Cooke, BC, AR Jones, ID Goodwin, and MJ Bishop 2012. Nourishment practices on Australian sandy beaches: A review. Journal of Environmental Management 113: 319-327.

Melbourne (see [3] for an example). The app will allow users to explore what NBSs have been implemented across Australia, and details (size, cost, materials, etc) of their construction. Where available, information about lessons learned, successes/failures, outcomes of any monitoring and evaluation will also be included to inform future management actions (e.g., the decision-support framework being developed in Project 1.6). This knowledge will be used to identify the key elements of best practice for each approach. The development of the app will allow for efficient maintenance and updating as new information becomes available beyond the life of the project.

This project addresses the Hub's key theme – People and Sustainable Use – by contributing to the development of innovative solutions to the protection and reinstatement of natural coastal defences. As this project also has clear links with the adaptation mission being led out of the Climate Systems Hub, we will engage regularly with Sarah Boulter to maximise connections with this mission.

This project is fundamentally about engaging with end-users, which is essential for compiling and synthesising all nature-based coastal protection projects across Australia. This was identified as a key end-user need and one of the impediments to implementing NBS for coastal protection over traditional hard engineering approaches. This project will leverage end-users previously engaged in developing the guidelines[1], as well as new end-users identified by collaborating researchers and partners involved in this project (e.g., the Australian Coastal Restoration Network).

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

The project team will work with the Hub's Indigenous facilitator with the view to seeking to engage with relevant Indigenous groups with responsibility for managing coastal lands for the purpose of compiling knowledge of any application of nature-based solutions and to seek guidance on how outputs can be tailored to meet their needs. Engagement will leverage existing and trusted relationships with collaborating researchers and partners (e.g., DAWE and Indigenous Protected Areas/Ranger Groups) to ensure we are communicating in a respectful and culturally sensitive manner.

Location of research

This is a desktop study. The majority of research, the conducting of online interviews and the development of the web app, will be undertaken at the University of Melbourne. The inventory being developed is national in scale and thus will have impact for all managers of coastal land throughout Australia.

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[3] https://covid19.science.unimelb.edu.au

Project 1.11: OzSET: Integration and publication of the Australian Surface Elevation Table dataset

Project description

Project summary

Australian coastal floodplains and wetlands are threatened by accelerating rates of sea-level rise. The assessment of vulnerability of these environments requires measurements of rates of vertical accretion, subsidence and elevation gain across a range of coastal settings. Australia's network of Surface Elevation Tables is one of the most extensive in the world, consisting of over 200 benchmark monitoring stations from Westernport Bay, Victoria to Darwin Harbour, NT. We will collate and make available through a national platform data on accretion, subsidence and elevation change in mangroves, saltmarshes, seagrasses and tidal freshwater forests, information vital to coastal risk assessment.

Project description

Sea level rise is an emerging threat to the coastal zone and to coastal wetlands. Coastal wetlands provide ecosystem services, such as carbon sequestration, improving water quality from land run-off through nutrient retention in sediments, plant uptake for production and denitrification. They also provide habitat for coastal fisheries species and a wide range of biodiversity and are of high cultural importance. While the capacity to map coastal wetlands nationally has increased rapidly over the last decades in Australia, monitoring of their responses to environmental change, including sea level rise has lagged, and remains in the hands of individual researchers using a range of methods in different states.

Mapping of changes to Australia's coastal wetlands is well advanced, particularly for mangroves (e.g. Lymburner et al. 2020). However, to provide a robust estimate of coastal wetland resilience, mapping should be supplemented with on-ground measures of key processes likely to drive change into the future (Rogers et al. 2012). One key measure of reliance is the extent to which wetlands are capable of accreting vertically at a rate matching the rate of sea-level rise. The Surface Elevation Table-Marker Horizon technique has been developed for this purpose. These instruments, developed in the USA, measure the vertical accretion of coastal wetland sediments and thereby permit assessment of whether wetlands are keeping pace with sea level rise (measured at tide gauges) or are subsiding relative to local sea level rise and thus vulnerable to permanent inundation and loss. This knowledge can underpin spatial models of the resilience of coastal wetlands to sea level rise, facilitate coastal planning, parameterise estimates of blue carbon sequestration and other potential changes in other ecosystem services over time. The figure below captures the essential elements and approximate locations of the ~200 existing SET-MH stations in Australia.

A steel rod, driven to ~10-20metres, serves as a fixed survey benchmark against which elevation change is measured. At the same time a feldspar marker horizon is introduced providing contemporaneous measures of sediment accretion. Upper subsidence is calculated as the difference between accretion and elevation gain. At all sites data is available on position within the tidal frame, suspended sediment concentration (derived from the MERIS instrument on the ENVISAT satellite), and bulk density and organic carbon concentration. We will also access information on shoreline trends in the vicinity of SET installations, accessed from DEA digital coastlines. The comparison of data will provide insight into processes influencing shoreline change. We do not intend to collect new data from this network under the current proposal, but rather collate all existing data, provide a meta-analysis and make data publicly available.
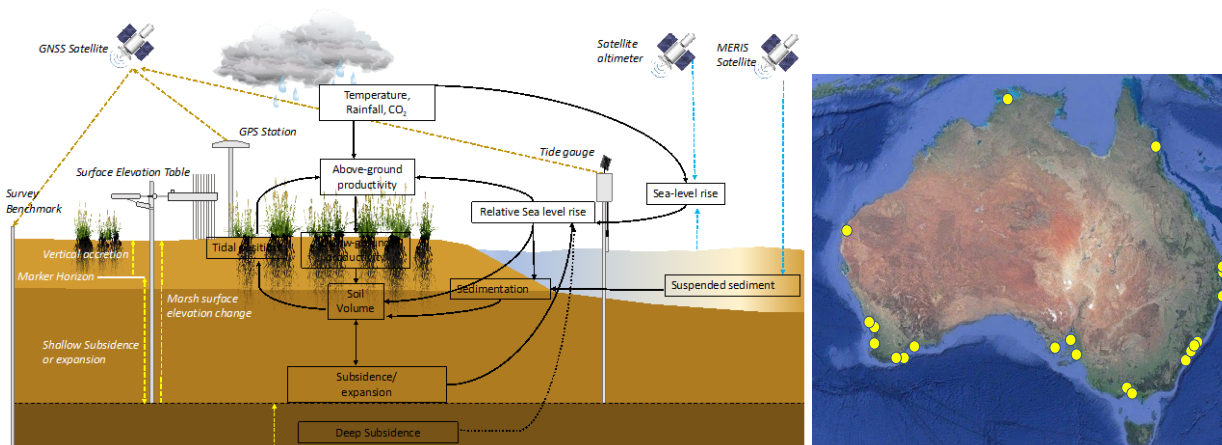
Figure 1: Elements of the SET-MH technique and centres of SET-MH stations in Australia.

The technique has been extensively applied to inform regional-scale models of sea-level rise in coastal lowlands in NSW (Oliver et al. 2011; Rogers et al. 2012) and Queensland (Traill et al 2011) Global and regional syntheses of trends in coastal wetland surface elevation change have been published in *Nature* (for mangroves, Lovelock et al. 2015 and for saltmarshes Saintilan et al. in review), and although we have national coverage with surface elevation tables in coastal wetlands in Australia (by research partners) this data is not readily available to the research community or stakeholders as it lies with individual researchers. Here we propose to develop a national platform for this data such that it can be linked to other national data to understand the impacts of sea level rise and its impacts on coastal wetland resilience.

Individual SET-MH stations currently exist in Victoria (48), NSW (57), Queensland (24), NT (9), WA (12) and South Australia (12). The majority were installed in 2000-2001, providing a 20-year dataset over a period of accelerating sea-level rise. These installations have been maintained by hub partners including Macquarie University, University of Wollongong, University of Queensland, University of Adelaide, Charles Darwin University and Edith Cowan University.

Table 1: Core data to be made publicly available (collated for each SET installation)

Rate of sediment accretion	Sediment accumulation above the baseline for each measurement period, and the linear trend through time
Rate of elevation gain	Elevation in relation to the benchmark (vertical position at installation) for each measurement period, and the linear trend through time
Rate of upper level subsidence	Difference between the rate of sediment accretion and the rate of elevation gain
Elevation deficit	Difference between rate of sea-level rise and the rate of elevation gain

The impact of sea-level rise on coastal environments, and associated ecosystem services is a central theme of NESP. The early availability of these data in NESP2 will facilitate the greater incorporation of these data across projects. Installation was funded by state and local government agencies seeking better information on the resilience of coastal sedimentary environments to sea-level rise. These data inform models of projected inundation and vulnerability, required under most state sea-level rise adaptation frameworks. The data allow the incorporation of dynamic elevation responses (feedbacks) between sea-level rise and vertical accretion.

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Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

This project provides data and information on which consultation with Indigenous landholders on options for managing their coastal lands can be based. Many researchers have existing relationships with traditional owners on whose land the surface elevation tables are deployed. These instruments may provide a catalyst for coastal wetland monitoring by Indigenous landholders.

This small project only concerns the collation of existing data but represents an opportunity to inform Indigenous stakeholders more broadly about the aims and outcomes of the SET-MH monitoring network. We intend to consult with Parks Australia concerning possible expansion of the network into Kakadu National Park in a subsequent phase. We envisage a future in which ongoing readings are supported by indigenous staff (e.g. sea rangers). The project team will work with the Hub's Indigenous facilitator with the view to seeking to engage with relevant Indigenous organisations.

Location of research

A meeting will be held in Ballina (NSW) in August to collect data for this national-scale project. Most of the desktop research will be conducted in Sydney.

The project will coordinate the collection of data from the following locations:

New South Wales	Victoria	Queensland	Western Australia	South Australia	Northern Territory
Tweed River	Rhyll	Moreton Bay	Exmouth Gulf	Port Broughton	Darwin Harbour
Hunter River	Quail Island	Maroochy River	Swan River	Adelaide	
Hawkesbury River	French Island	Daintree River	Peel Harvey Inlet	Torrens Island	
Parramatta River	Kooweerup		Leschenault Inlet	Tumby Bay	
Minamurra River	Corner Inlet		Oyster Harbour		
Jervis Bay			Culham Inlat		

Project 1.12 – Mapping critical habitat in Yanyuwa Sea Country

Project description

Project summary

Marra and li-Anthawirriyarra rangers seek to build on existing partnerships with CDU and JCU to map the intertidal habitats of the Yanyuwa Indigenous Protected Area (IPA) and coastal areas connected to it, an area of profound importance to these communities and the marine ecosystem of the Gulf of Carpentaria (GoC). Significant co-funding will be provided by the Mabunji Aboriginal Corporation (MAC) and DAWE Migratory Species Section to conduct a large-scale mapping project that will inform Marra and Yanyuwa community decisions that underpin sustainable management and facilitate continued connection with sea country. Co-funding from NESP2 is sought to provide salary for data processing and reporting for these surveys. This project also leverages existing funding allocated to training, capacity building, community consultation and communication products committed to by the rangers, CDU, JCU, the Australian and the NT Governments.

Project description

What problem does this project seek to address and how will it do this.

The Yanyuwa and Marra people in the GoC are custodians of some of the most significant seagrass habitat in the NT. Our understanding of seagrass habitats in this region is a critical knowledge gap. The area is culturally rich and has high biodiversity values, including the highest dugong abundance in the NT and extensive habitat for green turtles. Understanding the distribution and composition of these habitats is necessary to support the aspirations of the Marra and Yanyuwa people to sustainably manage sea country, maintain their strong connection to place, contribute to a Blue Carbon inventory and enable informed decisions by government with regard to coastal development. However, there are no recent benthic habitat maps of the Yanyuwa IPA to support key management decisions. The Marra and li-Anthawirriyarra rangers have sought to partner with CDU and JCU to map the intertidal waters of the IPA through the MAC. The scale and complexity of the islands (and benthic habitats) means that the $70K contribution from MAC and a further $70K from Migratory Species (DAWE) will fund the operational side of a survey of identified priority areas in the IPA and some of the adjacent Marra area. Co-funding from NESP2 will provide salary costs (not covered by the MAC grant or Migratory Species funds) to cover data processing, spatial analysis (mapping), technical reporting and engagement with the Traditional Owners of the Marra and Yanyuwa sea country on the value of these habitats to threatened species (dugongs and turtle) and sites of cultural significance.

How the project links to other research and/or the work of other hubs.
Related research scheduled for the same time period includes community consultation (July 2021), subtidal surveys of the Limmen Marine Park (Australian Government) the intertidal areas of the Limmen Bight Marine Park (Northern Territory) (October 2021), and other coastal waters that connect Marra and Yanyuwa sea country (Migratory Species, DAWE) (November 2021) (Figure 1).

Spatial data from our project will link in to the proposed NESP2 project *Synthesizing three decades of seagrass spatial data from Torres Strait and the Gulf of Carpentaria* (Alex Carter and Skye McKenna) to build the publicly available spatial database for the GoC. Spatial data will be formatted so results from these surveys are comparable with a previous data synthesis for the Great Barrier Reef (TWQ NESP 3.1 and NESP 5.4; Carter et al. 2016 and Carter et al. 2021).

How the research will be undertaken, including what is in and out of scope.
The survey will be undertaken in the Yanyuwa IPA, which encompasses the Sir Edward Pellew Islands in the southern GoC (Figure 1). As leaders in seagrass mapping and monitoring, JCU have applied their expertise to refine methods needed to overcome challenges encountered when

surveying remote benthic habitats under logistically difficult conditions. For these surveys, sampling will be co-designed in collaboration with the Marra and li-Anthawirriyarra rangers by considering:
- areas of greatest cultural significance and concern,
- budgetary and logistical constraints (i.e., surveys can only be conducted during a window of
- very low tides over 7 days),
- the need for reconnaissance for any future surveys of subtidal habitats.

Limmen survey gap (intertidal)
Yanyuwa IPA (Barni - Wardimantha Awara)
Limmen National Park
Limmen survey area 2021
Limmen Bight Marine Park
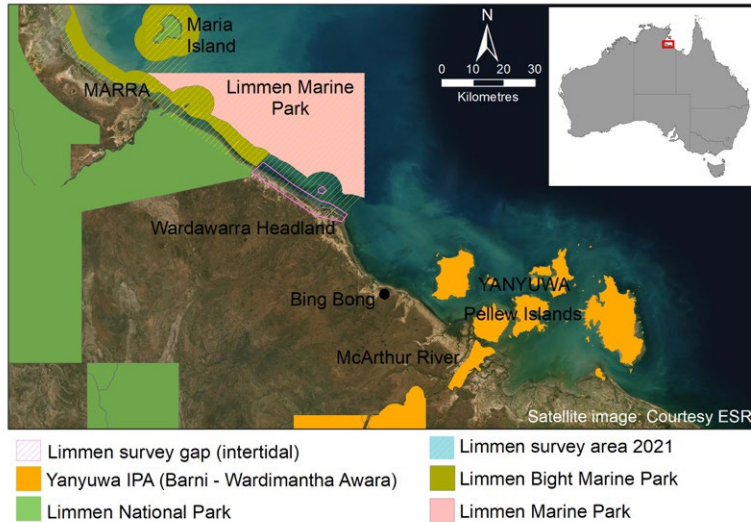Limmen Marine Park

Figure 1. The southern GoC highlighting the survey area that will be mapped in this project including the Limmen survey gap (pink stripe) and Yanyuwa IPA (orange) and adjacent coastal areas.

Intertidal meadows will be sampled at low tide using a helicopter and GPS to record the position of survey sites. This method is consistent with monitoring other benthic habitats in Queensland and is proven to be low risk because ideal tides have already been selected for November 2021, immediately following the Limmen Bight Marine Park survey. Helicopter surveys can occur in all but the most extreme weather conditions (e.g., cyclones, heavy storms) that are highly unlikely to occur in November. Seagrass presence/absence, biomass and species composition will be determined from three replicate 0.25 m^2 quadrats placed randomly within each site (10 m^2 circular area). Other benthic habitat will also be recorded including functional groups of algae and benthic macroinvertebrates such as hard and soft coral, sponges, and ascidians. Sites will be randomly scattered throughout the survey area. These data will be used to construct seagrass meadow boundaries.

Details of related prior research, if relevant.

This project will use the same method as previous large-scale intertidal benthic mapping funded by TWQ Hub NESP 3.5 and the TSRA in north-west Torres Strait (Carter and Rasheed 2016). Spatial data will be formatted using the same approach as that developed for TWQ Hub NESP Project 3.1 and 5.4 mapping synthesis for GBR seagrass (Carter et al. 2021). Existing data on turtles, dugongs, and other significant species, culturally important information (provided by the community), and spatial information on threats to the IPA will be discussed in our reporting to provide context.

Synthesizing Seagrass Data Project 1.13 will harvest all the available spatial data for Torres Strait and the GoC and make this available in a consistent form in a publicly available website (eAtlas). We will ensure spatial datasets produced from the Yanyuwa survey will be formatted so that they can be integrated into Project 1.13. This will allow for results from the Yanyuwa survey to be comparable with historical seagrass surveys in this area (e.g. Roelofs et al. 2005), and seagrass historical data and ongoing monitoring programs in the Gulf of Carpentaria (e.g. Karumba and Weipa annual monitoring) and Torres Strait, and with a previous data synthesis for the Great Barrier Reef (NESP Projects 3.1, 3.2.1 and 5.4; Carter et al. 2021). This standardization of spatial data is incredibly valuable when assessing seagrass condition and change in a regional context.

Summary of how it is expected that the research will be applied to inform decision-making and on-ground action.

Spatial data and bilingual maps will contribute to:

- Enabling the Marra and Yanyuwa people to negotiate on resource use.
- Understanding dugong and marine turtle habitats including migratory corridors.

- Enacting the *Environmental Protection and Biodiversity Conservation Act 1999* matters of national environmental significance, e.g. listed threatened species or listed migratory species.
- Supporting the objectives of *Australia's Strategy for Nature 2019-2030*.
- Future modelling of seagrass distribution, seagrass communities, and connectivity.
- Input into Environment Impact Statements (EIS).
- Developing long-term monitoring plans for the GoC and identifying knowledge gaps.
- Assessing exposure to risk (e.g. industry, tourism, water quality, climate change, etc).

How will the products/tools developed continue to be supported beyond the life of the project?

- Metadata and final spatial layers will be submitted to eAtlas and held on CDU and JCU servers.
- The final report will be publicly available on the NESP and eAtlas websites.
- Capacity-building of Marra and li-Anthawirriyarra Rangers will foster future ranger-led long-term monitoring.

Indigenous consultation and engagement

This project is a Category 1 (Indigenous Partnerships Strategy) project. The proposed surveys of the Yanyuwa IPA and Marra sea country have been conceived and driven by the Marra and li-Anthawirriyarra rangers of the MAC. The proposal builds on a long-term partnership between CDU and MAC. It also builds on planned engagement activities with the local community and training for Marra and li-Anthawirriyarra rangers in benthic habitat sampling in the Limmen Bight Marine Park (NT) and Limmen Marine Park (Commonwealth) (Figure 1) funded by the Australian and Northern Territory Governments and led by JCU and CDU in 2021.

Indigenous participation in these projects includes:

- indigenous-led community consultation on sea country allowing for intergenerational knowledge transfer between elders and younger Traditional Owners
- co-design of survey sampling sites and future monitoring
- training provided to rangers for on-country seagrass survey methods, including the purchase of equipment for ongoing monitoring
- training provided in data handling and processing (on-site and via an internship at JCU).

Aboriginal and Torres Strait Islander research includes all research that impacts or is of particular significance to Aboriginal and Torres Strait Islander peoples, including the planning, collection, analysis and dissemination of information or knowledge, in any format or medium, which is about or may affect Indigenous peoples, either collectively or individually.[1]

A Human Research Ethics application was submitted to the CDU Human Research Ethics Committee on May 17, 2021. This is a detailed application process which requires a research agreement to be implemented between the researchers and the Marra and Yanyuwa people collaborating on this project. Further, this approach aligns with the AITSIS code of ethics which requires a research permit under the following conditions:

- the research is about Aboriginal and Torres Strait Islander peoples, societies, culture and/or knowledge, Aboriginal and Torres Strait Islander policies or experience.
- there are Aboriginal and Torres Strait Islander individuals or communities contributing to the research.
- the research concerns Aboriginal and Torres Strait Islander peoples' lands or waters.

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[1] Walter M, Lovett R, Bodkin-Andrews G and Lee V, Indigenous Data Sovereignty Communique, Indigenous Data Sovereignty Summit, Canberra, 20 June 2018. https://www.aigi.com.au/wp-content/uploads/2019/10/Communique-Indigenous-DataSovereignty-Summit-1.pdf

Location of research

The research will occur in the southern Gulf of Carpentaria. Benthic habitat surveys will be carried out in the intertidal coastal areas adjacent to the Limmen Bight Marine Park (Marra Sea Country) (pink hashed area) and identified high priority areas in the Yanyuwa IPA in the GoC in the NT (orange area).

Community consultations conducted in July and September 2021 will enable prioritisation of sites to be surveyed that are supported by all collaborators and end users.

Mapping and data management activities based on these surveys will be undertaken at CDU (Darwin), JCU (Cairns campus) and MAC (Borroloola).

Spatial data from this project will contribute to a regional spatial synthesis for Torres Strait and the Gulf of Carpentaria (Carter and McKenna proposal in this NESP round).
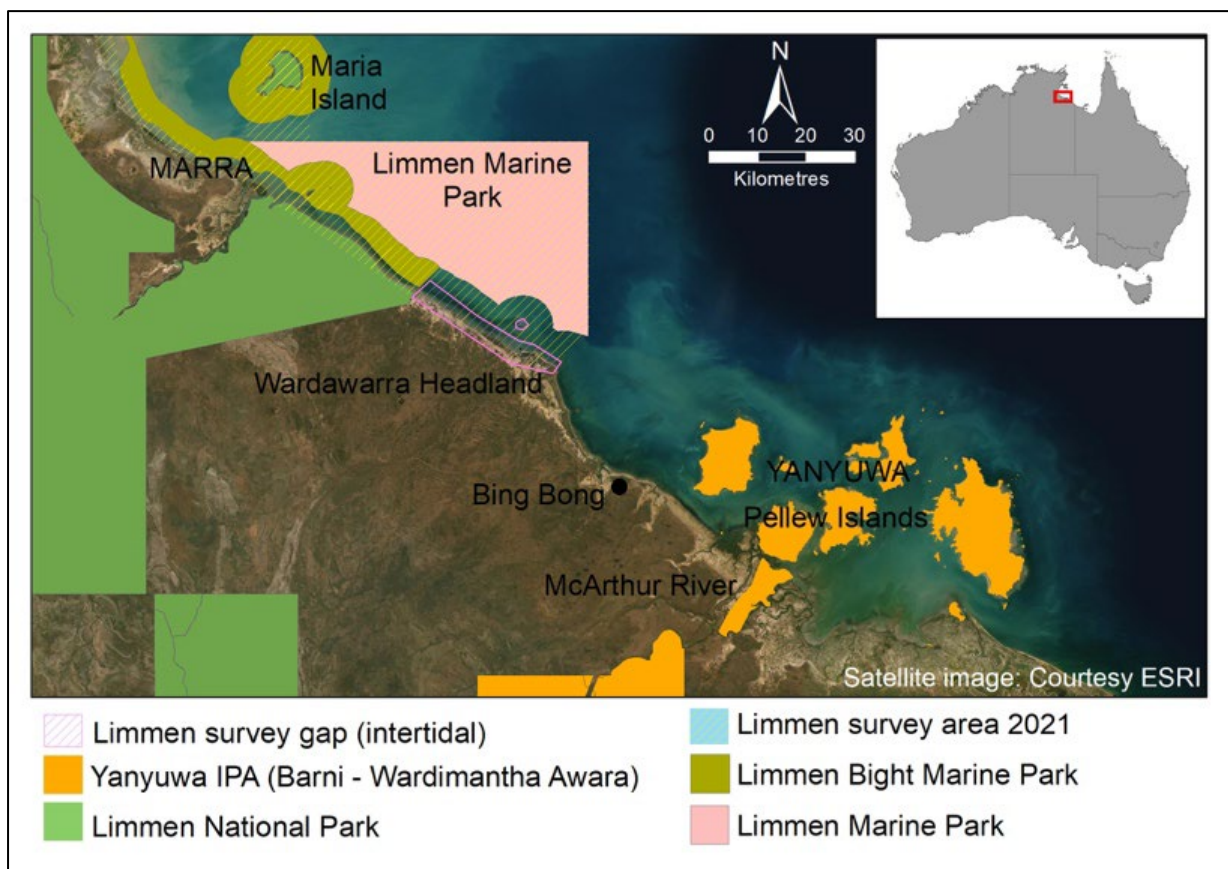
Project 1.13 – Synthesizing three decades of seagrass spatial data from Torres Strait and Gulf of Carpentaria

Project description

Project summary

The Gulf of Carpentaria and Torres Strait have globally significant seagrass habitat that provide food for threatened dugong and turtle, and habitat for commercially important fish and prawns. Key to understanding, managing, mitigating risk, and monitoring seagrass in this remote region is reliable data on seagrass distribution and species composition and how these changes through time. Data on seagrass has been collected in these areas since the 1980s, but data location and storage from these efforts remains disparate, in many cases not publicly available, and in some cases has already been lost. Our study will compile, validate and synthesize historical seagrass spatial data to create a publicly available database accessible on eAtlas. This product will provide end-users with a valuable spatial resource to assist management and monitoring of seagrass in the region.

Project description

What problem does this project seeks to address and how will it do this.

The proximity of the Gulf of Carpentaria and Torres Strait seagrass habitats to coastal processes exposes them to anthropogenic impacts and the loss of well documented ecological services (blue carbon, nutrient absorption, sediment stabilisation, food for iconic species, habitat for fish and prawns). There are few spatial data sets publicly available that document long-term changes in seagrass communities, and few validated and/or up-to-date long-term data sets for the Indo-Pacific that we know of. Compiling spatial data has not occurred for the Gulf of Carpentaria and is not up-to-date for Torres Strait. There is a risk that older data is not secure and, if not compiled and validated, is in danger of being lost (with some early 1980s data already lost). This project will compile and synthesize three decades of seagrass survey site data in a publicly available spatial database (eAtlas) to address the above concerns. This will provide management agencies, rangers, Traditional Owners, ports, industry, and researchers with a long-term spatial resource describing seagrass populations against which to benchmark change.

How the research will be undertaken, including what is in and out of scope.

The research will be undertaken as a desktop analysis. We will use the same approach as our recently completed spatial synthesis of Great Barrier Reef seagrass for Tropical Water Quality Hub NESP 3.1 and 5.4, where we compiled data from >81,000 sites collected over 35 years of surveys (Carter et al. 2021; http://doi.org/10.1002/lol2.10193). Standardizing the approach will ensure continuity in the data structure across the Gulf of Carpentaria and Torres Strait. Any spatial data from Torres Strait and the Gulf of Carpentaria are within the scope of this project. To achieve this, we will:

- Work with end-users, including management agencies, port authorities, industry, Traditional Owners and ranger groups to identify available data.
- Identify, check, validate and collate spatial data sets and obtain permissions from data owners to include in the project and to make it publicly available.
- Make data publicly available in a format compatible with the eAtlas interface for non-GIS users. Data and metadata will also be available with downloadable GIS shapefiles.

Trial programs/case studies to improve physical environment, if relevant.

N/A

Details of related prior research, if relevant.

Project	Details
TWQ Hub NESP 3.1: Seagrass mapping synthesis – a resources for marine park and coastal management Carter et al. 2016b	This project provided a synthesis of the available spatial data on seagrass in the Great Barrier Reef World Heritage Area (GBRWHA) collected between 1984-2014. This project produced easy to use GIS layers that provide key information on seagrass presence/absence, species composition, mapped meadows, and age and reliability of the data.
TWQ Hub NESP 3.2.1 & 5.4: Deriving ecologically relevant targets to meet desired ecosystem condition for the GBR Carter et al. 2016a Carter et al. 2021a, b Lambert et al. (in press)	This project derived Ecologically Relevant Targets for sediment loads of Burdekin basin and developed seagrass desired state across the Great Barrier Reef (GBR). To achieve this, we followed three steps:(1) an updated consolidation and verification of seagrass data at the GBRWHA scale (an update from NESP 3.1 with data collected 1984-2018), (2) a predictive model of the distribution of GBRWHA seagrass habitat and communities, and (3) an estimation of the desired state target for seagrass biomass in communities with sufficient data.
TWQ Hub NESP 3.5 and TSRA: Assessment of key dugong and turtle seagrass resources in north-west Torres Strait Carter & Rasheed 2016	This project described seagrasses in an identified data deficient region in north-west Torres Strait that contains large dugong and turtle populations. The baseline assessments from this project provided essential information to the TSRA, Australian and Queensland governments for dugong and turtle management plans, complementing dugong and turtle research studies in the region and building skills and capacity of Traditional Owners and Rangers.
Torres strait mapping: Seagrass consolidation 2002 – 2014 Carter et al. 2014	This project provided a synthesis of the available spatial data on seagrass in Torres Strait collected 2002-2014. This project produced easy to use GIS layers for TSRA that provide key information on seagrass presence/absence, species composition, mapped meadows, and age and reliability of the data. Since its creation this product has been used to identify data gaps and key seagrass habitat, with this information used to conduct baseline surveys of data deficient areas (e.g. north-west Torres Strait (2015), western Torres Strait (2020) and eastern Torres Strait (2020) and implement long-term monitoring programs.
Seagrass communities of the Wellesley Island Group Taylor et al. 2007	This was a joint project between Traditional Owners, CLCAC, NAILSMA and QLD government to survey seagrass habitat around the Wellesley Island group. The project was developed after Traditional Owners raised concerns over unhealthy dugong and turtle reported from hunters. The concerns were raised that this may have been as a result of seagrass dieback causing a shortage of food for the animals.
A survey of intertidal seagrass from Van Diemen Gulf to Castlereagh Bay, Northern Territory, and from Gove to Horn Island, Queensland Roelofs et al. 2005	This was a joint project between National Oceans Office (NOO), QLD & NT governments, seagrass scientists and Traditional Owners. The distribution, structure and composition of intertidal and shallow subtidal seagrass communities from an area representing almost 10% of Australia's mainland coastline were surveyed and described.

How the project links to other research and/or the work of other hubs.

Project/Research/Work	How our project links to other research

Port of Karumba, Weipa and Thursday Island long-term seagrass monitoring programs	Port monitoring will provide long-term seagrass data for this project. The outcomes from this project will feed back into program design, reporting, and dredging and port management plans.
TWQ NESP 3.1: Seagrass mapping synthesis – a resource for marine park and coastal management	Data and outputs from this project will continue to build on the eAtlas spatial dataset of 3.1 for the GBRWHA (1984-2014) by expanding into adjacent regions of Torres Strait and the Gulf of Carpentaria
TWQ NESP 5.4: Deriving ecologically relevant targets to meet desired ecosystem condition for the GBR	Data and outputs from this project will continue to build on the eAtlas spatial dataset for the GBRWHA (1984-2018) by expanding into adjacent regions of Torres Strait and the Gulf of Carpentaria
Mabunji Aboriginal Corporation and NESP MAC Hub RP2021: Mapping critical habitat in Yanyuwa Sea Country Led by Rachel Groom (CDU) with Alex Carter (JCU) and Catherine Collier (JCU)	Data and outputs from our project will link in to the proposed NESP MAC Hub Yanyuwa Sea Country Project (seagrass surveys scheduled for November 2021) to help inform project outputs and provide continuity of data and spatial layers across the Gulf of Carpentaria. Spatial data will be formatted so results from these surveys are comparable with our data synthesis to ensure continuity of spatial data for the Gulf of Carpentaria and permission will be sought to include these survey results into the synthesis.
Limmen Marine Park (Commonwealth) and Limmen Bight Marine Park (NT) Co-led by Alex Carter with Rachel Groom (CDU) and Catherine Collier (JCU)	Data and outputs from our project will link into the currently funded seagrass surveys (scheduled for October 2021) in the Northern Territory Limmen Bight Marine Park and Commonwealth Limmen Marine Park. Spatial data will be formatted so results from these surveys are comparable with our data synthesis to ensure continuity of spatial data for the Gulf of Carpentaria.

Australia's nature hub	Information from this project will support the objectives of *Australia's Strategy for Nature 2019-2030*:
	
	    1 Connect all Australians with nature
	
	    2 Care for nature in all its diversity
	
	    3 Share and build knowledge
	
	TSRA have identified commitments under this strategy and objectives through the Indigenous Land and Sea Ranger Program

DAWE – Recovery Plan for Marine Turtles in Australia 2017-2027	Data from our project can support information required for the recovery plan. Seagrasses are an important food source for turtles.

How this research will be applied to inform decision-making and on-ground action.

The spatial data produced for this project will be available to Commonwealth and regional management agencies as well as on-ground researchers, Traditional Owners and rangers to guide environmental decision making and on-ground action, including:

- Torres Strait *Dugong and Turtle Management Plans*.
- *Recovery Plan for Marine Turtles in Australia* (2017). The need to acquire up-to-date foraging habitat information to inform management of this listed threatened species has been identified.
- Understanding dugong and marine turtle habitats including migratory corridors.
- *Environmental Protection and Biodiversity Conservation Act 1999* matters of national environmental significance, e.g. threatened species or listed marine and migratory species.
- Support the objectives of *Australia's Strategy for Nature 2019-2030*. https://www.australiasnaturehub.gov.au/national-strategy

- Future modelling of seagrass distribution, seagrass communities, and connectivity.
- Input into State & Commonwealth development/EIS and dredge management plan assessments considering impacts to seagrass.
- Assessment and planning for spatial closure and fisheries management arrangements, e.g. Dugong Protected Areas and Fish Habitat Area.
- Spatial information for National Oil Spill Response Atlas (AMSA & MSQ).
- Essential knowledge of the location and composition of key environmental assets in the Gulf of Carpentaria and Torres Strait to develop long-term monitoring plans and target data gaps for future surveys.
- A foundation to create models assessing exposure to risk (water quality and other environmental impacts, climate change, etc).

How will the products/tools developed continue to be supported beyond the life of the project?

- Data, metadata and spatial layers created will be secured on a JCU server perpetually.
- Metadata and final spatial layers will be submitted to eAtlas to be held perpetually.
- Peer-reviewed open access data publication.
- Final report will be publicly available on the NESP, JCU and eAtlas websites.

Indigenous consultation and engagement

Our project is a Category 1 (Indigenous Partnerships Strategy) project. Our project is co-funded by TSRA and includes consultation and collaboration with Torres Strait and Gulf of Carpentaria Traditional Owners and ranger groups. Traditional Owners and rangers, and indigenous bodies such as NAILSMA and CLCAC, have participated in the data collection, project design and report writing that have produced the historical data we will synthesize for the region, and it is our intention for the collaboration to continue. We will explore opportunities for joint authorship.
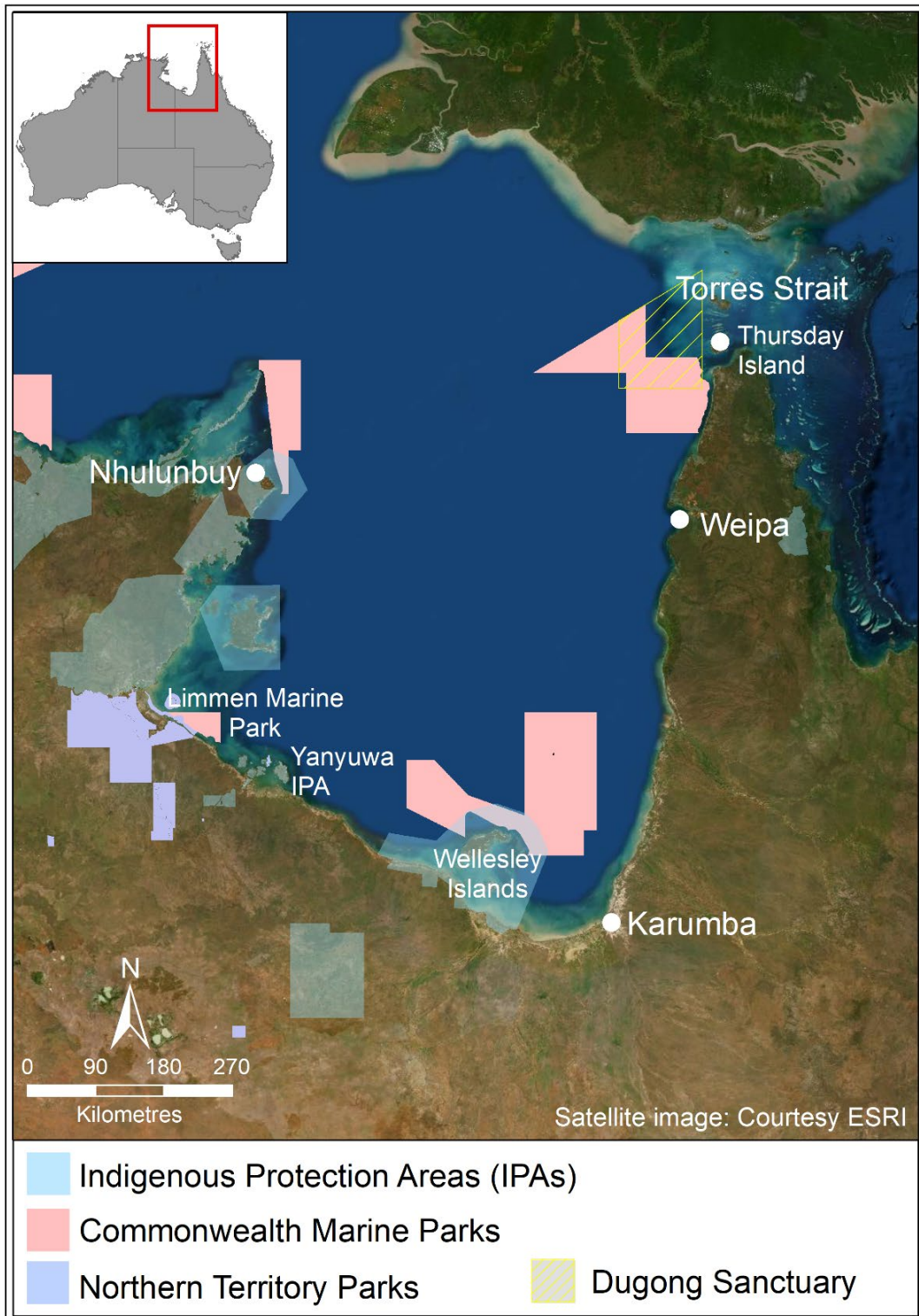
Our end-user engagement strategy is to engage early, encourage participation and collaboration, and ensure dissemination. This project is being guided by one of our end-users – TSRA – reflected in their cash contribution. TSRA have identified this project as critical to the management of Torres Strait Sea country. TSRA and Torres Strait rangers have been actively engaged through participation in data collection, project design, information gathering, and information sharing.

Early consultation with NAILSMA and CLCAC has identified this project as a "*valuable project that would be of use to the Rangers, both on the mainland and the Wellesley Islands*". Traditional Owners and rangers in the Wellesley Islands and Karumba participated in the original data collection that will contribute to this project, and CLCAC Rangers are engaged in annual monitoring at Karumba. NAILSMA and CLCAC will be engaged to help gather any additional data that has been collected since the original surveys, as will the Marra Aboriginal Rangers and li-Anthawirriyarra Sea Rangers who are conducting benthic mapping surveys with us in the NT Gulf (2021-2023).

Project outcomes and resources will be disseminated and shared with NAILSMA, CLCAC, Traditional Owners and rangers of the Gulf and Torres Strait through access to eAtlas, community flyers, project report and presentations at community workshops during already funded projects (e.g. annual seagrass monitoring in Torres Strait and QLD Gulf, seagrass surveys at Limmen Marine Park and Yanyuwa IPA).

Location of research

Our project is a desktop analysis which will be undertaken primarily at JCU Cairns, North Queensland. This project is regional in scale and the research output will impact Torres Strait, Cape York, and the Gulf of Carpentaria.

Legend:
- Indigenous Protection Areas (IPAs)
- Commonwealth Marine Parks
- Northern Territory Parks
- Dugong Sanctuary

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Project 1.14 – The role of dugong and turtle grazing in Torres Strait seagrass declines

Project description

Project summary

Dramatic declines in seagrass meadows in the **Torres Strait** Western Cluster were recorded in **2019 and 2020**. These meadows are culturally important and represent **significant foraging grounds for green turtles and dugongs**. This project will use a short-term field study to investigate the role of megaherbivore grazing in two key locations where seagrass declines have been most dramatic. This project has been **co-developed with the TSRA, Sea Rangers and Goemulgaw PBC** in response to community concerns about seagrass declines and the implications for the totemic megaherbivores they support. The results will inform **Traditional Owner led dugong and turtle management plans and help direct actions for remediation** as required.

Project description

What problem the project seeks to address and how it will do this

The Torres Strait Regional Authority (TSRA), Rangers and Traditional Owners have identified the widespread declines in deep-water, intertidal island and reef-top seagrass meadows in the Torres Strait Western Cluster as a critical concern. Seagrass meadow condition around Mabuyag Island, Orman Reefs and the Dugong Sanctuary has decreased dramatically from very good condition to poor and very poor condition in the latest Torres Strait Seagrass report

Figure 1: Orman Reefs- Mabuyag Island region

cards (Carter *et al.,* 2020). These meadows are a critical food source for green turtles and dugong in Torres Strait and are culturally important to the local communities.
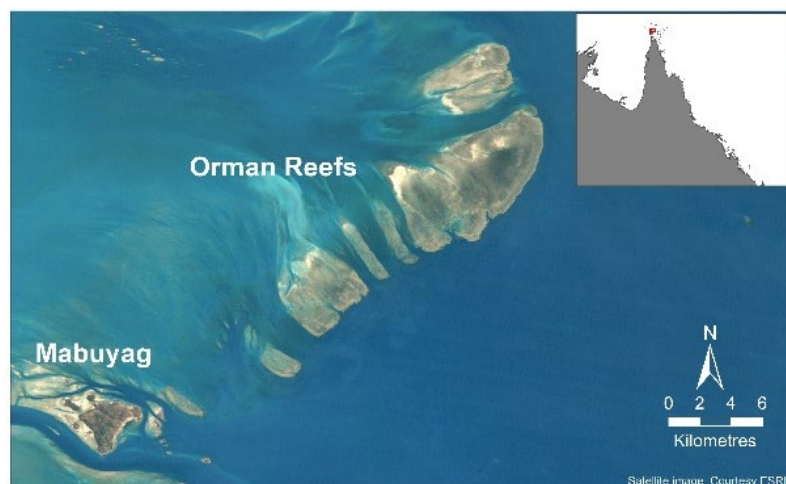
Traditional Ecological Knowledge (TEK) shows seagrass dieback events have occurred previously in this region, but the causes of these declines are unknown. Three potential causes of seagrass decline have been identified by scientists and the community: changed environmental conditions, disease, and increased herbivory. The community have taken samples and ruled out the presence of disease and changes in environmental conditions are being investigated. Grazing by megaherbivores (dugong and turtle) is an established top-down structuring influence in tropical seagrass meadows. Unusually large numbers of green turtles and dugong have been observed feeding in this area by researchers, Rangers and Traditional Owners. The community through the Goemulgaw Prescribed Body Corporate (PBC) and TSRA Sea Rangers have identified a need to understand the role of herbivory in these declines and have championed the co-development of this project in partnership with JCU researchers. Results will inform seagrass, dugong and turtle management at both a local and larger scale.

Seagrass diebacks have implications for the local communities who rely on healthy seagrass meadows and the animals they support. Any dieback events are also likely to cause large-scale movements of megaherbivores which would have implications for seagrass meadows and communities throughout the Torres Strait and northern Australia. In other parts of the world, megaherbivore grazing has caused large declines in seagrass meadows and in some cases total meadow collapse.

This project will identify the extent that grazing by green turtles and dugong is driving the recorded seagrass declines, to inform management measures and any interventions that may be required. This project will use a short-term field study adapting recent methods applied in the GBR to investigate the role of megaherbivore grazing in two key locations where seagrass decline has been most dramatic: the Orman Reefs and Mabuyag Island (Fig. 1).

How the research will be undertaken, including what is in and out of scope

Megaherbivore exclusion cages will be deployed in seagrass meadows and maintained by Rangers and the community. Seagrass metrics (biomass, species composition, shoot height) inside cages and adjacent control plots will be measured at the beginning, during (3 months) and at the end of the experiment (6 months) to understand the grazing pressure on seagrass meadows in both locations. The design of the study will follow the methods in Scott *et al.* 2020 and will be a balanced control and treatment set up with a minimum of six cages (Fig. 2) and six controls per site. This technique has been used successfully by the JCU Seagrass Ecology Group in

Figure 2: Megaherbivore exclusion cage GBR

various locations across the Great Barrier Reef (GBR) and has proved effective in defining megaherbivore grazing pressure in seagrass meadows (Scott *et al.* 2020; 2021a; 2021b). The timeframe of 3 to 6 months has been demonstrated to be sufficient to ascertain relative grazing pressure in these studies. The scope of this project is very well defined, differences in seagrass inside and outside of exclusion cages will be analysed to establish the role of dugong and green turtle grazing in structuring seagrass meadows in two locations where declines have been observed. These results will form the starting point to establish potential causes of decline in this area.

Details of related prior research

The JCU Seagrass Ecology Group have successfully carried out megaherbivore exclusion experiments to understand how green turtles and dugong structure seagrass meadows throughout the GBR as part of an ARC linkage project (Scott *et al.*, 2020, 2021a, 2021b and York *et al.*, in prep). The group also has a long history of seagrass research and monitoring in the Torres Strait and at the Mabuyag and Orman Reefs sites specifically. These studies conducted as part of the CRC Torres Strait and more recently as a direct partnership between JCU and the TSRA LSMU have established; the range of natural seagrass changes, capacity of local meadows for recovery from losses, and some of the climate drivers of seagrass change (Rasheed *et al.* 2008; Carter *et al.* 2014; Carter *et al.* 2020). As part of these studies, we have worked closely with the TSRA, local Mabuyag Rangers and Traditional Owners to monitor seagrass meadow condition and we have co-developed this project with these partners.

How the project links to other research and/or the work of other hubs

The results of this study link in with previous exclusion studies on the GBR adding to the understanding of how plant-herbivore interactions can structure tropical seagrasses, their ecosystem services, and the herbivores that depend on them. This work also adds to the global understanding of

plant-herbivore interactions in seagrass meadows, particularly in the context of the role of grazing in causing seagrass declines. Specifically, this work links to:

Australia's nature hub	Information from this project will support the objectives of *Australia's Strategy for Nature 2019-2030*: • Connect all Australians with nature • Care for nature in all its diversity • Share and build knowledge TSRA have identified commitments under this strategy and objectives through the Indigenous Land and Sea Ranger Program.
DAWE – Recovery Plan for Marine Turtles in Australia 2017-2027	Information from our project will support aspects of the recovery plan. Seagrasses are an important food source for turtles understanding the dynamics between them is a key requirement for management.
Goemulgaw PBC and local community	This project directly feeds into ongoing research and investigations into the causes of seagrass declines in the Western Torres Strait instigated by the Mabuyag community and rangers, including disease assessments in 2020 conducted by the DAWE lab in Cairns.

Summary of how it is expected that the research will be applied to inform decision-making and on-ground action

This project will provide essential information to the Mabuyag community and the TSRA on the role of herbivory in seagrass declines. The results of this project will inform Traditional Owner led dugong and turtle management plans. The immediate implications of the results will assist in understanding the likely prognosis of natural recovery and direct future effort to resolve the source of seagrass declines and what, if any, management interventions need to be applied. As the key managers from both the community (Goemulgaw PBC) and government (TSRA LSMU) are directly engaged with this research there will be a seamless flow of results through to the decision makers and provision of critical information to:

- Torres Strait Dugong and Turtle Management Plans.
- *Recovery Plan for Marine Turtles in Australia* (2017). The need to acquire up-to-date foraging habitat information to inform management of this listed threatened species.
- Understanding dugong and marine turtle habitats including migratory corridors.
- *Environmental Protection and Biodiversity Conservation Act 1999* matters of national environmental significance; e.g. threatened species or listed marine and migratory species.
- Support the objectives of Australia's Strategy for Nature 2019-2030. https://www.australiasnaturehub.gov.au/national-strategy

Indigenous consultation and engagement

This is a Category 1 (Indigenous Partnerships Strategy) project that will be undertaken with direct collaboration with the local community and co-funded by TSRA. This project has been developed in response to concerns from the community who have identified a need for the research and a desire to work with JCU scientists on this project. This project has been co-developed with the TSRA, Mabuyag Rangers and Goemulgaw PBC Chair Johnny Kris following discussions about seagrass declines around Mabuyag and how to understand potential causes of the decline (see attached letter of support). Members of the community including PBC Chair Johnny Kris and head Ranger Terrance Whap are active participants in this project, including design and the experimental set-up, and will take ownership of the data collection in a true partnership with the JCU researchers. The project will begin with a blessing ceremony with the Mabuyag community before the experimental set up. Rangers will jointly and independently assist with the maintenance of the exclusion cages and data

collection and future decisions on management. The key end user for this project, the TSRA, are guiding this project and their commitment is reflected in their matching cash contribution (see attached letter of support).

Working with Rangers to set up and monitor this experiment will provide the opportunity for training and continued knowledge sharing between JCU researchers and local Rangers. This will give the Rangers an opportunity to learn how to carry out this kind of experiment and the researchers an opportunity to learn TEK from the rangers.

We have consulted with the TSRA, Rangers from across the Torres Strait and the local PBC by holding a workshop in Cairns (May 2021) addressing the recent seagrass declines and discussing possible causes based on previous research and Traditional Ecological Knowledge.

The genesis of this project has come from a long-term (over 15 years) relationship between JCU researchers, the Mabuyag community and the TSRA through the Land & Sea Management Unit. Over the past year the Traditional Owners, JCU and TSRA have been working together to understand seagrass declines. The results of this project will be combined with data from JCU and Ranger monitoring surveys to understand how changes in seagrass meadow condition may be driven by megaherbivore gazing. These findings will inform local management measures by the TSRA and Traditional Owners and will also inform Torres Strait management more widely.

Project outcomes and resources will be developed in partnership with local Rangers and the TSRA and will be shared with the local community. Reports and products will be co-authored with Rangers and Traditional Owners participating in this study.

Location of research

This is a local to regional scale project that will take place in intertidal seagrass meadows on Mabuyag Island and Orman Reefs in the western Torres Strait (see Fig. 1). Both of these locations have seen seagrass declines in the past two years. Exact experimental locations on the reef and around Mabuyag will be determined in a scouting trip directly before the experiment commences and from existing data from the JCU / TSRA seagrass monitoring program. Locations will be selected based on logistical considerations and the presence of seagrass.

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Project 1.15 – Coastal wetland restoration for Blue Carbon in northern Australia

Project description

Project summary

Investment in restoration of coastal wetland ecosystems is increasing due to concerns around habitat loss, water quality, decline in fish catches, coastal inundation and erosion, and climate change. Coastal wetlands, including mangroves, saltmarshes, seagrasses and tidal freshwater forests like Melaleuca have significant capacity to sequester carbon dioxide contributing to blue carbon stocks. They provide habitat for coastal fisheries and a range of biodiversity and are culturally important. This project aims to develop a method, that can be widely used across Australia, to prioritise coastal wetland restoration sites for Blue Carbon projects based on a value-based framework that considers biophysical suitability, balancing of wetland values, condition, regulation and policy adequacy, and economic feasibility.

Project description

Problem statement

Australia has large blue carbon stocks many of which have been degraded or converted to non-wetland since European colonisation, and which provide opportunities for restoration for carbon credits that could provide income incentives to landholders and Indigenous land managers. However, factors influencing the opportunities and the economic feasibility for coastal restoration vary across Australia's coastline. For example, in QLD and NSW sugarcane and grazing on low-lying land associated with drainage and/or the construction of bund walls and fertilisation, provide opportunities for financing restoration through the Emissions Reduction Fund (ERF) blue carbon method under development by the Clear Energy Regulator for reintroduction of tidal flows, and through QLD's Reef Credits for nutrient reduction. However, these options may be relatively expensive compared to removal of stock or feral animals, which may also provide new economically feasible opportunities for blue carbon projects in northern Australia. Thus, the opportunity for restoration of low-lying land to tidal coastal wetlands for carbon credits is likely to vary, but an analysis of the variation in profitability over different regions with different farming systems, pressures, existing ecosystem services, and potential carbon gains, is yet to be done. Of special interest is the incorporation of biophysical and economic analyses with a regulatory framework that aligns within governments priorities, within ongoing projects in catchments and with local cultural values, such as the inclusion of Traditional Owners in decision-making. Although systems for payments for greenhouse gas (GHG) removals from coastal wetland restoration through introduction of tidal flows is under development in Australia, whether and where these payments are sufficient to incentivise restoration is not certain, yet fundamental to describing the opportunity for blue carbon projects across Australia.

Description of research

An assessment of financial opportunities for blue carbon restoration in the Wet Tropics of the Great Barrier Reef catchment (Hagger et al. in press, *Ecosystem Services*) has shown that there are large areas of coastal wetlands that could be restored to maximise their carbon storage. This project will build on this first assessment to incorporate policy feasibility to further characterise, within a whole-of-system (values-based) approach, land suitable for investments in coastal wetland restoration. The project addresses: 1) the need to identify land for investment in wetland restoration for blue carbon, while also increasing and maintaining important wetland values, such as biodiversity, fisheries and nutrient cycling, recognising that trade-offs may existing between ecosystem services ; 2) the need to incorporate current regulatory frameworks (e.g. Matters of State and National Environmental Significance, Ramsar, UNESCO and other protections) in the selection of wetland rehabilitation for

blue carbon; and 3) further refine land prioritised for wetland restoration through a value-based framework that considers particular services or values of a place and social feasibility. This project will support the development of a Prioritisation of Rehabilitation and Research for Aquatic Ecosystems developed by the Queensland Wetlands Program and the Land Restoration Fund, which is relevant for other states.

Assessment of realised carbon benefits of coastal wetland restoration requires spatiotemporally explicit approaches to assess economic feasibility. We have established the methods in one region (the QLD Wet Tropics, Hagger et al. in press in *Ecosystem Services*) focussed on assessing the biophysical and economic feasibility of restoring sugarcane and grazing land (and some abandoned aquaculture) through reintroducing tides for blue carbon, and selecting sites that maximised biodiversity, coastal fisheries and dissolved inorganic nitrogen (DIN) removal co-benefits. This research extends on this method over 9 months to assess: 1) how to incorporate biophysical and economic feasibility of blue carbon projects into regulatory frameworks within the QLD, WA, and potentially NT; 2) apply a whole-of-system (value-based) approach to identify potential sites for blue carbon sequestration and avoided GHG emissions, including values such as biodiversity, coastal fisheries, nutrient cycling, and cultural. We will apply the selection framework in the southern Great Barrier Reef (Fitzroy Basin Association NRM) where grazing is the largest land use, introduction of tides is proposed for ponded pastures that will likely be colonised by saltmarsh species and saltflats with low carbon sequestration, and knowledge of the distribution of coastal wetlands pre-European colonisation is mapped. We will also consider the potential implications of converting freshwater bunded wetlands (ponded pastures) to tidal wetlands. In addition, we will choose two other locations where the underlying data is available – one in south-west WA (with collaborators and end-users in WA), and the other yet to be determined in northern Australia. A possibility is the Ord River floodplain in east Kimberley region of WA / north-west NT, where large-scale irrigation and agricultural and aquaculture development is occurring (and will continue under the developing Northern Australia agenda). We will assess potential carbon credits earned by coastal wetland restoration over 25 years, accounting for forgone income to landholders from agricultural production or other land uses and the trade-off in values of converting freshwater to intertidal wetlands. We will explore the trade-offs in achieving multiple values versus climate change mitigation alone.

This project is focused on the NESP theme of "Maximising sequestration of blue carbon through cost efficient restoration" and "Ecosystem Restoration and Protection".

Output(s) to be delivered

The research and results produced from this preliminary study include the following outputs, which can be used to identify coastal wetland restoration opportunities across three different regions of Australia.

- We will incorporate our economic and biophysical framework of selection of potential restoration sites for blue carbon, with the values-based approach for wetland rehabilitation, for the three study regions – Fitzroy Basin QLD, south-west WA and northern Australia (possibly north-west NT).

- We will identify the potential restorable area and calculate the mitigation of carbon dioxide-equivalent (CO_2-e) annually from carbon sequestration in vegetation and soils and avoided GHG emissions from ceasing agricultural land use in three areas of contrasting characteristics. The selection will consider possible co-benefits and trade-offs in multiple values and identify key data gaps.

- If data allows, we will also calculate the water quality benefit, for example the amount of DIN removal per ha from the restored wetlands. The capacity for DIN removal though denitrification was used as the indicator for the preliminary study in the Wet Tropics because data on DIN retention in the sediments and biomass of mangroves, saltmarshes and Melaleuca are highly variable. We will consult with the Reef 2050 Integrated Monitoring and Reporting Program monitoring activities to inform the selection of the water quality indicator. If

possible, we will quantify the water quality benefit in the technical report for Fitzroy Basin NRM as it's highly relevant for the improving the health and resilience of the GBR.

Outcomes

This project will provide a systematic approach that incorporates biophysical, regulatory, and economical feasibility of potential areas for blue carbon projects. Importantly, these areas will provide realistic options for rehabilitation investment by incorporating ongoing projects and goals from the States, Councils and Traditional practices and values as well as identifying key gaps to support further nation-wide assessments. The resulting framework will be tested in case studies in QLD, WA and NT.

Indigenous consultation and engagement

This a Category 2 (Indigenous Partnerships Strategy) project. The value-based framework being developed by the QLD Department of Environment and Sciences incorporates as a key value the cultural importance of wetlands for Traditional Owners. The project has the capacity to incorporate land managed by first nation corporations, for example with the Nywaigi Aboriginal People of North Queensland in Mungalla Station, which have previously worked with MF Adame and N Waltham and have shown an interest in participating in blue carbon projects. Fitzroy Basin NRM Association (a proposed contributor to the project) has good connections with Traditional Owners on the coastal region (Darumbal, Guwinmal and Bayali) that we will try to engage in the project via Free Prior and Informed Consent process. Similar outcomes for other Indigenous organisations across northern Australia are possible, and the project team have already a strong track record of indigenous consultation and engagement.

Engagement with Aboriginal Biodiversity Conservation Foundation, Northern Australia Indigenous Land and Sea Management and Indigenous Carbon Industry Network will be undertaken to explore the broader opportunity for coastal wetland restoration by Indigenous land managers under a blue carbon market (Indigenous-led carbon projects), and consideration of traditional ecological knowledge and cultural values.

Location of research

This is a desktop study that will utilise available spatial data and data on carbon stocks, wetland values, agricultural production, farm gross margins etc. The proposed locations of the desktop studies are: 1) Fitzroy Basin, QLD; 2) catchments of south-west WA; and 3) northern Australia (possibly Ord River floodplain). The locations have been selected to represent contrasting climates (dry tropics, Mediterranean, and wet tropics), coastal wetland ecosystems (saltmarsh and/or mangrove), and agricultural land-uses. Therefore, the research outputs will be applicable to the study regions, and other regions nationally with similar climates and land-uses. This is a national project with three study regions across Australia.

Project 1.16 – Scoping Study: Research needs for assessment and monitoring of nutrients, chemicals and antimicrobials in the marine environment

Project description

Project summary

Water quality can be impacted by a large suite of chemical and microbiological contaminants introduced from a variety of sources. There are a number of emerging contaminants and broad ranges of point sources, including a variety of chemical (e.g. heavy metals, pharmaceuticals, pesticides, nutrients) and microbiological (e.g. pathogens, antibiotic resistant microbes) contaminants that are discharged in sewage, stormwater, estuarine flows and industrial wastes. This project will involve a desktop scoping study to collate relevant datasets and current water quality monitoring goals and activities; engage with key stakeholders through workshops, interviews, and surveys to further define priorities; and conduct a risk assessment to assess impacts to marine and coastal water quality. This project will deliver a clear framework for highlighting knowledge gaps, future research directions and water quality management priorities.

Project description

Issues and concerns associated with aspects of water quality have historically and continue to be identified as an important environmental issue that impacts environmental assets and social and economic values in many coastal areas throughout Australia. There also continues to be increasing pressures in the coastal zone and emerging knowledge gaps that need to be identified and prioritised. This includes understanding the distribution and impacts of organic and inorganic nutrients, microbiological contaminants and pathogens, antimicrobials and chemical pollutants in the marine environment, and development/identification of appropriate control technologies.

Some of the key questions include:

- Where in the Australian marine environment are antimicrobials, and antibiotic resistant microorganisms, likely to have a high impact on the environment or on human health?

- Where are the hotspots for water contamination (e.g. Waste water treatment plants, proximity to industrial sites or aquaculture farms) and what sites of environmental significance are nearby (GBR, RAMSAR sites)?

- In locations with high levels of AMR organisms, what are some viable emerging innovations or measures that can be implemented to reduce emissions of antimicrobials (antibiotics, biocides, metals) into the environment or remediate the site?

- What are baseline or trends in environmental levels of key chemicals of concern (e.g., pharmaceuticals, POPs, pesticides, heavy metals, hydrocarbons, etc.) in the Australian environment?

- What are the relevant sources of these chemicals?

- Where do inputs of nutrients lead to eutrophication events that have detrimental impacts on marine ecosystems (e.g. fish kills)?

- What are the known and emerging microbiological hazards that are either introduced within contaminated water or stimulated by nutrient inputs within key coastal habitats, what are their sources, and what are the best approaches for monitoring for them?

The delivery of up-to-date information on the levels and spatial and temporal distribution of chemical and microbiological pollutants in the Australian environment will provide a baseline for evaluating the effectiveness of future regulatory action to reduce pollution. We will use a risk-based framework (as for the Threat and Risk Assessment (TARA) in NSW) yielding information that will direct policy makers/regulators towards the chemicals and microorganisms of highest concern and consider other pressures or risk assessments.

This project will largely rely on consultation through a series of workshops and targeted engagements with partners and end-users in the NESP2 Marine and Coastal Hub communities, underpinned by desktop reviews and research into knowledge gaps. This includes engagement with the:

- NESP Sustainable Communities and Waste Hub
- Paddock to Reef program (https://www.reefplan.qld.gov.au/tracking-progress/paddock-to-reef)
- Outcomes of the NESP Tropical water quality hub

The following is in-scope for this project:

- Desktop research of existing water quality data and knowledge that considers the Australian mainland and its islands, particularly those relevant to Commonwealth Marine Parks

- Activity-based workshops involving key marine data users and collectors across government, industry and academia to develop an understanding of the current available data and knowledge gaps

- Workshop reports communicating outcomes and recommendations

- A project closure report communicating achievements and recommended next steps. This will include a risk assessment, addressing the known and predicted impacts of the range of contaminants highlighted throughout the scoping study, as well as the amenability and readiness of data to be spatially databased on a national scale, so that it can be interfaced with GIS reporting tools.

For more detail on in scope work, workshop topics and deliverables please see the Project Milestones.

The following is out of scope for this project:

Field-based surveys to examine specific aspects of water quality

During NESP-1, a 'National Outfalls Database' project was established to provide comparative information on the volume and composition of wastewater discharged to Australia's ocean and estuaries, using data contributed by water authorities. Data gathered in 2016 from 165 of the 175 ocean and estuarine outfalls provided a snapshot of wastewater discharges into Australia's coastal environment. As part of this project, an active, citizen science, sampling program was also developed at some locations to measure the impact of ocean outfall sites on coastal water quality.

Around the nation a variety of other assessments of marine water quality have been conducted by both researchers and state and local government environmental monitoring/management authorities (e.g. Beachwatch).

The proposed project will identify knowledge and data gaps pertaining to coastal and ocean water quality, by defining the key established and emerging chemical and microbiological water contaminants within Australian marine environments and their relative threats. This will inform decisions for prioritising research and water quality management foci. At a research level, this scoping work will identify areas where further knowledge is required from future targeted research programs, either within the NESP2 Marine and Coastal Hub, or external to the hub. At a decision-making/management level, this project will help to identify key metrics (including emerging threats) for inclusion in water quality monitoring and management strategies.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnership Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

The Project leaders will work with the Marine and Coastal Hub Indigenous Facilitators and Knowledge brokers to identify opportunities for Indigenous participation and appropriate engagement mechanisms. This will include an invitation to participate in project workshops as a means to increase understanding of sea country among project partners and to include Indigenous perspectives and values as part of the prioritisation framework.

Location of research

This project is national in scale and is intended to have impacts across the Australian marine estate. Most work will be conducted remotely, based out of Sydney, but other workshops may be identified.

Project 1.17 – Scoping Study: research needs for a national approach to socio-economic values of the marine environment

Project description

Project summary

Effective management of the marine estate requires recognition of the fact that we live in a connected human-natural system. Human uses of the marine environment often create pressures that drive overall condition, but it is also these uses that create 'benefits' or 'values' in the marine environment. Thus understanding the coupled relationships between humans and nature is essential to managing the marine environment that delivers environmental, social and economic outcomes. In this project we will work with stakeholders (particularly DAWE) through co-design to identify: (a) social and economic research priorities, and (b) existing social and economic data sets to address these priorities. This project includes, as a key differentiation from previous NESP MHB projects, an additional theme on implementation and behaviour change that will ensure research can inform the full pathway from policy to on ground action. This work will set the research direction for projects under the NESP 2 MAC and involve co-designed project proposals.

Project description

Australia's 35,000 km coastline (65,000 km including offshore islands) includes iconic coastal cities, vibrant regions, and natural environments of national and global significance. This marine estate underpins Australia's economy, livelihood, welfare, and international reputation. For example, Australia's 'blue economy' is valued at $68 billion pa. There are however multiple, cumulative pressures that threaten these environmental, social, and economic benefit. The Australian Government is committed to managing the marine estate such that Australians derive maximum social, cultural, and economic benefit. To achieve this, decision makers must balance multiple, sometimes competing, needs from the marine estate such as development, conservation, future proofing ecosystems and communities to climate change, and ensuring future resource needs are met. Delivering on these multiple needs from our marine estate requires a solid understanding of

> (a) the social, economic and cultural 'values' of our marine estate (and, by association, a solid understanding of the tools that are used to 'value' nature) – hereafter **valuing nature**.

> (b) best-practice ways of incorporating values into policy and decision making (including, ways of compiling environmental accounts in wetlands and/or the broader marine environment, of integrating multiple values into planning, and/or through other goal development, assessment and monitoring frameworks) – hereafter **integrating values into policy**; and

> (c) best-practices ways of effecting change through policy, taking into account social and psychological norms and proclivities to respond to, for example, behavioural incentives, market incentives and/or legislation – hereafter **implementing for success**.

A process is required to ensure that the choice of research activities addresses the right questions in the right regions and has strong support from the Department and from other research users. Previous research has identified and collated much biophysical data underpinning marine ecosystem services (e.g. NESP D7 on natural values and pressures, and https://eea.environment.gov.au/accounts/ocean-accounts/geographe-marine-park), and outlined ways

in which collect additional social and economic data to fulfill monitoring needs specific to marine parks (e.g., https://www.nespmarine.edu.au/document/measures-social-and-economic-monitoring-australian-marine-parks).   So initial steps for (a) and (b) have been undertaken. However, a more complete understanding of natural values and conditions is required as the underpinning for valuations. In addition there are new and emerging policy needs and thus scoping will take into account current policy settings that research must be responsive to.

At least some of the data relevant to those values is biophysical, and collated (or being collated through NESP2 work such as project 1.13), but not all. Furthermore, the D6 project was focused on marine parks and while we expect their findings to translate to the broader marine ecosystem, this project will be differentiated in that we start from a whole of marine estate perspective rather than being bounded to just marine parks. Moreover, we are unaware of any previous studies that have undertaken nation-wide reviews to identify knowledge gaps relevant to (c) for marine stakeholders (e.g. fishers). So this project will add value to previous work, focusing primarily on data and literature relevant to regulating service values (for (a) and (b)) and on data relevant to (c).

This project will address these research problems by using consultation and co-design to address:

- What socio-economic dimensions of the marine estate management matter most to marine policy makers/managers in which regions (e.g. world heritage areas, marine parks, coastal wetlands, areas of current/future high-intensity multiple use) and what are the most pressing (socioeconomic) information needs of those policy makers/managers? Answering this question will ensure we are able to prioritise future research efforts.
- What socio-economic methods and tools are available to meet those needs and what information is already available?
- What socio-economic research would be required to fill identified gaps – what data & which methods already exist, and what would need to be generated?
- What are some of the most important gaps to fill, in which region, how long is it likely to take to fill those information gaps, and would filling them help solve an identified problem? (i.e. what questions can we realistically expect to answer within the life of this hub, where, and to deliver which desired environmental outcomes)

The research approach will include: a four staged approach of 1) consultation with key managers of the marine estate (in, for example, world heritage areas, marine parks, coastal wetlands, areas of current/future high-intensity multiple use) to secure our understanding of information needs (some of which have already been provided to the hub), 2) synthesise existing data compilations – focused on those needs – at a national scale (including the identification of available spatial data products on environmental values (e.g. species distributions), threats, pressures to marine estate, and socio-economic uses and values drawing on NESP D7 published work and collaborating with NESP2 Mac project 1.13 for natural values and pressures where relevant), 3) review and synthesis of existing research that is aligned to manager needs for three broad themes (valuing nature, planning for multiple uses, implementing for success in particular drawing from NESP D6 and D7 work) – this will include a number of national and regional-scale data compilations completed by the NESP Marine Biodiversity Hub (e.g. data compilations completed for projects A12 for waters of northern Australia and SS2 for Australia's marine estate), 4) engagement with researchers, decision makers, and managers, verify the synthesis of findings, identify significant information gaps, and consider priorities for future research (noting methods of workshops or other engagement tools may vary due to COVID restrictions in place).

Activities that are in scope include: desktop reviews and synthesis activities; workshops with research users and researchers; consultation and planning meetings; prioritisation processes. Other in-scope activities include consultations with and active consideration of links with socioeconomic scoping studies in the Resilient Landscape Hub. **Activities that are out of scope** include: fieldwork, field-based data collection, socio-economic data collection and valuation work.

Outputs: We propose to have early discussions with marine managers to identify useful output types, so a definitive list is not provided here. Indicative outputs include:

1) A review/synthesis Report, based on published literature. This report will provide managers and research planners with a reference document, and will be delivered in modules addressing three themes (valuing nature, planning for multiple values, implementing for success) for different regions (e.g. GBR, the great southern reef). Each module will provide a non-technical summary of our state of knowledge (with links to key resources and references) and identify key knowledge gaps.

2) An inventory of relevant data sets (and data gaps) relating to known relevant ecological values, threats, and socioeconomic values. Because this project does not intend to generate new data (including social data or economic valuations) we are unlikely to supply direct data sets. The inventory is thus likely to be delivered in metadata format rather than as a compilation of data sets (which will have their own license requirements from the data owners); We expect the inventory will likely be embedded within the report but can also be supplied as a standalone metadata file.

3) Socioeconomic research priorities across the three themes (valuing nature, planning for multiple values, implementing for success) for different regions (e.g. GBR, the great southern reef); and/or

4) Co-designed research project(s) for the future

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

The project leader will work with the NESP2 Marine and Coastal Hub Indigenous Facilitator and Knowledge Brokers to identify opportunities for respectful Indigenous participation in this project. For example, regional native title representative bodies could participate in scoping activities designed to identify knowledge needs and interests.

Location of research

The proposed work is a desktop synthesis and review that will consider nested scales from local to national (e.g. national compilation of data available for research, local case studies such as Great Barrier Reef). Choices of case studies will reflect known research priorities and will include the Great Barrier Reef, responding to the known research needs aligned with the GBR 2050 Reef Plan and RIMReP, and pilot marine accounts to align with EEA research needs.

The research team members (CIs and RA) are based in Hobart and thus the desktop study will take place in Tasmania, but research outputs will provide national scale inferences to be drawn about what knowledge needs should be targeted where for future research and the ability to apply particular methods – such as environmental accounts – based on existing data. The research team will utilise their national networks and research collaborations to provide project outputs at the appropriate scales.

Project 1.18 – Microplastics in South Eastern Australian coastal waters: synthesising current data and identifying key knowledge gaps for the management of plastic pollution

Project description

Project summary

Plastic pollution is pervasive in coastal environments globally and in Australia. Due to their small size, microplastics (pieces <5mm) are readily ingested by marine organisms and potentially accumulate across food webs, raising concerns for biota, ecosystem services and human health. Yet, to define guidelines and support policy actions that curb microplastic pollution, managers and decision-makers lack clear, synthesised information on this multifaceted issue, including on occurrence, sources, and pathways of microplastics in coastal and marine environments. Therefore, this project aims to produce a synthesis of current data on microplastics in South Eastern Australian coastal waters (i.e. South Australia, Victoria and New South Wales) and identify key knowledge gaps for the management of plastic pollution.

Project description

It is estimated that over 8.3 billion metric tonnes of plastics have been produced since the 1950s, with plastic use continuing to increase worldwide[1]. However, large proportions of plastic waste enter the environment and end up in the oceans through many pathways, including river run-off, drain waters or sewage outfalls. Over 80 % of all marine debris is plastic, with plastic pollution an issue of concern worldwide. Impacts of plastic debris on marine life are widely documented including entanglement and false satiation due to ingestion. But plastics also degrade, fragment and leach chemical additives into the environment eliciting a variety of toxicological effects on aquatic organisms[2]. In particular, microplastics (pieces <5 mm) such as microbeads found in domestic and personal care products, clothing fibres or pieces that result from the breakdown and weathering of larger plastics are ubiquitous in marine environments and are found from coastal intertidal habitats to abyssal plains. Due to their small size, microplastics are readily ingested by marine organisms and have the propensity to accumulate across food webs, raising concerns not only for biota and ecosystem services but also for human health via exposure and ingestion of contaminated seafood[3]. However, a greater understanding of this intricate and multifaceted issue requires a comprehensive approach, underpinned by solid information on plastic contamination. Ultimately, to curb microplastic pollution, managers and decision-makers need clear, systematically synthesised information on the current situation of plastic contamination, including on microplastic occurrence, exposure, sources, and pathways, to define coherent guidelines, support policy options and inform evaluations of potential trade-offs that effectively reduce the entry of microplastics into coastal and marine environments.

To address this need, our project will undertake a review of information on coastal and marine microplastic information relevant to South Eastern Australia (i.e. South Australia, Victoria and New South Wales) to characterise the current context, highlight gaps, and help identify and prioritise solutions for improved management of plastic pollution. Specifically, we will:

- Undertake a systematic review, collating and synthesising the latest information relevant to South Eastern Australia, including grey literature, as well as other sources (e.g. NGO databases, government initiatives);

- Identify sources, sinks and potential impacts of microplastics from catchments and outflows to the coastal environment, as well as key knowledge gaps, opportunities and threats to guide microplastic management and support evidence-based policy actions;

- Organise targeted interviews and collaborative workshops with key organisations (e.g. EPA, DEW, SA Water, Melbourne Water, DAWE), NGOs, indigenous associations/leaders who are involved in the collection of plastic in coastal areas, and research groups (e.g. UofA, Flinders, Macquarie, UMelbourne) to supplement data collection, discuss knowledge gaps, and solutions for improved management.

The review will be conducted using tools such as Web of Science or Google scholar, using combinations of keywords relevant to microplastics and coastal areas. Additional data sources will be obtained via reference lists from research papers, grey literature and discussions with stakeholders. Using the information from above, our study will compile findings on the types (e.g. particle/polymers), abundance and chemical composition of microplastics in rivers, catchment, estuaries and coastal areas to identify reported sources, outflow and sinks of microplastic pollution in South Eastern Australia.

Our purpose is to make information readily available to end-users interested in the management of microplastic contamination. The report will compile currently available datasets, draw together the outcomes of interactions and workshops with stakeholders and end-users, and summarise findings and recommendations regarding key knowledge gaps, solutions for improved management, and future priorities.

We will focus on South Eastern Australia, where the greatest density of major population centres are located, and build on ongoing research on sediment, water (including wastewater) and biota, as well as on the expertise and knowledge of AUSMAP (Australian Microplastic Assessment Project / Total Environment Centre). Overall, the project will provide critical information to inform the development of mitigation and action strategies to reduce microplastic pollution in coastal and marine environments in South Eastern Australia, and beyond.

The development of a scoping document synthesising the information available on microplastic in coastal marine environments will support relevant state and local agencies to better understand plastic pollution issues. In doing so, it will also provide evidence to tackle gaps in knowledge that constrain the effective management of this growing problem. The study will also allow partners and stakeholders from different jurisdictions to compare management strategies and identify solutions to help position them for improved management.

Microplastics in coastal and marine environments are a priority issue for multiple stakeholders, including local and state governments, industry and the general public. Our comprehensive assessment compiling information from multiple sources responds to national priorities regarding the impacts of marine debris[4,5,6], and aligns with NESP's [i.e. Marine and Coastal Hub, Sustainable Communities and Waste Hub (SCaW)] cross-cutting priorities to deliver targeted information, support policy development, and management tools to reduce the impact of plastic waste in Australia's marine and coastal environments.

This project aims to engage with a broad range of end-users (national and state), leveraging their input as part of the process of compiling and synthesising information, to deliver information and structure project outputs that respond to critical end-user needs. In particular, we have discussed this proposal with the EPA, NSW DPIE, DEWA and water authorities in each of the three states, as well as local councils, who are all highly supportive of the proposed broad-scale scoping assessment. We will advance cross-hub collaborations with SCaW to deliver information, provide recommendations, and support management and regulatory processes to reduce the impact of plastic waste - a core element of SCaW's cross hub mission. Ultimately, we anticipate outcomes will help understand local and broad-scale plastic pollution issues, the potential impact of different sources, identify gaps in knowledge, discuss solutions for improved mitigation and management, as well as inform future work, underpin policy development, decision support tools and evidence-based priority actions.

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[2] Miller ME et al. (2020) PloS One (2015): e0240792
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[5] DAWE (2018) Threat Abatement Plan for the impacts of marine debris on the vertebrate wildlife of Australia's coasts and oceans. Department of Agriculture, Water and the Environment
[6] National Marine Science Committee, white paper on Urban Coastal Environments: Coastal Contamination theme

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category three projects communicate and share results with relevant Indigenous organisations.

The project team will work with the Hub's Indigenous facilitator with the view to seeking to engage with relevant Indigenous organisations. For example, we can seek opportunities for indigenous engagement to communicate the objectives of research, explore the prospect supplementing data collection and discuss local solutions. We could also seek to engage with the South Australia Sea Country Research Working Group.

Traditional owners and community stewardship are key to public awareness, developing insight and raising ambitions to tackle the problem of plastic debris in coastal and marine environments. Many coastal clean-up projects are driven and supported by traditional owners and Indigenous land managers.

Location of research

The research will be desktop, in collaboration among researchers but also end-users. The project will focus on South Eastern Australia (i.e. South Australia, Victoria and New South Wales).

Project 1.19 – Scoping Study: Horizon scan of key science questions in the decommissioning of offshore oil and gas infrastructure

Project description

Project summary

This project will address the growing global issue regarding the decommissioning of end-of-life offshore oil and gas (O&G) infrastructure with the aims of building the scientific evidence to support the decisions to either remove structures for onshore disposal (full removal is the default regulatory position in Australia under the OPGGS Act 2006) or leave them in the ocean for re-use as artificial reefs or other purposes (which would require a sea dumping permit under the Environmental Protection (Sea Dumping) Act 1981). The project will generate a collaborative scientific paper outlining the top pending science questions regarding the decommissioning of offshore O&G infrastructure and will provide a comprehensive road map for the coming decade on research priorities for this topic.

Project description

Background: Thousands of offshore O&G structures are approaching the end of their operating life globally. Most countries with offshore O&G activities, including Australia, have policies that require, at least as the 'base case', these structures are to be fully removed from the seafloor for onshore recycling and/or disposal. But there is growing interest from various stakeholders in expanding the range of allowable decommissioning options to improve on environmental, social (including safety), and economic outcomes. However, there are many unresolved science questions that must be addressed to inform best decommissioning decision-making and practice; but to date, there is no global consensus on what these issues are, and how they should be addressed.

Goal: This proposal to develop '*A horizon scan of key science questions in the decommissioning of offshore oil and gas infrastructure*' seeks to directly address this gap by providing a collaborative scientific paper on the top pending science questions regarding the decommissioning of offshore O&G infrastructure and a comprehensive road map of research priorities for the coming decade.

Approach: The project team will identify and select leading offshore O&G decommissioning experts – from industry, regulatory, and academia – to freely contribute from their perspective the top pending science questions relating to the decommissioning of offshore O&G infrastructure. Experts will be solicited across the full range of stakeholder fields as appropriate to the project's scope. The responses received will then be collated, themed, and presented at an online workshop where participants of the survey will vote and agree upon a final list of key questions to include within the project deliverable. The project team will form and lead response participants within writing teams as based on their expertise, each team addressing an individual key question. These writing teams will contribute towards the writing of a high-impact paper to be published in a peer-reviewed scientific journal, with the combining of the team's efforts coordinated, collated, and managed by the project team. The paper will be written for a broad audience to ensure that the research findings and recommendations are accessible to all stakeholders concerned with offshore O&G decommissioning.

The field of decommissioning science is developing rapidly and moving toward a synthetic approach. The opportunity now exists to contribute through this collaboration in a way that could have an influential and longstanding impact on future directions.

This collaborative 'expert solicitation' approach to developing horizon scan papers, as described above, is gaining popularity in many science fields as a transparent and systematic way of reaching consensus on an emerging topic. The proponent/project leader of this proposal (Prof. Peter Macreadie) has recently had success with this approach leading to multiple publication in high-impact journals, including within the O&G sector and the blue carbon field, respectively:

- Macreadie et al. (2018) Eyes in the sea: Unlocking the mysteries of the ocean using industrial, remotely operated vehicles (ROVs). *Science of the Total Environment*, *634*, 1077–1091. https://doi.org/10.1016/j.scitotenv.2018.04.049; and
- Macreadie et al. (2019) The future of Blue Carbon science. *Nature communications*, 10(1), 1-13. https://doi.org/10.1038/s41467-019-11693-w.

Indigenous consultation and engagement

This a Category 3 (Indigenous Partnerships Strategy) project. Given the global and offshore ocean-based nature of this project's scope, and its focus on expert elicitation, a targeted approach for Indigenous consultation and engagement is not envisaged here. However, Indigenous groups will be included as part of the projects' general engagement and knowledge repatriation. It is also further noted that the National Decommissioning Research Initiative (NDRI) will, during 2021-2022, be conducting a scoping study on oil rig decommissioning that will cover social stakeholders more broadly than is possible here. Prof Macreadie is the chair of the NDRI science committee and will have significant exposure to that scoping study. Further, efforts will be made by the project team to ensure diversity and inclusion across all stakeholders involved in the project is achieved, as applicable to the project's scope.

Location of research

This project will involve desktop research only, with virtual meetings, with all research conducted by Deakin University's Blue Carbon Lab personnel. The research output will be applicable globally.

Project 1.20 - Scoping Study: Marine and Coastal Threatened Species and Communities

Project description

Project summary

There are numerous species and ecological communities in Australia's marine and coastal environments that have formal threatened conservation status. Through a process of targeted reviews, expert elicitation and workshops with end-users, domain experts and others, this project will identify and co-design prospective research projects that best deliver information that will notably improve the status of key selected threatened species in Australia's marine and coastal environment. Outputs will include summaries of workshops outcomes and a set of co-designed research proposals for submission in future Hub annual research plans. This project also provides the platform for MAC Hub contributions to the RL Hub Cross-Hub Mission Project 7.0 on Threatened and Migratory Species and Ecological Communities.

Project description

Australia has 1890 threatened species and ecological communities listed as Matters of National Environmental Significance (MNES). There are also additional species listed because of Australia's responsibilities under migratory species and bilateral agreements. Whilst most of these are terrestrial, hundreds occur in the marine and coastal environment.

The Resilient Landscapes Hub has been charged with leading the cross-hub 'Threatened and Migratory Species and Ecological Communities' mission to support policy development, program management and regulatory processes to protect Australia's environmental assets in terrestrial, coastal and marine environments. This scoping study commits MAC Hub resources to working in collaboration with the RL Hub cross-hub Mission and to also pursuing some additional activity specifically related to identified marine and coastal priorities.

The program of work will focus on planning future research priorities needs and gaps, some of which will be proposed for funding by the MAC Hub under RP 2022 and future research plans. Project activities will include scoping, prioritising and co-designing a series of proposals for consideration under future research plans.

No fieldwork or field-based data collection are proposed in this project. It will rely on desktop reviews and synthesis, development of discussion papers, scoping workshops and consultations/planning meetings and other consultation activities. The Department of Agriculture, Water and the Environment (DAWE) has already provided a long list of research actions that will act as a starting point for this engagement and prioritisation process. However, the most effective conservation actions will require the support of a range of other key end-users and stakeholders who must also be engaged in this process.

A specific list of project outputs cannot be stated at this time, but it is anticipated that there will be a series of review and synthesis documents, workshop outcome reports and research plans developed. DAWE have provided a preliminary list of research needs as a starting point, but additional, wider consultation and initial scoping workshops may identify the need for additional priorities that will be considered during this planning phase.

In a small number of cases, prior discussions with DAWE means that more specific activities have been proposed (e.g., review of conservation plans for listed entities of development concern as identified with DAWE, using factors developed with DAWE) to be undertaken by researchers from the

MAC Hub in partnership with the RL Hub. In addition, the MAC Hub have, in this research plan, commissioned specific research on high priority threatened species topics - shorebirds (proposed under Project 1.21), bycatch reduction of sawfishes (proposed under Project 1.25) that also take advantage of specific review/synthesis and workshop processes to define future research priorities.

The MAC Hub will engage with a range of end-users, starting with a series of meetings with DAWE managers and working outwards from there. This will provide guidance on priority scoping actions that will guide the workshop and research development processes. It is highly likely that there will be a requirement for scoping processes across a range of key species groups such as marine mammals, marine turtles, bony fishes, sawfishes, sea snakes, shorebirds and seabirds, as well as ecological communities such as the giant kelp forests of SE Australia. Each will require the commissioning of relevant domain experts to lead sub-programs of work as appropriate to the tasks identified through the consultation process.

It is important to take the time to maximise the effectiveness of MAC Hub investments in future research plans. By taking this time and involving a range of end-users in a considered planning, consultation and prioritisation process, we will increase the likelihood of on-ground outcomes and long-term adoption. Doing this through an inclusive process that engages a wide range of end-users and stakeholders will have a number of important benefits. The Hub's research is far more likely to be used and result in on-ground action if local and regional stakeholders are engaged throughout the research process. Research that the Hub undertakes will have strong local and regional support and will therefore be much more likely to attract additional co-investment, which will add considerable value to the NESP investment. The Hub is likely to forge much stronger partnerships with local and regional organisations and this will increase access to a broader range of potential research sites.

In summary, this project involves a number of steps:

1. Undertake desktop reviews of knowledge gaps and research needs from past processes and documents, including how previous research is being used.

2. Identify potential key end-users including from state and federal governments, community and industry groups and NGO's.

3. Hold series of thematic domain workshops with key end-users to discuss findings of desktop reviews and undertake facilitated discussions to co-identify priority research questions and identify potential collaborators and co-investors.

4. Synthesise the outcomes from domain workshops and identify research co-ordinators and team members to lead the co-development of potential research projects.

5. Cross-check potential projects with other Hubs and the cross-Hub Mission Leader

6. Hold follow-up workshops and meetings with identified researchers and research users to co-develop more detailed research proposals in a collaborative process and establish project and/or regional steering committees. These project proposals will be included in Research Plan2022 and RP2023.

7. Produce reports that summarise the key issues and next steps on priority issues.

Indigenous consultation and engagement

This a Category 2 (Indigenous Partnerships Strategy) project. Clearly, the topic of this scoping study has significant relevance to Indigenous people. Given the specific topic and nature of the scoping study will evolve during its conduct, engagement with Indigenous people on specific topics has not been possible thus far. Indigenous stakeholders (particularly those with sea country) will be consulted and engaged throughout this project. This will occur in partnership with the RL Hub Cross-Hub Mission so as to avoid doubling up on consultation with the same Indigenous groups/people. As per the objectives of the MAC Hub Indigenous Engagement Strategy, researchers in this project will be

advised of relevant Indigenous groups and strongly encouraged to engage meaningfully. This project will also interact with the Indigenous Facilitators from all Hubs and with the proposed Indigenous engagement project in RP2021 of the MAC Hub.

Location of research

Though this is essentially a desktop project, it is national in scale in that it covers a variety of species and habitats across the nation. However, it will also provide planning for future activities that may be more localised.

Planning workshops will be conducted at a variety of geographic localities across the country and participants are expected to attend from all states and territories.

Project 1.21 - Australia's Coastal Shorebirds: Trends and Prospects

Project description

Project summary

Australia's coastal migratory shorebirds are declining rapidly, making them the focus of intense conservation efforts by multiple levels of government domestically and overseas. This project will deliver policy-ready results to DAWE in the form of (i) an updated national trend analysis to map the severity and geography of declines, (ii) data on whether the declines have decelerated, and (iii) data on the relative contribution of Australian and overseas causes of decline. Outputs will feed directly into planned threatened species listing updates in 2022, followed by a major update of the Australian Government's Wildlife Conservation Plan for Migratory Shorebirds. Results will also inform conservation action through Australia's Migratory Shorebirds Conservation Action Plan.

Background

Coastal Australia is home to 37 regularly occurring migratory shorebird species, with many protected areas including Ramsar sites designated on the basis of shorebird populations. Many migratory shorebirds are declining rapidly, and hence the focus of conservation efforts at multiple levels of government in Australia and overseas. However, trend data are now nearly 10 years old, meaning the information available to assess where conservation actions are needed most urgently and whether conservation efforts are helping species recover are outdated.

To ensure populations have the best chance at recovery and that resources are allocated where they are most likely to have the greatest positive impacts, it is critical to maintain up-to-date information on species trends. The timing of this analysis could not be better. The Australian Government Department of Agriculture, Water and the Environment (DAWE) and the Threatened Species Scientific Committee (TSSC) are planning a major reassessment of Australia's migratory shorebirds and DAWE is further planning to expand the Australian Government's Wildlife Conservation Plan (WCP) for Migratory Shorebirds in 2022. Both initiatives require current trend information for migratory shorebirds. Updated population trends would also contribute to fulfilling Australia's international commitments under three bilateral migratory bird agreements with Japan (JAMBA), China (CAMBA), and the Republic of Korea (ROKAMBA), and directly inform and guide conservation action through the 2022-2026 iteration of Australia's Migratory Shorebird Conservation Action Plan.

Aims and objectives

This project will analyse 30 years of shorebird monitoring data collected by citizen science groups across Australia and curated by BirdLife Australia's National Shorebird Monitoring Program (**Key Partner: BirdLife Australia**). The first national trend analyses used data from up to 2012 (Studds *et al*. 2017, *Nat Commun*, 8, 14895) and 2014 (Clemens *et al*. 2016, *Emu*, 116, 119), and results of these studies prompted EPBC threatened species listings for 8 species. This proposed study will update the national trend estimates, while also assessing the relative effects of human pressure and conservation efforts on population trends. This project will set the stage for building the next decade of coastal shorebird conservation activity in Australia, coordinated through the national mechanism of the **End User: National Migratory Shorebird Conservation Action Plan Steering Committee**, with representatives from national and state governments as well as leading shorebird experts.

Aim 1: Updated national trend analysis to map the severity and current distribution of decline

National shorebird monitoring data are immediately available from **Key Partner: BirdLife Australia**. We will estimate trends in abundance of the 37 regularly occurring international migratory shorebird species that visit Australia using hierarchical Bayesian models implemented in JAGS. Site-specific intercepts and slopes will account for variation in the average number of shorebirds and trend in shorebird numbers across sites, and we will generate annual scaled predicted abundances at regional and national scales. We will then calculate average annual percent change between the first and most recent year of the time series (or during any time period chosen, e.g., three generations for a particular species as per TSSC assessment criteria). National trend estimates will directly inform assessments by the Australian Government (**Key End Users: Migratory Species Section, Wetlands Policy Section DAWE; Threatened Species Scientific Committee**) as they deliberate appropriate listings for migratory shorebirds in 2022.

Aim 2: Determine whether declines have decelerated through conservation efforts

Recent conservation efforts around Australia and overseas might already have reversed some shorebird population trends, while other threats such as hunting may have been underestimated. Given this uncertainty, we will interrogate the results of the trend analyses to look for change in decline rates. We will statistically determine whether annual rates of change show any long-term trend, and establish which species are experiencing acceleration or deceleration in their declines. We will also collect information on conservation efforts within and outside Australia (e.g., newly designated protected areas, changes in protected area management) to test for associations between the level of conservation efforts and species' trends, including an assessment of National Reserve System coverage of important shorebird sites. The results will feed into the update of the WCP for Migratory Shorebirds (**Key Partner: Migratory Species Section, Wetlands Policy Section DAWE**).

Aim 3: Identifying regional hotspots of Australian impacts on shorebird populations

Habitat loss at key migration sites in the Yellow Sea has impacted Australia's migratory shorebirds, but Australia's coasts are also under pressure. While a full assessment of the drivers of decline is beyond the scope of this project, by estimating trends at multiple spatial scales (site, regional, national) we will identify regions where conditions within Australia are contributing strongly to shorebird population changes. We will do this by (i) quantifying heterogeneity in site-level trends in relation to regional trends to separate local from overseas drivers of population change and (ii) examining trends in the number of sites capturing ≥ 90% of species annual regional abundance. Regions with heterogeneity in site-level trends and where abundance is increasingly concentrating at fewer sites are potential conservation priorities for the 2022-2026 Migratory Shorebirds Conservation Action Plan (**End Users: Migratory Species Section, Wetlands Policy Section DAWE; National Migratory Shorebird Conservation Action Plan Steering Committee**).

Outputs and outcomes

This project arose from discussions with DAWE's Migratory Species Section, Wetlands Policy Section (Ramsar), the TSSC, and BirdLife Australia. Project outputs directly inform policy decision-making and on-ground conservation action both in the near- and long-term. They comprise **Output 1:** updated national and regional population trend estimates; **Output 2:** identification of regions in Australia where coastal conditions are contributing most to migratory shorebird population changes; and **Output 3:** recommendations on national conservation and research priorities for the next decade.

Outputs will immediately support the reassessment of migratory shorebirds by DAWE in 2022 by providing species-level estimates of national population trends and data on which threatened species listing criteria each species meets. We also expect strong interest from the Office of the Threatened Species Commissioner, especially concerning our findings for the national priority species, Far Eastern Curlew (*Numenius madagascariensis*). Second, DAWE indicated that results will feed into "a major update and expansion to the WCP for Migratory Shorebirds" and "guide migratory shorebird conservation in Australia for the next decade". Third, findings can immediately be translated into on-

ground action across Australia through the National Migratory Shorebird Conservation Action Plan in its upcoming 2022-2026 iteration. Fourth, DAWE has indicated that the research is "highly relevant to significant populations of coastal and migratory shorebirds on Christmas Island National Park, Pulu Keeling National Park, Norfolk Island, Kakadu National Park. Booderee National Park. Possibly relevant to coral cays in Coral Sea and Ashmore Reef marine parks. Longer term outcomes include a strategic assessment of future research and conservation priorities for coastal migratory shorebirds in Australia and throughout the East Asian-Australasian Flyway. This project will incubate those ideas and develop a larger strategic project on coastal migratory shorebirds that might be of interest to the Hub in coming years. Such a project could be broadened to include seabirds and comprise a full assessment of drivers of decline including impact of ingested plastics, connectivity between Australian and overseas sites, threats to important Australian sites, and development of management and habitat restoration guidelines.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

Substantial shorebird monitoring data has recently been collected by Indigenous organisations, notably the Carpentarian Land Council. We have been unable to initiate meaningful conversations about this new project within the brief timeframe of the current proposal development, but we intend to use this project to forge strong partnerships with these initiatives, learn about the discoveries about shorebirds in northern Australia arising from these projects, and work towards integrating those data into national and international analyses. Indigenous organisations have partnered with BirdLife Australia for shorebird monitoring in the NT, the Gulf of Carpentaria and Cape York, a firm and strong basis for further discussions. The project team will work with the Hub's Indigenous facilitator to plan a way forward to communicate and share results with relevant Indigenous organisations.

Location of research

This project is a desktop study that is national in scale, with outputs that will impact migratory shorebird conservation both nationally and regionally. The majority of the desktop research will take place at The University of Queensland School of Biological Sciences.

Project 1.22 – A photo-identification study of southern right whales to update aggregation area classification in the southwest of Australia

Project description

Project summary

The population of Southern Right Whales (SRW) in the Southern Hemisphere has been recovering slowly from near extinction due to its decimation from whaling before its ban in the mid-1970's. As the species recovers, there is increasing evidence of expansion of aggregation areas. Consequently, there is a need to update known established aggregation areas and Biologically Important Areas (BIAs) and update relevant Marine Parks management plans based on new evidence. This project proposes to collate and complete photo-ID matching since 2010 to 2020 in the southwest of Australia and upload images to the National ARWPIC catalogue. Evidence and recommendations will be provided, and results communicated to key stake holders, including national and state government departments, Wadandi Noongar aboriginal elders and Traditional Custodians and local Aboriginal Corporations, the commercial tourism and fisheries industries, the education sector and the local government and community.

Project description

Problem statement

Southern Right Whales (*Eubalaena australis*) are a highly regarded ecological value to Australia. The population of SRW in the Southern Hemisphere has been recovering slowly from near extinction due to its decimation from whaling before its ban in the mid-1970's. Two sub-populations occur in Australia – the eastern and the western. The western sub-population was estimated in 2018 at only 3200 with an increasing trend of ~6% (Smith et al. 2019; Bannister 2010, 2016). The species is **nationally** listed as **endangered** under the EPBC Act (1999), thus is a high priority species. Its continued recovery and its expansion into suitable breeding habitats is identified as a regional high priority (DSEWPaC, 2012).

The western sub-population of SRWs seasonally migrates between June-September to three large established (Head of Bight, Doubtful Island and Israelite Bay), two small established (Yokinup Bay and Flinders Bay) and four emerging aggregation (Twilight Cove; Hassel Beach; Cheyne, Wray, Dillon, and Bremer Bays; and Flinders Bay) nationally recognised areas, affording SRW greater protection at these sites (DSEWPaC, 2012). As the species recovers, there is increasing evidence of expansion in aggregation areas with SRWs returning to historic calving grounds (Burton et al. 2019; Charlton et al. 2019). Consequently, there is a need to update known established aggregation areas (DSEWPC, 2012) based on new evidence – a task that is particularly timely as the SRW Recovery Plan is due for review. Moreover, with increasing anthropogenic pressures in many of these areas, a re-assessment and dissemination of knowledge will ensure that it can be integrated into updates of Biologically Important Areas (BIAs) of Regionally Significant Marine Species (DAWE 2021) so that threats can be assessed more accurately and managed effectively.

A large number of vessel and land-based lateral and aerial (drone) photographs of SRW has been collected since 2010 in Australia's southwest (Flinders and Geographe Bays) by the proponents of this project who lead a long-term citizen science program on whales ('Southwest Whale Ecology Study' (SouWEST; http://souwest.org), now being integrated into the Geographe Marine Research Ltd.). SRWs can be readily identified by discerning unique patterns of callosities in their head region

captured in photos (called 'Photo-ID'). Through Photo-ID matching, SRW abundance, residency movement patterns, and life history information can be obtained to evaluate whether areas occupied by SRWs meet the Commonwealth criteria for classification as aggregation areas. Image pre-processing so far undertaken up to 2018 has produced over 600 photos with sufficient feature visibility and quality to include in matching, with over 70 individuals so far identified (Burton et al. 2019). With increased effort between 2018-2020 and prioritization of drone photo captures, invaluable new information is to be added to the existing pre-processed data for a full analysis of a decade of images. While Flinders Bay is recognised by the Australian Commonwealth as an emerging calving ground (DSEWPaC, 2012), based on new unpublished pre-processed SRW photo-ID images collected, it may well fit the criteria as a small aggregation area (DSEWPC, 2012). Geographe Bay has not yet been classified; however, data indicate that at the least, it fits the criteria for an emerging aggregation area, and may well fit those of a small established aggregation area (DSEWPC, 2012).

In contrast to Project 1.26, this project provides entire-season information required to update aggregation areas based on criteria regarding the total number of mother-calf pairs occupying the area and their residency periods (among other key criteria). Project 1.22 provides relative abundance and trend assessment over a broad area and brief window in time. These two projects are complementary, and together, significantly progress SRW management needs identified in the SRW Recovery Plan.

Description of research

This project will collate and complete photo-ID matching since 2010 to 2020 in the southwest of Australia (Flinders and Geographe Bay) with the feature scoring and image quality grading system used for the Australasian Right Whale Photo-Identification Catalogue (ARWPIC; AMMC 2021) applied for consistency. Following matching, Photo-IDs will be uploaded to the ARWPIC catalogue. Integration with the ARWPIC Catalogue will allow future comparisons among regions to be undertaken for a broader context. The work is proposed over a 9-month period, anticipated to begin August 2021.

Outputs to inform decision making

- A report including evidence and recommendations for updating aggregation area classification in the southwest of Australia according to the Commonwealth criteria will be provided. The report will be prepared in the form of a manuscript to be submitted for scientific peer-reviewed publication.

- Uploaded Photo-IDs from the southwest between 2010-2020 into the ARWPIC catalogue.

- Engagement and delivery of knowledge to key stakeholders, including the national and state governments responsible for EPBC listed species protection and managing of marine parks (Department of Agriculture, Water and Environment; Parks Australia; and WA Department of Conservation, Biodiversity, and Attractions), WA Department of Primary Industries and Regional Development (DPIRD), regional Elders and Cultural Custodians and Aboriginal Corporations (Undalup Association Inc. and Wadandi Noongar Elders Wayne Webb, Kelton Pell, Toni Webb and Sandra Hill and Wadandi Cultural Custodians Izaac Webb and Willian Haywood), tourism stakeholders (commercial whale watching companies and Busselton Jetty Inc. https://www.busseltonjetty.com.au/), local government (Busselton shire), and the local community.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a desktop study. Category 3 projects communicate and share results with relevant Indigenous organisations.

Consultation and engagement of regional Elders and Cultural Custodians and the Aboriginal Corporations (Undalup Association Inc. and Wadandi Noongar Elders Wayne Webb, Kelton Pell, Toni Webb and Sandra Hill and Wadandi Cultural Custodians Izaac Webb and Willian Haywood) will be undertaken as a key component of this work. The project will also support local aboriginal small business and elders through provision of acknowledgements, their sharing of cultural knowledge and welcome to countries where appropriate.

In 2020, the proponents supported the Pioneer Aboriginal Corporation with the Undulup Association's collaborative Camp program for aboriginal kids by running a Whale Dreaming event. The Camp provided the opportunity for aboriginal children from different regions to connect while learning from elders and increasing their knowledge of the diversity of the Noongar Nation. The proponents would look to integrating the new knowledge into future programs to connect kids to culture, science and nature in Western Australia.

Location of research

The project will be undertaken in the southwest of Australia, and has local, regional and national relevance. The photo-ID images have been collected in Ngari Capes Marine Park (which include Geographe Bay, Flinders Bay, and the Capes region; see Figure 1 below). On-ground stakeholder engagement will be undertaken in the broad southwest (Perth to Augusta and beyond), and virtually at the national level for Commonwealth and other relevant stakeholders. Data processing, analyses and report writing will occur in n Perth (at Edith Cowan University) and in Dunsborough (near Busselton, WA).

Figure 1. Region in which southern right while photo-ID images have been taken, including Ngari Capes Marine Park (Geographe Bay, Flinders Bay, and the coast between the Capes Leewin and Naturaliste), Western Australia.

Project 1.23 – Conservation of spotted handfish

Project description

Project summary

Spotted handfish are a critically endangered fish that inhabit a rapidly developing coast. We will continue to conserve them with on-ground actions guided by research. Previous NESP work (A10) helped developed a 23-year time-series of surveys, increased biological understanding and established effective management actions. This new work will recommence surveys of multiple local populations, after a two-year gap, to ensure potential impacts of development of the Derwent estuary and surrounds handfish populations or their habitats can be detected. We will also identify where to plant Artificial Spawning Habitats (ASH) where natural spawning structures have declined. We will continue to support our captive breeding program with industry and foster engagement with the indigenous and broader community through participation, talks, outreach, publications, and the National Handfish Recovery Team (NHRT).

Project description

Spotted handfish (*Brachionichthys hirsutus*, Lacepède, 1804) are a shallow water anglerfish, which were once common across the bays and estuaries of South-East Tasmania. By 1996, however, they had declined in numbers and were listed as Critically Endangered. Spotted handfish are a member of the most endangered family of bony fishes (Stuart-Smith et al. 2020) and are, with red and Ziebell's handfish, currently the subject of a Recovery Plan (DoE 2015).

Spotted handfish are habitat specialists (Wong et al. 2018) with no planktonic life stage to aid dispersal. Rather, they directly recruit from parentally guarded egg masses, which have been laid onto benthic structures such as stalked ascidians. Our new understanding of handfish genomics (Lynch et al. 2020) also discounts widescale adult or juvenile emigration, with local populations being genetically well-structured even within the confines of the Derwent estuary. Spotted handfish are a relatively short-lived species, with a maximum age of 10 years, and with 90% of the observed population ≤ 5 years of age (Bessell 2018). As they don't reach adulthood until they are >2 years old (Bruce et al. 1998), this only leaves a short window for reproduction. If spawning fails, then population declines may occur rapidly as cohorts quickly pass through the limited opportunity for breeding and die out. With low adult dispersal, outside recruitment to re-establish collapsed populations is also unlikely.

Analysis of 23 years of handfish survey data (1997-2019) showed that periodic collapses and booms occur across local populations, and the rates of change suggest that annual surveys are required to effectively respond with management interventions (Stuart-Smith et al. 2021). We hypothesize that declines in handfish populations occur both from chronic pressures and stochastic events. Chronic pressures include introduced pests like the northern Pacific seastar (*Asterias amurensis*) which consume the handfishes natural breeding habitat of stalked ascidians (Ross 2001; Ross et al. 2003) and vessel moorings, which more generally destroy habitat (Lynch et al. 2015). Examples of stochastic events include a local extinction at Primrose Sands in 2005 after a storm event (Green 2007) and a more recent decline at Ralphs Bay, following a bloom of eutrophicating algae (Lynch et al. 2016). Handfish population booms, the result of successful recruitment of cohorts, may be linked to the planting of Artificial Spawning Habitats (ASH) (Lynch et al in prep). Previous research has shown that targeting ASH plants to locations were stalked ascidians are sparse, provides an efficient approach to this conservation intervention (Hormann 2019).

There are a wide range of industries and human activities that have overlaps with spotted handfish populations. These activities have increased in tempo with the renewed economic growth of the greater Hobart region. Activities include increased demand for coastal infrastructure such as jetties, moorings, and wharfs as well as larger scale developments such as marinas and aquaculture. Other infrastructure such as marine pipelines or cables may also provide a barrier to handfish movements and further fragment local populations. Changes to adjacent catchment processes, such as new developments may increase sediment and nutrient loads, which can produce algal blooms that smoother habitat. Anchoring of vessels near-shore, on top of local handfish populations, may also impact the species, especially in the breeding season. During the previous period of research, numerous planning, and development authorities and both proponents and opponents sort advice regarding impacts on spotted handfish. A new development, the Arm End golf course and associated re-cycled water irrigation scheme, borders three local spotted handfish populations that are a distinct genomic grouping. We have engaged with Arm End and collaboratively identified a need to undertake surveys of these local populations and compare to the other more remote populations as part of their mitigation plan to avoid any negative environmental impacts.

To answer key research questions to inform conservation management of spotted handfish we proposes to: 1) continue the long-term survey program at 9 locations and model our results, 2) count ascidians during surveys to target future ASH plants at locations with low densities of natural spawning habitat, 3) provide advice on mitigation for government and industry regarding any observed impacts on local spotted handfish populations in this rapidly developing urban estuary, 4) maintain our Ambassador Fish and captive breeding populations with our industry partners, 5) integrate an indigenous CSIRO staff member as a diver on the survey program and build both knowledge exchange and outreach with this community as well as the general public, 6) use this outreach knowledge to identify any unknown local populations of spotted handfish and 7) collaborate with a Netflix film crew who are filming spotted handfish behaviour for The Blue Planet II.

Methods and locations are now well established (Lynch et al. 2015; Foster et al. 2017) and our proposal is to continue to survey the 9 Derwent estuary sites prior to the handfish breeding season (August 2022), conducting 8-10 transects at each. This will avoid the third year of data gaps in our time-series, which would be the longest gap since surveys commenced in 1997. This addresses Recovery Plan Actions 4a, 4b, 4d and 4e. Besides handfish, we will also count ascidians on transects, which allows for the efficient targeting of future ASH plants at locations where ascidian density is sparse (Lynch et al. 2018; Hormann 2019) (Actions 1c, 1d). The surveys also provide performance assessment of the ASH planting and other conservation interventions at a population level.

Establishment of captive bred populations of handfish is a priority for both State and Federal governments (Actions 3b-c) to raise the profile of the species as 'Ambassador fish' and as an intervention to avoid extinction. In partnership with SEALIFE Melbourne Aquarium and Seahorse World and with permitting from CSIRO the State and Federal government, we have established two captive populations of spotted handfish. While progress has been made with captive breeding, it is not yet routine or predictable. We will maintain these captive populations with our industry partners with new brood stock as required. From these outputs we will submit a population modelling paper to a high impact journal and a technical report. Two other related papers (handfish genomics and Environmentally Friendly Moorings – EFMs- for habitat conservation) are also in late stages of drafting. Footage from the Netflix film crew will also be made available for use by NESP.

Preliminary modelling suggests that the spotted handfish population have stabilised and may have benefited from the planting of ASH. Previous outreach work as part of A10 identified four new local populations outside of the Derwent estuary. The new project will move to further secure spotted handfish from extinction, allow for continued recovery and potentially improvement of spotted handfishes conservation status. We will continue our Ambassador Fish program with our industry partners and look forward to captive breeding success and re-stocking of sites where fish have become locally extinct. We will also continue our surveys of local populations, which will allow for robust performance assessment of the above management actions and to quickly detect any local

impacts. We will continue our outreach program with, industry, scuba clubs, community groups, government, MAST, mooring owners, citizen scientist, schools and the indigenous community.

The spotted handfish is being conserved via a Recovery Plan which is implemented by the National Handfish Recovery Team (NHRT), the PI and CI are members of the team and report progress on a semi-annual basis. The NHRT is constituted between the Tasmanian State and the Commonwealth government, and also includes member from UTAS, CSIRO, Zoo and Aquarium Association, Australia Sea Life Melbourne Aquarium, Seahorse World, Sydney University, Marine Life Tassie, Reef Life Survey Foundation, Aquenal and Marine Solutions. We also provide reports to Derwent Estuary Program, NRM South, MAST, Arm End and the Office of the Threatened Species Commissioner.

There are two Environmentally Friendly Mooring (EFM) projects that link to this research. The first is in North West Bay in Tasmania and the other is in NSW. These projects aim to further develop the CSIRO's EFM designs and encourage the uptake of EFMs through both the development of standards and incentives. EFMs provide a method to decrease destructive impacts on spotted handfish habitat. Two PhD projects, on red handfish and EFMs are also underway (year 2 and year 3 respectively). Captive breeding work on spotted handfish has informed similar work on other species, such as red handfish.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement. Category 3 projects communicate and share results with relevant Indigenous organisations.

The project team will reach out to relevant Indigenous representative bodies in South-east Tasmania to communicate the research project objectives and findings. The project team will include an Indigenous CSIRO staff member on the handfish dive team who will also assist with reaching out to relevant Indigenous representative bodies in South-east Tasmania.

Location of research

There 9 long-term monitoring sites in the Derwent will be surveyed. This work is at the regional scale. Sites names and GPS locations are provided.

Location of research for spotted handfish

Site	Code	Estuary	Lat	Long
Battery Point	BP	Derwent	-42.88944	147.33937
Half Moon Bay	HMB	Derwent	-43.01396	147.40306
Opossum Bay	OB	Derwent	-42.98298	147.39555
Ralph Bay	RB	Derwent	-42.93350	147.42542
Mary-Ann Bay	MAB	Derwent	-42.97004	147.40157
Sandy Bay	SB	Derwent	-42.90749	147.34911
Howrah Beach	HB	Derwent	-42.88295	147.39508
Tranmere	TR	Derwent	-42.92501	147.41055
Bellerive	BR	Derwent	-42.88010	147.37820

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Project 1.24 - A pilot study into the movement and dispersal of sawfishes

Project description

Project summary

The aim of this project is to test the utility of satellite telemetry to elucidate the movement and dispersal in large sub-adult and adult sawfishes, which are a poorly understood life-history phase of this globally and nationally endangered group. In 2021, research and monitoring surveys carried out by DPIRD (Fisheries WA) will provide a unique opportunity to access larger size classes of sawfishes in northern Western Australia. This project seeks to use this opportunity to generate a preliminary dataset on the suitability of satellite telemetry approaches that will guide future research on this taxon to inform the recovery plan.

Project description

Problem statement

Sawfishes are one of the most globally endangered group of vertebrates, with all five species listed by the International Union for the Conservation of Nature as critically endangered or endangered (Dulvy et al. 2016). Four of the five species occur in Australian waters where their populations are considered to be relatively healthy compared to other parts of their global distribution (Yan et al. 2021). Over the past decade, a significant body of work on neonate and juvenile sawfish distribution, nursery areas and ecology has been generated, highlighting the global importance of northern Australia and Western Australia in particular for the conservation of the species (Morgan et al. 2017, Lear et al. 2019, Morgan et al. 2021). Although the growing knowledge of sawfish nurseries is instrumental in delineating critical habitat, current knowledge displays a substantial life-history bias. Most research has been focused on neonate or young juvenile age classes with little to no data available on larger individuals (> 2m) and adults. Data on the distribution of habitat requirements of adults and larger sub-adults is currently limited to rare captures by scientific surveys, commercial fishing interactions or historical records gleaned from rostra retained as trophies. Both types of data have considerable geographic bias, suffer from small sample sizes and therefore are unlikely to provide a comprehensive understanding of the distribution and habitat requirements of these critical life-history stages.

Several issues identified by the Draft Sawfish and River Shark multi-species recovery plan issues paper will benefit from a better understanding of the distribution of large sawfishes, specifically the exposure to several threats such as commercial and recreational fishing across national and international jurisdictions, habitat degradation, the degree of spatial protection adult sawfish receive from commonwealth and state marine parks and their exposure to marine debris. In the absence of unbiased data on the distribution of the whole population, quantifying and mitigating the above threats remain a challenge. To further refine our understanding of the threats faced by sawfish populations, which remains a crucial aspect to current and future listing assessments and to devise mitigation strategies it is critical to fill the substantial knowledge gap regarding the ecology of large sub-adult and adult sawfish. The first step in doing so, is to identify the best method of data collection.

Satellite telemetry via platform-terminal transmitters (PTTs or SPOT) offers a fishery independent tool to study the movement of individuals animals and therefore removes spatial biases that can be inherent in survey data and other types of telemetry (Hussey et al. 2015). However, for fully aquatic animals and especially benthic species such a sawfish, satellite telemetry provides a unique challenge, in that individuals must spend sufficient time at the surface so that the ARGOS satellites can estimate the location of the tag (and its carrier). To alleviate this problem, satellite linked archival tags (PSATs) use light-level geolocation to estimate global position, which in turn can be transmitted

after the tag detaches from its carrier. Highly turbid environments, including the tidal waters of northern Australia, provide a unique challenge for light-level geolocation, since poor light penetration at depth complicates the estimation of location (Stevens et al 2008). However, since the initial unsuccessful pilot study by Stevens and colleagues on the use satellite telemetry as a tool to study the movement of sawfishes, a number of developments, both technological and methodological, provide new opportunities to study the movement of adult sawfish.

Description of research

This project will make use of several gill-net surveys planned to occur in FY 2021 for fisheries research and monitoring purposes by DPIRD (Fisheries WA). These surveys provide a rare opportunity to access larger sawfish in some of the most remote areas of northern Australia.

The surveys will be conducted in Kimberley region and have previously captured green, dwarf, narrow and largetooth sawfish. Specifically, the project will survey Prince Frederick Harbour in York Sound, 80 Mile Beach and Roebuck Bay. All sites are inshore and in proximity to state Marine Parks and inshore from commonwealth Marine Parks. During the dry season of 2021, we will opportunistically tag sawfish during these surveys with the following tag types:

1. Towed Smart Position Only Tags (SPOTs)
2. Towed Argos-linked Fastloc GPS tags (SPLASH tags)
3. Pop-off archival tags (mini PAT)

Both 1 and 2. have successfully been employed in the study of smalltooth sawfish in the Atlantic (Carlson et al. 2014) and hold promise in their application in Australian waters, particularly in those species expected to undertake larger scale movements, such as green sawfish. Over short-intermediate scales, dwarf sawfish have been shown to only make small movements in very shallow water (Morgan et al. 2021) and we will test the ability of towed GPS tags to provide data of sufficient resolution to identify their spatial ecology. We will evaluate the utility based on the following:

1. The number of locations received
2. The quality (error) in positional data
3. The duration of deployment

Because of the rarity of sawfishes and their infrequent capture, this project will use a proactive approach to ensure success. Rather than focusing on a given species, we will opportunistically tag all sawfish of adequate size (2.5m total length and greater) captured as part of any of the surveys. We will alter the technology utilised depending on the species, for instance, for sawfish that are likely to disperse into deeper water (e.g. green sawfish), we will deploy pop-up archival tags only, as greater depths likely preclude the use of any tag that relies on sufficient surfacing intervals. Whereas tags placed on sawfish (e.g. dwarf sawfish) captured in coastal intertidal areas will be equipped with tags that acquire position directly through satellite. Due to the cost of satellite tags and likely low sample size, our project is unlikely to offer direct comparisons of the technologies and instead we will use the process of elimination, where we trial tags believed *a priori* to have the greatest potential will first be employed.

For any sawfishes captured on this voyage, we will also collect tissues samples for addition to the national sawfish tissue database which will enable next-of-kin analysis which is utilised as the basis for population size estimation that is critical for evaluating progress against recovery plans for these species. Tissue samples from captured sawfish will be made accessible to CSIRO Oceans and Atmosphere researchers investigating close kin mark recapture.

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Indigenous consultation and engagement

This a Category 3 (Indigenous Partnerships Strategy). DPIRD currently works collaboratively with multiple Indigenous ranger groups to achieve shared objectives relating to aquatic resources in the Kimberley. Participation with Indigenous ranger groups is envisaged to occur as part of this project, depending on the area and nature of the survey. Engagement in relation to this project and will occur as part of regular research and monitoring updates between DPIRD and relevant Traditional Owner groups.

Location of research

The on-ground location of the project are coastal waters, around the west Kimberley. Although the activities are focused regionally, they have national significance, as tagged fish may cross state boundaries and their distribution stretches across northern Australia. Specifically, we will provide tags to research scientists and technical officers on the following surveys:

Nearshore gill-net surveys – for the past three years, DPIRD has been performing gill-net surveys in nearshore waters stretching the Kimberley coast to provide information on aquatic resources for monitoring and assessment purposes. These surveys have captured and subsequently released dwarf sawfish, green sawfish and narrow sawfish in healthy condition, specifically in the areas surrounding the Walcott Inlet and 80-mile Beach. For the remainder of the dry-season of 2021, three sites will be visited by DPIRD that are likely to yield sawfish captures: Prince Fredrick Harbour, 80 Mile Beach and Roebuck Bay.

Project 1.25 Sawfish bycatch mitigation workshop for northern Australian fisheries

Project description

Project summary

The project will coordinate a workshop with state and commonwealth fishery managers, fisheries biologists, researchers, DAWE recovery plan team, NGO's and traditional owners to understand the issues around sawfish bycatch and develop methods to improve data recording to enable estimates of sawfish catch rates. The long-term goal of the meeting is to develop a nationwide monitoring strategy for sawfish that will enable DAWE to assess the status of sawfish and assess the effectiveness of the recovery plan actions and whether mitigation measures are having an impact on sawfish populations.

Project description

The project has arisen from consultation with the DAWE Marine and Freshwater Conservation section and aims to provide a synthesis of the issues around EPBC listed sawfish bycatch in state and commonwealth fisheries in northern Australia. Three species are listed under the EPBC act (*Pristis pristis*, *P. zijsron* and *P. clavata*) with *Anoxypristis cuspidata* listed as a migratory species and there is currently a nomination to up-list this species as well as *P. pristis. Pristis pristis* and *Anoxypristis cuspidata* are currently under the EPBC Act threatened species listing assessment; the sawfish and river shark national recovery plan is currently under review.

CSIRO is currently leading a project with the Northern Prawn Fishery Industry (NPFI) and AFMA to obtain estimates of sawfish catch rates in the Northern Prawn Fishery (NPF). This project will attempt to obtain population estimates of *A. cuspidata* using close kin mark recapture (CKMR) methods and compliments the NESP A1 project (Marine Biodiversity Hub) investigating population structure in this species. While the NPF is leading the way with observer coverage and estimates of sawfish bycatch, data from gillnet fisheries that interact with all four sawfish species are largely lacking.

To address the issue of sawfish bycatch, we aim to run a 2-3 day workshop with state and commonwealth fishery managers, fisheries biologists, researchers, DAWE recovery plan team, NGO's and traditional owners to understand the issues around sawfish bycatch and develop methods to improve data recording to enable estimates of sawfish catch rates. The long-term goal of the meeting is to develop a nationwide monitoring strategy for sawfish that will enable DAWE to assess the status of sawfish and assess the effectiveness of the recovery plan actions and whether mitigation measures are having an impact on sawfish populations.

There are currently two ongoing assessments on sawfish population status that are significantly hampered by a lack of data on the population status of both *P. pristis* and *A. cuspidata*. Improved sawfish reporting in logbooks as well as collection of tissue samples through on-board observers and training of fishers to collect samples should enable sufficient samples to be collected from rarely encountered species over 2-3 years that will enable CKMR methods to be used to estimate abundance.

A coordinated, national wide approach to a long-term tissue collection program is essential to obtain an improved understanding of sawfish population status.

The project will conduct a national workshop to share knowledge and update research priorities through consultation with key management, indigenous and researcher groups from QLD, NT, WA and commonwealth fisheries. The outcomes would be a set of priorities based on a wholistic framework for coordinated research addressing conservation and management requirements for the identified species on a national level. The project timing coincides well with current listing consideration for these species.

Approach

We propose a 2-3-day workshop to:

- Present data on logbook reporting of sawfish in Australia.

- Identify issues around under-reporting, lack of reporting and species identification.

- Identify best practice industry standards for obtaining data on bycatch of threatened endangered and protected species (TEPS).

- Develop methods and protocols to improve bycatch reporting of sawfish (and other TEPS – dugong, turtles, crocodiles and dolphins) in remote fisheries.

- Establish a national tissue collection initiative for sawfish across northern Australia (this will primarily be from commercial fishers but will also include sawfish researchers).

- Establish a national collection of sawfish samples that will enable CKMR estimates of abundance once sufficient samples are available.

Output(s) to be delivered

- A set of Priorities for future research and overview of larger NESP2 proposal(s).

- Synthesis documents covering each species (aimed at publication/dissemination through the hub) on the biology and management of sawfish within Australia.

Outcomes

- A larger proposal for NESP 2 based on synthesis and review of previous NESP science and recent allied research.

- An integrated approach to management of EPBC listed sharks and other species as per the 2015 Senate estimates review. This would involve formation of a national shark science and management advisory group.

End-user engagement

The proposal as written has been developed in consultation with DAWE Marine and Freshwater Conservation section. We have also included threatened species committee representatives and state fisheries/conservation managers. Note that due to the project timeline full consultation with all people listed has not been possible.

Project background

While the three *Pristis* species have been included in the multi-species recovery plan for sawfish and river sharks there has been limited success in establishing population estimates for sawfish in Australia due to a lack of reporting in commercial fisheries. Under reporting/lack of reporting and identification issues in logbooks combined with limited observer coverage in inshore gillnet fisheries confound this issue.

There is an urgent need to consider future directions and outline a coordinated plan across state and federal jurisdictions for future research that is coordinated and addresses outstanding components of the recovery plans.

To address the issue of sawfish bycatch, we aim to run a 2-3 day workshop with state and commonwealth fishery managers, fisheries biologists, researchers, DAWE recovery plan team, NGO's and traditional owners to understand the issues around sawfish bycatch and develop methods to improve data recording to enable estimates of sawfish catch rates. The long-term goal of the meeting is to develop a nationwide monitoring strategy for sawfish that will enable DAWE to assess the status of sawfish and assess the effectiveness of the recovery plan actions and whether mitigation measures are having an impact on sawfish populations.

The project has arisen from consultation with the DAWE Marine and Freshwater Conservation section and aims to provide a synthesis of the issues around EPBC listed sawfish bycatch in state and commonwealth fisheries in northern Australia. Three species are listed under the EPBC act (*Pristis*

pristis, *P. zijsron* and *P. clavata*) with *Anoxypristis cuspidata* listed as a migratory species and there is currently a nomination to up-list this species as well as *P. pristis*.

CSIRO is currently leading a project with NPFI and AFMA to obtain estimates of sawfish catch rates in the NPF. This project will attempt to obtain population estimates of *A. cuspidata* using close kin mark recapture (CKMR) methods and compliments the NESP A1 project investigating population structure in this species. While the NPF is leading the way with observer coverage and estimates of sawfish bycatch, data from gillnet fisheries that interact with all four sawfish species are largely lacking.

The project will contribute to the scoping research needs for a national approach to threatened and migratory species project run by the Threatened Species Mission Leader Helene Marsh. We have contacted Helene and she has agreed to attend the workshop if we are successful in this application.

- Present data on logbook reporting of sawfish in Australia
- Identify issues around under-reporting, lack of reporting and species identification
- Identify best practice industry standards for obtaining data on bycatch of TEPS
- Develop methods and protocols to improve bycatch reporting of sawfish (and other TEPS – dugong, turtles, crocodiles and dolphins) in remote fisheries.
- Establish a national tissue collection initiative for sawfish across northern Australia (this will primarily be from commercial fishers but will also include sawfish researchers).
- Establish a national collection of sawfish samples that will enable CKMR estimates of abundance once sufficient samples are available.
- Improved sawfish reporting and identification will result in estimates of bycatch across northern Australia that are currently lacking.
- Direct estimates from commercial fishery bycatch combined with CKMR estimates of abundance will enable recovery plan objectives and listing status to be evaluated. At present it is not possible to assess sawfish population status without considerable fishery independent data that are currently lacking.

We will engage a visual artist to capture the outcomes of the meeting and produce a graphic that outlines the best approach at improving monitoring to develop estimates of catch.

Indigenous consultation and engagement

This a Category 3 (Indigenous Partnerships Strategy) project. We are mostly focused on the fishing industry but will engage with relevant Indigenous groups. We are currently in consultation with Indigenous groups in northern Australia that may wish to attend the workshop.

These groups include the Northern Land Council, Southern Gulf NRM and Indigenous Land and Sea Ranger program.

However, the issue of sawfish bycatch is largely one of improved managed of commercial fisheries at a state and federal level and while sawfish researchers in Australia are currently engaged with traditional owners, exactly how indigenous knowledge contributes to estimates of sawfish catch in commercial fisheries is uncertain. We are open to suggestion on how to best engage with Indigenous leaders on this issue.

Location of research

National workshop to be held in Brisbane or Darwin (potentially to coincide with meetings to assess the recovery plan)

Desktop work following the meeting will occur in Brisbane and Hobart where Richard Pillans and Toby Patterson are located.

Project 1.26: Relative abundance of the 'western' population of southern right whales from an aerial survey off southern Australia

Project description

Project summary

Aerial surveys of southern right whales (*Eubalaena australis*) have been conducted across the southern Australian coast from Perth (W.A.) to Ceduna (S.A.) since 1993, as part of a long-term program to monitor the recovery, and inform the Conservation Management Plan (2011-2021), for this *Endangered* species (under the EPBC Act). The 2020 aerial survey recorded substantially lower numbers of whales than in the previous 13 years, and the lowest number of non-calving whales since the program started. An aerial survey conducted by this project in August 2021 will provide a relative estimate of annual population size for determining longer term population trends and contribute to determining if 2020 was an anomalous year or an indicator of some longer-term change to recent recovery rates and the female breeding cycle.

Project description

Related prior research and statement of problem

Surveys establishing relative abundance estimates, population trends and reproductive parameters of southern right whales from the 'western' population have been conducted since 1993. These surveys have provided the majority of information on the population recovery of the species post commercial whaling, given the 'eastern' population has shown little recovery. Data provided by these surveys have informed previous recovery plans and the current Conservation Management Plan (2011-2021) for the species. The NESP Marine Biodiversity Hub (MBH) has funded these surveys (under Project A7) over the last six years (2015-2020), with the data generated from the surveys providing important input into the NESP MBH project (A13) on population connectivity between the 'eastern' and 'western' populations for a national assessment of the species. The 2020 aerial survey recorded substantially lower numbers of whales than previous years, similar to numbers recorded in 2007 (Smith et al. 2021). It also revealed the lowest number of non-calving whales since 1993, with the low numbers of this group of whales contributing substantially to the overall low numbers recorded. Unusually low numbers of whales have been recorded during surveys in 2015 and 2007, with these years identified as anomalous years (Bannister et al. 2016). Numbers recorded by the 2020 survey suggest this year may have also been an anomalous year, which may reflect some disruption to the approximate 3-year female breeding cycle. Unpredictable fluctuations in relative overall numbers and associated fluctuations in cohort structure have been reported in other southern right whale populations in the Southern Hemisphere, such as South Africa (e.g. van den Berg et al. 2021). These have been suggested to reflect fluctuations in food availability on feeding grounds in the Southern Ocean and near the Antarctic continent that influence migratory behaviours. Calving rates of southern right whales have consequently been suggested as a potentially viable indicator of climate change impacts in the Southern Ocean (Newson et al. 2009). In order to establish if 2020 was in fact an anomalous year, or an indicator of some longer term and continuous change to recent recovery rates, continuing monitoring of the population is needed. Undertaking a survey in 2021 will also ensure that the long-term program for the region maintains an uninterrupted time series. This is particularly important as due to the non-annual breeding cycle (typically every 3 years); annual surveys are essential to maintain an acceptable level of precision in estimating population trends and key life history parameters such as calving intervals to track the recovery of the species (Bannister et al. 2011).

Methods

An aerial survey utilising established protocols developed and used in previous surveys of the south-west Australian region will be undertaken during August 2021 when seasonal whale numbers are estimated to be highest across the region. The surveys will be conducted using a high wing, single engine aircraft (Cessna 172) crewed by a pilot/observer and photographer/observer. The survey will be flown along the southern coast of Australia between Cape Leeuwin (Western Australia) and Ceduna (South Australia) and will follow the coast at approximately one nautical mile offshore, at a survey altitude of 1000 feet. Dependent on weather, it is expected that the survey will take 5-6 days to fly the region and back (based on previous surveys). A GPS track is recorded throughout the flight and when an individual(s) is sighted, the time of sighting, number of animals and their life stage are noted. The aircraft will then descend to 500 feet and photographs of the individual markings on each whale's head (known as callosities) are taken. These photo-identification images allow an individual to be matched with any previous photographed sightings of the individual, both within the projects long-term dataset and with the Australasian Right Whale Photo Identification Catalogue (ARWPIC) dataset managed by the Australian Antarctic Division Data Centre of DAWE.

Outputs

Numbers of whales recorded by the survey will provide a relative estimate of annual population size, and when combined with the longer-term dataset, a relative trend of the 'western' population. Photographs will be processed and uploaded to ARWPIC and then coded and matched against the catalogue to identify potential resights of individuals. The data from the survey will be an essential contribution to a larger dataset aimed at determining absolute abundance, spatial connectivity, changes in life history parameters across the population and environmental influences on these, however it is beyond the scope of this project to carry out such analyses.

The specific outputs from the project include:

1. A report that details: Overall numbers of southern right whales observed within the survey region, their gender and life stage where possible, and the spatial distribution of individuals;
2. An estimate of relative abundance and population trend and further insights the survey outputs provide to establishing whether 2020 was an anomalous year;
3. A summary of the photographs taken, the extent to which they have been submitted to the ARWPIC, and any subsequent matching of individuals;
4. Recommendations for next steps that can inform further work on southern right whales within the context of the Conservation Management Plan.

Application of research to inform decision making and links to other Hubs

Survey results will directly inform the Australian Department of Agriculture, Water and the Environment Conservation Management Plan for the Southern Right Whale (2011-2021). As part of the long-term dataset, it will contribute to an assessment of the conservation status of Australia's right whales and determine if listing this species as Endangered under the EPBC Act remains appropriate. Specifically, it will address the 'very high priority' Action Area B1 in the CMP, to 'continue to obtain and refine population abundance and trends for the south-west population' by 'maintaining a long-term aerial survey and photo-identification monitoring of the south-west coastal region (Cape Leeuwin to Ceduna) on an annual basis'. It also addresses, in part, the 'high priority' Action Area B2 to 'investigate a two-population model'. The photo-identification data from the surveys provides important information to NESP MBH Project A13 on the connectivity and demographic independence between the 'western' and 'eastern' populations to investigate temporary or permanent movement between these groups.

Research outputs from this project will be used in co-ordination with the Resilient Landscapes Hub to support the conservation of habitat important for priority threatened and migratory species and update the recovery plan for southern right whales.

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Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement. Category 3 projects communicate and share results with relevant Indigenous organisations.

In previous aerial surveys there has been no participation of Indigenous groups given the limited capacity to include additional staff in the aircraft (2-3 people max), the highly specialised skills of the staff (e.g. pilot and photographer) and long-term consistency of data gathering required for the survey. However, there is potential for engagement with relevant Indigenous groups across the region surveyed in terms of communication of outputs from the project.

Previously, information on the long-term right whale aerial survey monitoring program in combination with the long-term land-based right whale project at the Head of Bight (in South Australia) conducted by the Great Australian Bight Southern Right Whale group, have been presented to the Yalata Aboriginal Community coinciding with their Whale of a Day in August. We will seek to continue this engagement in collaboration with Dr Claire Charlton of Curtin University and, if possible, contribute to the Yalata Community's annual Whale of a Day.

Location of research

Aerial surveys of southern right whales are regional in scale and will be conducted across two States along the south-west Australian coastline (~1 nm off the coast), from Perth (Western Australia) to Ceduna (South Australia).

Project 1.28 - Future-proofing restoration & thermal physiology of kelp

Project description

Project summary

For restoration to be effective, the cause of habitat decline must be understood and overcome. But this is problematic when climate change is driving habitat loss since it cannot be reversed or ameliorated prior to restoration. A previous NESP project led by this team (Project E7, Marine Biodiversity Hub) identified warmwater-tolerant strains of giant kelp from remnant patches in eastern Tasmania, where the species has experienced precipitous declines due to ocean-warming. These strains have high potential to assist with 'future-proofing' kelp forest restoration, however it is still unclear what the physiological mechanisms are that provide their improved thermal tolerance. This project is designed to better understand these physiological mechanisms to advance kelp restoration efforts in Australia and globally, and progress toward the identification of populations of Australian kelp that may be resilient to (or especially threatened by) ocean warming and climate change.

Project outline

Kelp forests create complex habitats for a diverse and productive community of associated organisms[1,2]. These underwater forests also support coastal food-webs, and fisheries, and a suite of other ecosystem services including nutrient and blue carbon cycling. However, across many regions of Australia and the world, kelp forests are in decline and under threat from a range of stressors including urbanisation, overgrazing, and ocean warming and marine heatwaves due to climate change[2,3].

One potential tool for the conservation and management of these critically important ecosystems is habitat restoration[3]. However, for restoration to be effective, any driver of habitat decline must be understood and ameliorated. This is problematic when climate change and ocean warming are driving kelp forest decline since these cannot be overcome prior to restoration interventions. Given these direct impacts, and the scale and rate of ongoing climate-driven environmental change worldwide, there is growing recognition of the need to implement adaptive and 'future-proofed' restoration.

Australia is positioning itself as a global leader in kelp forest and future-proofed restoration. Both our southwest and southeast coastlines are characterised as global ocean-warming hotspots[4], while we have several dominant species of kelps that are living close to their thermal limits and have already been significantly impacted by ocean warming and climate-driven change[2,3]. These include losses and range-edge retractions of common kelp (*Ecklonia radiata*) on the west and east Australian coasts due to warming and tropicalisation of herbivorous fish species, and significant declines of giant kelp (*Macrocystis pyrifera)* forests (which led to the 2012 listing of giant kelp forests as a Threatened Ecological Community under the EPBC Act)[2,5].

Building on the successful NESP Marine Biodiversity Hub *Project E7* and leveraging pre-existing kelp cultures developed over several years[6], this project will explore the physiology and heritability of kelp thermal performance. Specifically, we aim to ascertain the mechanisms responsible for the warmwater tolerance we have identified in particular giant kelp strains, and the persistence of these traits through cross breeding. Our work has pioneered techniques of giant kelp restoration (i.e. we have established two sites that together support over 200 healthy developing warm-tolerant giant kelp) that are readily transferable to other species, and the proposed work extends this further.

Problem statement

Prior work has demonstrated the presence of warm-tolerant family-lines of giant kelp sourced from remnant kelp patches in eastern Tasmania, where the species has experienced precipitous declines over recent decades. However, whilst we have identified strains to assist with future-proofing kelp restoration, it is unclear what the physiological mechanisms are that provide the improved thermal

tolerance of those kelp. It is also unknown whether cross-breeding the identified warm-tolerant giant kelp strains will impact and potentially improve their thermal tolerance capacity.

Experimental details

Using our established giant kelp gametophyte cultures, testing facilities, and well-developed methods, the team will cultivate (i) previously identified warm-tolerant giant kelp family-lines along with (ii) targeted crosses of warm-tolerant giant kelp and (iii) strains of average thermal tolerance (i.e. controls) at both a 'normal' and 'elevated' temperature (16 & 24 °C). Totalling ~18 unique strains, this will result in a total of ~108 experimental units (3 replicates of 18 strains at 2 temperatures). Once an adequate biomass of kelp (i.e. several grams) has been achieved, we will run a suite of physiological tests on each of the kelp strains, including:

- C:N ratio (to examine nutrient status)
- fatty acid content (to examine cellular membrane integrity)
- oxygen production and PAM fluorometry (to examine photosynthetic performance)
- pigment content (to examine photosynthetic machinery)
- transcriptomics* (to examine differences in genetic expression & regulation)
  due to the high cost of these analyses, they will only be conducted on a selection of the top performing pure-strains and crosses vs. the controls (~50% of all the strains)

Altogether, these tests comprise a broad assessment across the key putative physiological mechanisms of thermal tolerance in seaweeds[7]. Moreover, the fatty acid content and transcriptomic approaches are particularly state-of-the-art, and almost unexplored for kelps and other seaweeds[8]. This proposed work also presents a timely synergy with a recently-successful, short-term CSIRO project (*Giant Kelp genotyping – Negative Emissions FSP initiation study*) that is genotyping and sequencing our giant kelp strains (and on which the Project Leaders are key collaborators).

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category three project for Indigenous engagement as it is a laboratory Category 3 projects communicate and share results with relevant Indigenous organisations.

A NESP1 Marine Biodiversity Hub project (Project E7 – a Category 2 project for Indigenous engagement) identified warm-tolerant giant kelp strains as the foundation of ongoing kelp restoration trials at two sites. One of these sites was chosen in collaboration with a local Indigenous community, the weetapoona Aboriginal Corporation (wAC). This community has a long history of knowledge of the site, including observing the local demise of giant kelp, and our ongoing engagement is intended to facilitate knowledge-sharing and the collaborative restoration of their Sea Country.

The project team will continue their relationship with wAC under this project using existing communication channels to develop a shared understanding about the purpose of this research extension, its findings, and implications for wAC.

Location of research

The pre-existing giant kelp cultures, testing and cultivation equipment, and lab facilities are already established at IMAS Salamanca, Hobart. This proposed work will continue at this location, whilst processing of some of the lab samples will occur at other UTAS locations.

Project 1.29 – Scoping Study: New Approaches to Marine Monitoring

Project description

Project summary

Australia's has the third largest marine estate of any country in the world. Much of our marine and coastal resources are in offshore or sparsely populated areas meaning that our ability to monitor and assess our environmental resources and values is particularly challenging. To maximise our understanding of our marine and coastal environment, we need to take advantage of emerging technologies and approaches. This includes citizen science, community monitoring and Indigenous Rangers. In particular, it is expected that these groups will utilise the same technologies as mainstream science, thus these emerging technologies can bridge the gaps between science and community science to operate in unity. This project provides a series of workshops and engagement processes to best explore how to most effectively deploy technologies and community science programs to achieve maximum benefit and synergy in environmental monitoring.

Project description

There are numerous new technologies that have the ability to transform the way and efficiency with which we monitor our marine and coastal environments. There is no doubt they offer much promise. However, there are numerous new technologies, and most research institutions have or are rapidly developing their capability in a range of new technology fields. The issue isn't the lack of technology, for this is abundant, it's choosing between the large range of technologies, the numerous research groups offering such capabilities and the ability to match this technological capability with required and priority end-user needs, that is the challenge.

Even where a particular technology, delivery provider and end-use need are identified, there is still the question of capability of uptake of the technology in the intended on-ground applications (e.g. when used by ground staff in the field), data handling, processing, analysis and storage (new tech inevitably exponentially increases the amount of data collected), and compatibility/comparability with historical long-term monitoring datasets.

It is not the intent of the NESP MAC Hub to further develop certain technologies or approaches and then look for an application for them. Rather, the preferred approach is to determine the key monitoring/assessment needs and then how they are best met through the astute application of technology and approaches. Thus, this intended scoping study, will necessarily be run in parallel and partly dependent upon, outcomes from proposed Hub scoping studies on Threatened Species, Protected Areas and Indigenous Participation that will identify key issues in monitoring and assessment. This project will provide guidance on how to adopt technology and approaches to monitoring and the pro's and con's of doing so.

It should be noted here that this project covers both new technology and new approaches. The latter covers the use of citizen science, community participation and Indigenous participation, especially Indigenous Rangers. Community science (including all of those just listed and more) has been utilised in broad-scale monitoring and assessment for many years. Outcomes have been mixed and overall, community science has only succeeded in certain limited fields and topics. However, with the advent of new technologies, community science participants will, in many situations, likely be using the same technology and field collection methods as mainstream scientists. For example, citizen scientists and Indigenous Ranger groups can collect field eDNA samples and use exactly the same drones and underwater cameras in the same way as do mainstream scientists. The processing of the eDNA samples or the drone/camera footage may be done in science labs, but the field work is the same. Technology has greatly reduced the gap between mainstream science and community science

to the point they may become almost identical in some integrated programs, especially when involving collection of in-field information. The challenge for science is to integrate with the vast opportunities afforded by this congruence.

This scoping study will coordinate a series of workshops/engagements with a range of experts and potential end-users on key areas of technology including eDNA/genomics, drones and camera technologies. For example, although a relatively recent technological innovation, most research institutions have developed or are developing eDNA capability, as are some private lab providers. This technology offers great transformative potential but currently has relatively limited applications in formal monitoring programs (compared to its potential) and there are no standardised national methods. Key issues include the use of national infrastructure such as museums and Bioplatforms Australia, for the benefit of all. These workshops will range from low-profile technical discussions to broader, higher profile events that allow a wider range of providers to demonstrate their utilisation of technology in affecting practical change in monitoring programs. In our experience, a lot of end-users don't fully appreciate all the requirements of adopting new technology, leading to numerous projects being commissioned but not adopted in formal monitoring. Utilisation of new approaches requires a lot more than just incorporating new technologies into field data collection. We will focus especially on back-end processing and data handling issues in our scoping work to provide guidance (in written format) to potential end-users on all the issues that must be considered before adopting new technology-based approaches.

In addition to technology itself, the project will examine the applications of technology in community science. Case studies will be examined and one in particular is already showing great promise. The Reef Census (www.greatreefcensus.org/) is integrating with new technologies to monitor remote marine locations, using freely provided vessels (tourism and dive boats, superyachts and fishing vessels) and volunteer labour. In 2020 alone, this program captured >13,000 images from >540 distant reef sites, collecting the only data available for many of these. The design of the sampling program was overseen by an esteemed scientific expert panel. Image collected are being run through image analysis software and sourced to community participants with a scientific evaluation of the accuracy between the two methods of assessment. The program has significant technological (dell, Intel) and philanthropic support (Disney, Netflix, Nickelodeon).

It is expected that these workshops and this project in general, will be of interest to the Resilient Landscapes Hub as well, given their interests in broad-scale monitoring. The Northern Australian Environmental Resources (NAER) Hub also started their Hub with a scoping study on new technology which later resulted in the commissioning of two technology-related projects in eDNA.

This scoping study will draw upon an enormous body of recent and emerging work on new technologies and, in addition, their adoption in community science. At the end of the scoping study, it is intended that the MAC Hub will be in a position to put forward in its future research plans, several larger, substantive, well planned, application-oriented studies that demonstrate the transformative application of new technologies and integrated community science approaches in marine and coastal monitoring.

This scoping study is essentially a series of workshops and programs of work under the one theme. As such, there is no single Project Leader to contract. RRRC will manage the finances and working with the Hub leaders, seek to engage specific domain experts to deliver sub-programs works on specific topics. The exact nature of these topics and the specific scope of works to be delivered will be decided by the MAC Hub leadership after initial engagement with key end-users and potential domain experts to map out the conduct of the project.

Indigenous consultation and engagement

This a Category 2 (Indigenous Partnerships Strategy) project. Given the specific topic and nature of the scoping study will evolve during its conduct, specific Indigenous engagement has not been possible thus far. However, the potential utilisation of new technology and approaches by Indigenous groups, especially Indigenous Rangers, is of relevance to this project. We will conduct workshops

that include and actively seek to involve participation of leaders of Indigenous groups that undertake or desire to undertake, monitoring with new technologies. Several Indigenous groups are already using some of technologies we seek to cover. Their views on the value of such technologies will be sought.

Indigenous stakeholders (particularly those with sea country) will be consulted and engaged throughout this project. As per the objectives of the MAC Hub Indigenous Engagement Strategy, researchers in this project will be advised of relevant Indigenous groups and strongly encouraged to engage meaningfully. This project will interact with the Indigenous Facilitators from all Hubs and with the proposed Indigenous engagement project in RP2021 of the MAC Hub.

Location of research

Though this is essentially a desktop project, it is national in scale in that it covers a variety of species and habitats across the nation. However, it will also provide planning for future activities that may be more localised.

Planning workshops will be conducted at a variety of geographic localities across the country and participants are expected to attend from all states and territories.

Project 1.30 – National Assessment of Climate-Driven Species Redistribution using Citizen Science Data

Project description

Project summary

This project will develop a report card assessing Australian marine species to determine species that have undergone recent changes in distribution, either shifting into each state, or into new areas within states. This report card will draw upon citizen science databases and use a robust decision tree analysis to outline which species are shifting, and with what degree of certainty. Project objectives are to **1.** draw upon citizen scientists to identify climate-driven changes within the Australian marine estate; and **2.** communicate to and engage with the public on issues of climate change and biodiversity *using their own citizen science information*. The report card can be used to drive public interest in the NESP MAC Hub and in the status of biodiversity in Australia.

Project description

Problem statement Where whole communities or ecosystems have been explored, between 25-85% of species have been documented as shifting distribution in response to climate. Climate-driven changes in species distributions (or ranges) affect ecosystem structure and function, impact both fisheries and conservation, and often require specific management as species leave existing locations or enter new areas. A recently published systematic review of all published scientific literature on range shifts within Australian waters revealed at least 198 species shifting, but also substantial geographical and taxonomic gaps (Gervais, Champion, Pecl 2021). This study also showed that 1/5th of the studies incorporated citizen science information, demonstrating the huge contribution citizen science can make. However, many of the citizen science databases have not been systematically searched and analysed to assess formally species changes in distribution. The Redmap (Range Extension Database and Mapping Project) Australia project, for example, has been a national initiative/program since 2012 and now has enough data collected over time to enable such an assessment, and the iNaturalist Australasian Fishes project has amassed over 122,000 observations (many designated as 'research grade' with a community consensus on a precise identification) that are also yet to be analysed. This represents a significant untapped resource that will enable assessment of potential changes in species distributions and also to identify particular regions or taxa that might require targeted research effort.

Description of research Currently, a static report card produced in 2013 is available on the Redmap website for Tasmania only (https://www.redmap.org.au/article/the-redmap-tasmania-report-card/), which was developed via a robust peer-reviewed analysis, to formally assess shifting statuses of species and provide a degree of confidence of each range shift (Robinson et al. 2015). The proposed new report card will provide accessible information of an assessment of the range shifting status of each species (e.g. 'Is this species shifting range/distribution or not?') given citizen science observations, with a degree of confidence (high, medium, low). The report card will be underpinned by a robust assessment process previously developed by our team, assessing *a*) the certainty of a particular species 'original' distribution, *b*) what new out-of-range information we have from observations, and *c*) what these two factors combined mean for the likelihood of a range shift into the new area (e.g. Robinson et al. 2015). After the scientific assessment, the online report card will be designed via face-to-face consultation with community members who contribute to the Redmap project, and stakeholders (managers and policy people and public communicators) who will use it. This mechanism helps to promote transparency and clarity around data use, to further support all project objectives. The process will entail:

1. Data sourcing, cleaning and processing from Redmap, iNaturalist, Reef Life Survey, and if possible, Eye on the Reef.
2. Formal assessment of historical distribution limit for species
3. Scientist workshop with experts working on species range shifts to determine if the Robinson et al. 2015 method can be improved, based on the recent surge in range shift literature since then (detailed in Bonebrake et al. 2018)
4. Decision tree analyses based on improved Robinson et al. method resolved in step 3.
5. Report card constructed in collaboration with stakeholders, including state-based resource managers
6. Report card tested & feedback on design, clarity of communication etc from citizen scientists contributing the data
7. Dissemination of report card – online, social media, newsletters, industry articles, boat shows, media (e.g., The Conversation) and to government and community stakeholders (see Research end-users).

Output(s) to be delivered: The Redmap project has gathered scientific evidence to support proof of concept as i) an effective early indication of changes in species distribution (i.e. species range shifts; - Fogarty et al 2010; Robinson et al. 2015), and ii) a successful mechanism for community engagement that has improved understanding of marine environmental issues, including climate change (Nursey-Bray et al evaluation 2017; Bannon 2016). This national assessment using Redmap and at least two other citizen science databases will provide state-based report cards showcasing which species are likely to be undertaking changes in distribution, and with what degree of certainty (as per Robinson et al. 2015). We will also undertake a high-level expert assessment of potential interactions with threatened species for any 'new' species shifting into regions.

Outcomes

a. Provide an assessment of potential changes in species distributions for 200-300 key species within Australia's EEZ
b. Provide an early indication of species or regions that are priority areas for targeted scientific research. Although this assessment will focus on range extensions only, regions with high rates of range extension may indicate regions that could/should be assessed further for range contractions via further targeted study.
c. Provide a demonstration of the value of citizen science
d. Engage with the broader public on climate change, using their own information

Indigenous participation: This is a national desktop assessment of species potential changes in distribution using all available citizen science data (Redmap, iNaturalist, Reef Life Survey), and as such engages all fishers, divers, naturalists, and boaters. We would be happy to work with the NESP Indigenous Facilitator, in whatever way they assess as appropriate. There is an Indigenous group in South East Tasmania that is interested to see what species appear to be shifting into the area, to compare to their longer-term understanding of the region.

End-user engagement: End-users will be engaged during each stage of the project. Redmap already has an evaluated (Nursey-Bray et al. 2017; available on request) comprehensive engagement strategy and we also produce an annual engagement plan, that provides a thorough approach to communication with participants, the scientific community, and the broader public. We regularly seek formal feedback from the Redmap community on our communications, and evaluate and adjust accordingly. Thus, we already use evidence-based approaches to assess the success of our activities and will continue to do so in assessing the success of the new report card. Fishers and divers have been engaged and consulted regarding what species are listed on Redmap to target sightings for in the first place, and are then invited via the extensive network on Facebook, Twitter, and the electronic newsletter to 'review' the report card as per the Tasmanian based card from 2013 (where contributing divers and fishers provided excellent input on the design of the report card, requesting different symbols, greater/shorter explanations etc). Engagement and dissemination will also occur via iNaturalist, Reef Life Survey and Research Partner institute avenues.

Broadly, Redmap has already made contributions to:

- National Senate Enquiries on climate change;
- Ongoing publications of work advancing our understanding of marine climate change in Australia (over 30 peer-reviewed articles in scientific journals);
- Direct engagement with over 1,000 fishers & divers in submitting valuable observations of marine species & engagement with tens of thousands more marine users via face-to-face events, online newsletters & social media;
- Continuing to be at the forefront of community outreach and citizen science; and
- Subsequent recognition as finalists two years running in the prestigious Eureka Awards (for Innovation in Citizen Science), an international award for effective climate change communication, as well as six other awards.

Links with other research/Hubs and relevance of outputs to decision making/action: This assessment of species most likely and most rapidly shifting in distribution and into each state will focus/guide the allocation of regional research effort across Australia among end users. Linkages with other NESP Hubs will be elucidated in consultation with DAWE and on advice from the Marine and Coastal Hub Leader. The output (national report card) will assess and report on which species are likely to be shifting most rapidly into new areas to support management of biodiversity under climate change. This project is aligned with the Climate Systems Hub Mission as this project records species distributional changes due to marine warming. We will also examine potential shifts identified in the resulting report card for potential impacts on threatened species in the new part of their range.

Indigenous consultation and engagement

This a Category 3 (Indigenous Partnerships Strategy) project utilising existing data. This is a national desktop assessment of species potential changes in distribution using all available citizen science data (Redmap, iNaturalist, Reef Life Survey), and as such engages all fishers, divers, naturalists, and boaters. We would be happy to work with the NESP MAC Hub Indigenous Facilitator, in whatever way they assess as appropriate.

Location of research

As the project will use existing citizen science databases — Redmap, iNaturalist and Reef Life Survey data, the project is a desktop study and analyses will mostly be carried out at the University of Tasmania and James Cook University. The scope of the project is national.

Project 1.31 – Scoping Study: Indigenous Participation and Research Needs

Project Description

Project summary

This scoping study builds on the engagement undertaken during the development of the NESP proposal for the Marine and Coastal Hub, where 42 Traditional Owners and Native Title holders across mostly northern Australia provided support for our bid. This period of engagement identified the need to consult widely with Indigenous leaders and groups before committing to substantive research projects. This scoping study provides the resources to begin such a consultation with Indigenous partners on their aspirations for the Marine and Coastal Hub. It will also provide a vehicle for the Hub to actively engage the NESP Indigenous Facilitators Network.

As part of the Australian Government policy on Closing the Gap and consistent with Part 6 of the Northern Australia Indigenous Development Accord, this scoping study will explore how best to execute increased Indigenous ownership over participatory research and how such a program can deliver on the Department's stated aspirations of meaningful and substantive engagement of Traditional Owners. This scoping study will bring together key Indigenous leaders and groups to plan, prioritise and evaluate potential research directions. Specifically, this scoping study will engage with Indigenous Australians to develop a cohesive set of prospective projects for investment under future Hub research plans, that deliver up to large-scale, broader picture goals for Indigenous people. This will require marshalling of Indigenous knowledge and development and enhancement of Indigenous relationships. Consultation will involve both Indigenous only and Indigenous-researcher meetings and workshops. We are seeking ethical Indigenous engagement, equitable participation and co-design and co-delivery of national environmental research priorities, while substantially increasing the outcomes for social, economic and cultural terms for Indigenous people.

Project description

Today the Indigenous Estate covers > 45% of Australia (greater than 78% of Northern Australia); as confirmed through 450+ registered Native Title determinations, in conjunction with 1,230 registered Indigenous Land Use Agreements and 76 proclaimed Indigenous Protected Areas. However, the capacity for economic, social and cultural development on this vast and growing estate has not achieved its potential due to a lack of an enabling policy and practical environment that supports improved education, health, housing, innovation and technology uptake. Traditional Owners are '*land rich and cash poor*' – the land and sea scape (the environment) are their most significant economic asset. Traditional Owners argue that there has been little formal R&D support for developing and examining how the land and sea scape (through approaches such as 'ecosystem services') can contribute to culture-based economies on country, where development aspirations are met while cultural and environmental assets are protected.

This scoping study, which we propose as a cross-Hub activity between the Marine and Coastal Hub, and the Resilience Landscape Hub, proposes to ethically and actively engage with a network of Indigenous leaders (Traditional Owners and Native Title Holders) to assist DAWE, researchers and the identified NESP Indigenous facilitators to develop a strategic, cohesive and co-designed series of projects for consideration under future Hub research plans. This scoping study is just the start of what we consider to be an on-going investment throughout the Hub life, with on-ground Indigenous organisations to develop and implement participatory research. The scoping study will explore the potential strengths, benefits and costs of a coordinated platform for Indigenous engagement that will support the mainstreaming of Indigenous participation and knowledge repatriation in environmental research.

Indigenous people have long criticized the conduct of research, researchers and the western orthodox approach to research with Indigenous peoples in Australia and throughout the world. Typical western orthodoxy breaks complex systems down into silos and treats them as separate entities, whilst Indigenous people continue to articulate their completeness, or wholeness, and the need to include all aspects of life when dealing with the special relationship between people, country and the spiritual world.

This is a major disjunction between Western orthodox and Indigenous peoples' world view and has resulted in criticism that past research involving Indigenous people has been inherently biased against Indigenous people in the design, conduct, and adoption and therefore disempowering for Indigenous people. Recent international recommendations for improving research practice involving Indigenous people; include dedicated funding for Indigenous-specific research facilities, funding for Indigenous academics and research networks, and ethical guidelines. In Australia, the most substantial Indigenous-led or informed research has been in the health field, although such innovative approaches remain under-developed in other critical areas such as the environment, climate change, technology, entrepreneurship and especially research relevant for Indigenous settings in rural and remote Australia.

Indigenous people have few opportunities in traditional business enterprise necessitating a new perspective and approach to build the knowledge capital that will help Indigenous groups engage in emerging and novel environmental markets and to create sustainable long-term enterprise. These groups point to the success of the regulated carbon market in northern Australia, as an example of a practical base for developing integrated conservation and enterprise development programs that can deliver real and measurable biodiversity, economic and social impacts.

A fundamentally important aspect to realising the potential of the Indigenous land and sea estate, is to improve alignment, engagement and collaboration with Australia's national environmental research priorities and to ensure those priorities are informed by Indigenous landowners, managers and decision makers.

Methodology

The scoping project will conduct a series of facilitated workshops and direct engagements with identified stakeholders to determine the priority research directions for future Marine and Coastal Hub investments on Indigenous issues. This engagement and consultation will be conducted in such a way as to:

- Improve the adoption of best practice principles (UNDRIP/FPIC) to ensure NESP research is relevant to Indigenous peoples, best practice, innovative, measurable and while delivering environmental outcomes also delivers enduring economic, social and cultural benefit.
- Ensure the NESP research paradigm is compatible with collective consensus decision making, is ethical and recognizes the ownership of natural resources (land, biota, and knowledge).
- Create efficient governance reflecting local and regional input into the NESP research needs, program design and implementation and the subsequent evaluation of outcomes including knowledge transfer/brokering.
- Achieve greater impact – through co-development of research priorities, approaches and partnerships that build resilience and prosperity in the Indigenous and broader community which will generate opportunities and benefits and that are currently being missed.
- Amplify the recognition, use and value of Traditional knowledge, customs and practice while increasing the opportunity for intergeneration knowledge transfer in the Indigenous community; and
- Support the current Indigenous Facilitators and create succession, leadership and pathways for the Indigenous research sector to generate enduring employment, economic, social and cultural outcomes at a national level.

Workshops will be held across the country (e.g. Darwin, North Queensland and Perth (northern WA), Hobart and NSW (Covid-permitting). An additional workshop will be held in Canberra to

specifically capture Departmental priorities and considerations as to the value of such an approach and whether a network will operationalise the Department's stated intent for Indigenous engagement and improve the on-ground outcomes.

Within DAWE we plan to engage, either through workshops or direct consultation with:

- Heritage Branch
- Parks Australia
- Reef Branch
- Protected Species and Communities Branch
- GBRMPA
- Wetlands section
- Environmental Biosecurity Office
- Monitoring, Evaluation, Reporting and Improvement Section, MERI Program Delivery Branch
- Bushfire Recovery Programs Branch.

We will engage with additional areas as they are identified as needing to contribute to the project. We will also utilise and include the NESP Indigenous Facilitators Network in our consultations.

Outcomes from these extensive consultations will be recorded in a report that captures the outcomes of the workshops and any recommendations for improved engagement with Traditional Owners for research and land and sea management, especially associated with the Indigenous Estate. The report will help inform the future investment by the Marine and Coastal and other NESP Hubs into the Indigenous engagement agenda. In addition to the report, the key outcomes will be a series of impactful, well-supported, co-designed, Indigenous led (wherever possible) research projects for consideration in 2022 Hub research plans.

Roles

This scoping study was initiated by Indigenous groups and will be Indigenous led. Skills will be sought from the North Australian Indigenous Land and Sea Management Alliance, numerous other Indigenous organisations and supported by Hub Leaders (especially Professors Damien Burrows and Michael Douglas) and the Indigenous Facilitators from all 4 NESP Hubs.

Outputs.

By September 2022, this project will deliver a complex, multi-partner agreed value proposition for operationalising Indigenous research participation and engagement and provide a series of potential research project options. Additionally, the technical report will consider:

- Approaches for maximising Traditional Owner participation in research program including research activities involving the Indigenous Estate.
- Approaches to amplify the recognition, use and value of Traditional knowledge, customs and practice in research approaches.
- Methods for including Traditional Owner evidence guidance of based policy and land use planning.
- Novel approaches to developing research priorities, and partnerships that build resilience and prosperity in Indigenous communities.

Note:

The Marine and Coastal and Resilient Landscape Hubs have committed to working together to achieve improved Indigenous participation in environmental research. The Hubs have committed 10% of the research investment to Indigenous led research. The Hubs will also reach across to other Hubs and agencies to achieve agreed outcomes.

Outcomes

This project will provide a response to the Traditional Owners and Native Title holders who argue that there needs to be a greater engagement with the national environmental research priorities and how the research is conducted and delivered on land and sea country (with particular reference to the Indigenous Estate).

The outcome will influence the future investment approach to Indigenous led research of the Hubs.

Indigenous Consultation and Engagement

This a Category 1 (Indigenous Partnerships Strategy) project of considerable importance to Indigenous people. The scoping study will utilise the Hubs Indigenous Facilitators, Mr Stan Lui, Mr Kenny Bedford and Professor Stephen van Leeuwen in conjunction with the NAILSMA and Indigenous leaders across Australia including input from the original 42 northern Indigenous organisations. These organisations include but is not restricted to Native Title holders, Prescribed Bodies Corporates, identified Traditional Owners and other bodies which represent or advocate for Indigenous peoples.

By engaging Indigenous leaders across Northern Australia, the aspirations outlined in the Indigenous Accord for the Development of Northern Australia can be incorporated into Indigenous led and co-development research. Traditional Owners knowledge and approaches to engage and research delivery will be mainstreamed to maximise current and future impact.

The joint Hub approach between the Marine and Coastal and Resilient Landscapes Hubs (and other NESP Hubs will be invited to join) for consultation with Traditional Owners will enhance input to the developing strategy and minimise cross talk stemming from too many Indigenous engagement mechanisms.

Location of Research

The geographical extent of the scoping study will be determined by the engagement of Traditional Owners and Native Title holders across Australia. A Departmental focus workshop in will be conducted in Canberra.

This scoping study will focus on national objectives while the information derived will be from a localised Traditional Owner base.

Project 1.32 – Scoping Study: Supporting Regional Planning in Northern Australia

Project description

Project summary

Development in northern Australia has had bi-partisan political support for many years and thus receives significant policy and funding profile. However, the agenda is widely considered to have under-achieved against aspirations, becoming a heavily contested space with poor outcomes for development and environment. Disputes over environmental issues are central to this contestation affecting development proponents, government agency decision-makers and affected communities. We believe we can make a positive contribution to easing (often known as de-risking) this contestation. A key issue is availability of agreed data/information/knowledge to all parties. We plan to run this agenda in partnership with the Resilient Landscapes Hub and the CRC for Developing Northern Australia, thus covering terrestrial, marine and socio-economic issues in strategic partnership. Given the many parties and wide range of issues involved, we will require extensive planning and consultation in the first year in order to develop a coherent research investment strategy for future years.

Project description

The project builds on the NESP1 cross Hub project *Integrated Assessment Project for Northern Australia* and research undertaken by the CRC for Developing Northern Australia (CRCNA) in relation to Australian Government's White Paper for Developing Northern Australia, the Northern Australia Indigenous Development Accord, and the Review of the *Environmental Protection, Biodiversity and Conservation Act*, *1999*. (EPBC).

The Australian Government's White Paper for Developing Northern Australia is focused on realising the full economic potential of the north, including a plan for implementing these policies over the next two, five, 10 and 20 years. Whilst aspirational, little attention has been paid to problems facing the system of prioritising, planning, assessing and approving sector development proposals while protecting our natural and cultural assets. Several research works commissioned by the CRCNA have shown that developers, landholders and the wider community have communicated their clear frustration with current development and approvals processes, along with deep concerns identified by the Samuels EPBC Act review that Australia biodiversity continues to decline in the face of development and is not adequately protected. Finally, the north's Traditional Owners have long been concerned the EPBC Act does not frame their relationship with development in ways that positively protect cultural concerns and enable diverse economic development interests in the landscape. The Northern Australia Indigenous Development Accord (the Accord) is an intergovernmental agreement that recognises that Indigenous participation in the economy is essential to fully realise the development of northern Australia and provides a framework for governments to work together and individually to advance Indigenous economic development in northern Australia.

To help address this three-way issue and to assist in achieving sustainable development in the north, we are proposing a project that scopes a clear way forward, based on high quality ecological data, a comprehensive understanding of stakeholder needs, legislative requirements and Traditional Owners rights and aspirations.

Project description

This project will develop, in partnership with the Resilient Landscapes Hub and with close coordination with the CRC for Developing Northern Australia, a research strategy to create three place-based case studies in 'key development areas', that will showcase a real-world methodology for protecting biodiversity and cultural assets within a sustainable development framework.

By collaborating closely with the relevant divisions within DAWE to identify appropriate stakeholders, the scoping study engagement will target; the Office of Northern Australia, Queensland, Northern Territory and Western Australian Government Agencies, Research Advisory Committees, Industry organisations, conservation groups and Native Title holders of the Indigenous Estate, in a series of workshops and will identify new pathways to achieve positive development outcomes and explore improved approaches to the way the unique environment of Northern Australia can be better managed and protected.

This project specifically aims to deliver on the Informing Policy and Decision-Making component of the MAC Hub, specifically de-risking landscapes for investment.
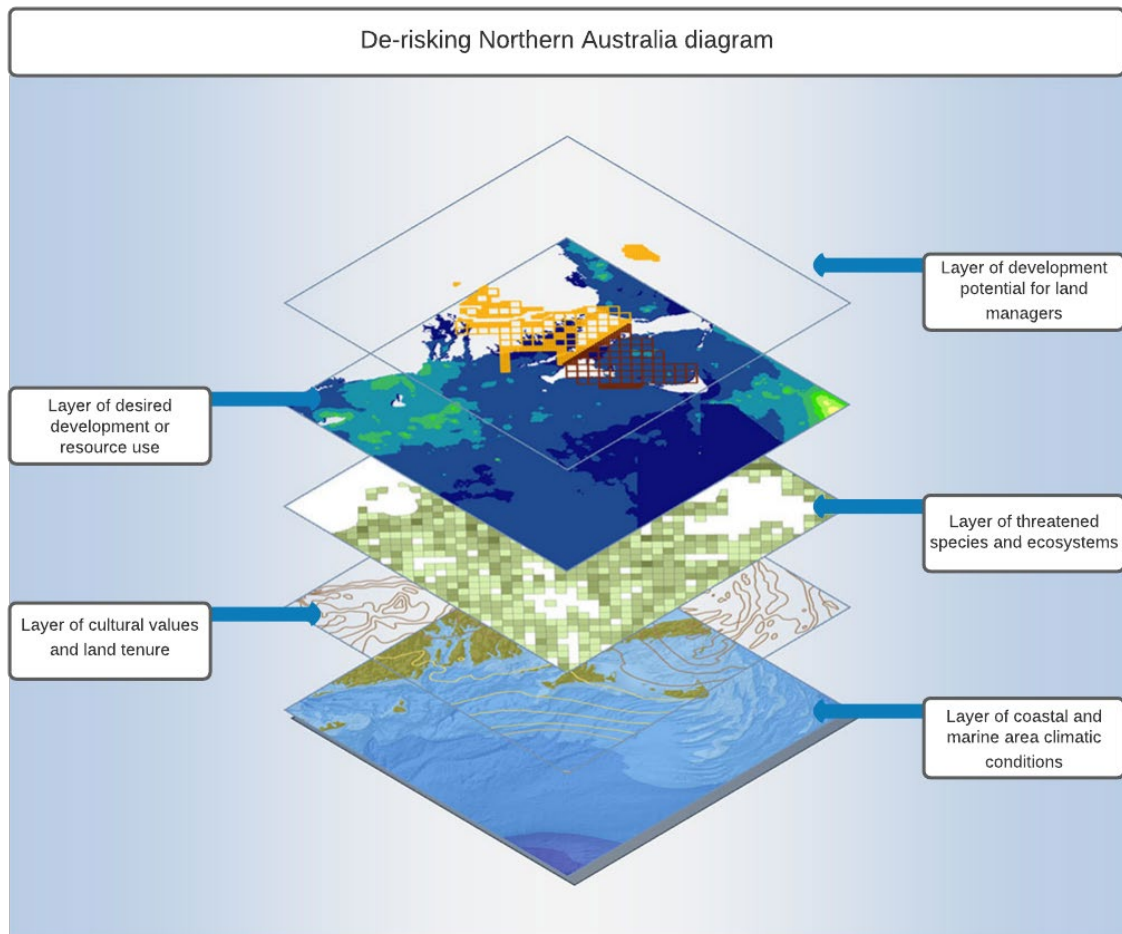
Methodology

The scoping project will conduct a series of facilitated workshops and direct engagements with identified stakeholders to develop the research strategy for the three case studies across Northern Australia. We envisage an initial partner workshop to elicit expert advice on the methodology for the de-risking case studies followed by multi-stakeholder workshops, with participants from science and government and traditional owners across Northern Australia. Workshops will be held in Darwin Brisbane, North Queensland and Perth; an additional workshop will be held in Canberra to specifically capture Departmental priorities and considerations.

Within DAWE we plan to engage, either through workshops or direct consultation

- The Assessment Branch
- Environmental Information
- Environment Protection Reform Branch
- Parks Australia
- Reef Branch
- Heritage Branch
- Protected Species and Communities Branch
- GBRMPA
- Supervising Scientist Branch
- Wetlands section
- Environmental Biosecurity Office
- Monitoring, Evaluation, Reporting and Improvement Section, MERI Program Delivery Branch
- Bushfire Recovery Programs Branch

We will engage with additional areas as they are identified as needing to contribute to the project.

Whilst we will not be able to fully develop the methodology until we have conducted further end-user engagement and held initial workshops, we have a preliminary program based on end-user engagement conducted to date. It is clear that the contested debate we refer to in the Project Description above can be traced back to insufficient available information, resulting in poor planning, development proposals and heightened community concerns. We propose to contribute to easing this situation by filling information gaps at large spatial scales, creating data layers of the distribution of marine and coastal resources across northern Australia. This is schematically shown in the below diagram. Here it can be seen how information (expressed as data layers) from many different types of projects (marine resource mapping, threatened species distribution, climate change (sea-level rise), Indigenous cultural values, economic values and development precincts all combine to assist with the decision-making process.

De-risking Northern Australia diagram

- Layer of development potential for land managers
- Layer of desired development or resource use
- Layer of threatened species and ecosystems
- Layer of cultural values and land tenure
- Layer of coastal and marine area climatic conditions

To achieve the data layers illustrated above requires the production of broad-scale data layers using consistent approaches. It is proposed that our workshops will identify existing data sources (the extent of current information), develop mechanisms for expressing consistency across this data (so that like can be compared with like – this will be discussed in project 1.5 (review of wetland inventory knowledge gaps), and from the gaps identified, determine how to fill them (e.g. via field data collection, distribution modelling, Bayesian modelling). Various mechanisms for gap filling may be required and it is here that interactions with other projects in our Research Plan are importantly linked. Various threatened species projects, especially our Scoping Study 1.20 and the project on shorebirds 1.21, will be required to populate these data layers. Mechanisms for information gap-filling may include traditional approaches to mapping, noting that projects 1.12, 1.13 and 1.14 (all seagrass mapping projects) contribute to this effort; trialling new methods for large-scale monitoring/assessment (the subject of scoping study 1.29); the involvement of citizen science (also the subject of scoping study 1.29); use of Indigenous Rangers (to be discussed in 1.31 Indigenous engagement scoping study). A blue carbon potential layer would be an important data layer in the decision-process and the only blue carbon method currently approved is tidal re-introduction and we have three case studies on this in our small-scale project 1.15. The NESP 1 cross-Hub project on IEA in Northern Australia makes a contribution by providing a baseline of datasets (via metadata) that may be required as part of this scoping study. NESP1 Marine Hub A12 (seascapes of northern Australia) will make a more substantial contribution through its species distributional data. This project will also require input from numerous other past and present non-NESP projects. Because of the scale of northern Australia, the above-described approach will have to be trialled in case study locations. Selection of these case study locations will be consulted and scoped within this scoping study.

In addition to developing these data layers, this all has to be accepted by and feed into the regional planning environment. This will be a major part of this scoping study and will require particular engagement with the CRC for Northern Australia, the Office of Northern Australia and the Qld, NT and WA state govts. This in itself will be a major part of this scoping study.

Workshops:

Discussion papers with appropriate subject matter will be developed for each of the workshops to guide discussions on the relevant pathway forward. The issues covered will include, but not be limited to the following:

- The utilisation of the integration methodology developed through the NESP 1 cross-Hub *Integrated Analysis for Sustainable Regional Development: Northern Australia.* This includes the incorporation of existing data sets from Australian and State Governments and Councils and the identification of gaps in data and knowledge. Additionally, ecological and species data mining from *easily to access* Environmental Impact Assessments and other consulting reports will be pursued along with marine and coastal species distribution maps from existing research across Northern Australia.
- Key Development regions and the downstream environments, that have been prioritised by the State and Territory jurisdictions, will become the basis from which the case studies areas are selected. Within the case study selection process consideration of existing jurisdictional land management regulatory frameworks and water allocation and management policies will be undertaken.
- The development of a values-based framework that can identify key factors influencing trade-offs/offsets values in ecosystems such as wetland, salt marsh, mangrove and blue carbon restoration opportunities.
- A preferred engagement approach to Traditional Owner groups within the case study sites will be developed through the Indigenous Leaders network, encompassing development, environment and cultural protection agendas.
- A review of Australian Government policy and process approaches within existing assessment legislation and how these interact with State and Territory processes will be considered. Gaps and options for streamlining will be identified.

The technical report will aim to deliver the most appropriate case study sites to test cost effective real-world approaches to improved development assessment, and environmental and cultural protection for Australian and State Government decision makers. This technical report will inform the future investment by the MAC and RL Hubs into the northern Australia de-risking development agenda.

Roles

The project research team has many decades of experience in facilitating placed based governance in northern Australia and the Great Barrier Reef. As additional skills are required e.g. regulatory review these will be added to the team. Overall responsibility will be Professor Alan Dale, the Hub Co-Leader Prof Damien Burrows and Sheriden Morris. The Indigenous Facilitators will provide a link to the Scoping Study 1.31 - Indigenous engagement and participation. Alan Dale provides a strong link with the CRC for Northern Australia. This team provides deep research access to a national network of researchers capable of contributing to the resolution of the issues facing the Northern Australian development agenda. As the research leader, Prof Allan Dale brings a track record of cross-sector engagement, building organisational capability and responsiveness, marshalling professional expertise, steering and implementing change, dealing with uncertainty and delivering on intended results.

Outputs.

By September 2022, this project will deliver a complex, multi-partner agreed pathway that will deliver:

- Landscape scale case studies in Western Australia, Northern Territory and Queensland.
- Methodologies for fine scale mapping of ecologically valuable ecosystem and species distribution mapping across the key case study sites.
- Approaches for maximising Traditional Owner participation in the case studies and in broader development and conservation and cultural protection agendas.
- Methods for data management and storage and best options for public access.
- Deep-dive learning experiments demonstrating what it takes to deliver real-world sustainable development within the sensitive environs of the Northern Australian context.

Note:

The Resilient Landscape Hub and the Marine and Coastal Hub have committed to working together to achieve improved biodiversity and cultural outcomes across Northern Australia. The Hubs will also reach across to other agencies operating in north, in particular the Office of Northern Australia and the CRC for Developing Northern Australia to develop a mutually agreed process. We will also engage with the Climate Systems and Sustainable Communities and Waste Hubs to test their potential contributions to this project.

Outcomes

This scoping study will provide a systematic approach that incorporates biophysical, regulatory, and cultural feasibility of potential case study areas for future investments that we anticipate making in this Hub. Importantly, these areas will provide realistic options for sustainable development by incorporating the ongoing goals from the States, Councils and Traditional practices and values as well as identifying key gaps to support further assessments. It will also identify the factors influencing restoration opportunities, off-sets, trade-offs in ecosystem values including a values-based framework that can be applied to other regions of Australia to identify blue carbon restoration opportunities.

The overarching framework will form the basis of investment for the Hubs future case studies in QLD, WA and NT.

Indigenous consultation and Engagement

This a Category 1 (Indigenous Partnerships Strategy) project of considerable importance to Indigenous people. This scoping study will utilise the Hub's Indigenous Facilitators, Mr Stan Lui and Mr Kenny Bedford in conjunction with the proposed Indigenous Research Network to facilitate the input from over 42 northern Indigenous organisations into the project. These organisations include but are not restricted to Native Title holders, Prescribed Bodies Corporates, identified Traditional Owners and other bodies which represent or advocate for Indigenous peoples. Given that the Indigenous estate dominates Northern Australia and Indigenous interests in water, land, catchment health and future economic opportunities their direct participation is essential.

By engaging Indigenous leaders across Northern Australia, the aspirations outlined in the Indigenous Accord for the Development of Northern Australia can be incorporated into the methodology developed within the de-risking case studies. Through co-development of the project, Traditional Owner knowledge and approaches to engagement and dispute resolution will be mainstreamed throughout the delivery of the project and beyond.

The joint Hub approach between the Marine & Coastal and Resilient Landscapes Hub for consultation with Traditional Owners will maximise input to the developing strategy and minimise cross talk stemming from too many indigenous engagement mechanisms. This approach helps to fulfill the request of Traditional Owner communities to reduce the 'humbug' of elders by multiple researchers and will focus engagement on issues that are of direct importance to indigenous groups. This approach also strengthens the process of informed consent over the sharing of knowledge and the pathway to knowledge repatriation.

The project lead and participating researchers have an large established indigenous network and when combined with groups such as the North Australian Indigenous Land and Sea Management

Alliance, Aboriginal Biodiversity Conservation Foundation, Indigenous Carbon Industry Network, Indigenous Land and Sea Corporation, the Prime Minister's Indigenous Reference Group, the Minister for Environment's Indigenous Advisory Group, the National Indigenous Australians Agency and the proposed Indigenous Research Network, delivers a comprehensive approach to indigenous participation and engagement.

Research, Government and NGO partner institutions will also be encouraged to support employment pathways by providing professional development opportunities and capacity building for Indigenous peoples. This would include opportunities for doctoral, postdoctoral and graduate programs within the institution. Indigenous land and sea ranger groups will be given the opportunity through partnership with research projects to enhance and improve the community's capacity to monitor natural environmental assets within their sea country.

Location of research

The majority of the work for the scoping study will occur in across Northern Australia with workshops in Darwin, Brisbane, Townsville, Perth/north WA and a Departmental workshop in Canberra.

This scoping study is planning a case study, in future years, that will include local, regional and national objectives. The case studies will be designed to scaled-up or be transferred to other regions, as appropriate. The choice of locations is a key outcome from the scoping and co-design process.

Project 1.33 EP: Application of environmental DNA to survey Bathurst Harbour Tasmania for the endangered Maugean skate

Project description

Project summary

This study will use Environmental (e) DNA to determine the presence/absence of the endangered Maugean skate (*Zearaja maugeana*) in Bathurst Harbour, Tasmania. *Zearaja maugeana* is classified as endangered based on its small population (~ 3000 individuals, Macquarie Harbour, Tasmania, 2016) and restricted distribution (Bathurst and Macquarie Harbours). Initially discovered in Bathurst Harbour in 1988, it has not been recorded there since 1992. Additionally, recent research suggests that the Macquarie Harbour population may be declining. As such, there is an urgent need to determine the current status of the Bathurst Harbour population. This research will address this need.

Project description

Determining the presence of endangered marine species is important for the implementation of effective management strategies to minimize impacts on the populations and conserve the species. Confirming presence relies on locating the animals, which can prove challenging for species with low population numbers. A variety of methods have been used to determine the presence of rare marine species, including fishing and underwater visual surveys. Genetics has proven to be a viable alternate technique for detecting the presence of rare or cryptic species in the wild, by seeking DNA evidence in environmental samples of sediments, ice, or water [1-4]. Environmental DNA (eDNA) has been used for over a decade to investigate the presence of a variety of organisms, including microbes [5], plants and animals [4, 6], delivering unique information on past and present biodiversity [3]. Vertebrate eDNA is DNA that is deposited in the environment through a variety of bodily processes, including the shedding of skin, hair, or feathers, or through defecation, urination, or excretion of saliva.

In the aquatic environment, the presence of a rare species can be assessed by taking a water sample and testing whether the DNA fingerprint of the target species is present. Using eDNA to determine presence of rare or cryptic species can be more efficient than detecting the animal itself, and eliminates the risks associated with capture techniques that may be harmful to the individuals. Additionally, developing a species-specific eDNA assay requires only a single DNA sample of the target species from which genetic primers are designed. This species-specific approach uses real-time, or quantitative, polymerase chain reaction (PCR) tests (qPCR) to target individual eDNA sequences of the focal species and is confirmed through Sanger nucleotide (building blocks of DNA) sequencing [7]. eDNA techniques have been applied in the marine environment to detect marine mammals, teleosts, and elasmobranchs in the wild [4, 6, 8-10].

This study will use eDNA to determine the presence of the endangered Maugean skate (*Zearaja maugeana*) in Bathurst Harbour on the southwest coast of Tasmania. *Zearaja maugeana* has been classified as endangered under the Australian Environment Protection and Biodiversity Conservation Act (1999) and the Tasmanian Threatened Species Protection Act (1995) based on its small population size and restricted distribution, as it has only been reported from two remote estuarine systems in Tasmania, Bathurst Harbour and Macquarie Harbour on the west coast [11]. Initially discovered in Bathurst Harbour in 1988, *Z. maugeana* has not been recorded in that locality since 1992, with only four individuals ever sighted, despite extensive fishing and underwater visual surveys conducted over a number of years, with the most recent survey in 2016 [12, 13]. The lack of

confirmed sightings has raised considerable uncertainty as to the current status of the Bathurst Harbour population, implying either a very small population size or even localised extinction.

Bathurst Harbour has been a marine protected area since 2005 and, being in a wilderness area, is subject to minimal anthropogenic disturbance. Unlike Bathurst Harbour, Macquarie Harbour has a number of anthropogenic influences, including historic mining, salmon farming and river flow into the harbour being influenced by hydroelectric power generation. As a result, the environmental conditions have undergone significant changes in recent decades, particularly in respect to dissolved oxygen levels, which have declined [14].

In contrast to Bathurst Harbour, *Z. maugeana* has traditionally been more readily encountered in Macquarie Harbour. However, it is not considered abundant in this location, with an estimated population of only 3000 individuals in 2016 [13]. Additionally, recent research has highlighted the vulnerability of early life stages to the changing environmental conditions, long-term changes in the size structure of the population, and the mortality of individuals following significant environmental events. Collectively these issues emphasise the vulnerability of the Maugean Skate in Macquarie Harbour and the need to consider further conservation action to support the persistence of this unique micro-endemic skate in Tasmania [15].

Given the vulnerability of *Z. maugeana* in Macquarie Harbour, it is important to determine if the species still exists in Bathurst Harbour, as this will inform the current conservation status and influence appropriate conservation actions for the species. Species-specific primers and probes have already been designed to detect low concentrations of *Z. maugeana* eDNA from as little as one litre of water collected at depth (10-15 metres) in Macquarie Harbour [8]. The technique was validated for use in detecting *Z. maugeana* in the wild, with the identity of the eDNA confirmed as *Z. maugeana* by sequencing the qPCR products and aligning these with the target sequence for a 100% match. In conjunction with recent methodological updates for this rapidly advancing method [1, 2, 5, 16-18], we will use these already developed *Z. maugeana* eDNA tools, as a validated alternative technique to the traditional survey methods, which have failed to detect the presence of the species in Bathurst Harbour for nearly three decades. Additionally, being a marine protected area, the application of non-destructive sampling methods such as eDNA are especially appropriate. Specifically, we will systematically sample water throughout Bathurst Harbour and test for *Z. maugeana* eDNA over two seasons (i.e., two separate sampling periods), as catchability has been shown to vary seasonally in Macquarie Harbour [13]. Water samples from the main *Z. maugeana* aggregation site in Macquarie Harbour will also be examined over one sampling period to act as a positive field control.

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2. Sepulveda, A.J., et al., *Improved detection of rare, endangered and invasive trout in using a new large-volume sampling method for eDNA capture.* Environmental DNA, 2019. **1**(3): p. 227-237.
3. Pedersen, M.W., et al., *Ancient and modern environmental DNA.* Philosophical Transactions of the Royal Society B: Biological Sciences, 2015. **370**(1660): p. 20130383.
4. Thomsen, P.F., et al., *Detection of a diverse marine fish fauna using environmental DNA from seawater samples.* 2012.
5. Patil, J.G., et al., *Development and evaluation of a PCR based assay for detection of the toxic dinoflagellate, Gymnodinium catenatum (Graham) in ballast water and environmental samples.* Biological Invasions, 2005. **7**(6): p. 983-994.
6. Foote, A.D., et al., *Investigating the potential use of environmental DNA (eDNA) for genetic monitoring of marine mammals.* 2012.
7. Patil, J.G., et al., *Specific detection of Pacific oyster (Crassostrea gigas) larvae in plankton samples using nested polymerase chain reaction.* Marine Biotechnology, 2005. **7**(1): p. 11-20.
8. Weltz, K., et al., *Application of environmental DNA to detect an endangered marine skate species in the wild.* PLoS One, 2017. **12**(6): p. e0178124.
9. Simpfendorfer, C.A., et al., *Environmental DNA detects Critically Endangered largetooth sawfish in the wild.* Endangered Species Research, 2016. **30**: p. 109-116.
10. Sigsgaard, E.E., et al., *Monitoring the near-extinct European weather loach in Denmark based on environmental DNA from water samples.* Biological Conservation, 2015. **183**: p. 46-52.

11. Edgar, G.J., et al., *Conservation of natural wilderness values in the Port Davey marine and estuarine protected area, south-western Tasmania.* Aquatic Conservation: Marine and Freshwater Ecosystems, 2010. **20**(3): p. 297-311.
12. Treloar, M., N. Barrett, and G. Edgar, *Biology and ecology of Zearaja maugeana, an Endangered skate restricted to two south-western Tasmanian estuaries.* Marine and Freshwater Research, 2016. **68**(5): p. 821-830.
13. Bell, J., et al., *Movement, habitat utilisation and population status of the endangered Maugean skate and implications for fishing and aquaculture operations in Macquarie Harbour.* 2016.
14. Ross, J. and C. MacLeod, *Environmental Research in Macquarie Harbour. FRDC 2016/067: Understanding oxygen dynamics and the importance for benthic recovery in Macquarie Harbour. Progress Report.* 2018.
15. Moreno, D., et al., *Vulnerability of the endangered Maugean Skate population to degraded environmental conditions in Macquarie Harbour.* 2020.
16. Stauffer, S., et al., *How many replicates to accurately estimate fish biodiversity using environmental DNA on coral reefs?* bioRxiv, 2021.
17. Kirtane, A., et al., *Quantification of Environmental DNA (eDNA) shedding and decay rates for three commercially harvested fish species and comparison between eDNA detection and trawl catches.* Environmental DNA, 2021.
18. Wood, Z.T., et al., *Experimental assessment of optimal lotic eDNA sampling and assay multiplexing for a critically endangered fish.* Environmental DNA, 2020. **2**(4): p. 407-417.

Indigenous consultation and engagement

Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is considered a category 3 project for Indigenous engagement. Category 3 projects communicate and share results with relevant Indigenous organisations.

This project is focused on understanding whether or not the Maugean skate still occurs Bathurst Harbour, part of the Tasmanian Wilderness World Heritage Area (TWWHA) and also the Port Davey Marine Reserve. The TWWHA contains many culturally important coastal sites, in this context the project team will communicate the intent of this project and share the results of this research with interested Indigenous organisations. We will instigate engagement with the Tasmanian Regional Aboriginal Communities Alliance (TRACA) and the Aboriginal Heritage Committee of the Department of Primary Industries, Parks, Water and Environment.

Location of research

On-ground work will be in Bathurst (Fig. 1) and Macquarie (Fig. 2) Harbours in Southwestern and Western Tasmania, respectively and is local in scale, as these are the only known locations of the Maugean skate. Note that for this research, Bathurst harbour includes Bathurst Channel (Fig. 1).
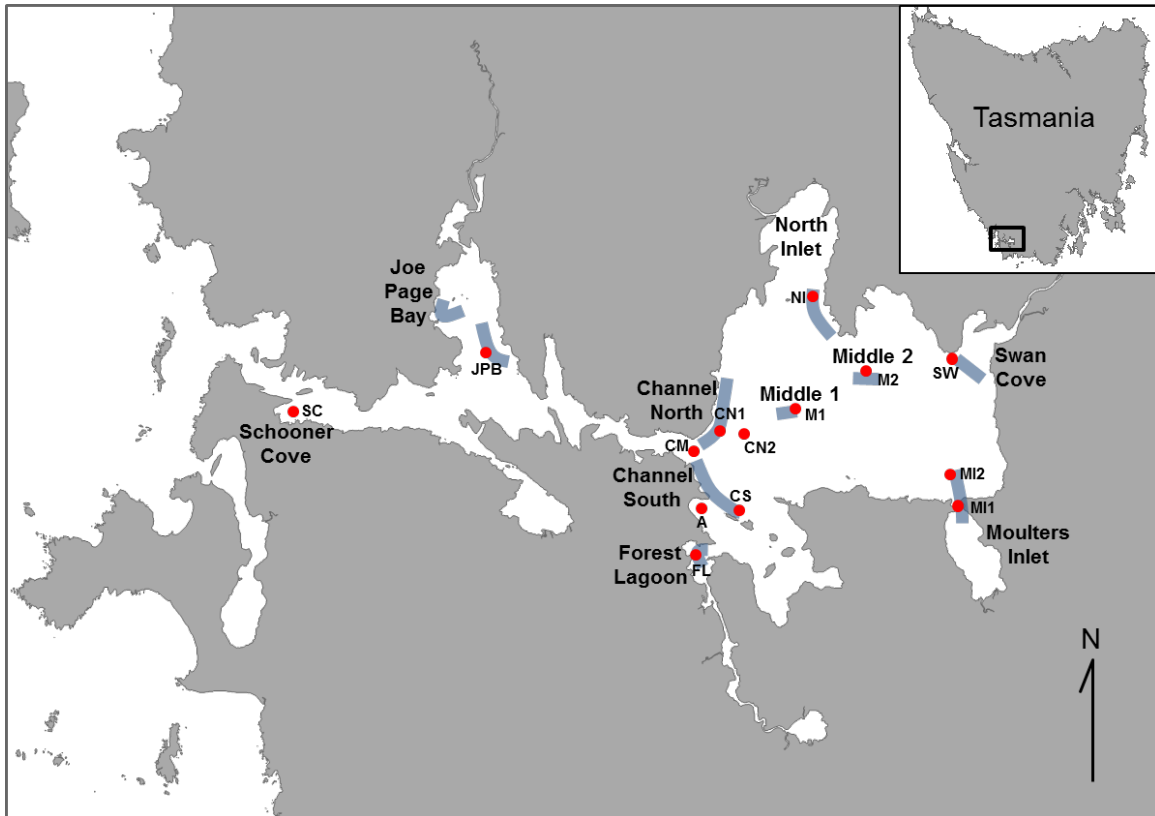
Fig. 1: Bathurst Harbour and Bathurst Channel, Tasmania. Blue lines and red circles denote netting/longline and water sampling sites, respectively, from the last attempted capture survey for Maugean skates at this site (See Bell, J., et al., Movement, habitat utilisation and population status of the endangered Maugean skate and implications for fishing and aquaculture operations in Macquarie Harbour. 2016). These sites will be used as a starting point for site selection in this proposed study.
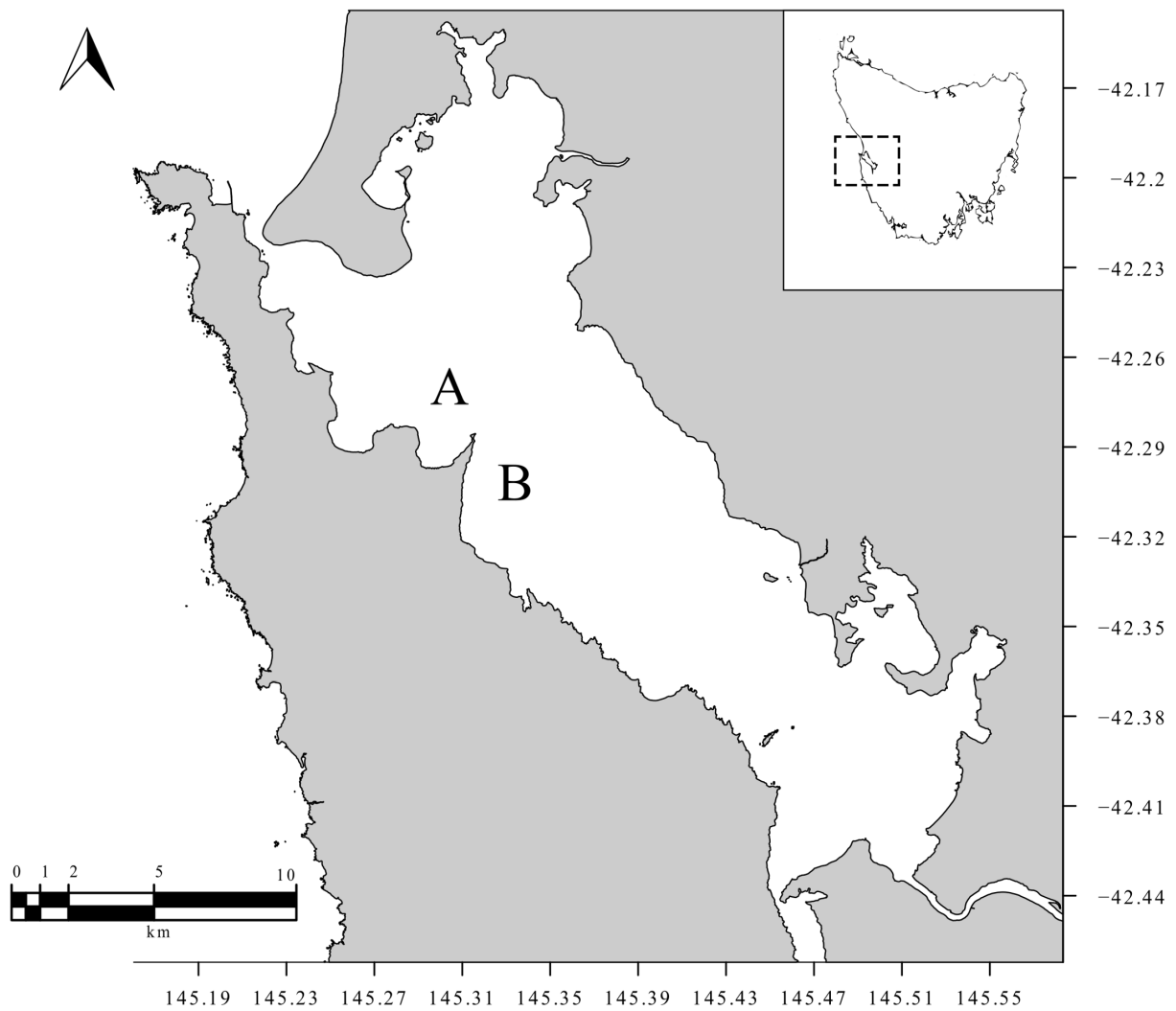
Fig. 2: Macquarie Harbour, Tasmania. This map shows the location of the two sampling sites used in Weltz, K., et al. (2017; Application of environmental DNA to detect an endangered marine skate species in the wild. PLoS One, 2017. 12(6): p. e0178124) to collect water at depth from Macquarie Harbour, including Table Head (A) and Liberty Point (B), which have traditionally been the sites of greatest Maugean skate abundance. These sites will also be used in this proposed study.