

National Environmental Science Program

Marine and Coastal Hub research plan
2023 – Project plans



Project 3.1 – Regional planning in northern Australia: Building a community of practice and sentinel case studies for supporting improved approaches to achieve ESD.

Project description

Project summary

This project grows momentum from NESP MAC Hub Project 1.32, which engaged northern Australians on the need for improved regional planning to deliver Ecologically Sustainable Development (ESD) outcomes. Project 1.32 identified Stage 2 investment to build: (i) a strong regional planning community of practice across the north; and (ii) three longer-standing sentinel case studies for improving regional planning practice within northern regions (WA, NT and Qld). In a methodological sense, the northern Australian community of practice will build on the network foundations established in Project 1.32, and will focus on scanning best practice approaches across the north, exploring innovative ways to communicate these approaches, and ensuring the network is strengthened through regular newsletters and targeted symposiums. The sentinel case study approach will inform policy and practice improvement at the jurisdictional and Commonwealth scales, and will apply Governance Systems Analysis approaches developed under previous NERP and NESP investments. This innovative method employs highly deliberative and evidence-based approaches to the practical analysis of complex governance systems in highly contested landscapes like northern Australia.

Given the emerging Commonwealth focus on regional planning effort based on the Samuel review, this project represents perfect timing to focus on best practice, including knowledge management, as well as the opportunity to support emerging Commonwealth, State and Territory efforts regarding these reforms. It particularly addresses the headline issue identified in the MaC Hub 2023 Research Plan which seeks to “address the governance requirements and barriers for regional planning nationally”. This particularly includes an emphasis on northern Australia (i.e. de-risking landscapes).

Project description

This project can be described in the following terms:

Problem Statement

The Samuel review of the EPBC, research from CRCNA (de-risking) and cross-cutting themes from previous NESP Hubs (i.e. Integrated Environmental Assessment) have all called for an increased focus on Commonwealth sponsored regional planning in the north to reverse poor outcomes from Australia’s current environmental and economic decision making. These above research efforts suggest that current environmental decision making across northern Australia is not effectively servicing environmental outcomes, economic investment *and* Indigenous interests in country. In the absence of a strong existing practice network, this project seeks to ensure practice quality is considered and promoted from the start of these new efforts.

Project Approach

This project will be delivered through: (i) instigating and developing a strong regional planning community of practice (i.e. evidence-based network of government agencies, practitioners and stakeholders) across the north; and (ii) scoping 3 longer-standing sentinel case studies aimed at informing and supporting improved practice within regions (WA, NT and Qld). The project will not attempt to do regional planning, but instead directly support emerging regional planning efforts across Northern Australia. For this reason, case studies efforts will be carefully negotiated with all three jurisdictions and prospective regional communities.

Research Delivery

The community of practice component of this research will seek to build a stronger practice network emerging from Project 1.32 through targeted knowledge sharing events, webinars, newsletters and information products. Also building on Project 1.32, the case study approach will require: (i) a negotiated identification of case regions (3 months); (ii) a collaborative analysis of current regional planning governance systems and the integration of knowledge systems (12 months); and (iii) the negotiation of Stage 3 regional planning system improvement priorities and an associated future investment plan (3 months).

Research Method

Community of Practice: The objective of this approach is to lift capacity among all sectors involved in ESD-related approaches to regional planning in the north. Our community of practice approach will build on the extensive government, industry, conservation sector, Traditional Owner and research networks built during Project 1.32. The method applied will include: (i) regularly scanning the network for innovations and new developments in regional planning; (ii) considering new ways to communicate this information and to grow capacity within the network; and (iii) progressing targeted communication and capacity building approaches, but specifically at least including newsletter-based approaches and targeted symposiums.

Sentinel Case Studies: The objective of the sentinel case studies is to, through targeted analytical research, improve landscape outcomes within real world regional planning activities across WA, Queensland and the NT (including minimising the impact of terrestrial development of marine environments and marine protected areas). This is also intended to inform policy and practices in regional planning that is increasingly being adopted across the Commonwealth, but particularly in relation to reform of the *Environment Protection and Biodiversity Conservation Act*. The method applied will be Governance Systems Analysis (GSA). The GSA method was developed and trialled under previous NERP and NESP investment cycles, and is particularly suited to cross-realm planning. It is based on theoretically informed approaches to analysing complex governance systems but carries this work out in a way that deeply engages system stakeholders and supports them in their own approaches to improvement of the system at hand (in this case regional planning for ESD). Learnings from this case study work and from the community of practice network will also be synthesised to help inform both policy and practice improvements at the Commonwealth scale.

Research Foundations

This project strongly arises from the key findings of the MaC Hubs Project 1.32: *Supporting Regional Planning in Northern Australia*. Following extensive engagement across the Australian Government, State and Territory Governments, Local Government, Industries, communities and Traditional Owner institutions across the north, this project delivers on the key “next stage” research activities identified as being a priority to be progressed through this MaC Hub Research Plan investment.

Hub and Research Alignment

The project strongly links to the regional planning research efforts of the Resilient Landscapes Hub (via Michael Douglas) and supports aligned research (De-risking and Water Security) investment through the CRCNA.

Research Impact

The research will be directly applied to inform decision-making and on-ground action through: (i) effectively extending best-practice regional knowledge and approaches across all key stakeholders, but particularly through close collaboration with the Department of Climate Change, Environment, Energy and Water. It will also support improved decision making directly within 3 sentinel case regions, one of each of the three Northern Australian jurisdictions.

Indigenous consultation and engagement

This a Category 1 (Indigenous Partnerships Strategy) project of considerable importance to Indigenous people. Consistent with the MaC Hub's Indigenous Partnership Strategy, strong Indigenous input was received during Project 1.32 as a precursor to design thinking in relation to this project. Key engagements have included NAILSMA, ILSC and the Torres and Cape Indigenous Councils Alliance. The project team also has strong relationships with various regional traditional owner networks with an interest in catchment scale decision making, including Cape York Land Council, the Wet Tropics Rainforest Aboriginal People's Think Tank, and traditional owner advisory arrangements in the Burdekin, Fitzroy and Reef catchments.

In relation to pan-northern Australian aspects of the project, the Project Team has kept a strong linkage to the emerging (NESP-supported) National Indigenous Environmental Research Network (Project 3.2), which aims to facilitate structured research input from over 42 northern Indigenous organisations. In this context, we will be particularly focussed on supporting Traditional Owner interests across the north increasing their capacity and influence within emerging regional planning activities. These organisations include but are not restricted to Native Title holders, Prescribed Bodies Corporates and 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.

The Project Team also has a strong relationship with the Indigenous leaders across Northern Australia and has actively supported the Indigenous Reference Group to further its aspirations outlined in the Indigenous Accord for the Development of Northern Australia. Principles outlined in the Accord will be incorporated into the project methodology developed both in respect to building a pan-northern community and practice and within the de-risking case studies.

Working with joint Hub approaches between the Marine & Coastal and Resilient Landscapes Hub for consultation with Traditional Owners will also maximise input to the developing project strategy and minimise cross talk stemming from too many indigenous engagement mechanisms. This approach will help 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 has a large established indigenous network across the north, combined with groups such as the North Australian Indigenous Land and Sea Management Alliance, the Indigenous Carbon Industry Network, the 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. The proposed National Indigenous Environmental Research Network (Project 3.2), delivers a comprehensive approach to indigenous participation and engagement.

Research, Government and NGO partner institutions will also be encouraged to support inclusion and employment pathways by providing professional development opportunities and capacity building for Indigenous peoples at scale. This could include opportunities for doctoral, postdoctoral and graduate programs within the institution.

The project will not develop its own ICIP regarding Indigenous interests in regional planning but will instead support Traditional Owner institutions to build their own ICIP strengths, empowering them to have a stronger voice in respect to emerging new approaches to regional planning and decision making. This might look like the project supporting Traditional Owners to develop their own institutional policies and procedures in relation to regional planning.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National	Regional – Nth Australia	Local
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Northern Australia	The project, through the Community of Practice and its wider regional planning governance recommendations, will have a Northern Australian wide focus.		
Northern Western Australia	The project, through the WA Sentinel Case Study analysis and recommendations, will have specific relevance to a northern WA region to be determined through jurisdiction and stakeholder-based negotiation within the research process.		
Northern Territory	The project, through the NT Sentinel Case Study analysis and recommendations, will have specific relevance to an NT region to be determined through jurisdiction and stakeholder-based negotiation within the research process.		
Northern Queensland	The project, through the Qld Sentinel Case Study analysis and recommendations, will have specific relevance to a northern Qld region to be determined jurisdiction and stakeholder-based negotiation within the research process.		

Project 3.2 - Developing a National Indigenous Environmental Research Network – Marine and Coastal research case studies

Project description

Project summary

The proposed National Indigenous Environmental Research Network (NIERN) is an Indigenous-led strategic initiative to establish a community of practice that supports current environmental research needs and priorities, enhance future research agendas, mobilise investment opportunities, bolster the impact and durability of research outcomes and empower Indigenous Australians to participate in the national environmental scientific research agenda. This project will experiment with conceptual models for establishing a working NIERN to provide evidence that will guide Indigenous organisations, policy makers and researchers that aim to support Indigenous leadership and participation in environmental research.

The NESP 2020 review reported that *“Indigenous peoples seek earlier involvement in land and sea country research. This means being formally included in the project design, development and delivery.”*

We will work with Indigenous organisations, government agencies and researchers across Australia to provide a national perspective of current processes used to establish new research priorities and projects and use case studies to explore how Indigenous led approaches could augment these projects through Indigenous participation at all project stages.

Project description

Problem Statement

At a recent national workshop at the Australian Marine Science Conference in Cairns, facilitated by the NESP Marine and Coastal Hub and NAILSMA, Indigenous leaders from across Australia (full table of participants listed below) identified opportunities and constraints for Indigenous participation and leadership in environmental research in Australia’s marine and coastal regions. One of the critical gaps in current environmental research funding is lack of resourcing to properly engage local Indigenous organisations in the development and implementation of research priorities and projects. A major challenge is that national research priorities are abstracted from local and regional processes. This means that the first time Indigenous organisations engage with research projects are once they have been developed and are being implemented.

Common issues raised by Indigenous groups regarding environmental research include inadequate resourcing for Indigenous-led and Indigenous governed research institutes, lack of dedicated funding for Indigenous academics, limited resources to support research networks and a need to improve ethical guidelines and research protocols.

A functional Indigenous led research network will improve all forms of research practice involving Indigenous Australians.

Project justification

NIERN builds on previous and existing endeavours by government to promote Indigenous Australians and their aspirations from the recognition of traditional knowledge and for new knowledge that addresses their research needs, particularly when those needs relate to matters which impact upon them, their rights and their land and sea estate. NIERN seeks to build on this investment, upscaling Indigenous participation. This project is a priority because government programs explicitly include statements on Indigenous engagement, participation and leadership in the development and implementation of environmental policy but there are currently no Indigenous led initiatives that support this work.

Project Scope

This project will use key Indigenous research themes (e.g. participation, cultural authority, partnerships, healthy people, Indigenous leadership, training and equity of funding) to develop and test new approaches to environmental research programme implementation and design at a variety of geographic and jurisdictional scales.

A senior Indigenous researcher will lead the project and will establish a national project steering committee, comprising experienced Indigenous members involved with environmental research, to guide research aims and methods, provide feedback on project outputs and produce relevant project communication. Human ethics approval and Indigenous cultural and intellectual property agreements will guide the way in which research is done, how information will be shared and communicated and how Indigenous participants will be engaged and acknowledged.

The project leader will work with the steering committee and research partners to identify suitable case studies. The case studies will be research projects or national environmental priorities that operate across states and work with Indigenous organisations at different scales (local, regional, state and territory and national). These case studies will be used to develop and test conceptual elements that will underpin the practical implantation of a NIERN at different scales.

A conceptual model of the NIERN will be developed that describes how a network could be practically implemented and operate at the different scales in which the case studies are operating. At the same time, a conceptual model will be developed describing the processes used to develop the case study research projects in the absence of a NIERN. This work will describe how funding decisions were made, how research priorities were defined and how Indigenous organisations were included in project development.

Using the conceptual models developed for NIERN and current research projects a systems model will be developed that overlays the two models and describes areas where models overlap and where there are gaps. Analysis will include an assessment of additional costs required to implement the missing elements and a discussion of the substantive changes that are required to meet the objectives of Indigenous people and organisations. The analysis will be contextualised within jurisdictional constraints, government environmental priorities and research gaps that underpin informed policy. Federal government policy leads will be engaged to document the underlying processes that influence policy decision that underpin investment in the research programs supported in the case study areas.

The project team will work with Indigenous organisations, researchers, and other relevant stakeholders in the case study areas through regular meetings and field work to collect qualitative data through structured interviews and participatory action methods. In addition, the team will work through the national network and steering committee to document examples of environmental research projects that provide insights for project outputs. These examples will be used to develop communications material that present positive Indigenous participation and leadership in environmental research projects. Stories will be developed through project activities that will amplify the stories of Indigenous environmental research and management. This work proposes to film and document research work within a select group of Indigenous communities. The work will produce a television series titled 'On Land and Sea Country' with consent for the footage and interviews able to be used for television and documentary content for First Nations TV and for potential distribution to

National Indigenous TV (NITV), mainstream television, and for the development of media resources for education, media training and creative media.

Using the selected case studies, research outputs and conceptual model analysis a research paper will be produced, led by the Indigenous research team and co-authored by the steering committee members and case study participants, that presents a pathway for establishing a NIERN and highlights critical gaps in contemporary practices.

NESP Project linkages

This project has direct relevance to research projects in all the NESP hubs and the development of research projects that seek to work with Indigenous people or on their lands and seas. The project team will facilitate an online workshop with Indigenous Facilitators from all the NESP hubs to document how other hubs are working with Indigenous organisations to establish research priorities and develop projects.

Project Impact

Project leaders will work with key regional partners and the steering committee to build and test the foundations of the proposed National Indigenous Environmental Research Network. Expected outcomes include;

- The establishment and adoption of best practice principles (UNDRIP/FPIC) to ensure research is user focused, relevant, innovative, measurable and delivers outcomes that have enduring economic, social, cultural and environmental benefits.
- Provide tangible approaches to ensure research investment and projects are compatible with and do not undermine customary decision-making systems, supports collective consensus decision making processes, enhances ethical research approaches and recognizes the ownership of natural resources, including land, water, biota, knowledge and Indigenous Cultural Intellectual Property.
- Create efficient governance reflecting local and regional input into research needs, program design, research approaches and implementation, while supporting the subsequent evaluation of outcomes including knowledge transfer and brokering.
- Establish mechanisms for developing Indigenous led research priorities, approaches and partnerships that build resilience and prosperity in the Indigenous and broader community which will promote equitable benefit sharing and generate transformational opportunities that are currently being overlooked.
- Amplify the recognition, use and value of Indigenous Traditional Knowledge, traditions, customs and practice while increasing the prospects for intergeneration knowledge transfer within the Indigenous community.
- Create pathways for succession and leadership opportunities for the Indigenous research sector that generate enduring employment, economic, social and cultural outcomes at a national level

Indigenous consultation and engagement

NIERN has been initiated and developed by Indigenous Australians and the project will be fully managed and run by them. It is an Indigenous-led strategic initiative to establish a community of practice led by Indigenous practitioners to support current research needs and priorities, enhance future research agendas, mobilise investment opportunities, bolster the impact and durability of research outcomes and above. Please see list of participants and contributors below for extent of Indigenous involvement in the development of the NIERN concept.

This project will be conducted collaboratively and with full consent of all participating Traditional Owners. Traditional knowledge and Indigenous Cultural and Intellectual Property (ICIP) will be managed following established standards (Our Knowledge Our Way Guidelines). Where these exist, we will work under established agreements that clearly sets out the purpose, benefits and responsibilities of any collaborative partnership, where these do not exist we will establish new research agreements. If there is agreement to share cultural knowledge we will also establish and Indigenous cultural and intellectual property (ICIP) agreement.

The project team will seek free, prior and informed consent from collaborating Indigenous organisations (or other relevant cultural authority) as part of any agreement associated with this project. The project team will work closely with collaborating Indigenous organisations to identify and develop appropriate research outputs for communicating the findings of this research to Indigenous people. We plan co-authorship of publications with Traditional Owners where they want to share their data and knowledge.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National <input checked="" type="checkbox"/>	Regional <input checked="" type="checkbox"/>	Local <input checked="" type="checkbox"/>
Location(s) – gazetted region /place name	Specific locations will be decided following consultation with local and regional organisations, the project steering committee.		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	TBA once consultations with case study regions are complete.		

Project 3.3 – Guiding research and best practice standards for the sustainable development of Offshore Renewables and other emerging marine industries in Australia

Project description

Project summary

Australia is entering a phase of rapid development of offshore renewable energy (ORE) projects and there is an immediate need to ensure these developments occur in a socio-ecologically sustainable manner. This project will identify existing environmental and cultural data and best-practice monitoring standards to inform the sustainable development of ORE projects (primarily wind) in Australia and enabling regulatory decisions to be compliant with Environment Protection and Biodiversity Conservation (EPBC) Act and the Offshore Electricity Infrastructure (OEI) Act requirements. This project plans to run in conjunction with a second project that focusses on the immediate priorities of regulators, with a focus on the confirmed area of declaration for ORE off the east Gippsland coast, Victoria. Critical to informing the direction and focus of these projects is guidance from an ORE Program Steering Committee, that will comprise representatives from relevant sections within DCCEEW, NOPSEMA, and MaC Hub partners involved in this project.

Project description

There is a rapidly developing offshore renewables sector proposed in Australia's Commonwealth and State waters which will involve planning, commissioning and installation, operation, maintenance, and eventual decommissioning of significant infrastructure. There are several Commonwealth and State agencies responsible for administering licensing and regulatory processes for such projects, as well as species protection and environmental management under various pieces of environmental legislation. These agencies rely on a strong scientific evidence base to support decision making under key national environmental legislation and to drive efficient regulatory processes. In situations where there are high levels of scientific uncertainty, regulators are required to take a precautionary approach and industry progress may be hampered. Government and industry have a shared responsibility to ensure quality environmental data is gained and made available in a timely way to underpin effective decision making and sustainable development.

Under the EPBC and OEI Acts, the onus is on industry proponents to conduct necessary field studies and research to support their project-related environmental impact assessments, as well as ongoing management of their activities if approved to proceed. Industry collection of such data would ideally use standardised methods, and ensure that there is an opportunity to maximise the use of those data more broadly across industry and by government. Government has a responsibility to conduct monitoring and research to support biodiversity conservation and protected area management, regional planning, and project approvals. Similarly, when the government collects and stores environmental data in standardised and transparent ways, the findability, accessibility, interoperability, and reusability of those data is improved. The NESP Marine and Coastal Hub (MaC Hub) has an important role to play in assisting with shaping future research priorities and associated data standards, and the ability to create an inventory of relevant data to ensure the development of the

Offshore Renewable Energy (ORE) industry in Australia results in optimised environmental and social outcomes.

The project will be informed and guided by an ORE Steering Committee (to be formed), with this committee articulating the knowledge needs of assessors, regulators, proponents, and other stakeholders where ORE projects are planned for Australia's continental shelf waters, with a focus here on temperate Australia matched to current proposal areas (Figure 1).

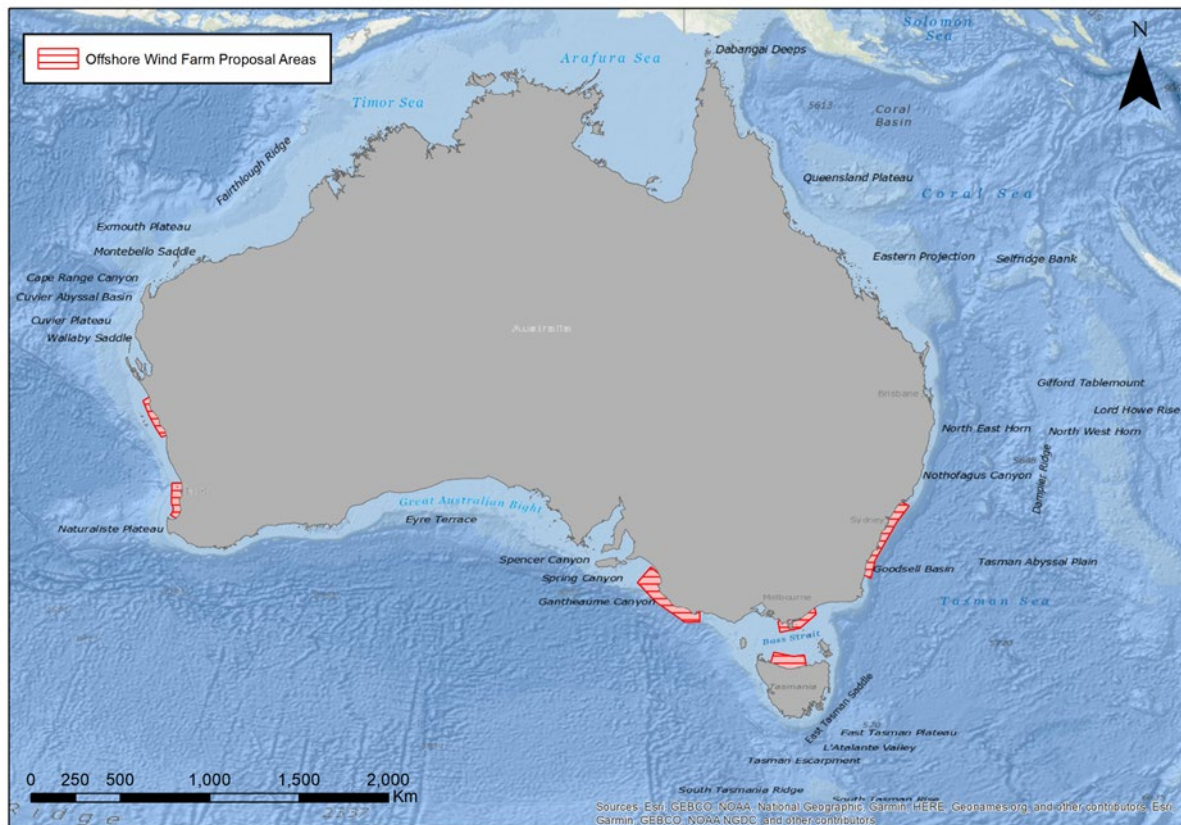


Figure 1: Current proposed offshore wind farm areas in Australia (2022).

The outcomes of this project will contribute to the ecological and sustainable development of ORE projects, with a focus on identifying information that allows regulatory decisions to be compliant with EPBC Act (and subsidiary documents) and OEI Act requirements. Specifically, the project will develop an inventory of existing information sources and expertise that can contribute to addressing the identified needs and priority gaps, including scoping new standards. The project aims to ensure improved transparency and awareness of existing and future research and data, reduce duplication, and improve collaboration of research effort. In doing so, the project progresses a national collaborative approach to ORE project-related research.

Considerable biophysical and species information is available to inform the ORE approvals process, but this information is mostly contained in grey literature or specific data portals, often dispersed across many research organisations, and is available in varying levels of detail for different areas. This includes data on seabed geomorphology, biodiversity, species distributions, Matters of National Environmental Significance (MNES) and other ecosystem components. The project will develop an inventory of existing information sources and expertise with respect to the following thematic areas:

- *Seabed geomorphology and habitat characterisation* – including full coverage seabed mapping (bathymetry) and shallow sub-seabed profiling, substrate composition, and habitat characterisation.
- *Interactions with oceanography* – e.g., potential influence on coastal processes including sediment transport.

- *Interacting species and habitats* – including, but not limited to, seabirds and shorebirds (migratory and resident), migrating terrestrial birds that traverse areas planned for development, mammals, bony fish, sharks and rays, and invertebrates, with a focus on threatened and migratory species, and species of cultural significance and including (where available), data on abundance, behaviour, distribution, and important habitats.
- *Potential impacts of installation, operation, and decommissioning* – e.g., habitat modification (including dredging/impact to wetlands), anthropogenic noise during installation, ongoing noise and electromagnetic fields generated during operation activities, increased vessel activity, collision risk and barrier effects on birds.
- *Monitoring needs and associated best practices* – identification of existing recognised best practice standards, monitoring potential impacts and evaluating the effectiveness of monitoring programs for supporting mitigation and management and/or regulatory needs from installation through to decommissioning (e.g., the NESP field manuals for marine sampling to monitor Australian waters), and gaps where such standards are yet to be developed. See <https://marine-sampling-field-manual.github.io/>
- *Indigenous communities and ORE development areas* – identification of specific Indigenous communities that are located in areas adjacent to current ORE development areas (Figure 1), identification of any existing Sea Country plans for these communities, identifying any existing information on cultural values, further notes on preferred methods of engagement for these indigenous communities potentially impacted by ORE developments.

The developed inventory that lists existing information and associated sources and expertise will be publicly available, and identify best practice methods by various government departments, proponents, and researchers for use in the planning, development, operation, and decommissioning phases of the offshore renewable sector. In doing so, the project will clearly identify where knowledge and data gaps presently exist, and where data may exist but are not able to be accessed or used to facilitate the sustainable development of the ORE industry (i.e., confidential data).

Experience from the development, management and decommissioning of the Australian oil and gas industry, i.e., research aimed at understanding the influence of offshore structures in marine ecosystems, will inform this research project. Further, international experience and lessons learnt will be garnered via the direct engagement of international experts with experience in impact assessments and monitoring of ORE and infrastructure in the Northern Hemisphere (North Sea) to ensure that the best available information and applicability to the Australian context can be synthesised. Such engagement will ensure that Australia is abreast of international standards and that management and regulation is based on robust and appropriate information and best practice.

The data inventory will provide the foundations in this component to assess knowledge gaps required for potential future evaluation of cumulative effects and interactions across multiple locations and with other sectors (noting previous work done by the NESP Marine Biodiversity Hub and underway elsewhere).

There are some key knowledge needs for assessors, regulators and proponents that are beyond the timeframe and scope of this project. These centre around an immediate need for broadly understanding overlap between ORE developments and key stakeholder groups (e.g., recreational and commercial fishing sectors, and local communities). There remains a need to understand stakeholder values, preferences, and social licence for ORE. This includes views on potential ORE environmental impacts, economic and social benefits (e.g., employment), design and positioning of ORE, and broad community aspirations and alignment of these aspirations with ORE. Further, preferred methods of engagement need to be outlined to properly understand and quantify these aspects. These aspects are beyond the scope of this study, but necessary to support the sustainable development of ORE in Australia.

Lastly, the success of this project is contingent on timely and clear articulation of the roles and knowledge needs of agencies involved in planning, assessment, approval, and regulation processes with respect to development of ORE in Australia.

Indigenous consultation and engagement

Indigenous engagement in 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 a Category 3 project for Indigenous partnerships with opportunities for communication.

The project team recognises that Indigenous communities are likely to be impacted by ORE developments. This project will conduct a concise desktop analysis to identify specific Indigenous communities that are located in areas adjacent to current ORE development areas, identify existing Sea Country plans for these communities, identify existing information on cultural values, further notes on preferred methods of engagement for these Indigenous communities potentially impacted by ORE developments. The project team includes specific Indigenous capability with prior experience in engagement. Where targeted communication is required with First Nations corporations, Traditional Owners and community, such discussion will draw on existing relationships established by project research partners and the NESP MaC Hub.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National <input type="checkbox"/>	Regional <input checked="" type="checkbox"/>	Local <input type="checkbox"/>
Location(s) – gazetted region /place name	Temperate Australia (see Figure 1)		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	<p>Offshore wind farm proposals are presently in areas aligned with the following Traditional Owners:</p> <p>Midwest - (Kalbarri) – Nhanda peoples Southern Yamaji group Whajuk and Wardandi Noongar Peoples Leeuwin - (off Binningup coast) – Pindjarup Noongar peoples Samphire - Lancelin-Two Rocks (Perth) – Yued Noongar peoples South Australia Bass – west coast Tasmania Eden Hunter Illawarra – Wodi Wodi peoples Newcastle Ulladulla Wollongong Port Kembla Gippsland- Gunaikurnai people Portland- Gunditjmarra people Port Fairy- Eastern Maar</p> <p>This list may change throughout the project.</p>		

Project 3.4 – Better Management of Catchment Runoff to Marine Receiving Environments in Northern Australia

Project description

Project summary

There are many catchments in northern Australia where increased catchment development is proposed. This is largely in the form of irrigation development, but also increased cattle stocking rates. Given the relatively low levels of such development in many catchments to date, there is a strong desire to maintain the integrity of coastal and marine receiving environments after the implementation of future developments. The baseline understanding of water quality in receiving marine environments and in the contributing catchments is very limited across much of northern Australia, making management and other development decisions very challenging. However, there are examples of intensive grazing and irrigation developments in northern Australia, e.g. in the Lower Burdekin Delta, adjacent to the Great Barrier Reef coastline, where lessons can be learnt to fast-track understandings and management and set testable hypotheses about the potential impacts of development in other northern catchments. This project aims to take advantage of these existing examples to improve the quality of decision-making around the impact of terrestrial runoff on the marine environment, providing a template for decision-makers.

Project description

The economic development of northern Australia is a bipartisan priority for the Australian Government and Queensland, NT and WA state/territory governments, and presents substantial opportunities for development in agriculture. However, to date, development has been poorly coordinated, resulting in poor quality development applications and limited progress. At the same time, in areas where development has occurred, has often occurred with limited background information on downstream impacts to the coastal and marine zone.

The coastal waters of northern Australia provide important habitats including mangrove forests, and seagrass beds. These habitats support critically endangered and culturally significant species such as migratory shorebirds, and crocodiles. Additionally, they support commercial fisheries species, such as barramundi and prawns. Studies to date have focussed on GBR catchments and the downstream impact of development. Whilst many of the examples from this region focus on eutrophication, excessive sediment loads and the impact on water quality in coastal waters, in many other parts of northern Australia, there has been limited development, and nutrient loads from catchments remain low. Studies in the Flinders, Gilbert and Norman River catchments (earmarked for water development) show that the nutrients associated with the freshwater flow in the wet season is critical for fuelling productivity and providing the food supply for animals in the estuaries and nearshore. Additionally, the freshwater flows cause coastal flooding, providing an additional habitat and food supply for a number of diadromous species. Juvenile fisheries species that cannot tolerate the low salinity also move out into deeper waters and are caught by the fisheries as adults.

Therefore, these studies point to the importance of freshwater flow volumes and associated nutrients in sustaining coastal environments and demonstrate the potential risks of excessive water extraction. They provide learnings that may be relevant to other northern Australia catchments where water development is underway or planned, e.g. Daly River, Ord River. The estuaries and nearshore of these rivers are poorly studied. The Ord River is perennially flowing due to the construction of Lake Argyle for hydroelectricity upstream. Damming of the river has fundamentally changed the river

system (both upstream and downstream of the engineering structure), and further development is likely to impact nutrient and sediment loads to the estuary and nearshore, with flow on effects to the species that rely on these habitats. A previous study of the Ord River estuary highlighted that the extreme tidal range creates highly turbid waters which limits primary productivity in the water, but during low tide, intertidal habitats are highly productive.

The Daly River is a perennially flowing river fed primarily by groundwater in the dry season, with augmentation with overland flow in the wet season. The estuary and nearshore is poorly understood. Studies in Darwin Harbour, 150-200 km to the east, have shown that the harbour is nutrient limited, with the extensive mangrove areas providing localised nutrient and carbon inputs. However, it is difficult to generalise about the status of the mouth of the Daly River, and its comparability with other northern NT river systems.

Increased agricultural activity can impact on sediment loads transported to the marine environment. Sediments are critical to the productivity and sustenance of habitats such as mangrove forests downstream. Intensification of cattle grazing may increase erosion, and transport of sediment downstream. This may reduce tidal exchange in river mouths, reduce the depth of coastal waters and smother seagrass beds with implications for the functioning of these systems. A study in the Flinders River catchment showed that river channel erosion is already occurring and intensification of cattle grazing is likely to increase sediment loads downstream. Conversely, dam construction traps sediment and nutrients, reducing the loads transported downstream. Impacts of this vary depending on the system. Understanding current and future sediment loads to coastal waters is a critical component of this proposal. Remote sensing approaches provide a mechanism to undertake these studies.

Given the learnings from studies already undertaken in the Gulf of Carpentaria and the Great Barrier Reef catchments and associated coastal waters, there is value in examining the relevance of these learnings more broadly across northern Australia. Therefore, this project aims to:

- 1.) In a literature review summarise what is known about the impacts of terrestrial runoff on the productivity and health of marine environments northern Australia and examine the relevance for at least three key high-profile development locations in Gilbert-Flinders (Qld), Daly (NT) and Ord (WA)
- 2.) Undertake workshops with key stakeholders in Government, traditional owner groups, NRMs etc to learn from and share knowledge from these studies and propose methods for future modelling, monitoring and research to fill in knowledge gaps
- 3.) Using current and historical satellite imagery over the study catchments with flow hydrographs, define distribution of freshwater river plumes for sediment and nutrients, and their relationship to river flow to examine future plume extent under future development and climate scenarios
- 4.) Examine changes in mangrove distribution using change analysis modelling to determine greenness of mangrove forests in study locations and relationships with catchment hydrology
- 5.) Test hypotheses developed for the Flinders and Gilbert systems on other river systems earmarked for further water development, i.e. Daly, Ord, to determine the critical nature of nutrient inputs from catchments in fuelling estuarine and coastal productivity, assess groundwater contributions to estuarine flow using isotopic measures.

With respect to Aim 3, river flood plumes will also be characterised in the study catchments to evaluate the extent of terrestrial inflow to the marine and coastal area. In the GBR catchments, mapping and modelling of plume extent has been important and necessary in understanding the frequency and extent of plumes on the reef. Using the same or slightly modified/tailored modelling algorithms, the same approach will be applied to the study catchments to understand the risks of catchment flow on coastal and marine receiving environment. We will focus on nutrients and sediments, however, this could be extended to include photosystem-II herbicides using GBR algorithms. Were possible, we will collate and use local available water quality data to train and calibrate the modelling (though these data might not be necessary available). A part of this modelling

will be to include future climate scenarios and potential development and associated changes to catchment flow.

With respect to Aim 4, mangrove habitats are an important component of coastal ecosystems in northern Australia and have been subject to stressors from large scale meteorological events, such as the mangrove dieback in the Gulf of Carpentaria. Therefore, at numerous locations across the mangrove ecosystems, we will use remote sensing from Landsat imagery to calculate long-term (1987-present) changes in the NDVI (normalised difference vegetation index) as an indicator of mangrove canopy health. Changes in NDVI will be correlated with measures of river flow, sea level and temperature – being key environmental influences of mangrove canopy cover. The NDVI is a widely used metric to assess the ‘greenness’ of vegetation, including mangrove forests. At all sites, Bayesian time series decomposition will be used to identify abrupt changes in the canopy health estimated from Landsat imagery, following the methods described in Zhao et al (2019). All likely changepoints (and credible intervals) will be identified, including the estimated probability of occurrence. Once identified, we can also further investigate potential events occurring at the time driving the change.

With respect to Aim 5, we will test whether nutrients contributed from catchments are crucial for the productivity of estuaries and the nearshore. This will build on research and approaches developed by Burford (Burford et al. 2011, Burford and Faggotter 2021) which demonstrated that primary productivity in estuaries and the nearshore (Flinders, Gilbert and Mitchell River estuaries) could be enhanced with nutrient additions, and conversely, that reducing nutrients from catchments, e.g. due to water development would reduce productivity. This method would be tested in the mouths of the Ord and Daly Rivers in the late dry season when nutrient deficiency is likely to be at its highest. It would help to substantiate whether water development in the Daly and Ord Rivers is likely to compromise productivity in the estuaries and nearshore of these rivers. In addition, samples would be taken for isotopic analysis to compare the groundwater contributions to freshwater flow to the estuaries.

This project complements an existing project commissioned by the CRC for Developing Northern Australia (CRCNA) which focuses on engaging stakeholder to develop research needs for the same three key catchments proposed here, except that the CRCNA work focuses on the terrestrial and freshwater reaches of these catchments (but will extent to the estuaries and coasts), whereas this proposal solely focused on the marine receiving environment. However, the two projects are able to take advantage of parallel engagement processes with key catchment stakeholders and parallel involvement of some of the same researchers. Engagement with key stakeholders in those catchments is currently underway.

This project also builds upon work done by the NESP Marine and Coastal Hub under their RP2021 Project 1.32 *Supporting Regional Planning in Northern Australia* and complements the proposed northern Australia governance community of practice proposal (Project 3.1). There are other studies also undertaken in Gulf of Carpentaria Rivers that can be drawn on including the Northern Australia Water Resources Assessment of the Flinders, Gilbert and Mitchell, the previous NESP and TRaCK research projects, and current research in the NESP Resilient Landscapes hub on effect of water development on freshwater biodiversity and cultural values.

References

- Burford, M. A., et al. 2011. *Marine and Freshwater Research*, 62, 141-151.
Burford, M.A. & Faggotter, S.J. 2021. *Marine Pollution Bulletin* 169, 112565
Zhao, K., et al. 2019.. *Remote Sensing of Environment*, 232, 111181.

Indigenous consultation and engagement

This project is a category 2 for Indigenous consultation and engagement. The project team acknowledges and understands the importance of working with Traditional Owners of Sea Country.

Engagement with Traditional Owners for all three catchments is planned. This project is currently collaborating and has ongoing communication with a number of Indigenous ranger groups and communities to deliver this research. This project will adopt the Marine and Coast Hub's Indigenous Engagement Partnerships Strategy (IPS) and will operate under the NESP Indigenous Partnerships Principles.

This project will be conducted collaboratively and with full consent by Traditional Owners. Traditional knowledge and Indigenous Cultural and Intellectual Property (ICIP) will be managed following established standards (Our Knowledge Our Way Guidelines). Where these exist, we will work under established agreements that clearly sets out the purpose, benefits and responsibilities of any collaborative partnership, where these do not exist we will establish new research agreements. If there is agreement to share cultural knowledge we will also establish and Indigenous cultural and intellectual property (ICIP) agreement.

The project team will seek free, prior and informed consent from collaborating Indigenous organisations (or other relevant cultural authority) as part of any agreement associated with this project. The project team will work closely with collaborating Indigenous organisations to identify and develop appropriate research outputs for communicating the findings of this research to Indigenous people. We plan co-authorship of publications with Traditional Owners where they want to share their data and knowledge.

The project will include Indigenous engagement and capacity building within the Flinders/Gilbert estuaries and nearshore environments, which are the traditional lands to the Kurtjar, Kukatj, Gungalidda and Garawa peoples who form part of the larger consortium known as the Carpentaria Land Council Aboriginal Corporation (CLCAC). They commenced water quality monitoring in their rivers with the aim of protecting their waterways, after receiving training in 2022 by CI Burford. They are also undertaking water quality monitoring in adjacent rivers, i.e. Albert, Leichhardt and their estuaries. Additionally, they undertake mangrove surveys of these adjacent rivers. This project proposes to collaborate with them in terms of knowledge sharing on the importance of freshwater flow for the estuary and nearshore and identifying key knowledge gaps needed to assist them in managing their water resources.

Similarly, this research team will communicate and collaborate with the Miriwung- Gajerrong peoples who are the traditional owners of the Ord River estuary. They are part of the Kimberley Land Council is the peak indigenous body Indigenous Salt Water Advisory Group (ISWAG) in Western Australia. They have an interest in protecting and maintaining their coastal environments across the Kimberley region. This project proposes to share knowledge of impacts of water development on estuaries and nearshore environments in the Gulf of Carpentaria to inform monitoring and planning activities by ISWAG. Techniques for monitoring would also be shared.

While not currently engaged with the Wadjigan and Kiuk people, who are the traditional owners of the mouth of the Daly River estuary and part of the Northern Land Council (NLC) this team will establish communication and work with the TO's to understand how terrestrial runoff impacts their land and sea country.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National	Regional	Local

	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Location(s) – gazetted region /place name	Daly River mouth, Ord River mouth, Joseph Bonaparte Gulf Flinders River mouth, Gulf of Carpentaria Gilbert River mouth, Gulf of Carpentaria		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	Kurtijar, Kukatj, Gungalidda and Garawa – Flinders and Gilbert estuary regions Miriuwung- Gajerrong – Ord estuary region Wadjigan and Kiuk – Daly estuary region		

Northern Australia, with a focus on the Gilbert-Flinders catchments (Qld), Daly Catchment (NT) and Ord catchment (WA).

To date, the project team has engaged with key stakeholders in each of these catchments. The complementary CRCNA project has just commenced and recently started their first engagements with some of the same stakeholders through preliminary meetings, and the arrangement of Technical Advisory Groups.

Project 3.5 – Supporting regional planning in northern Australia: Building knowledge, skills and partnerships for understanding seagrass distribution

Project description

Project summary

Northern Australia has vast development opportunities but limited knowledge of the environment to inform decision making. This region has globally significant seagrass habitat, supporting dugong, green turtle, and commercially important fish and prawns. Key to managing impacts to species in these habitats is reliable data on seagrass distribution and how this changes over time. Achieving this requires large-scale mapping and a ranger-led monitoring network in remote communities. This project will map seagrass habitats across northern Australia through targeted mapping expeditions in data deficient regions. It will strengthen relationships with coastal communities, build-on existing knowledges and skills, co-design training resources with rangers to undertake monitoring, trial new technologies for monitoring, and synthesise historical and new seagrass data into an open access resource.

Project description

Problem statement

The proximity of northern Australian seagrass habitats to coastal development and threatening processes increases their vulnerability to pressures/threats and the loss of ecological services (blue carbon, nutrient absorption, sediment stabilisation, food for iconic species, fisheries habitat). In remote northern Australia, little is known about seagrass habitats for extensive areas of the coast. Data is patchy and few large-scale mapping surveys have been undertaken, but the information available on seagrass and the species that seagrass supports such as dugong, indicate extensive seagrass habitat occurs throughout the region. This data has been collected by many different stakeholders using multiple methods and is not readily accessible. There is a concern that older data is not secure and, if not compiled and validated, is at risk of being lost. Such data is critical information for the increasing number of Indigenous communities and rangers establishing sea country protected areas and aspiring to manage their sea country. Through establishing monitoring programs, coastal Indigenous communities are better able to understand habitat health in a both-ways knowledge framework and apply adaptive management to species and resources in their sea country. These monitoring programs are also vital for assessing environmental impact of future developments in the north. This project will address these problems by:

1. Mapping selected benthic habitats, with a focus on seagrass, using methods consistent with previous and ongoing surveys in northern Australia.
2. Establishing a benchmark of seagrass habitats for Traditional Owners, Indigenous communities, rangers, management agencies, ports, industry, and researchers to assess change.
3. Partnering with management agencies and ranger groups to co-design mapping and monitoring methods in remote areas that utilise novel technology such as drones.

4. Compiling and synthesizing historical seagrass data into a publicly available spatial database (eAtlas) to create a permanent record.
5. Interpreting and reporting on survey findings, including providing advice on options for establishing monitoring programs.

Project justification

To grow a strong and sustainable future for northern Australia decisions on the use and management of resources need to be underpinned by up-to-date information. Activities within coastal zones and adjacent catchments influence the extent and condition of seagrass habitats. The cultural, commercial and ecological values that seagrass habitats support may be at risk if we do not know where they occur.

Building capacity for future ranger-led seagrass monitoring is essential given the traditional custodianship of seagrass resources throughout much of northern Australia. Furthermore, rangers have local knowledge and local access to remote northern Australia locations.

Project Scope

The surveys will be undertaken with local/regional partners and the information will be collated in a format consistent with existing public data and easily incorporated into future modelling. We will:

1. Work with end-users including Traditional Owners (Aboriginal Corporations and ranger groups), government, management agencies, and research agencies to identify: (1) priority areas for surveys, (2) potential for co-investment in surveys, and (3) data available for spatial synthesis of seagrass data.
2. Partner with Traditional Owners, Indigenous communities, rangers and other regional partners to co-design, conduct and report on seagrass surveys in target areas. Survey methods will include helicopter and drones for assessing the extent and biomass of intertidal seagrass and boat-based drop camera surveys for subtidal seagrass. We will use the same methods as previous and ongoing projects (e.g., in Torres Strait, Queensland ports, Great Barrier Reef habitat mapping, Lismore Bight, Yanyuwa IPA, South East Arnhem Land IPA) to ensure consistency in methods and comparability of data. Bilingual maps will be produced if agreed to by the Traditional Owner partners.
3. Co-develop seagrass monitoring methods that can be used by rangers in remote areas including applying new technology such as drones and Automated Underwater Vehicles.
4. Create a publicly available synthesis of seagrass data for northern Australia in a format compatible with the eAtlas interface. Data and metadata will also be available with downloadable GIS shapefiles. We will use the same method as for our spatial synthesis of Great Barrier Reef seagrass data (NESP 3.1 and 5.4) and Torres Strait and Gulf of Carpentaria seagrass data (NESP2 1.13).
5. Report back to end users/Traditional Owners/ranger groups/communities for each survey region through on country meetings, community brochures, mapping products, and reports.

Each activity will attain Human Research Ethics Committee approval as required for any research work conducted on sea country with Aboriginal and Torres Strait Islander Peoples and develop a Research Project Agreement as detailed further in the Indigenous Consultation and Engagement section.

Prior research

Project	Details
NESP TWQ Hub 3.1, 3.2.1, 5.4, NESP2 MAC Project 1.13: Seagrass mapping synthesis. Led by Alex Carter, Rob Coles (JCU), Skye McKenna (JCU), Catherine Collier (JCU)	Synthesis of the available seagrass spatial data in the GBR, Torres Strait and the Gulf of Carpentaria collected 1982-2022. Data and outputs from this project will build on it by expanding this work into adjacent regions.
NESP TWQ Hub 3.5 and TSRA: Assessment of key dugong and turtle seagrass resources in north-west Torres Strait	This project described seagrasses in an identified data deficient region in north-west Torres Strait that contains large dugong and turtle populations providing essential information

Led by Alex Carter and Michael Rasheed (JCU)	to the TSRA, Australian and Queensland governments for dugong and turtle management plans.
Limmen Marine Park (Commonwealth) and Limmen Bight Marine Park (NT) (2021-2022) Led by Catherine Collier and Alex Carter (JCU) and Rachel Groom (CDU)	Benthic habitats were mapped in the southern Gulf of Carpentaria (NT) in collaboration with li-Anthawirriyarra rangers and NT Parks.
DBCA: Conserving critical seagrass habitat for dugong: an integrated assessment across the Pilbara. Led by Kathryn McMahon and Paul Lavery (ECU), Amanda Hodgson (MU) and Chris Cleuger (JCU)	This project focused on three areas of known dugong use to understand the density and spatial distribution of dugong via drone surveys, and how this distribution is related to the benthic habitat. In addition, in these three areas seagrass abundance, condition and resilience was monitored over time.
WAMSI: Defining thresholds and indicators of Primary Producer response to dredging related pressures. Led by Mat Vanderklift (CSIRO), Kathryn McMahon and Paul Lavery (ECU).	There were two relevant sub-components in this project, the abundance, condition and resilience of seagrass in the Exmouth Gulf region over time, and the genetic diversity and connectivity in that region. In addition, there was a snapshot at 10 sites across the Pilbara on seagrass abundance and condition.

NESP Project linkages

Project/Research/Work	How our project links to other research
Mabunji Aboriginal Corporation and NESP2 MAC Project 1.12: Mapping critical habitat in Yanyuwa sea country (2021-2023) South-East Arnhem Indigenous Protected Area seagrass mapping (2022-2023) Led by Catherine Collier and Alex Carter (JCU) and Rachel Groom (CDU)	The southern Gulf of Carpentaria is an area rich in biological diversity with dugong and turtle moving throughout the region. Data on habitats from these areas (South East Arnhem Land IPA and Yanyuwa sea country) can be used for understanding the extent and resilience of habitats and their dependent species in the southern Gulf of Carpentaria more broadly, and vice versa. There may be opportunities for li-Anthawirriyarra rangers who have had experience in designing and undertaking seagrass surveys, to support the aspirations of other ranger groups that will contribute to this project through on-site training and sharing of knowledge. Spatial data will be formatted so results from these surveys are comparable. We will seek permission to include data from this project to help predict seagrass distribution across northern Australia.
Blue carbon mapping Rachel Groom (CDU)	Industry-funded (INPEX) blue carbon mapping research along the NT coast and the development of metrics to support a new method for carbon trading.
Planned NESP project on dugong in WA led by DBCA	This project will work with the dugong team (Project 3.10) to investigate maximising the synergies of the two projects.
Planned NESP project on mapping shallow and mesophotic reef habitats within Australian Marine Parks (focus on North and North-west networks)	This project will work with the mapping team (Project 3.17) to investigate maximising the synergies of the two projects.
WAMSI Mardie Research Program	A new offset project is commencing in the Pilbara to map mangrove, algal mat and saltmarsh habitats and assess the ecosystem value of these systems. There is the potential to leverage off this project to include ground-truthing of seagrass habitat.
Karumba port long term monitoring Michael Rasheed (JCU)	Karumba's 30-year long-term seagrass monitoring program will provide context on seagrass condition (e.g. decline/recovery trajectory) for adjacent meadows in the southern Gulf of Carpentaria (Gilbert and Flinders surveys)

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:

- Essential knowledge of the location and composition of key environmental assets across northern Australia to develop long-term monitoring plans and target data gaps for future surveys.
- A foundation to assess risk (water quality, water extraction and other environmental impacts, coastal development, climate change, etc).
- *Environmental Protection and Biodiversity Conservation Act 1999* matters of national environmental significance; e.g. threatened species or listed marine and migratory species.
- Understanding dugong and marine turtle habitats including migratory corridors.
- Support the objectives of *Australia's Strategy for Nature 2019-2030*.
<https://www.australiasnaturehub.gov.au/national-strategy>
- Future modelling of seagrass distribution, values, resilience and connectivity.
- *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.
- Input into State & Commonwealth development/EIA/EIS and dredge management assessments considering impacts to seagrass.
- Assessment and planning for spatial closure and fisheries management arrangements, e.g., Dugong Protected Areas, Indigenous-led management areas, and Fish Habitat Area.
- Data, metadata and spatial layers created will be secured on a JCU/ECU/CDU server perpetually and made publicly available through online repositories where appropriate.
- Metadata and final spatial layers will be submitted to eAtlas to be held perpetually.
- Peer-reviewed open access data publications.
- Survey reports for each IPA/Sea Country/region and final report will be publicly available on the NESP, TropWATER, CDU, ECU and eAtlas websites.

Indigenous consultation and engagement

Our project is a Category 1 (Indigenous Partnerships Strategy) project. Selection of survey locations will include consultation, co-design and collaboration with a number of Traditional Owners and ranger groups between Exmouth (WA) and the Gilbert River (QLD). Our end-user engagement strategy is to engage early, encourage participation and collaboration, and ensure dissemination. Early discussions with Carpentaria Land Council Aboriginal Corporation for the Gilbert-Flinders survey (QLD), Tiwi Land Council from the Tiwi Islands (NT), Kimberley Land Council (WA), and Karajarri Traditional Lands Association (WA) have received positive responses regarding collaboration on this project. Torres Strait Regional Authority are also interested in collaborating on developing drone-based methods for ranger-led seagrass mapping and monitoring. Workshops will be held in early 2023 to further discuss the potential for partnership, approach, scope, and opportunities for co-support including additional sources of funding to value-add to the methods.

Project outcomes and resources will be shared with Indigenous collaborators and end users across the survey area through eAtlas (www.eatlas.org.au), community brochures, project reports and presentations at community workshops.

Each activity will attain Human Research Ethics Committee approval as required for any research work conducted on sea country with Aboriginal and Torres Strait Islander Peoples. This requires us to:

- Abide by the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) [Code of Ethics for Aboriginal and Torres Strait Islander Research](#) and "[A Guide to applying The AIATSIS Code of Ethics for Aboriginal and Torres Strait Islander Research](#)"
- NHMRC [Ethical conduct in research with Aboriginal and Torres Strait Islander Peoples and communities: Guidelines for researchers and stakeholders \(issued August 2018\)](#)
- Attain free, prior and informed consent from the relevant TOs where the research work will be conducted.
- Develop a Research Project Agreement with TOs which will include:

- Opportunities to develop a communication network between the science team and Traditional Owners and Indigenous communities to exchange and share updates on the project throughout the project.
- Employment opportunities for members of Indigenous communities.
- Payment for TOs time where appropriate.
- Opportunities to attend in person presentations and/or information webinars about the research work.
- Returning results to the TOs in an accessible medium and format negotiated with them.
- Data co-ownership and access, including establishing an ICIP agreements.

The following opportunities will also be available:

- i) 1. Co-authorship – opportunities for co-authorship will be available and encouraged for Traditional Owners and rangers from each region and sea country being reported.
- ii) 2. Capacity building/training – all surveys will be co-designed and undertaken by local rangers and Traditional Owners. This will provide training in seagrass survey and monitoring methods with the aim of rangers being able to lead seagrass monitoring in the future. This is crucial to provide longevity in data collection, monitoring, and planning. Opportunities for Indigenous training and internships in data analysis and data management at any of the lead institutions will also be explored.
- iii) 3. Indigenous employment – Indigenous employment will be sought for the part-time co-ordination and technical position offered at Edith Cowan University
- iv) 4. Indigenous students – emerging Indigenous scientists will be encouraged to participate in surveys. PhD projects that support the objectives of the overall project will also be offered, and we will seek ways to offer these to Indigenous students.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National <input type="checkbox"/>	Regional <input checked="" type="checkbox"/>	Local <input checked="" type="checkbox"/>
Location(s) – gazetted region /place name	This project spans northern Australia. Field studies will be prioritized around the receiving waters of the Gilbert and Flinders Rivers in the Gulf of Carpentaria (QLD), either the Tiwi Islands or Darwin – Daly River mouth (NT), and at least one site along the Pilbara/Kimberley coast (WA) (Figure 1). Final site selection in NT and WA will be determined following consultations with Traditional Owners, rangers and end-users, and be informed by capacity of potential partners, local/regional priorities, IP/data sharing, representation of different seagrass habitats across the north, compatibility with related research (e.g., dugong surveys), and ability to leverage additional funds for surveys (e.g. for adjacent Commonwealth Marine Parks). New and historical data will be synthesised across northern Australia between Exmouth (WA) and Torres Strait (QLD). Project leads and technical staff are based at three institutions: ECU (Perth), CDU (Darwin) and JCU (Cairns). Project management, data analysis and desktop studies (e.g. data synthesis) will occur from these locations.		

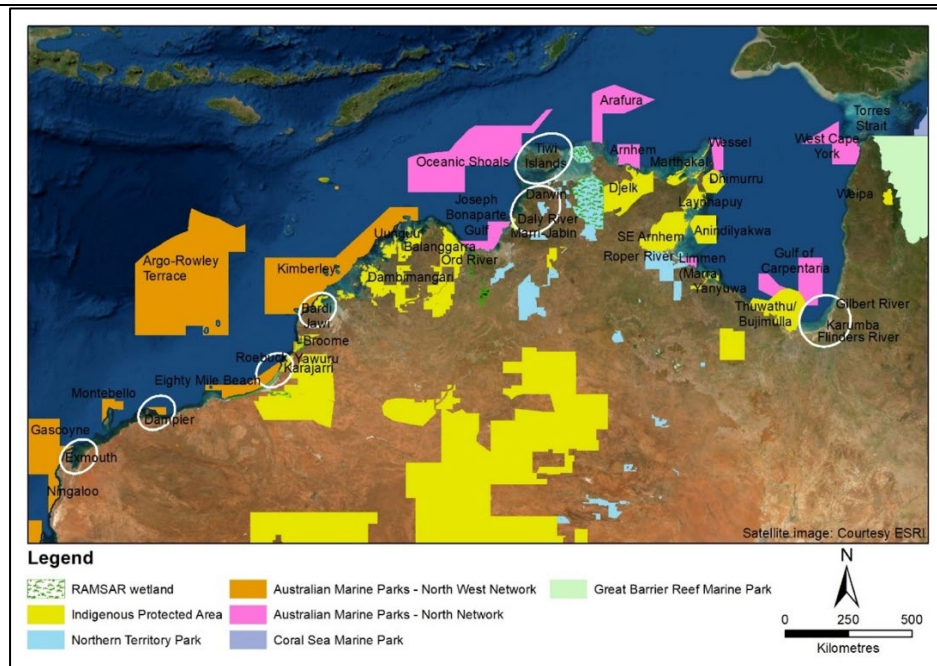


Figure 1. Northern Australia study area, including protected areas. White circles = short-list of survey areas.

Aboriginal or Torres Strait Islander nation or traditional place name(s)

- Gilbert River receiving waters – Kurtjar country
- Flinders River receiving waters – Gkuthaarn and Kukatj country
- Tiwi Islands, including Melville and Bathurst Islands (Ratuwati Yinjara) – Tiwi people including sea country of eight landowning groups (Malawu, Wurankuwu, Jikilaruwu, Mantiyupwi, Munupi, Marrikawuyanga, Wulirankuwu, Yimpinari)
- Darwin (Garramilla) – Larrakia country
- Daly River receiving waters – Wadjiginy, Tjerratj, Maranunggu, Marrathyel Malak-Malak, and Kuwema country
- Northern Cape Leveque/Sunday Islands & Buccaneer Archipelago – Bardi Jawi country
- Broome (Rubibi) and Roebuck Bay – Yawuru country
- Karajarri Indigenous Protected Area – Karajarri country
- Eighty Mile Beach – Ngarla, Karajarri and Nyangumarta country
- Dampier/Karratha – Murujuga, Ngarluma, Yindjibarndi and Yaburrara
- Montebello Islands – Yaburrara country
- Exmouth Gulf – Jinigudera and Thalanyji country

Project 3.6 – Improving data on the distribution and ecological value of temperate subtidal seagrass in tayaritja (Furneaux Group of Islands), Tasmania

Project description

Seagrass meadows are a dominant marine ecosystem of tayaritja¹ (Furneaux group of Islands) in the north-eastern waters off Tasmania, with historical coarse mapping indicating extensive beds of *Posidonia*, *Amphibolis*, *Heterozostera* and *Zostera* seagrass. The beds of *Posidonia* and *Amphibolis* are potentially some of the largest and deepest extents found in temperate waters of Australia. Lack of data on the distribution and ecological value of these seagrass habitats represents a significant knowledge gap in understanding Australian wetland natural assets that provide a range of ecological, social, cultural and economic values. This project aims to map the extent and ecological composition, population structure and blue carbon value of the seagrass beds around tayaritja in partnership with the Tasmanian Aboriginal Centre. This project will help managers and the Aboriginal communities to understand the significance of these seagrass meadows and understand how they may be monitored.

Background and scope

- Seagrass habitats are one of the most important benthic habitats in temperate coastal waters of Australia, but spatially continuous mapping data of seagrass is lacking in many areas, particularly the subtidal habitats on the open coast. Seagrass habitats are areas of high biological diversity, provide nursery, feeding and shelter for many species shelter, and combined with nutrient uptake and pathogen reduction, contribute to near shore water quality. They are also a critical component of internationally significant bird areas and RAMSAR wetlands. As blue carbon ecosystems, seagrass habitats store significant organic carbon in the underlying sediments across millennial timescales. However, the spatial heterogeneity of carbon storage in seagrass sediments needs to be better understood to improve the accuracy of Blue Carbon assessments.
- The key knowledge gap on the extent and distribution of coastal seagrass habitats in eastern Bass Strait was identified in the MaC Hub national wetlands scoping study (Project 1.5). Coarse scale mapping of the region several decades ago identified beds of *Posidonia*, *Amphibolis*, *Heterozostera* and *Zostera* which extend to depths of ~ 25 m and cover an area of at least 500 km² (which when compared to a total seagrass area along the NSW coast of ~180 km² highlights its significance). In this project we seek to use a combination and integration of close-range remote sensing methods to map the extent and ecological values of seagrass beds around tayaritja and undertake a survey of seagrass in intertidal lagoons within Logan Lagoon RAMSAR site on Flinders Island.
- High resolution satellite remote sensing using Sentinel 2 (10 m) and Planet Dove (3-5 m) sensors will be used for baseline mapping to identify the extent and spatial composition of the seagrass beds around tayaritja. A field campaign will be deployed to validate these data with field

¹ tayaritja is the palawa kani name for the Furneaux Islands Group. This project refers to the Furneaux as tayaritja, recognising the significance of this area to the Tasmanian Aboriginal communities.

photo quadrats and rhizome coring. From these data we will produce maps showing seagrass extent, spatial variability and species composition, for those areas where water depth or water clarity is not limiting differentiation.

- The project area is a culturally significant area for the Tasmanian Aboriginal communities. Currently the Tasmanian Aboriginal Centre (TAC) is working to establish a Sea Country Indigenous Protected Area in the region. This project will support Tasmanian Aboriginal communities to learn more about the seagrass meadows in the region and how they can be monitored which will assist the community to care for tayaritja Sea Country. The project will provide training to Indigenous Rangers on how they may monitor seagrass into the future.

Approach

Activity 1: Collection of existing data to review the presence/ absence of seagrass habitat in the Furneaux group region.

- The seagrasses around tayaritja are present across a range of environments from the intertidal to deep water (~25 m). In this region, due to the vast expanse of the area requiring mapping, we will employ remote sensing techniques to identify the seagrass habitats. Three existing data sources have been identified as the primary information for this project and the first activity (Milestone [4]) will be to collate and review these data for the suitability of accurately identifying the presence and absence of seagrass.
 - a) In 2021 the Australian Hydrographic Office (AHO) conducted a bathymetric LiDAR survey. This data is to be made available through the AusSeabed portal at the end of 2022 and will provide base bathymetric data to construct a depth map for the region. LiDAR data sometimes contains additional reflection information which can be interpreted to create maps of the benthic habitats. We will review the availability this data set for its suitability and completeness to classify the benthic habitats.
 - b) The 2021-22 AHO survey collected coincident aerial photography for the regions that LiDAR data was acquired. This imagery will be assessed for it's usefulness as a data source for mapping shallow seagrass habitats of the island group.
 - c) For the shallower clearer water where seagrass features can be differentiated from space, satellite based remotely sensed imagery such as Sentinel 2 and Planet Dove will be assessed. Sentinel 2 imagery is freely accessible and therefore several cloud free images could be combined to meet the suitability of this project.
- Benthic habitats will be mapped into the following classes consistent with the Seamap Australia National Benthic Habitat Classification Scheme based on pixel coverage: Dense seagrass (>90% seagrass cover), seagrass dominated (>50% seagrass and <50% sand), sand dominated (<50% seagrass and > 50% sand), bare sand (100% sand coverage) and mixed substrates with red/brown algae (including reef associated habitat).

Activity 2: Collection of new data to validate the presence/absence of seagrass habitat in the tayaritja region.

a) Field validation of maps classified from remote sensing imagery

- Field surveys will be conducted in Spring 2023 at selected sites using video survey methods and direct sampling using cores (see section b). A spatially balanced sampling design will be used to identify prospective reference sample locations across different depth strata following standard operating procedures.
- Depending on water depth, either an umbilical drop camera and frame containing a 50 x 50 cm quadrat, or a remotely operated vehicle (ROV) will be used to acquire species and density estimates of seagrass and other benthic habitats at each sample site. Video data will be classified to the lowest taxonomic level from the video based on the form of the seagrass.

- Photoquadrats will be annotated using Squidle+ and also trial a machine learning approaches from classification of benthic photo quadrates and forward-looking close range collected imagery. Additional existing machine learning AI (e.g. Reefcloud AIMS, CoralNet) will be trialled to test it automated annotation ability.

- If using Sentinel data, final classification maps will be evaluated using an independent testing set of validation data for accuracy assessment. In addition we seek to create a review and feedback process with local experts to share knowledge of the area. All spatial data will be made available via the Seamap Australia data portal (Milestone [7]).

b) Collection of seagrass samples to determine ecological significance (i. blue carbon storage, ii. genetic connectivity and iii. cultural importance) in the Furneaux Group region.

i) Blue carbon storage

- During the field survey core samples of seagrass will be collected using a spatially balanced design, with 4 replicate 120-cm long, 5-cm diameter cores collected at 18 sites. Cores will then be capped, refrigerated and extruded in the laboratory and sectioned at 10 cm intervals to determine the cumulative soil carbon stock and changes with depth. Environmental and biological drivers of seagrass carbon storage will be characterized as a function of the seagrass cover, meadow type, sediment particle size, water turbidity and proximity to other vegetated habitats. We will also use the strong relationships between blue carbon stocks and climatic conditions (temperature, rainfall, solar radiation) to project future changes in carbon storage across all RCP scenarios for the years 2050 and 2090 to determine changes in environmental suitability for blue carbon stocks in the tayaritja region.

ii) Genetic connectivity

- Understanding the resilience and long-term viability of seagrass ecosystems requires information on the levels of genetic variation and its spatial distribution within and between populations. The genetic structure and patterns of connectivity between seagrass meadows in and around tayaritja have not been characterized to date. Here we propose sampling 18 sites around tayaritja for each of 4 species (*Posidonia australis*, *Amphibolis antarctica*, *Heterozostera nigricalis* and *Zostera mulleri*), and using a reduced representation genomic sequencing approach generate a panel of SNP (single nucleotide polymorphisms) markers for each species.

iii) Species identity and cultural importance:

- Seagrass beds provide shelter and food to diverse community of associated flora and fauna, including *Phasianotrochus* spp., which are culturally significant for Tasmanian Aboriginal people, especially women who continue the cultural practice of shell necklace making. The shells used in necklace making, commonly known as maireener / kelp shells (*Phasianotrochus* spp.) live in seagrass meadows and on seaweeds. Shell necklace-making is the oldest continuing cultural practice in Tasmania – a significant tradition for Aboriginal women that is still handed down through each generation. Aboriginal women have maintained a strong cultural knowledge of shell-collecting areas. In recent years shell collectors on the islands have reported a decrease in the number of shells available for harvest. This project will provide the Tasmanian Aboriginal communities with baseline information on the extent and composition of seagrass in the tayaritja region which is expected to support the establishment of future monitoring programs.

- Previous research on seagrass has demonstrated that the associated faunal community is positively influenced by structural complexity of the seagrass species, biomass, and epiphytic loads. However, in Tasmania seagrass habitats are relatively understudied and there is little knowledge about how different species and their condition influence the associated ecological community. This research will quantify how each of the dominant seagrass species commonly found in the tayaritja region influences the associated epifauna, infauna and microbial communities in shallow waters (>5 m depth). At 3 randomly selected sites, 50 replicate samples of seagrass (10 replicates for each of the 4 species) and 10 samples of bare sediment will be collected on snorkel or via wading using 150 mm radius corer. The Tasmanian Aboriginal Centre rangers will also support engagement on the project

design and research plan, recognising the cultural significance of tayaritja to the Aboriginal communities.

- *Activity 3: Developing knowledge and a workflow to advance our understanding of seagrass habitat in tayaritja.*
- This project will significantly improve our knowledge of the extent and spatial distribution of seagrass in a high priority temperate marine region. It will inform our understanding of the role seagrass ecosystems play as a globally important carbon sink. This project aims to link standard operating procedures for different field methods integrated with remote sensing methods building on existing publicly accessible review, with this study and integrating it with the online remote sensing toolkit and the findings of the best practice working group part of the Coordinated Global Research Assessment of Seagrass System (C-GRASS). This is of significant interest to the Tasmanian Aboriginal community as a conservation value and a potential economic value, due to the emergence of the blue economy. The resulting spatially-explicit maps will also be used to pinpoint areas for successful blue carbon projects both now and in the future.
- Genetic sampling will provide information about patterns of connectivity, levels of genetic diversity and the relative importance of sexually versus asexual reproduction in maintaining populations, which is crucial for determining the current ecological status and inform future management of these important ecosystems.

Indigenous consultation and engagement

Indigenous engagement and collaboration 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 a Category 2 project for Indigenous partnerships. Category 2 projects involve collaboration and opportunities for knowledge sharing.

The NESP Marine and Coastal Hub (southern node) is undertaking broad-scale engagement with Tasmanian Aboriginal communities to improve understanding about the NESP, the Hub and funded research projects. Engagement will include discussion on current projects with the view to identifying 'interested Indigenous organisations' that would like to continue or deepen engagement on specific projects. This is an important for this project as a range of Indigenous organisations may have an interest in research focusing on habitat for the molluscs that produce the shells used in shell necklace making, a culturally significant practice of Tasmanian Aboriginal people, especially women.

- The project team have engaged with the Tasmanian Aboriginal Centre (TAC) in developing this project plan. We have discussed opportunities that this project presents for the Tasmanian Aboriginal communities, including participation in project design, data collection and sharing knowledge about seagrass and how they can be monitored through programs like Seagrass Watch. The TAC, in partnership the Aboriginal Land Council of Tasmania, were recently funded by the Australian Government to undertake a project to establish a Sea Country Indigenous Protected Area (Sea Country IPA) in waters around tayaritja. This project complements TACs plans to establish a Sea Country IPA in the waters of tayaritja by providing baseline maps of shallow water habitats and will support the establishment of a community-based seagrass monitoring program. We will also seek to use TAC vessels and coxswain to complete field-based activities and provide for training opportunities (e.g. in seagrass monitoring and gear deployment training for rangers).
- The project team will also undertake cultural awareness training to help ensure that the research respects Tasmanian Aboriginal communities and the cultural significance of tayaritja.

- We will also implement a collaborative approach to the project where the early stages will focus on building shared understanding about reciprocal benefits of the project. We will establish a research agreement with the TAC that clearly sets out the purpose, benefits and responsibilities of the collaborative partnership. If there is agreement to share cultural knowledge, we will also establish an Indigenous cultural and intellectual property (ICIP) agreement. The project team will seek free, prior and informed consent from TAC (and other relevant cultural authorities) as part of any agreement associated with this project. The project team will work closely with TAC (and other relevant cultural authorities) to identify and develop appropriate research outputs for communicating the findings of this research to the Tasmanian Aboriginal communities.

Location of research

This project is regional in scale and will focus on the visible marine ecosystems of tayaritja (Furneaux group of Islands) in the north-eastern waters off Tasmania (Figure 1). Field research will be conducted in the region and include the Ramsar sites of Logan Lagoon and the analytical areas of the research will be conducted at the host institutions in Tasmania, Victoria and Queensland.



Figure 1 Visible areas of the seafloor as identified in Google Earth imagery.



Figure 2. Location of Logan Lagoon in the south east region of Flinders Island.

Project 3.7 – Identifying and overcoming barriers to coastal and marine habitat restoration and Nature based Solutions in Australia

Project description

Project summary

Overcoming barriers to marine and coastal restoration, and Nature-based Solutions (NbS) adoption is critical to safeguarding Australia's marine estate. We focus this research on three thematic areas that represent roadblocks and opportunities for more inclusion in implementing and scaling-up restoration and NbS:

1. Engaging policy & permitting regulators to identify and breakdown barriers for marine and coastal habitat restoration;
2. Understanding and up-take of NbS by the engineering sector; and
3. Inclusion of Aboriginal and Torres Strait Islanders in restoration and NbS

The research will be conducted through in person and/or virtual workshops, with the outcome being advancement of effective approaches to overcome these challenges.

Project description

There is an increasing need for and investment in coastal and marine restoration around Australia to help manage habitat and biodiversity loss, water quality, coastal inundation and erosion, and blue carbon assets. These projects are undertaken by a range of Commonwealth, state and local government agencies, NGOs, and community groups, and range across different habitat types and scale. However, a number of barriers currently preclude widespread uptake and implementation of habitat restoration and nature-based solutions (NbS) in Australia, which centre on: 1) policy and legislative barriers; 2) engineering adoption of NbS; and 3) Aboriginal and Torres Strait Islander inclusion and co-design.

1/ Policy and legislative barriers - Identifying and dismantling barriers to marine and coastal restoration, and NbS, was a key principle identified in the recently completed road map to marine and coastal restoration (NESP M&C 1.6). Presently, laws/policy, governance, social and cultural perception/acceptance act as a barrier to the implementation of restoration projects in Australia. Proponents must go through the same permitting pathway as development approvals aimed at preventing harm to the environment – a process, which is costly and time consuming, and is not fit for purpose for projects with a clear environmental restoration and protection goal. Identifying the required approvals and regulating agencies is fundamental in progressing towards the installation of large-scale projects (recognising that there still must be regulatory oversight of restoration projects to ensure that projects add value and are not pervasive, contributing to problems or challenges in the future). There are also significant differences between states in their legislative and policy frameworks, and this project creates a key opportunity to investigate and document the various approval processes for habitat restoration projects.

This project will focus on two primary types of restoration interventions, which is: (1) oyster reef restoration, and (2) tidal reintroduction for wetland restoration, with a specific focus on the projects in Queensland and South Australia funded by the Australian Government Carbon Ecosystem

Restoration grants. We will examine the social, legal, regulatory, and policy influences that have allowed reef restorations to succeed in some jurisdictions (e.g., South Australia's >1 m long ribbon reefs) and stall in others (e.g. NSW). Data will be collected through a desktop study of legislative permitting processes in three jurisdictions (Qld, NSW, Tasmania and SA), and through semi-structured interviews with key decision-makers. This data will include information on complexity of processes, timeframes for permitting and legislative safeguards for the environment, society and industry. This work will be undertaken by legal scholars in collaboration with social scientists that have been working to understand the benefits for recreational and commercial fishers, conservation and coastal society and the need for genuine benefits for all stakeholders. It will also anticipate the arrival of natural capital investment by big business. We also acknowledge the need to include Commonwealth Departments in this assessment, as some projects will require EBPC approval (e.g. where there may be a significant impact on a Ramsar wetlands, threatened and migratory species). The anticipated outcome of this project will be advice for governments/potential proponents on how to navigate the legal and permitting process in' each case study jurisdiction. As part of this assessment and investigation, we will work closely through the Wetland and Aquatic Ecosystems Task Force, which is currently operated by the Australian Government with members from each states involved.

2/ Engineering adoption for NbS: NbS are a potential solution to two pervasive problems in coastal management: the loss of coastal ecosystems; and protection against an increased risk of coastal hazards. To use NbS for coastal protection at scale, local and state government stakeholders claim that the key barriers to uptake of nature-based methods is a lack of expertise, examples being used and clarity in the options available (NESP 1.10). Coastal managers will commonly look to engineering and/or environmental consultants to design coastal protection infrastructure, which in the past have been "dismissive of suggestions to use a hybrid approach" (NESP 1.10 survey respondent). There has been little engagement with the engineering sector to understand their barriers to offering a NbS solution to their clients (i.e., coastal managers or private property owners). This is a significant gap in understanding and overcoming the barriers to upscaling NbS. There is an opportunity to build on NESP 1.10, which identified key NbS methods being successfully used nationally, and use this to identify where in the initiation to implementation process of coastal protection projects are there barriers to using NbS over a traditional approach. Future funding would be targeted at creating the tools or processes needed to make NbS standard practice alongside traditional protection approaches.

The NbS theme will be addressed through a workshop that will bring together representatives from local, state and federal government, and the key engineering/environmental consultancies in Australia. By bringing the clients and consultants in the same room along with key researchers working on NbS we will have a series of focussed sessions working through the barriers and proposing next steps for overcoming these.

3/ Aboriginal and Torres Strait Islander inclusion and co-design: In terms of scaling habitat restoration and NbS nationally to be more inclusive and co-designed, increased engagement with Indigenous communities is also required. Traditional Owners are rights holders and therefore are a key end-user group with whom strong and meaningful engagement is required. Globally, the engagement and leadership of communities are key to the success of restoration projects; therefore, increasing inclusion of Aboriginal and Torres Strait Islander groups who have strong connection to land and sea, is an important avenue for scaling restoration / NbS.

Building on outcomes from NESP MAC 1.6, this research theme aims to gain a deepened understanding of specific processes that Indigenous groups have gone through to undertake work on Country. It will explore the barriers that inhibit Indigenous communities in terms of participation, design and implementation of restoration and NbS. The project will aim to discuss barriers and solutions to Aboriginal and Torres Strait Islander inclusion in marine habitat restoration and NbS projects and open opportunities for co-design of research in future research. The project will develop case studies, using the case study methodology through in-depth interviews, to examine the experiences of successful Indigenous-led restoration or NbS projects [e.g. engaging with Shark Bay (Malgana Traditional

Owners); Kabi Kabi Traditional Owners, Mungalla Rangers, N QLD]. A desktop-analysis focussing on how legislation is relevant to indigenous participation in restoration will be conducted as an alternative if sign on by Indigenous groups is delayed or is not able to be confirmed in the time span of the project. In doing so, we will develop a draft process/framework of respectful inclusion – rather than just expecting this inclusion to occur. We are also looking to include this topic as a special session at the AMSA 2023 conference, to further understand the process of inclusion, when shaping the goals and outcomes for the investment.

Network workshop on marine and coastal restoration: A network workshop will be held in Canberra is proposed to bring together core project team members, key representatives of major restoration organisations (e.g. OzFish, TNC etc.), and members of DCCEEW and state government agencies. This workshop will be critical in the adoption and leveraging the outcomes within agencies involved in financing restoration, administering policy and legislation, and involved in habitat restoration and NbS monitoring and reporting. This workshop will also be an opportunity to also showcase the Australian Coastal Restoration Network and Living Shorelines Australia (developed through NESP 1.10) and forge a stronger network among government, academic, practitioners and managers.

Indigenous consultation and engagement

Indigenous consultation and engagement 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 a Category 2 project for Indigenous partnerships. Category 2 projects involve collaboration and opportunities for knowledge sharing.

An Indigenous project team member (Mibu Fischer, CSIRO) will convene meetings with Indigenous groups to identify barriers and actions to overcome on the road to restoration. She will lead the research activities, including the Human Ethics approval processes. A 0.5FTE Indigenous cadet or honours student is costed into the project, and a potential candidate has been identified. From NESP MAC 1.6 there was evidence of restoration activities being undertaken by Traditional Custodians that have been successful, but also equally there were aspirations for activities that were previously limited due to a range of barriers. The barriers identified by Traditional Owners were mostly different to the barriers for practitioners. More in-depth understanding to the specific processes and pathways to restoration that have been undertaken by Traditional Owners is needed to create a pathway for success for other communities who are trying to participate in these activities.

Meetings and interviews with targeted individuals will be harnessed to describe case studies of successful restoration within/by Traditional Owners. Funding is budgeted for one in-person visit to an Indigenous Community by core team members, and other interviews will be held virtually. Indigenous participants will be compensated for their involvement. A clearer understanding of the successes and barriers for Traditional Owners will help identify any pathways for non-Indigenous practitioners to co-manage and co-lead restoration or NbS activities with Traditional Custodians.

The project team will implement a collaborative approach to the project where the early stages will focus on building shared understanding about reciprocal benefits of the project. Where these exist, we will work under established agreements that clearly sets out the purpose, benefits and responsibilities of any collaborative partnership, where these do not exist we will establish new research agreements. If there is agreement to share cultural knowledge we will also establish an Indigenous cultural and intellectual property (ICIP) agreement. The project team will seek free, prior and informed consent from collaborating Indigenous organisations (or other relevant cultural authority) as part of any agreement associated with this project. The project team will work closely with collaborating Indigenous organisations to identify and develop appropriate research outputs for communicating the findings of this research to Indigenous people. The project team will be also obtaining Human Ethics Approval (via CSIRO) before any engagement is commences.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National	Regional	Local
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Location(s) – gazetted region /place name	1) Barriers to approval and governance – New South Wales, South Australia, Queensland 2) Barriers to NbS – representatives from all states and territories; 3) Inclusion in co-design – New South Wales, South Australia, Queensland, WA (TBC – Kabi Kabi, Quandamooka, Malgana)		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	Yet to be confirmed: Kabi Kabi, Malgana, Quandamooka, Bundjalung		

Project 3.8 – Carbon abatement and biodiversity enhancements through controlling feral ungulate disturbance in wetlands

Project description

Project summary

Feral ungulates (e.g., cattle, pigs, buffalo) damage wetlands, reducing biodiversity, water quality and cultural heritage values, but funding for management has been inadequate. Feral ungulates may contribute to greenhouse gas emissions (GHG) through their disturbance of soils and vegetation, but the levels of carbon abatement achieved with their control is not well characterised across Australia. This project will work with Traditional Owners, academics and governments to characterise the benefits of feral ungulate control in wetlands, providing science that will underpin development of an Emission Reduction Fund method, where payments for carbon credits and biodiversity enhancements would fund management of feral ungulates on Country.

Project description

Across Australia wetlands are negatively affected by feral ungulates because they impact vegetation cover, disturb soils, enhance erosion, lead to poor water quality, reduce biodiversity (flora and fauna), and damage cultural heritage values.

Although not yet widely assessed in Australia, disturbance to wetlands can lead to GHG emissions, including enhanced CO₂ emissions as vegetation and soil carbon decomposes, loss of carbon sequestration potential, and enhanced methane emissions, arising from lowered soil oxygen concentrations and altered wetland hydrology.

Despite the widespread damage feral ungulates cause, investment in their management has been intermittent and inadequate to address the problem and thus populations thrive. Many Traditional Owners undertake feral ungulate control programs and collect data on their impacts and effectiveness, but these activities are not well funded over large areas. To be effective, management of feral ungulates must be funded over extended periods, which requires novel approaches to financing the management of feral ungulates. Payments for carbon abatement and biodiversity enhancement by removing feral ungulates from wetlands may provide a stream of finance that could support long term management of feral ungulates. This research seeks to provide science that can underpin development of payments for carbon abatement and biodiversity enhancements with feral ungulate control.

However, measuring and monitoring GHG abatement is highly technical which has limited the capacity of Traditional Owners to characterise GHG abatement as a result of their feral ungulate management activities. This research will fill this gap, linking scientists with Traditional Owners that have monitoring programs assessing the impacts of feral ungulates on GHG abatement and biodiversity. The goal is to link measurements of GHG abatement and biodiversity with Traditional Owner monitoring of their wetlands impacted by feral ungulates to develop empirical relationships that can be used by Traditional Owners to estimate the GHG abatement and biodiversity outcomes of their management activities. These empirical relationships may be used to develop a carbon abatement methodology for the Clean Energy Regulator (Emissions Reduction Fund), which could lead to generation of Australian Carbon Credit Units for reducing damage from feral ungulates.

Traditional Owners and their industry networks (e.g., Indigenous Carbon Industry Network, Aboriginal Carbon Foundation, NAILSMA) have strong interests in developing new carbon abatement programs as well as a wealth of experience with established Clean Energy Regulator carbon abatement methodologies. They will therefore guide the direction of the science for this project.

Quantitative studies of fenced and unfenced coastal wetlands in northern Australia have revealed that the removal of feral ungulates can result in vegetation cover increases of up to 20 times and plant species richness increases of up to four times, including recovery of uncommon species (Sloane et al 2021). In the Southeast Arnhem Land Indigenous Protected Area, northern Australia, visual Indigenous indicators of wetland condition (grass cover, yarlbun (water lily), and turbidity) were found to match changes in macroinvertebrate richness and abundance (Russell et al. 2021) and in the Archer River basin, terrestrial invertebrate richness and abundance were correlated with pig damage to wetland sediments (Perry et al. 2021). These rapid assessments could be used as indicators of biodiversity change, as an alternative to laborious 'Western' invertebrate analyses (Russell et al. 2021).

Project Justification

The State of Environment Report found that feral ungulates are one of the largest sources of risk to Australia's natural environments and their biodiversity. Feral pigs, cattle and goats were among the top 10 invasive species that are affecting the greatest number of IPBC Act listed threatened taxa. This project contributes to incentivising their control.

This project addresses key recommendations of the State of Environment Report for Indigenous people. This project supports "inclusion of the Indigenous voice in the national environmental discussion, and increased participation in decision-making" and seeks to support "Self-determination is a key focus, having our people employed in and leading data collection and monitoring projects as well as providing evidence of how to heal Country."

Project Scope

This research will be a collaboration among Traditional Owners and scientists, guided by experts in traditional knowledge-western science collaborations and the development of carbon abatement methods (NAILSMA, Indigenous Carbon Industry Network [ICIN], Dr Emilie Ens). The Feral Herbivore Working Group of the ICIN will provide an important steering and communication group for this research.

Our plan as scientists is to work with and build on knowledge already accumulated by Traditional Owners that are actively managing feral ungulates and evaluating the impacts of their activities.

At study sites in different types of wetlands, seasonal GHG emissions will be made with and without disturbance from feral ungulates (paired, using surveys or existing exclusion plots) in conjunction with measurements of soil carbon, vegetation and other site characteristics. GHG emissions will be assessed seasonally in the field using chambers attached to GHG analyser. In selected sites, we will undertake biodiversity assessments, such as invertebrate sampling, plant species richness, and vertebrate surveys of key faunal groups (birds, small mammals, reptiles and amphibians), and compare these results to frequently measured characteristics, such as vegetation cover, ground disturbance, and weed species to determine their potential use as biodiversity indicators.

This project comprises the following "in scope" activities:

1. Measure and monitor GHG fluxes (CO₂, CH₄), soil and vegetation carbon stocks and biodiversity metrics (where needed) at sites monitored by Traditional Owners. Measurements will augment those of existing programs.
2. Identify indicators that may best be used to predict GHG abatement and biodiversity change. Review the monitoring programs and indicators used by Traditional Owners to monitor Country.
3. Collate data on the costs of feral ungulate control measures (e.g. fencing, shooting, trapping etc...) to support cost/benefit analyses.

4. Synthesis 1 is a synthesis report on the scientific and traditional knowledge evidence for feral animal removal as a carbon abatement and biodiversity enhancement strategy.
5. Synthesis 2 is a synthesis report on potential income from carbon abatement and enhancement of biodiversity with feral ungulate control and a cost-benefit analysis of feral control activities.

Out of scope

- New experimental setups (additional exclusion fencing or other on-ground experiments)
- Continuous monitoring of methane and CO₂ (we can only do campaign-based measurements).
- Models of the distribution of feral ungulates or their control.

Project validation

Many of our research partners have research that demonstrates the environmental and biodiversity benefits of removing feral ungulates from wetlands.

Evidence that non-native ungulate species disturb soils and result in significant GHG emissions is demonstrated globally for pigs (O'Bryan et al. 2021) and from within Australia (e.g., Limpert et al. 2021). Disturbance of soil by feral pigs is modelled to lead to CO₂ emissions that are globally significant (O'Bryan et al. 2021). There is experimental evidence globally and from within Australia that managing non-native animals in wetlands, often through exclusion by fencing, can reduce CO₂ emissions, enhance carbon stocks in biomass and soils, as well as enhancing biodiversity. In northern Australia there is strong accumulated Indigenous and scientific evidence derived from non-native ungulate exclusion experiments by the Yirralka Rangers over numerous sites that show that exclusion of non-native animals from wetlands results in improved wetland condition and vegetation cover (Sloane et al. 2020, Ens et al. 2016, Wartman et al. 2021). Fencing resulted in increased vegetation cover from 50 to 100% above unfenced control plots (Ens et al. 2016, Sloane et al. 2020). Exclusion plots in freshwater wetlands in the Wimmera region of Australia (sheep grazing excluded) found 30% higher soil carbon concentration compared to grazed plots and that continuously grazed plots had higher fluxes of CO₂ ($8.69 \pm 10.61 \text{ g CO}_2 \text{ m}^{-2} \text{ day}^{-1}$) compared with exclusion plots ($6.92 \pm 15.86 \text{ g CO}_2 \text{ m}^{-2} \text{ day}^{-1}$). In other nations, exclusion of cattle in the Netherlands caused an 37% increase in the soil carbon stock (from 32 to 44 Mg C ha⁻¹, Elschot et al. 2015). In Germany removal of large grazes reduced soil compaction and improved soil structure (Keshta et al. 2020), and exclusion of large grazers enhanced soil elevation gains in USA wetlands (Janousek et al. 2021).

Systematic surveys of terrestrial fauna (birds, small mammals, reptiles and amphibians) in tropical savanna in proximity to wetlands in the Archer River catchment, Cape York Peninsula, Queensland, Australia, found that the richness and abundance of terrestrial fauna were not limited by the intensity of pig damage to wetland (Perry et al. 2021). However, fauna composition was strongly correlated with wetland type, the vegetation community, and location (Perry et al. 2021), which likely masked significant effects. More evidence of the impacts of feral ungulates on terrestrial fauna is needed, controlling for these strong drivers and accounting for seasonal variation in presence and abundance.

Past NESP research has shown GHG fluxes from the first 12 months of non-native animal exclusion experiments in the Archer River catchment varied substantially both within and between wetlands that were fenced and unfenced. The mean (range of mean) flux across all six sites was 38 (6 – 87) mg m⁻² h⁻¹ for methane, 1304 (1078 – 1983) mg m⁻² h⁻¹ for carbon dioxide, and 2 (1 – 4) mg m⁻² h⁻¹ for nitrous oxide. When these values are scaled to annual emissions and expressed as CO₂ equivalents (with global warming potential for methane and N₂O applied) they range between 90 – 170 Mg CO₂e ha⁻¹ year⁻¹ for CO₂; 13 – 190 Mg CO₂e ha⁻¹ year⁻¹ for methane; and 26 – 100 Mg CO₂e ha⁻¹ year⁻¹ for N₂O. These values are lower than those reported for disturbance of mangrove and saltmarsh soils with extraction activities (e.g., for extraction for aquaculture has soil CO₂ emissions of 935 – 1,727 Mg CO₂e ha⁻¹ year⁻¹, IPCC Wetlands Supplement) and higher emissions than those reported for drainage of coastal wetlands without soil disturbance (28 Mg CO₂e ha⁻¹ year⁻¹, IPCC Wetland Supplement). Thus these preliminary data indicate emissions from soil disturbance by ungulates in Australian

coastal wetlands are likely important sources of emissions, and therefore that excluding ungulates may provide avoided emissions from soils as well as reinstating soil carbon sequestration.

Prior research

The Northern Australia Environmental Resources (NAER) Hub has pioneered research into effects of feral ungulates and how to assess the success of control measures (Perry et al. 2021). This project builds on this work by assessing carbon abatement and extending the geographical scope.

Review of activities to control the impacts of feral ungulates

Government programs to control disturbances caused by feral ungulates have been insufficient and often short-term and have failed to control the extent of the environmental damage. There have been a range of federal, state and local government programs that have attempted to control non-native ungulates on coastal floodplains for biodiversity values (Ross et al. 2017), to preserve cultural heritage (Sloane et al. 2019) and control diseases. For example, The Threat Abatement Plan for the Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (2017) and the Feral Action Plan (2021), set out a national framework to guide coordinated actions to contain the spread of this threatening process and manage the impact on threatened species and ecological communities as listed under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). States have also invested in research, and developed programs and resources (<https://wetlandinfo.des.qld.gov.au/wetlands/management/pressures/feral-pigs/>).

Programs with feral ungulate management activities have included the Australian Government's National Landcare Program and the Indigenous Protected Area Program. Aerial and ground feral ungulate culling was a part of the widespread Brucellosis and Tuberculosis Campaign of the 1980s where buffalo numbers across the Top End of the Northern Territory were significantly reduced (Freeland et al. 1990). However, these efforts have been sporadic, and therefore often not successful and activities have lapsed after the funding program elapsed, and consequently, populations of non-native species have continued to increase over time (Ross et al. 2017, see <https://www.abc.net.au/news/rural/2019-11-21/nt-buffalo-population-on-the-rise/11713352>. Recent reports from Territory Natural Resource Management group indicate that buffalo numbers have increased by 17% in 2020, <https://www.abc.net.au/news/rural/2020-12-23/nt-buffalo-numbers-rising-as-culling-is-replaced-by-mustering/12997984>). In southern and eastern Australia, the Subtropical and Temperate Coastal Saltmarsh communities are listed as Vulnerable, with restrictions on their removal, but there are no restrictions on their use for grazing when they occur on private lands (about 50% of these saltmarsh communities occur on private land). Thus, protection has been unable to prevent their ongoing degradation and loss (Creighton et al. 2016).

Activities to remove feral ungulates

Activities to remove impacts of feral ungulates include fencing of domestic and feral ungulates and culling of feral ungulates (e.g., baiting in accordance with approved chemical use, culling through shooting from helicopters at times/areas that are known to be most effective, sterilisation and other emerging methods). Although most landowners aspire to reduce damage due to ungulates on their land, often because of loss of amenity (e.g., reduced land and water quality, stench and other negative impacts) and because these animals can be dangerous to humans, ongoing funding and widespread coordinated uptake of effective management across different land tenures has been lacking.

Estimates of the potential scale of carbon abatement through control of feral ungulates

Fencing to exclude non-native ungulates from coastal wetlands has been effective in reducing their impacts (Ross et al. 2017), and therefore the likelihood of uptake and efficacy is high in some regions if fences are maintained. For example, fencing of over 300 hectares of wetlands have demonstrated the potential of fencing as a restoration action in Victoria, and an estimated additional area of land of at least 30,000 ha may be available (Wartman et al. 2021). The government of South Australia has

also indicated high potential for uptake in the Yorke and Eyre Peninsulas. In the Archer River catchment, Queensland a total 5.3 km of cattle exclusion fencing, and 11.8 km of pig fencing was used to protect a combined area of 1,626 ha of wetlands and a sea turtle rookery (Ross et al. 2017). Fencing costs were estimated at \$85,500 to \$140,000 (\$3,500/km, National Heritage Trust, 2004 to an upper estimate of \$8,000/km). Using a conservative abatement estimate of 1.8 tCO₂e ha⁻¹ over 25 years (for conservativeness we include avoided CO₂ emissions from soil disturbance and no avoided GHG emissions or vegetation change) this may generate 73,000 t CO₂ or approximately \$2,200,000 in Australian carbon credits units (at \$30 per tonne CO₂e), which would accommodate the cost of fencing and on-going maintenance for projects.

The wetland area affected by feral ungulates in northern Australia that represents the volume of carbon abatement could be very large (>100,000 ha) based on the distribution maps of feral pigs (Threat Abatement Plan for Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*), 2017)), but the exact area of wetlands affected is not known. Finlayson et al. (2005) noted that an area of up to 54,912 km² (ca. 5.5 million hectares) could be considered swamp or land subject to inundation across northern Australia, that could therefore be affected by feral ungulates. In the NT there are an estimated 35,250 head of buffalo on the coastal floodplains (Territory Natural Resource Management 2019) and estimates of over 20,000 head have been estimated in the Bulman-Arafura Swamp region (Austin et al. 2011). In the Kimberley, feral cattle have densities of (0.3–10.0 km²) and have negative impacts on macropod densities (Reid et al. 2020). In other agricultural floodplains of temperate Australia, grazing occurs extensively on coastal saltmarsh land, although the area of land affected has not been quantified (Creighton et al. 2016). Buffalo and cattle also contribute methane through enteric fermentation, which has been investigated by the Reducing Emissions from Livestock Research Program (RELRP) of the Australian Government and the Feral Herbivore Working Group of the Indigenous Carbon Industry Network. The number of Traditional Owner groups that could be interested in a feral ungulate control as a wetlands carbon abatement method may be in the order of hundreds of communities. For example, there are 70 Indigenous corporations with coastal land in the Great Barrier Reef catchments that could participate in this method, with many others across Australia with similar opportunity. Indigenous landowners manage approximately 85% of the Northern Territory coastline (Altman et al. 2007). The willingness of Traditional Owners to take-up payment for ecosystem service schemes (particularly through the ERF) is high and where implemented has provided benefits to Traditional Owners (Robinson et al. 2016, Ansell et al. 2019).

Local councils that face significant pressures from feral ungulates in their wetlands. Management actions are expensive (e.g., shooting, trapping) and thus they are interested to support research that could lead to further financial incentives to control feral ungulates. Landholders grazing stock in wetlands in temperate Australia may also be interested in this research and the implications for their land management and diversifying potential income streams.

Preliminary assessment of costs of feral ungulate control measures

Collation of the costs of feral ungulate control in wetlands can support a cost benefit analysis of control and abatement. Feral ungulate management using either exclusion fencing, or aerial culling has proven effectiveness and is commercially viable if the management effort (human capacity) and approach (technology/methods) are resourced well enough to be sustained. Fencing of stock from coastal wetlands has been demonstrated as effective at improving the condition of coastal wetland vegetation and soils.

One of the most used techniques to exclude non-native ungulates from land is exclusion fencing. Exclusion fencing technologies are well developed in Australia. For example, there are many Australian providers of fencing for feral animal exclusion (https://www.westonfence.com.au/exclusion-fencing/?gclid=CjwKCAjwr56IBhAvEiwA1fuqGlijEBbcQCwHoOuW5lxGnT-YUd9lcetNYqh2TKpSmsff9-VGG1qWuURoCOWcQAvD_https://www.waratahfencing.com.au/customer-solutions/wild-pigs-exclusion-fence) that could support this activity. Additionally, industry groups already provide

guidance on fencing for feral animal exclusion

(https://sugarresearch.com.au/sugar_files/2017/02/Exclusion_fencing_for_feral_pig_control.pdf), as do the federal (<https://www.environment.gov.au/system/files/resources/b39c119e-c58a-4473-9507-db68da31a95c/files/catalogue.pdf>) and state governments (e.g. https://www.daf.qld.gov.au/__data/assets/pdf_file/0008/63926/IPA-Feral-Pig-Control-Manual.pdf). The Victorian Coastal Wetland Restoration program has preliminary fencing projects for wetlands rehabilitation (<https://www.bluecarbonlab.org/our-research/wetland-restoration/>).

Modifications of fencing to minimize negative impacts on native animal movements on floodplains has also been developed, which has the major advantage of treating the threat of feral animal impact directly on wetlands while maximising the services provided in completing the fencing works (Waltham et al. 2021).

Aerial culling is a well-established process in many states and may also be a cost-effective option for some landholders. Costs have been estimated for goats where the cost per km² per 10% population reduction achieved ranged between \$33-\$112 (Bayne et al. 2000). Aerial culling of camels was estimated to cost about \$19 per km², or about \$20/animal (Drucker et al. 2010). Additionally, other methods of cost-effective ungulate management are emerging (e.g. sterilisation) that could also increase uptake and reduce costs (Scasta et al. 2020).

NESP Project linkages

This project is linked to the work of the NESP Resilient Landscapes Hub including projects on Monitoring and tools for Ramsar sites, Indigenous knowledge and management of Indigenous estates, and monitoring resilient landscapes. Kakadu National Park, the site of RLS Hub and MAC Hub activities, will be one of the focal study sites.

This research is linked to the work of the NESP Resilience Hub including:

- National overview of monitoring frameworks and tools for Ramsar sites
- Best-practice management for feral predators (cats and red foxes)
- Addressing Kakadu's strategic research needs
- Protecting threatened species in safe havens

This research is synergistic and complementary with a range of other ARC funded projects and NESP projects that will contribute to this research:

- "A multi-species approach to managing feral animals in tropical savannah landscapes." Australian Research Council Linkage Project LP120200537 (2013-2016) Chief Investigator Assoc Professor Hamish Campbell, CDU.
- "Can coastal floodplains of north Australia survive ferals and rising seas?" Australian Research Council Linkage (2020-2024). Chief Investigator Dr Emilie Ens, Other investigators Prof Damian Gore, Tim Ralph, Prof Andrew Skidmore; partner investigators include Laynhapuy Indigenous Protected Area Yirralka Rangers with Senior Cultural Advisor Yumutjin Wunungmurra.
- "Activating blue carbon." ARC Laureate Fellowship (2021-2025). Prof Catherine Lovelock, UQ
- "Investigation of impacts of feral pigs on biodiversity of wetlands of Archer River." National Environmental Science Program, Northern Australia Hub Project 2.5 (2015- 2020). Lead by CSIRO, in collaboration with James Cook University (Dr Nathan Waltham) and Queensland State Government.
- "Science evaluation of coastal wetland restoration approaches in Great Barrier Reef catchments (Round Hill feral pig exclusion fencing case study)". National Environmental Sciences Program Tropical Water Quality Hub. Led by James Cook University (Chief Investigator Dr Nathan Waltham) and involving Queensland Government and Burnett Mary NRM Group.
- Victorian Coastal Wetland Restoration Program 2: <https://www.bluecarbonlab.org/our-research/wetland-restoration/>, funded by the Victorian Government (2018-2021). Led by Deakin University (Prof. Peter Macreadie, Dr Melissa Wartman, Dr Paul Carnell), and involving 15 partners.

- Indian Ocean Marine Research Centre, CSIRO, Estimating Australia's Blue Carbon Potential supported by BHP. Dr Mat Vanderklift and Dr Andy Steven.
<https://www.bhp.com/sustainability/community/communitynews/2021/08/estimating-australias-blue-carbon-potential/>

Traditional Owner-led Research

- Indigenous land management organisations and Indigenous ranger groups within the Indigenous Carbon Industry Network have been conducting their own research on the impacts of feral ungulates and the effectiveness of control measures. They have convened a Feral Herbivore Working Group which has developed a draft methane avoidance by managing buffalo populations carbon abatement method for the voluntary market. The Feral Herbivore Working Group of the ICIN will provide a fora to evaluate the effectiveness, quality and transparency of this proposed NESP research.

Management of non-native species in coastal wetlands aligns with national, state and local priorities for protection of biodiversity. This method strongly aligns with Australia's commitments to the Convention on Biological Diversity and the Ramsar Convention. This method also aligns with policies and strategies of the Reef 2050 Plan, as increasing the health of coastal wetlands is important for the health of the Great Barrier Reef.

Synergies with other strategies and policies include:

- Clean Energy Regulator, Co-designing methods: a framework for collaboration. March 2021.
- Land Restoration Fund, Queensland Government
- South Australian Blue Carbon Strategy
- Queensland Wetlands Strategy
- JAMBA, CAMBA and ROKAMBA agreements for migratory species in the East Asia-Australasian Flyway
- Management of national parks and wildlife services of Commonwealth and state governments
- Environment Protection and Biodiversity Conservation Act 1999
- Threat Abatement Plan for the Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (Australian Government 2017)
- Australia's Strategy for Nature
(<https://www.environment.gov.au/biodiversity/conservation/strategy>)
- Victoria's Climate Change Act 2017 and Victoria's Climate Change Strategy 2021 establish the framework for supporting and delivering climate change adaptation.
- The Natural Environment Climate Change Adaptation Action Plan 2022-2026 (NECCAAP, Vic Gov) is a strategic document that provides direction for undertaking adaptation for the natural environment across Victorian landscapes to establish practices, systems, and knowledge to enable effective adaptation to climate impacts on Victoria's natural systems
- Protecting Victoria's Environment – Biodiversity 2037 sets directions for biodiversity conservation in a changing climate and targeting the management of threats to habitats and species that promote climate resilience.
- Victoria's Marine and Coastal Policy 2020 takes take a pathway approach to coastal planning by considering options to maintain public access and allow for coastal habitat migration, where marine and coastal Crown land foreshores are lost due to sea level rise, erosion or inundation. The restoration of blue carbon coastal wetlands is a primary tool to achieve nature-based adaptation outcomes in response to climate change

- Australia's commitment to the Sustainable Development Goals (SDG) and can address SDG 14 life below water, as many marine species use coastal and floodplain wetlands for phases in their life cycle or feed on animals that use coastal wetlands (e.g. commercial fish species, mud crabs); SDG 13 climate action, as healthy coastal wetlands sequester CO₂; SDG8 decent work and economic growth, particularly for Traditional Owners engaged in land-sea management and SDG3 Good health and Wellbeing by removing feral ungulates and promoting Indigenous access to healthy bush foods and clean water.
- Additionally, this method aligns with the Blue Mud Bay Action Plan, part of the Nitmiluk Heads of Agreement of the Northern Territory, which reflects the The Blue Mud High Court case which recognised Traditional Owners' rights to exclusive access to water in the areas covered by the Aboriginal Land Rights Act 1976 (NT). This land-mark court decision means Traditional Owners control access to 85 per cent of the NT coastline, including the intertidal zone.

Project impact on informing management

This research will be applied to develop a new ERF method that provides sustained finance for management of wetlands on Country. We expect this to be a game-changer for Traditional Owners (similar to the ERF savanna burning methodology), enhancing the scope of their management of Country for carbon abatement benefits, which would deliver benefits for biodiversity and carbon abatement, as well as social benefits.

- This research will provide underpinning data/evidence that inform decisions on ERF method development by the Clean Energy Regulator.
- This research will provide advances in stakeholder engagement that inform decisions by the Clean Energy Regulator on ERF method development. This essentially preparing the way for co-designed method development (<https://www.cleanenergyregulator.gov.au/ERF/method-development/developing-methods>, "Involving stakeholders early and regularly in the method development process will help to ensure that methods can draw on their knowledge to improve usability, remove barriers and avoid unintended consequences."
- Financial incentives (based on the proposed development of a new carbon abatement method) will inform decisions made by Indigenous Communities participating in projects to control feral ungulates that are funded through carbon abatement, increasing options for funding management of Country.
- Additional financial incentives through the development of an ERF method will stimulate on-ground activities to control feral ungulate populations in Australia,

This research will also inform the development of Biodiversity Certificates that were recently announced by the Commonwealth Government (<https://www.pm.gov.au/media/biodiversity-certificates-increase-native-habitat-and-support-australian-landholders>). The process for developing Biodiversity Certificates is undergoing development and thus this research has the opportunity to inform the process and future decisions about certification for biodiversity enhancements.

- This research will inform decisions on method development for Biodiversity Certificates that will be developed under the Clean Energy Regulator's process.
- Additional financial incentives through development of a Biodiversity Certificate method will stimulate on-ground activities to control feral ungulate populations in Australia.

Indigenous consultation and engagement

This project will be a category 1 Indigenous engagement project. This project was developed in consultation with ICIN, the Kimberley Land Council and NAILSMA. We also took direction from the Aboriginal Carbon Foundation. We contacted a range of Traditional Owner stakeholders via email,

either directly or through their research partners discussing collaborations under this project. Co-design will occur on study locations (see below).

We planned that all research conducted will be conducted collaboratively and with full consent by Traditional Owners and funds are allocated for collaborative payments. Traditional knowledge and Indigenous Cultural and Intellectual Property (ICIP) will be managed following established standards (Our Knowledge Our Way Guidelines, CSIRO 2020; and ICIN's Guidelines for Seeking FPIC from Indigenous communities for Carbon Projects, icin.org.au/resources). We plan co-authorship of publications with Traditional Owners where they want to share their data and knowledge.

Funding for an additional Indigenous research position has been proposed.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

For ERF method development evidence of GHG emissions from a broad range of sites across Australia (different environmental settings) is needed. We plan to build on existing research and existing research partners of Traditional Owners. Some of our locations for on-ground research are known and have been discussed in detail (LHIPA – Emilie Ens, Kakadu – Luke Einoder) and are a part of existing experimental approaches (Western Port – Mel Wartman), and some are yet to be decided on with Traditional Owners (need further co-design), and therefore cannot be named precisely (Cape York– Justin Perry/Nathan Waltham, Eyre Peninsular – Alice Jones). Other locations may also be considered if they can be accommodated within planned field activities, including site managed by local and state government agencies. We intend to sample in wet and dry season at each location during the three years of the project.

The Laynhapuy Homeland Aboriginal Corporation has feral ungulate exclusion plots on floodplains (established 2018), where rangers monitor vegetation and soil parameters (Ens et al. 2019); Kakadu National Park has large populations of feral ungulates. Managers are planning an intense feral herbivore management campaign in 2022-2023. In Cape York, a range of partners (CSIRO, NAILSMA, JCU) have worked with Traditional Owners to remove feral pigs and cattle in the Archer River basin and to assess the impacts of management, including exclusion fencing (Perry et al. 2021). The Wunambal Gaambera have evaluated the distribution of feral cattle on floodplains (Reid et al. 2020). We also plan to work with collaborators in Western Port, Victoria, where Traditional Owners have been fencing cattle from saltmarshes (Wartman et al. 2021) and potential sites in the Eyre Peninsula, South Australia

(https://cdn.environment.sa.gov.au/landscape/docs/ep/2021_control_policy_pest_plant_and_animal.pdf).

At which spatial scale is the project working	National	Regional	Local
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Location(s) – gazetted region /place name	1. Laynhapuy IPA, Northeast Arnhem Land, Northern Territory 2. Kakadu National Park, Alligator Rivers Area, Northern Territory 3. North Kimberley region, Western Australia 4. Archer River, Cape York, Queensland 5. Western Port, Victoria 6. Eyre Peninsular, South Australia		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	1. Laynhapuy IPA 2. Ngombur 3. Uunguu coast, Wunambal Gaambera Country 4. Aak Puul Ngantam 5. Bunurong 6. Barngarla		

Project 3.9 - Establishing an Indigenous led approach to coordinated vertebrate pest management in northern Australia.

Project description

Project summary

Wild livestock (particularly pigs, buffalo and cattle) are one of the primary threats to coastal ecosystem values in northern Australia. Wild livestock poses significant threats to cultural and livelihood values on Indigenous managed and owned lands and impact threatened species, water quality and other elements of biodiversity. Recent research has highlighted the importance of feral animal impacts on coastal wetlands and ecosystems that have implications for greenhouse gas accounts and other important national environmental assets such as mangrove restoration, coral reefs, marine turtle nesting and wetlands values.

Research is being done on feral animal impacts on several prominent and important values including carbon stocks, marine turtle depredation and sediment loads impacting coral reefs and seagrass. This research has direct relevance to regulated and voluntary carbon and biodiversity markets. The development of new carbon abatement and sequestration methodologies and associated biodiversity protection markets could lead to economic opportunities for Indigenous owned and managed assets in northern Australia. However, in the absence of Indigenous leadership in the research that underpins method development, there is a risk that the potential economic and social benefits of these new methods won't be realised, will erode Indigenous rights and limit local participation in long term management and monitoring of threats.

This project will support the development of Indigenous led methods for feral animal management with the aim of establishing methods that account for the values and cultural boundaries that underpin activities on the Indigenous estate. We will do this research in partnership with Indigenous organisations that have long term feral animal management programs, developed with Traditional Owners and operating within the cultural and environmental boundaries of the homelands they manage.

In the absence of accepted methods that enable Indigenous land managers to collect accurate population management and impact data for feral animal management, coupled with an understanding of the preparedness and constraints (training, resources and access) of Indigenous landowners, we have a large blind spot in national efforts to quantify impact and define best practice for control.

This project will complement NESP MAC hub projects that are quantifying feral animal impact on blue carbon and other coastal ecosystem impacts. We will work with a subset of Indigenous organisations across northern Australia to record feral animal management skills and experience and identify common management and monitoring methods. We will explore the potential for unifying common methods without impacting local decision making and participation in the socially and environmentally diverse Indigenous managed landscapes of northern Australia.

Project description

Problem statement

Robust and measurable management of environmental impacts caused by wild livestock on coastal ecosystems in the vast and remote Indigenous managed estates in northern Australia will require

regional cooperation and consistent methods for assessing changes to wild livestock populations and associated impacts on environmental, social and cultural values. Often, regional coordination uses a tenure blind approach with the aim of optimising pest animal population reduction across land use types. This approach ignores the inherent complexity of cultural governance and values that underpin decision making on Indigenous land.

Successful management needs to consider impacts of feral animals on multiple values in the context of place (agricultural vs environmental impacts) and develop accessible and robust methods for quantifying the impact of management, e.g population reduction, on specific values.

The management of vertebrate pests, especially pigs, is difficult to sustain when it is reliant on intermittent government funding and when planning and facilitation is primarily supported by government programs. To achieve national impact, a sustained and targeted approach is required that specifically targets the impact of pests on the diverse environmental, social and cultural values across the nation.

Contemporary regional coordination approaches have emerged from agricultural systems in southern Australia where there are well developed extension pathways and relatively clear legal boundaries and land use types. In the vast and remote Indigenous managed estates of northern Australia, the cultural landscape and decision-making processes are complex and diverse.

This project aims to derive information specific to the Indigenous managed lands of northern Australia, to support investment in Indigenous organisations for the development of approaches to robustly manage and monitor the impacts of feral animals on coastal ecosystems in northern Australia.

Project justification

Feral pigs and wild ungulates (buffalo and cattle) are one of Australia's most significant environmental and biosecurity threats. Effective long-term management of these threats across Indigenous managed land assets in northern Australia will require the leadership and participation of Indigenous Land and Sea managers and an understanding of the constraints facing coordinated approaches. This is particularly important in the context of federal, state and territory policy that directs and resources the management of feral animal impacts. In the absence of a clear understanding of the challenges and opportunities for coordinated feral animal management on Indigenous land, new policy areas such as the development of regulated blue carbon methodologies, development of methods suitable for biodiversity markets and national approaches for biosecurity threat management, are likely to be ineffective or cause unnecessary conflict. This project will facilitate Indigenous organisations to have input into how coordinated approaches may work within their cultural, environmental and social contexts which will enable thoughtful policy response and the development of programs and funding opportunities that have appropriate incentives that optimise Indigenous participation.

A clear understanding of the constraints and gaps in effective management and monitoring will enable government departments, researchers and NGOs to directly invest in sustained and measurable outcomes.

Project Scope

This project will be undertaken over 18 months and will include a desktop study coupled with interviews and workshops with Indigenous land and sea management organisations, practitioners and land councils that will establish a roadmap for Indigenous led coordinated feral animal management in northern Australia. This work will be contextualised against other NESP projects that are quantifying threats and developing accounting methods for assessing greenhouse gas emissions and coastal ecosystem environmental impacts.

The project will include a spatial analysis element.

1. Map Indigenous land management tenure across northern Australia (building upon previous mapping of the Indigenous estate produced by ICIN).

2. Within Indigenous managed tenure we will use case studies to define the critical spatial elements required to quantify the challenges for coordinated regional management of feral animals (e.g access - roads and tracks, infrastructure -fuel and communications, water and vegetation. We will use case study locations in each state to establish the difficulty of obtaining the critical mapping elements (i.e which elements are publicly available, which elements are sensitive and which elements are bespoke and need to be derived for each location).
3. For each of the case study management areas, we will summarise proportional hidden tenure constraints and other boundaries that are relevant to decision making but not publicly available (e.g Indigenous Land Use Agreements, Section 19 agreements – e.g mustering licences).
4. For each management area we will conduct a skills audit (with consenting organisations) in the context of management and impact accounting (e.g number of trained shooters, experience with feral animal control, presence and type of management plans, data collection, management and mapping capabilities, impact assessment methods, history of feral animal management).

The spatial mapping, skills audit and consultation with Indigenous organisations will be used to contextualise the inherent constraints for managing feral animal impacts across northern Australia and to identify critical resource and skills gaps that require investment (research or operational). The mapping and analysis will also provide critical information for developing appropriate regional coordination of feral animals.

NAILSMA will work with the Indigenous Carbon Industry Network to seek feedback from their members on project activities, communicate project outputs support a joint workshop to discuss the project outputs at the National Indigenous Carbon Forum in April 2023 with a specific emphasis on describing opportunities and current gaps for Indigenous led approaches. The project will inform the National Feral Pig Management Action Plan and will work with the Indigenous advisory committee to inform the implementation of the action plan in northern Australia.

NAILMSA will work with representatives from the case study sites and the ICIN feral animal working group to produce a co-authored research paper that describes a framework for regional coordination on Indigenous managed land in northern Australia and summarises the critical information used to identify feral animal management constraints. Outputs from the project will include a technical report, mapping products and a co-authored research paper.

Prior research

This project leverages substantial research led by Indigenous organisations on Cape York, the Kimberly and Arnhem Land in partnership with NGO's and research organisations. Research leaders and Indigenous organisations are working together through large scale projects (e.g. CSIRO led Smart Farms project in Arnhem Land and Cape York to establish values-based approaches to planning through the integration of new technology and Indigenous knowledge and values - <https://www.csiro.au/en/news/News-releases/2021/SpaceCows-Using-AI-to-tackle-feral-herds-in-the-Top-End>) and through collaborative process such as the ICIN facilitated feral livestock working group. Mimal Land Management and Warddeken Land Management have led the development of locally led buffalo management which includes detailed reporting on potential carbon methodology development that will guide this research. Feral animal impact research and management methods used by Wunambal Gaambera in the northern Kimberly region of WA has informed this proposal. Coordinated planning and feral cattle and pig control has been done in partnership with CSIRO, APN and Kalan Enterprises (<https://neslandscapes.edu.au/wp-content/uploads/2021/11/Defining-metrics-of-success-for-feral-animal-management-in-northern-Australia-final-report.pdf>). ICIN produced documents will be used to inform the project (PFIC best practice guide, spatial mapping of Indigenous management land - [Indigenous Carbon Industry Network \(icin.org.au\)](https://indigenouscarbonindustry.org.au/)).

NESP Project linkages

This project will be directly relevant to projects planned for the NESP MAC hub including; Carbon abatement and biodiversity enhancements through controlling feral ungulate disturbance in wetlands (Project 3.8).

Project impact on informing management

Traditional large-scale management of feral vertebrates in northern Australia has been largely ad hoc with limited coordination of methods (both for controlling populations and measuring impact). Most often land managers use the reported number of animals killed as a proxy of progress towards stated management goals – e.g. reducing environmental or agricultural impacts – however, rarely can the action of feral animal removal be linked to the aims for undertaking that control (e.g. linking number of animals killed with environmental, social or cultural benefit).

Ultimately, this project aims to establish a pathway to establish a robust set of feral animal assessment and control tools that quantify feral animal impacts and risks in the context of defined social and environmental benefits on Indigenous land.

- 1) identify the thresholds of control actions required to achieve desired outcomes
- 2) assess and report the progress of animal control activities towards local and nationally defined values including a trusted mechanism that can be used for carbon and biodiversity accounting.
- 3) effectively communicate the efficacy of control activities to local stakeholders and land owners as well as statutory agencies,
- 4) identify when management actions are not meeting the pre-determined values driven outcomes and
- 5) rapidly adapt actions using evidence-based observations to ensure goals are met.

This project will work with Indigenous land managers across northern Australia and Industry bodies such as ICIN to undertake an audit of current practices, skills and constraints. This important data set will underpin an understanding of what is required to support scalable Indigenous-led coordinated feral animal control across northern Australia.

The development of accounting methods for blue carbon and biodiversity impacts on coastal wetlands in the context of feral animal control requires equally robust methods for feral animal management and monitoring. Through the Indigenous land management lens, it is important that methods provide incentives for local participation and leadership in management activities (i.e. methods that require external delivery are not supported). This project will establish a pathway for development of methods that maximise local leadership and participation particularly in the context of participation in carbon and biodiversity accounting schemes.

This project will provide evidence to support the development of Biodiversity Certificates (<https://www.pm.gov.au/media/biodiversity-certificates-increase-native-habitat-and-support-australian-landholders>) on Indigenous land in northern Australia. Biodiversity markets have the potential to provide new untied revenue for Indigenous organisations and, if policy is well informed, promote innovative Indigenous led approaches to management. This could lead to profound and sustained positive social and environmental impact if the incentives promote local participation and enable adaptive approaches.

Indigenous consultation and engagement

This project is a category 1 for Indigenous consultation and engagement. This project is being led by an Indigenous organisation (NAILMSA) and will collaborate with other Indigenous organisations operating across a variety of scales (Traditional Owner led land and sea management organisations,

Land Councils and Indigenous representative organisations) to co-design the outputs, collaborate on collating and interpreting spatial information and training audits and communicate results widely through extended networks and through Indigenous led forums. This project proposal has emerged from decades of work with Indigenous organisations who have identified barriers to implementing regionally coordinated feral animal management and lack of consultation when considering regional planning for feral animal management and control activities. Additionally, Indigenous organisations have supported training and practical experience in feral animal management in remote areas and have indicated that highlighting these skills and identifying skills development areas that require investment is important for the continued growth of a capable remote workforce. This project will work directly with established Indigenous land and sea management organisations to support direct participation in the creation of project outputs from the Indigenous land managers and their organisations that are ultimately responsible for delivering on ground outcomes. Research outputs that involve direct input from Indigenous organisations will include co-authorship on research outputs. The project will resource Indigenous organisations involved in case studies to collect the required information. NAILSMA employs Indigenous project officers to complete project tasks. ICIN will be resourced to communicate outputs to their members and to facilitate project input at the national Indigenous Carbon Forum in 2023 and during facilitated online forums.

This project will be conducted collaboratively and with full consent by Traditional Owners. Traditional knowledge and Indigenous Cultural and Intellectual Property (ICIP) will be managed following established standards (Our Knowledge Our Way Guidelines). Where these exist, we will work under established agreements that clearly sets out the purpose, benefits and responsibilities of any collaborative partnership, where these do not exist we will establish new research agreements. If there is agreement to share cultural knowledge we will also establish and Indigenous cultural and intellectual property (ICIP) agreement.

The project team will seek free, prior and informed consent from collaborating Indigenous organisations (or other relevant cultural authority) as part of any agreement associated with this project. The project team will work closely with collaborating Indigenous organisations to identify and develop appropriate research outputs for communicating the findings of this research to Indigenous people. We plan co-authorship of publications with Traditional Owners where they want to share their data and knowledge. The project will seek human ethics approval that will cover all publicly available project outputs and the use and re-use of any sensitive data collected during the project.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National	Regional	Local
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Location(s) – gazetted region /place name	Kimberly (WA), Arnhem Land (NT) and Cape York (Queensland)		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	The project team has discussed potential case study locations with organisations in northern Australia and there is broad scale support for the work at regional and local scales. Final locations will be determined following human ethics approval.		

Project 3.10 – A partnership approach to filling key knowledge gaps on dugongs in northern Australia using novel technologies

Project description

Project summary

In Australia, the dugong is protected under the EPBC Act 1999 as a listed migratory, and listed marine species, it is also a *Matter of National Environmental Significance*. The dugong is culturally significant to the coastal Aboriginal and Torres Strait Islander peoples of northern Australia and has a high biodiversity value. This project includes five activities that will contribute to addressing key knowledge gaps about the spatial and temporal patterns in the distribution, abundance, connectivity and health of dugong populations. The project is designed to inform management in several regions of high value habitat across northern Australia. Transversal to the activities described below is a strong partnership approach with Traditional Owners and members of the wider community. The project will be co-designed, co-produced and will co-deliver research and monitoring outputs. The studies will utilise and advance emerging technologies (e.g., aerial images collected from planes and drones, Artificial Intelligence, population genomics) with the ultimate goal of enhancing data quality, reducing research and monitoring costs, and increasing accessibility of monitoring tools to non-experts.

Project description

1. Activity 1: Assessing trends in the distribution and abundance of dugongs during the transition to imagery surveys along the eastern coast of Queensland

Since the 1980s, it has been established practice to survey the Great Barrier Reef (GBR) for dugongs every five years using trained human observers in light aircraft (henceforth ‘observer surveys’) with empirically-derived corrections for detection bias. The efficacy of this survey schedule was confirmed by prospective power analysis as part of the Reef 2050 Integrated Monitoring and Reporting Program (RIMREP) process (Marsh et al. 2019). The southern GBR (sGBR) was last surveyed in 2016 (now overdue) and the northern GBR in 2018 (due for survey in 2023). These surveys are timely as they follow a period of extreme weather and continued decline of coastal health; the condition of the dugong along the sGBR is stated as “poor” and its trend is “deteriorating” (Clark et al. 2021).

There are multiple reasons (human safety reasons, cost efficiencies and data integrity) to explore the potential of new technologies such as aerial imagery in survey design. Such changes have the potential to enhance the monitoring of dugongs and other species of marine megafauna in Australia and globally (e.g., Marsh et al. 2019, Hodgson et al. 2020). The main objective when investigating aerial imagery in dugong surveys is to enhance survey methods and accuracy in abundance estimates. A federally funded review of our state of knowledge in the transition from observer surveys to imagery undertaken by Cleguer and colleagues (ongoing) (1) explicitly outlines the experimental research needed to enable a new survey approach - integrated with historical surveys; and (2) recommends that the next dugong aerial surveys along the eastern coast of Queensland in 2022-2023 be undertaken using a traditional observer survey while incorporating aerial imagery experiments to contribute to the technological transition. JCU-TropWATER has secured funds from the Australian Department of Climate Change, Energy, the Environment and Water (DCCEEW) to undertake the dugong surveys in QLD (\$200K cash contribution) and is awaiting confirmation of additional funding

from the Great Barrier Reef Foundation (GBRF) to fund this work across the GBR (\$900K cash contribution). While this funding will be sufficient to conduct the aerial survey using piloted airplanes and capturing aerial imagery simultaneously, additional funding is required to complete the analysis of the imagery data. This is a critical step in determining whether aerial imagery alone will be sufficient for monitoring dugong populations.

2. Activity 2: Assessing the trends in the distribution and abundance of dugongs during the transition to imagery survey in the Shark Bay and Ningaloo/Exmouth Gulf area

A significant proportion of the world's dugongs are found in north-Western Australian waters from Shark Bay in the Gascoyne through the Pilbara and Kimberley. Similar to the description for the GBR (see section above), the Department of Biodiversity, Conservation and Attractions (DBCA) has conducted observer surveys of Shark Bay approximately every five years since 1989 to create a time series dataset on dugong abundance and distribution. These surveys have been extended to the Pilbara (Ningaloo Marine Park & Exmouth Gulf) because of the likely movements of dugongs between these two regions (Gales et al. 2004; Holley et al. 2006) and to better understand dugong distribution in the Pilbara. The last of these surveys occurred in 2018 (Bayliss et al. 2019), with the next survey due in June 2023. Nationally, a federal Transition Strategy is being developed to guide the transition from traditional observer surveys to aerial imagery surveys, as it is recognised that imagery surveys have the potential to improve data quality and accuracy and to minimise human risk (e.g. Hodgson et al. 2013). This activity proposes to undertake the 2023 aerial survey using methods that will inform, and be a step in that transition.

The outcomes from the experimental work led by the JCU-TropWATER group on the eastern Queensland coast in late 2022 (Activity 1) will influence the design of the approach (survey platform, design and protocol) to be undertaken in the next survey of the Shark Bay and Ningaloo/Exmouth Area (Activity 2). DBCA and JCU-TropWATER have been collaborating with Murdoch University (WA) on the methods to assess the detection probability in observer versus imagery surveys, survey design and analysis of aerial imagery as the key components of the transition to imagery surveys. These Shark Bay and Ningaloo/Exmouth surveys will be conducted using either a combined platform approach (imagery and observers) or imagery only (using long-range drones or piloted aircraft), pending results from Activity 1.

Initial consultation has begun with traditional owners through the *Nynggulu (Ningaloo)* Joint Management Body (JMB) that share joint management responsibility of Ningaloo Marine Park. Dugong monitoring by aerial survey has been endorsed by the JMB and, if the application is successful, in-person meetings will be facilitated with the traditional owners for knowledge sharing of dugong in Exmouth. Indigenous trainees and rangers (employed by DBCA) will participate in the surveys as observers in both Shark Bay and Exmouth if 'observer surveys' are required (i.e. if the surveys are not conducted via aerial imagery only). Additional meetings and further discussions are required through JMB's, with Malgana and also with traditional owner groups not in joint management arrangements (e.g. Exmouth Gulf).

3. Activity 3: Using population genomics approaches to identify populations and their level of connectivity across northern Australia

Central issues in wildlife conservation include identifying populations and units for conservation, assessing population size (see above sections) and connectivity, assessing the potential of populations to persist and adapt to environmental change, and understanding the factors that affect this potential (Hohenlohe et al. 2021). Genetic information can inform these issues and provide critical information for designing effective management strategies.

Population genomics uses many markers across the entire genome and can now help us address questions about connectivity, genetic diversity, levels of inbreeding and kinship, and investigate source and sink populations. In this study, we will use a reduced representation population genomics approach to identify populations and understand the relationships among them by estimating present day connectivity, while taking into account historic connectivity and population size changes across northern Australia. Consultation with research institutions, traditional owner groups, and government agencies across northern Australia have led this study to focus on the Gascoyne region (Pilbara and Kimberley), Gulf of Carpentaria, west Cape York and Torres Strait region, for reasons of (1) end-users' interest in such study, and (2) availability of dugong samples.

4. Activity 4: Assessing the body size and body condition of dugongs using drone-based photogrammetry

Assessments of individual animal health and condition can signal early signs of population level effects in wildlife, but relying on wild animal captures can be challenging, hindering our understanding of the wellbeing of populations. In marine mammals, photogrammetry techniques have been applied broadly for measuring body size and estimating body condition of several taxa including manatees (Castelblanco-Martínez et al. 2021, Ramos et al. 2022). These methods produce reliable body length estimates (Webster et al. 2010; Wong and Auger-Méthé 2018) and can be used to investigate trends in growth and survival (Cheney et al. 2018), and to identify regional differences in morphometric patterns (van Aswegen et al. 2019).

This activity will be conducted through a PhD studentship and will aim at developing photogrammetry methods using small aerial drones for accurate morphometric measurements of dugongs' body size and condition. The first stages of the study will follow a method validation process using data from known sized animals (dugong-like decoys, and live and stranded animals). We will then aim to work with partners and co-contributors to the NESP project to identify natural regional differences in morphometrics of dugongs in places of high dugong conservation value.

5. Activity 5: Developing community-led dugong monitoring with traditional owners in the Kimberley region.

In the Kimberley, dugongs have very high cultural and conservation significance. They inhabit the traditional Sea Country and native title determination areas of numerous Indigenous communities across the region, are a cultural food source for many Indigenous communities and are identified as a significant value of all Kimberley saltwater Healthy Country plans. In their *Kimberley Indigenous Turtle & Dugong Initiative 2022–2032* (hereafter T&D Initiative), the Kimberley Indigenous Saltwater Advisory Group (ISWAG) highlighted the shared obligation to manage Sea Country to ensure dugong and sea turtle populations are healthy and sustained into the future. In particular, the T&D Initiative identifies both key information gaps and means of collaboratively addressing these priorities that will assist in healthy country management. Importantly these rely on building Indigenous capacity in marine science.

In section 3 of the T&D Initiative, ISWAG acknowledged that there is potential for rapidly evolving technology to improve data collection efficiency and decrease data processing effort. In this activity, Indigenous Sea Country managers from the Kimberley and western scientists will partner to assess the usefulness and cultural appropriateness of various methods and work together to develop capacity within Indigenous communities to answer priority knowledge needs on dugong. This may include using drones to monitor dugong abundance and distribution at a fine scale or the collection of samples for genetic analyses (to feed into Activity 3). This project will progress once discussions have been had with JMB's, ISWAG and with traditional owners where joint management arrangements do not apply. An initial discussion has identified the ISWAG forum to be held in the Kimberley in late 2022 as an appropriate forum where all 9 saltwater country ranger groups in the Kimberley will be represented and from then the project can be planned further. The project has been added as an agenda item for

the upcoming ISWAG meeting where the aspirations in the T & D Initiative will be discussed and a priority identified from these to develop into Activity 5.

Indigenous consultation and engagement

This project is a category 1 for Indigenous consultation and engagement. Engagement has already occurred with many Indigenous groups from Qld, NT, Torres Strait and WA. This will continue throughout the projects and is transversal across all activities.

Indigenous research aspirations were identified in the preliminary consultations for this project and will be incorporated into the research led by Aboriginal and Torres Strait Islander partners. The projects will be co-created and co-designed so that there is reciprocity and benefit achieved across all activities. The information from all projects will support Indigenous-led sea country management. For the Kimberley ranger groups, activity 5 will align with Healthy Country Plans, Marine Park Management Plans and joint management arrangements with DBCA and the *Kimberley Indigenous Turtle & Dugong Initiative 2022–2032* that will inform the hunting guidelines for customary harvest. It is possible that learnings from this research can be shared across the Indigenous partner groups to strengthen this management approach across northern Australia.

Each activity will:

- Abide by the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS)
- Seek Human Research Ethics Committee approval as required for any research work conducted on Sea Country with Aboriginal and Torres Strait Islander Peoples.
- Seek the provision of free, prior and informed consent from the relevant Traditional Owner (TO) where the research work will be conducted.
- Endeavour to develop a Research Project Agreement with TOs which will include:
 - Opportunities to develop a communication network between the science team and TOs and indigenous communities to exchange and share updates on the project throughout the project
 - Employment opportunities for
 - Data co-ownership and access

Co-authorship will be extended to TOs and rangers for all projects where Indigenous Knowledge is shared and included in publications. All involved research partners have experience in publishing with TOs and rangers in technical reports and also peer-reviewed scientific publications (e.g Bouchet et al. 2021, D'Cruz et al. 2021, Ungunmerr-Baumann et al. 2022).

There will be opportunities for a focus on training and capacity building for rangers in all project activities. For example, this will include direct participation by TOs and rangers in aerial surveys in Shark Bay and Exmouth (Activity 2), training in the collection and storage of dugong DNA samples and interpreting results from genetic analysis (Activity 3), training in the collection of aerial imagery data on dugong body measurements (Activity 4) etc. Training and upskilling rangers will likely be a strong focus of Activity 5 but the methods and technologies need to be confirmed.

Location of research

The project is at a National scale with most field studies occurring in Western Australia, Northern Territory, Torres Strait and Queensland. The table below summarises where each of the activities are planned to occur across all four states of northern Australia (D: Desktop activities, F: Field activities). Note that for activity 4 (dugong photogrammetry) the location of the field research has yet to be determined through future consultation with partners and end-users and during the first year of the PhD.

At which spatial scale is the project working	National <input checked="" type="checkbox"/>	Regional <input checked="" type="checkbox"/>	Local <input checked="" type="checkbox"/>
Aboriginal or Torres Strait Islander nation or traditional place name(s)	<p><i>Activity 1:</i> Aboriginal and/or traditional place names across the entire Great Barrier Reef Marine Park (GBRMP), Hervey Bay and Moreton Bay (QLD).</p> <p><i>Activity 2:</i> <i>Gathaagudu</i> (Shark Bay) and <i>Nyinggulu</i> (Ningaloo).</p> <p>Activity 3: Aboriginal and/or traditional place names across the entire GBRMP, Hervey Bay and Moreton Bay across QLD, Torres Strait, NT and WA.</p> <p>Activity 4: Aboriginal and/or traditional place names across the entire GBRMP, Hervey Bay and Moreton Bay across QLD.</p> <p>Activity 5: TBC Potentially: <i>Yawuru Nagulagun</i> (Roebuck Bay, Broome) <i>Ardyaloon Bardi</i> (Dampier Peninsula), <i>Bardi Jawi Gaarra</i>, <i>Mayala</i> and <i>Mailalam</i> marine parks, <i>Lalang-Gaddam</i> (Horizontal Falls, Camden Sound, North Kimberley) on Dambeemangardee sea country.</p>		

Activity ID	QLD	Torres Strait	NT	WA
Activity 1	D: Townsville	-	-	-
Activity 2	-	-	-	D: Perth F: Shark Bay/Ningaloo/Exmouth Gulf
Activity 3	D: Townsville	F: across	F: across	F: across
Activity 4	D: Townsville F: Moreton Bay, Hervey bay, Cleveland Bay, Hinchinbrook	TBC	TBC	TBC
Activity 5	N	N	N	D & F: Kimberley region Broome and Dampier Peninsula

Project 3.11 - Multi- fishery collaboration to assess population abundances and post release survival of threatened sawfish in northern Australia

Project description

Project summary

To improve sawfish reporting and obtain an estimate of sawfish abundance and stock structure, we propose a large-scale collaborative project between industry, State and Commonwealth agencies and lead research institutions to gather tissue samples from across northern Australia. The project will have a focus on developing trust between research and the commercial fishing industry that will achieve the following:

- Industry led reporting and sampling programs will be established throughout Australia's northern fisheries.
- Tissue samples will be used to assess sawfish abundance and stock structure using Close-Kin Mark-Recapture (CKMR).
- Estimates of post-release survival will be obtained from satellite tagging and improved reporting.
- Data on abundance and post release survival will be used to assess the sustainability of sawfish bycatch.

The research also aims to improve reporting of sawfish along with other EPBC listed species in northern Australian fisheries. If enough tissue samples are collected, close kin mark recapture will enable estimates of adult population size for four species of sawfish. Post release survival and abundance estimates will be used to determine the sustainability of sawfish captured as bycatch in state, territory and Commonwealth Fisheries. Improved estimates of bycatch, population connectivity, adult abundance and post release survival were identified as the highest research priorities in the Sawfish and River Shark multispecies recovery plan.

Background

Northern Australia supports several commercial gill net and trawl fisheries that capture sawfish as bycatch. Sawfish are not targeted by any commercial fishery in Australia; however, their toothed rostrum makes them highly susceptible to capture in net fisheries. Within Australia, three out of the four occurring species are listed as Vulnerable and Migratory under the EPBC act (*Pristis pristis*, *P. zijsron* and *P. clavata*). The fourth Australian species, narrow sawfish (*Anoxypristis cuspidata*) is listed as a Migratory species. Both *A. cuspidata* and *P. pristis* are currently under nomination to be up-listed to Endangered under the EPBC act.

While there is concern that fisheries are potentially impacting sawfish populations, estimates of sawfish abundance, catch rates and post release survival are lacking. Sawfish are nationally and internationally recognised as being at risk from fishing activities with all sawfish species having experienced dramatic population declines and reduced geographic range. Given their typical

elasmobranch life histories, sawfish populations are likely to take several decades to recover from these significant reductions in populations (Brewer et al 2004). While northern Australia is one of the last global strong-holds for four sawfish species once found globally, there is insufficient data to assess their population status. The lack of data on sawfish population size combined with inadequate reporting data from Australian commercial fisheries (Pillans et al. 2022a) makes it impossible to determine the impact of ongoing bycatch on sawfish populations. This uncertainty means there is urgent need for effective monitoring of sawfish in commercial fisheries and for robust estimates of sawfish abundance.

Project description

The project outlined here has three main components:

- The project team includes representative of key fisheries in northern Australia and a key goal of the work is to embark on a significant initiative to build trust and facilitate communication between the fishing industry, research providers and management. This will underpin industry to self-lead development of accurate reporting schemes to resolve uncertainty in catch rates.
- Close industry involvement in this project will enable the collection of sufficient tissue samples to apply the close-kin mark recapture methods developed in the previous NESP marine hub. An ongoing FRDC funded project between CSIRO and the Northern Prawn Fishing Industry is working on estimation of narrow sawfish (*A. cuspidata*) abundance via samples obtained from Northern Prawn Fishery crew member and AFMA observers. The current NESP proposal will utilise both samples collected under the existing CSIRO/NPFI project and expanded sampling from other fisheries around northern Australia. Therefore, between this existing project and this proposed project for NESP2, we will obtain the first estimates of absolute abundance of breeding populations of all sawfish species found in Australia.
- It is known that many fisheries operators across various sectors, take effort to release captured sawfish alive. However, there is currently no data on the fate of released animals. Therefore, the final aim of this proposed project is to use satellite tags to monitor the fate of released sawfish and characterise the degree of post release mortality (PRM) after fisheries interactions. Tags will be deployed across the major fishery sectors and throughout the species distributions. The project PI (Pillans) is submitting an EOI to FRDC for support for this component.

The NESP northern node leaders, DCCEW staff and CSIRO have jointly noted the need for this simultaneous FRDC project which would be closely integrated with the NESP2 project proposed here. **However, it is important to note that the CKMR and monitoring aspects of this current proposal are viable even if the EOI to FRDC for PRM research is not supported in the next round.**

With these three components we will deploy a coordinated and integrated approach that will see fishing industry supplying tissue samples and meta-data on size, sex, and location. These tissue samples will be used to develop improved estimates of age and growth of sawfish in Australia and to develop epigenetic estimates of age enabling age estimation of live-released animals. Sequencing of both nuclear and mitochondrial DNA from the same samples will provide Single Nucleotide Polymorphism (SNPs) inform CKMR estimates of abundance and other population parameters (including adult survival, sex ratio, and population connectivity). The project will develop streamlined reporting mechanisms to allow for characterisation of sawfish catch rates throughout the North and finally satellite tagging from industry vessels will provide information on post-release survival, habitat usage and short-term movement and dispersal rates.

A critical component of the research is developing trust between industry, research providers and management agencies. In developing this proposal, we have engaged extensively with the relevant commercial fishing organisations in the NT and QLD. The project will include a dedicated component

to engage with Industry to ensure samples are collected, and to disseminate information and research outcomes directly to industry sectors contributing to the project.

The previous NESP Marine Biodiversity Hub made significant investment in the development of Close-kin mark recapture. The method uses next generation sequencing of tissue samples to establish whether individuals are closely related. The number of, for example parent-offspring individuals or individuals which share a parent (half-siblings) is directly related to the number of breeding adults supporting the population. These methods were successfully applied to several threatened elasmobranch species in the previous hub including white shark, grey nurse shark, speartooth shark and northern river shark.

The difference between those species and sawfish is that they could be sampled adequately by researcher field programs. This has proven challenging for sawfish species. Hence the need to employ the much larger coverage of the relevant commercial sectors to obtain samples. As mentioned above, in this regard, the project will extend the collaborative research/industry partnership approach being applied within a FRDC-funded CSIRO project on narrow sawfish.

The project aims to determine the paramount quantity of concern for preserving a population: that is, the abundance of breeding aged animals. Additionally, CKMR can jointly estimate total adult survival rate. By coupling abundance and data on bycatch rates and post-release survival, the project will estimate what level of mortality the populations can sustain while remaining stable and eventually rebuild. By establishing feasible reporting and handling standards with industry and looking at post-release survival across different fisheries and gear types, the research will directly inform effective management/mitigation measures. Therefore, the research will provide the data that industry requires to self-organize and proactively respond to sawfish declines and the population monitoring schemes to ensure an ongoing evidence base for management decisions.

Indigenous consultation and engagement

This project has category 2 Indigenous consultation and engagement. This project is currently collaborating and has ongoing communication with a number of Indigenous ranger groups and communities to deliver this research. This project will adopt the Marine and Coast Hub's Indigenous Engagement Partnerships Strategy (IPS) and will operate under the NESP Indigenous Partnerships Principles. The project will include Indigenous engagement and capacity building within ranger groups including the Aak Puul Ngantam (APN) Rangers in Aurukun, Queensland and the Malak Malak and Timber Creek in the Northern Territory. Both CSIRO and CDU have established relationships with these groups. CSIRO currently has an existing engagement and training programs with the APN Rangers and Timber Creek Rangers. These engagements were established through APN (Melissa Sinclair) and the Northern Land Council (Richard Campbell), respectively. The engagement with Timber Creek Rangers has been ongoing since 2017 and APN since 2021.

The project will also continue a long-standing partnership between CDU and the Malak Malak Rangers where, when necessary, stranded sawfish are rescued and relocated from drying floodplain waterholes. Over 110 *P. pristis* tissue samples will be contributed to the project from Malak Malak Country and additional sawfish tissue will be obtained through the partnership. The Malak Malak have independently identified a research question in relation to the population size of *P. pristis* in the Daly River, wishing to understand the local population size. Charles Darwin University has been engaged with the Malak Malak Rangers since 2013 and this relationship has previously been a focus of NESP (<https://www.nespmarine.edu.au/news/sawfish-rescue-caught-video>).

Training will include sawfish sampling methods, species identification, tissue sampling and attaching satellite tags. There will also be a community engagement component where researchers give presentations to the community and schools in Aurukun and Timber Creek.

Sawfish are an important cultural species in the Victoria River and have been recorded up to 550 km upstream of the river mouth. CSIRO has recently identified Indigenous harvest of sawfish in the Victoria River as a significant source of mortality and have recently started talking with Northern Land Council on an education campaign within the school and communities around sawfish status. The aim is to provide Traditional Owners with national information about sawfish status and the multiple threats that juveniles face in upstream habitats. Through signage, t-shirts and presentations our aim is to improve education around sawfish in the Victoria River region. We are working with the Northern Land Council to determine the most culturally appropriate approach to sawfish conservation and education in the region and aim to continue this work under the NESP project. Education and engagement with the Traditional Owners will directly address recovery plan objective 3: Reduce and, where possible, eliminate adverse impacts of Indigenous fishing on sawfish and river shark species.

There will be opportunities for co-authorship if publications arise from research with Indigenous Ranger Groups. There will be scope for co-authorship and design of education material and artworks. There will be capacity building and training in all projects that will include sawfish sampling methods, species identification, tissue sampling, attaching satellite tags and passive and active water quality measurements.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National	Regional – Nth Australia	Local
		<input checked="" type="checkbox"/>	<input type="checkbox"/>
Location(s) – gazetted region /place name	Inshore and offshore waters from Joseph Bonaparte Gulf to Cape York Peninsula include freshwater reaches of rivers.		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	Jaminjung, Nungali, Ngaliwuru, Karangpurru, Bilinara, Ngarrinman, Malak Malak, Manganyi, Alawa, Mara, Ngalakan, Wik, Winda Winda		

Project 3.12 – Closing the gap in bycatch reporting and population assessment of sea snakes in Northern Australia

Project description

Project summary

Venomous sea snakes comprise a significant component of the bycatch of coastal trawl and trap fisheries across northern Australia. Safety concerns and difficulties in species identification by crew members mean that most sea snake interactions are inaccurately reported. By partnering with commercial operators and fisheries agencies, this project will develop an observer program to train crew members, enabling: i) improved safety, accuracy, and consistency of sea snake bycatch reporting, ii) generation of broadscale data to assess species- and fisheries-specific population status for at least 20 species of sea snakes, two of which are EPBC-listed as critically endangered, and iii) the reduction in disparity between fishery and fishery independent reporting of sea snake bycatch.

Project description

Problem statement and project justification: Sea snakes comprise a significant component of bycatch species across multiple coastal trawl and trap fisheries in northern Australia. Due to the venomous nature of these species, they are an occupational health and safety hazard onboard commercial fishing vessels, and are quickly removed during operations. This reduces the reporting of return status and species identity for sea snakes in most fisheries sectors. Subsequently, a large proportion of sea snake interactions in these fisheries are either not recorded or are misidentified in crew member observer programs (CMOPs). This is evident in the mismatch between bycatch data reported in fisheries logbook data and fisheries-independent trawl surveys within the Exmouth Gulf and Shark Bay. In addition to this, interactions of sea snakes with the trap fishery across the Pilbara coast are currently poorly understood.

This is especially concerning for Western Australian fisheries, which interact with two Australian-endemic sea snake species that are listed as critically endangered under the EPBC Act and IUCN Red List. These are the leaf-scaled sea snake, *Aipysurus foliosquama*, and the short-nosed sea snake, *A. apraefrontalis* (which was identified by the DCCEEW as one of nine reptile species in the '100 Priority Species' list).

Project Approach: This project will utilise existing relationships with trawl and trap fisheries stakeholders including commercial operators, state/territory and federal fisheries agencies. The overall objective is to align multiple CMOPs and train crew members to enable i) improved safety, accuracy, and consistency of sea snake bycatch reporting by commercial fishers in line with their MSC accreditation, ii) the generation of broadscale data needed to assess species- and fisheries-specific population status for sea snakes, and iii) the reduction in the mis-match of sea snake bycatch reporting between fishery collected and fisheries independent sources. This project will focus on the trawl and trap fisheries that operate in Shark Bay, Exmouth Gulf and Pilbara in the first instance, and at a later stage will be extended to the Northern Prawn Fishery.

This project will take a phased approach over 3 years to build a network of key stakeholders and research users, develop and deliver crew member training, and implement a CMOP across key trawl and trap fisheries in northern Australia. This will require the employment of a post-doctoral researcher to run the operations and training components, and lead data analyses.

Phase 1: Network building - Existing fishery and government-led CMOPs vary in scope and methods for data collection. Through a workshop involving fishery managers, fishery scientists and commercial operators, we will review the data currently being collected, and identify gaps in current practices for monitoring interactions with sea snakes. This stakeholder workshop will develop a standardised method for sea snake bycatch reporting across various existing CMOPs, and extend these to contribute additional data (i.e., capture and recapture rates, life-history parameters and reproductive information, genetic connectivity).

Phase 2: Training crew members - Outcomes of the workshop will be used to design, develop and deliver training to crew members from trawl and trap fisheries. This training will build on previous training resources developed by this project team for trawl operators in the Exmouth Gulf and Shark Bay Prawn Managed Fisheries. Training will cover protocols for safe handling, bite first aid and clinical outcomes of sea snake bites, species identification, and methods for specimen/sample and data collection. This will enable participating crew members to safely handle, more accurately identify species, and collect fisheries relevant information and samples from bycaught sea snakes during commercial operations.

Phase 3: Ongoing data collection and analysis - Ongoing assessment of data collected during the first year of the project will be used to review and refine procedures and remove inefficiencies. This information will be used to update training and operating procedures for stakeholders involved to collect fisheries relevant information on sea snake bycatch. Final analyses will quantify disparities between fishery and fishery-independent CMOP data before and over the course of the project and will yield fishery-specific estimates of sea snake encounter rates, species assemblages, seasonal and multi-year patterns of bycatch rates, life history data, and contribute to genetic connectivity analyses, for at least 20 species that commonly interact with commercial fisheries in Australia.

Project links to other research and hubs: This project builds on previous research conducted by the research team (including the previous NESP Marine Biodiversity Hub A8 project) and will work directly with industry and government agencies. This project also value-adds to a current one-year project funded by Parks Australia through the 'Our Marine Parks Grant' which is looking at understanding the role of Australian Marine Parks (AMP) in connecting and conserving sea snakes. The current proposal will collect additional genetic and population health data in collaboration with industry stakeholders in regions outside AMPs and is out of scope for the Parks funded project. Combined, the data collected across these two projects will provide a more complete picture of sea snake status across Northern Australia. The training and industry-led data collection proposed here can be used to collect similar data on other conservation priority species identified by the MaC steering committee (e.g., sawfish), and there is significant opportunity for links with other research groups that work in this space.

Expected outcomes:

- Increased accuracy and consistency of industry reported sea snake bycatch data, evidenced by a closer alignment between fishery and fishery-independent survey data
- Collection of sea snake interaction data in fisheries where previous reporting has not been conducted (i.e., Pilbara fish trap and trawl sectors, which overlap the ranges of two critically endangered-listed species)
- Improved safety standards of crew members interacting with sea snakes (including use of personal protective equipment, handling practices, knowledge of proper snake bite first aid).
- Collection of critical spatial distribution, life-history information and population data for at least 20 species of sea snakes across northern Australia. This is beyond the scope of traditional research surveys and will contribute to ecological risk assessments (DPIRD) and assessments of conservation threats and status (DCCEEW).
- Capacity for fisheries and environmental agencies to continue sea snake observer programs beyond the life of the project, via the development of training resources (ppt presentations, printed/online guides to species identification and bite first aid) and data analysis pipelines.

- Final report detailing the methods used and resulting spatial distribution, life-history and population data obtained through the project.

Indigenous consultation and engagement

This project is a category 2 for Indigenous consultation and engagement. Sea snakes have varying levels of significance and use in Indigenous communities, but it is yet unknown how important sea snakes are, especially in remote regions across northern Australia and in regions that are closely located to commercial fisheries operations. Consultation and engagement with appropriate Indigenous communities is thus an important step in research on these species.

This project will build on previously established relationships with the Anindilyakwa and Thamarrurr Rangers and Traditional Owners in the Northern Territory (adjacent to the Northern Prawn Fishery grounds) that were involved with previous sea snake research as part of the previous NESP A8 project. Initial engagement with additional groups across the Shark Bay and Pilbara regions has been started, and during the project direct consultation will be conducted by including and inviting Traditional Owners and Rangers that are interested in participating in stakeholder and training workshops. The groups initially targeted for this additional engagement in the northwest will include the Malgana, Nyangumarta and Karrajarri groups. Contact with these communities will be facilitated through existing AIMS relationships and as part of other ongoing sea snake and marine research conducted within this region.

Engagement will be underpinned by best global practice standards, approaches such as the AIMS Indigenous Partnerships Plan and separate Policy which outline our clear commitment to engage with Traditional Owners of Sea Country. The continued engagement and consultation process during the course of this project will include the opportunity for interested groups to provide input in the research planning and development of training materials during the first stakeholder workshops (Category 2; Collaborate). Traditional Owners and Rangers involved in the follow up workshops will be trained alongside commercial fishers in safe handling and identification of sea snakes. These workshops will also provide an opportunity for two-way learning, where researchers and commercial fishers can learn from the Traditional Owners about the traditional ecological knowledge and cultural values of sea snakes to local communities. All stakeholders including Traditional Owners and Ranger groups that are involved will be provided the opportunity to have input into the final report prior to submission to NESP.

We recognise that Traditional Owners are the custodians of Indigenous Cultural and Intellectual Property (ICIP). To ensure that Traditional Owners rights to ICIP are respected we will only record and use ICIP with the free, prior and informed consent of Traditional Owners.

Location of research

Locations of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National	Regional	Local
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Location(s) – gazetted region /place name	Field work: Exmouth Gulf, Shark Bay, Pilbara, Gulf of Carpentaria, Joseph Bonaparte Gulf		

	Desktop studies: Adelaide, South Australia; Darwin, Northern Territory (impact on coastal fisheries in Western Australia, Northern Territory and Queensland)
Aboriginal or Torres Strait Islander nation or traditional place name(s)	<p><i>Palyadi Manu</i> is a Yinikutira name for the Northwest Cape</p> <p><i>Ningaloo</i> is a Nyinggulu name</p> <p><i>Malgana</i> is the Gutharraguda name for Shark Bay</p> <p>Pilbara derives from <i>bilybara</i> in the Nyamal and Banyjima languages</p>

Project 3.13 – Eastern Grey Nurse Shark population abundance and trend

Project type: Hub research project	
Project status: New project submitted for approval	
Cross-cutting initiative:	Yes Threatened and Migratory Species Initiative (Helene Marsh).
Project start date: 01/01/2023	Project end date: 31/12/2023
Total project budget: \$ 638,410	NESP funding: \$ 284,355 Co-contributions (cash and in-kind): \$ 354,055
Project leader details:	Name: Russell Bradford Organisation: CSIRO Oceans & Atmosphere Phone: 0412 623 228 Email: russ.bradford@csiro.au Name: David Harasti Organisation: NSW DPI Fisheries Phone: 0408 669 273 Email: david.harasti@dpi.nsw.gov.au

Project description

Project summary

The eastern population of grey nurse shark, *Carcharius taurus*, is listed as Critically Endangered under the *EPBC Act* 1999, and a strategy to ensure recovery was implemented in 2002 with the development of the first recovery plan. The recovery plan updated in 2014 identifies priorities that require ongoing research that form the basis of this proposed project. This includes research to refine the abundance and trend estimate for the eastern Australian population of grey nurse shark and examine the potential for range expansion into Victorian waters. This will add value to recent age and growth estimates and examine epigenetic ageing of juveniles. Such information is important to inform the assessment of current conservation arrangements such as spatial closures.

Project description

The eastern population of grey nurse shark, *Carcharius taurus*, is listed as Critically Endangered under the *EPBC Act* 1999. A strategy to ensure recovery of the grey nurse shark population in eastern Australia was implemented in 2002 with the development of the first recovery plan (EA 2002). The recovery plan has been reviewed twice (DEWHA 2009 and DoE 2014), detailing several advances made in the conservation of the species. However, the 2014 recovery plan (DoE 2014) states two key areas that require ongoing research:

- *improving the population status leading to the removal of the grey nurse shark from the threatened species list of the EPBC Act; and*
- *ensuring that anthropogenic activities do not hinder the recovery of the grey nurse shark in the near future, or impact on the long-term conservation status of the species.*

The CSIRO and NSW DPI (with partners in Queensland and Victoria) provided the first robust estimate of adult abundance for the eastern GNS population in 2018 (Bradford et al. 2018). This estimate indicated that the adult population was approx. 2000 (950 - 3100) and that the trend in abundance was highly likely to be increasing at a rate of approx. 3-4% per annum. Bradford et al. (2018) concluded that recovery actions were effective, but that easing of protective measures was not recommended at that time. In 2021, the Grey Nurse Shark was listed as one of the 100 priority species under the Australian Government's Threatened Species Strategy. Priority species have been selected to help focus the efforts of the Australian Government and partners on threatened species recovery actions.

Conservation planning requires a revised estimate of grey nurse shark abundance which would reduce several key areas of uncertainty in the 2018 estimates, reflecting (1) length, and consequently inferred age, estimates for sampled animals were inaccurate and (2) growth curves for the Australian population were not available (the report used growth curves based on data from the US).

We therefore propose to update the GNS estimates by incorporating recent advances such as epigenetic ageing and to employ improved sampling protocols to obtain greater precision in length measurements. This will reduce bias in the abundance estimate and the collection of additional samples should reduce the uncertainty around the trend in abundance if we also use the older samples with their uncertain length measurements.

Overall, the key components of the project are:

- Collecting contemporary samples from juveniles only (for which vertebral ages are more accurate than mature animals and for which length is a better indicator of age) and incorporating stereo video analysis to obtain accurate length estimates.
- Using growth curves derived from Australian GNS samples involved in the ageing project undertaken by NSW DPI.
- Investigating epigenetic ageing of juvenile grey nurse shark using tissue samples from GNS with vertebral age (collected by a recent project by NSW DPI).
- Including Indigenous Sea Rangers to participate in sample collection in NSW and investigate potential range expansion into Victorian waters. Understanding expansion into Victorian waters is important to get a much more accurate picture of the distribution and abundance of the eastern Australian GNS population.

Reference:

Bradford, R. W.; Thomson, R.; Bravington, M.; Foote, D.; Gunasekera, R.; Bruce, B. D.; Harasti, D.; Otway, N.; Feutry, P. (2018). A close-kin mark-recapture estimate of the population size and trend of east coast grey nurse shark. National Environmental Science Programme, Marine Biodiversity Hub, CSIRO.

Is this a cross-hub project?

No.

Does this project contribute to a cross-cutting initiative?

Yes.

This project will provide input into:

- Protected place management (Marine and Coastal Hub)

- Threatened and migratory species and threatened ecological communities (Resilient Landscapes)

The project will contribute to Outcome 2 of the Protected Place Management Initiative (Increased evidence base through consistent approaches to collect, analyse and report relevant data for adaptive management of protected places)

The project will do this by:

- Undertaking surveys of waters outside of the existing footprint of GNS distribution (Gippsland, Victoria) to identify range expansion into historical areas of habitation (requires Indigenous engagement).
- Providing an updated abundance estimate and trend in abundance for the eastern GNS population.
- Providing information to Parks Australia on the status of the Grey Nurse Shark Key Natural Value.

This project sits within the Marine and Coastal Hub.

Indigenous consultation and engagement

Indigenous engagement and participation in 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 a Category 2 project for Indigenous partnerships. Category 2 projects involve collaboration and opportunities for knowledge sharing.

Evidence suggests that grey nurse shark have extended their range from the NSW/Victorian border into Victorian coastal waters at least as far west as Wilsons Promontory. Along this stretch of the Victorian coastline there are three Indigenous clans: Brataualung, Tatungalung, and Krauatungalung peoples. Presently, the project team are in contact with all of these clans as well as others further to the west of Wilsons Promontory, including a project aimed at transferring scientific skills to a group of Sea Rangers from the Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC). In Victoria, this project would expand our relationship with GLaWAC to investigate further skills transfer and active project engagement aimed at surveying some Gippsland marine waters for the presence of grey nurse shark.

In NSW, Aboriginal engagement as part of the grey nurse shark tissue sampling component from the wild population will involve providing sea-time experience and on-water training for Gumbaynggirr and Yaegl coxswain trainees, who have already been gaining vessel and ocean experience with Dr Hamish Malcolm. This capacity building is supported through NSW Marine Estate Management (MEM) Strategy and coordinated through the Coffs Harbour and District Local Aboriginal Land Council (Garby Elders rangers program) and the Yaegl Local Aboriginal Land Council. Hours of work undertaken by the trainee coxswains are paid for through the MEM Strategy and is an in-kind contribution to this project. Additionally, there are plans to involve the Worimi council from Port Stephens and Karuah by providing them with sea-time and on-water training for a proposed Coxswains course being undertaken at the end of 2022. As part of the MEM Aboriginal engagement program, it is also planned to implement a scientific diving course for Aboriginal rangers in northern NSW (Coffs Harbour and Port Stephens) and at the completion of the training, NSW DPI is aiming to use newly certified Aboriginal scientific divers (if approved to be on the NSW DPI diving register) to assist with the diving operations in this project which would be an in-kind contribution (TBD) funded by MEMS.

This project will provide opportunities for Indigenous engagement in field surveys through assistance on field surveys as well as skills transfer opportunities. Developing the capacity within Indigenous

organisations (e.g., Sea Rangers) to undertake field work will assist with employment prospects as well as future monitoring within their respective regions. Where appropriate and with agreement, opportunities may be available Indigenous participants to undertake cross-community and/or joint capacity building secondments.

We will also implement a collaborative approach to the project where the early stages will focus on building shared understanding about reciprocal benefits of the project. We will work under established agreements that clearly sets out the purpose, benefits and responsibilities of the collaborative partnership, where these do not exist we will establish new research agreements. If there is agreement to share cultural knowledge we will also establish and Indigenous cultural and intellectual property (ICIP) agreement. The project team will seek free, prior and informed consent from collaborating Indigenous organisations (or other relevant cultural authority) as part of any agreement associated with this project. The project team will work closely with collaborating Indigenous organisations to identify and develop appropriate research outputs for communicating the findings of this research to Indigenous people.

Which Three-category approach the project meets	Communicate	Collaborate	Co-design
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National	Regional	Local
	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Location(s) – gazetted region /place name	Broughton Island, NSW - Worimi Seal Rocks, NSW - Worimi Forster, NSW - Worimi Cod Grounds, NSW - Biripi Southwest Rocks, NSW - Gumbainggir Coffs Harbour - Gumbainggir Gippsland region, Victoria – Krauatungalung, Tatungalung, Brataualung Hobart, Tas - Nipaluna		
Aboriginal or Torres Strait Islander nation or traditional place name(s)			

Project 3.14 – Assessing changes in black rockcod abundance and size

Project description

Project summary

This project will assess the relative abundance and size of the threatened black rockcod (*Epinephelus daemeli*) to inform how the species is responding to conservation and management actions. In 2010, a broadscale survey (81 sites) was undertaken in northern NSW and Lord Howe Island, followed by subsequent surveys of a subset of these sites approximately every 4-5 years. This project proposes to repeat the surveys of the initial 81 baseline sites to assess if protection measures, such as marine protected area sanctuary zones, are assisting in recovery of black rockcod. Overall, this will provide a 13-year time series (2010 – 2023) that will be used to indicate if black rockcod are increasing in abundance, getting larger, and/or becoming more widespread, all indicators that can be used to assess if recovery actions being implemented are effective.

Project description

The black cod (*Epinephelus daemeli*) is listed as a vulnerable species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the (NSW) *Fisheries Management Act 1994*. Long-term monitoring of the population abundance was identified as a high priority by the NSW black rockcod recovery plan and the NSW Fisheries Scientific Committee. This project aims to assess changes in species abundance and size over time by resurveying key long-term black cod monitoring sites for time-series patterns as well as undertaking a temporal comparison (two times 13 years apart) at previously surveyed broadscale sites. The primary questions examined by this project are: 1) are black rockcod increasing in abundance at key sites through time?; 2) does their size structure now include a higher proportion of bigger individuals (given they are protogynous hermaphrodites that change sex at 1m and that none have been recorded in surveys near-to expected maximum length)?; 3) are they becoming more widely spread on reefs in northern NSW and Lord Howe Island? Increases in these are indicators of recovery, whereas lack of increase indicates lack of recovery. Increases in all three indicators will provide confidence that current management actions are leading to recovery of this threatened species.

In 1984, black rockcod were fully protected from being taken legally by fishing in NSW by being listed as a threatened species. Yet a lack of baseline and benchmark data at the time of protection and no information until ~25 years after protection commenced, mean that the true effectiveness of this protection is not actually known. Although they are a protected species, they are still caught (although legally must be immediately released), can die post-release from embolism (DPI observations), and are occasionally illegally taken (from compliance data). This current program addresses that gap from 2010 and into the future, by enabling comparison of relative abundance and length of this long-lived and slow-growing large apex species, from the benchmark survey in 2010-11. Without effective ongoing spatial and temporal data at various scales, knowledge and information will return to an anecdotal level and recovery planning will be less informed. Not repeating the broadscale survey undertaken in 2011, will remove one of the recovery metrics (are black rockcod becoming more widespread and abundant) and strongly hinder the overall evaluation of recovery. A consequence of this could be a decline in abundance not detected.

Relative abundance of black rockcod is determined using underwater visual census (timed-swim method) with two divers using stereo video cameras (stereo-DOV) for accurate length measurements. The timed swim method has proven to be much more practical for black rockcod surveys, compared

to transects and baited remote underwater videos (BRUVs), as it allows divers to thoroughly search through key habitats such as caves and overhangs. Notably, the same dive team will be used for this survey as from the previous surveys, thus limited observer bias between surveys. Since the initial broadscale survey (81 sites) in 2011, key sites (22) have been monitored annually over two time periods (2010 – 2014; 2018 – 2023) in northern NSW and twice at LHI (14 sites: 2011, 2019). Key sites are focused on black cod populations within marine parks (SIMP, CBMP, PSGMLP, LHIMP) as these are known to contain the highest black cod abundance. The initial broadscale survey will be repeated in 2023 as part of this project. Overall, this will provide a 13-year time series (2010 – 2023) incorporating two 5-year time periods with each period including a broadscale survey, enabling a range of temporal and spatial comparisons.

This project builds on existing monitoring by NSW DPI, some of which has been published:

- Francis MP, Harasti D, Malcolm HA (2016). Surviving under pressure and protection: a review of the biology, ecology and population status of the highly vulnerable grouper, *Epinephelus daemeli*. *Marine & Freshwater Research* 67: 1215-1228
- Harasti D, Gallen C, Malcolm H, Tegart P, Hughes B (2014). Where are the little ones: distribution and abundance of the threatened serranid *Epinephelus daemeli* in intertidal habitats in New South Wales, Australia. *Journal of Applied Ichthyology* 30 (5) 1007-1015
- Harasti D, Malcolm HA (2013). Distribution, relative abundance, and size composition of the threatened serranid *Epinephelus daemeli* in New South Wales, Australia. *Journal of Fish Biology* 83(2) 378-395

This project links to the previous work undertaken by NSW DPI as indicated in the above publications. NSW DPI have the two lead scientists on black rockcod in Australia (D. Harasti & H. Malcolm) who have both been implementing research on the species since 2010. At this stage, this project does not have any links to other hub projects.

This project will provide Commonwealth and state marine park managers and DPI threatened species managers with details on black cod abundance and size structure across four NSW marine parks (Port Stephens-Great Lakes Marine Park, Solitary Islands Marine Park, Cape Byron Marine Park and Lord Howe Island Marine Park). Managers will be able to utilise the information to base management decisions for the protection and long-term conservation of the species. For example, previous data collected by NSW DPI is currently being used in the revised management plan for the Port Stephens-Great Lakes Marine Park to ensure that important sites for black rockcod are afforded the highest level of protection (i.e. sanctuary zones). Data will also be used by the NSW Fisheries Scientific Committee in national assessments of the population status of black cod. The data will also be used by the NSW Fisheries Scientific Committee for their national reassessment of the black cod listing using the nationally adopted Common Assessment Method that is based on IUCN criteria. Scientific journal papers from this research inform more broadly on Serranid conservation, with a scientific paper intended following surveys in 2023.

The broader community will benefit from this research as well as more select marine user groups such as divers. Black rockcod as a threatened species will benefit through recovery planning and actions informed by this research. The local diving community in locations such as Port Stephens and Coffs Harbour will be involved in the project through reporting of sightings during the projects duration. Both state and Commonwealth Government agencies (i.e. NSW DPI-Fisheries and Dept of Climate Change, Energy, the Environment and Water) will benefit as the agencies responsible for ensuring recovery of this threatened species, as it will inform to whether existing management arrangements are suitable or whether more management interventions are required to assist with species recovery. This project includes sampling black cod sites within Commonwealth Marine Protected Areas; both Pimpnel Rock and the Cod Grounds are two sites which are known to be important for black rockcod and the only sites shallow enough in Commonwealth waters along the mainland coast that

can be surveyed by scuba diving. The diving surveys for black rockcod will provide data on the status of this threatened species within these marine parks.

This research will support both state and Commonwealth agencies to meet their responsibilities to threatened species and help with public communication, education and extension. Additionally, this species is susceptible to hook and line fishing, a listed key threatening process that is managed by NSW DPI, and an observed decline in black rockcod abundance would lead to reassessment of threats to this species.

Indigenous consultation and engagement

Capacity building/training, Indigenous employment

Indigenous engagement and collaboration 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 a Category 2 project for Indigenous partnerships. Category 2 projects involve collaboration and opportunities for knowledge sharing.

The project team will collaborate with several Indigenous organisations and build on existing partnership they have established with the New South Wales Government. Collaboration in this project involves providing sea-time experience and on-water training to four Gumbaynggirr and one Yaegl coxswain trainees, who have already been gaining vessel and ocean experience with Dr Hamish Malcolm. We will also involve Bundjalung Arakwaal rangers on board vessels used in surveying sites in Cape Byron Marine Park. This capacity building is supported through NSW Marine Estate Management Strategy and coordinated through the Coffs Harbour and District Local Aboriginal Land Council (Garby Elders rangers program) and the Yaegl Local Aboriginal Land Council. Hours of work undertaken by the trainee coxswains are paid for through the MEM Strategy.

We will also implement a collaborative approach to the project where the early stages will focus on building shared understanding about reciprocal benefits of the project. We will work under established agreements that clearly sets out the purpose, benefits and responsibilities of the collaborative partnership, where these do not exist we will establish new research agreements. If there is agreement to share cultural knowledge we will also establish an Indigenous cultural and intellectual property (ICIP) agreement. The project team will seek free, prior and informed consent from collaborating Indigenous organisations (or other relevant cultural authority) as part of any agreement associated with this project. The project team will work closely with collaborating Indigenous organisations to identify and develop appropriate research outputs for communicating the findings of this research to Indigenous people.

Location of research

Statewide (NSW) in scale

Sites will be distributed in northern NSW, Solitary Islands Marine Park, Port Stephens-Great Lakes Marine Park and Lord Howe Island Marine Park

Project 3.15 – Informing southern right whale management through continued monitoring, determination of aggregation areas and development of approaches to increase data flow efficiencies and utility

Project description

Project summary

This project will deliver priority information on southern right whales to address key knowledge gaps through: (i) updating long-term population abundance trends via aerial surveys of the western population and testing of platforms for improving photo-identification data flow efficiencies; (ii) the collection and utilisation of photos of the western population to identify biologically important reproductive areas and inform the estimation of population parameters; (iii) development of integrative methods for combining opportunistic and more formally collected observations, to expand the utility of datasets and (iv) collection of movement and genetic data to assess the connectivity and population identity of whales at the boundary of the eastern and western subpopulations. It will also conduct a consultative process for prioritising future work for informing future NESP work.

Project description

The population of southern right whales (SRWs) in the Southern Hemisphere has been recovering slowly from near extinction due to its decimation from whaling. Due to the relatively small numbers of whales that breed off the Australian coast, the species is listed as endangered under the Environment Protection and Biodiversity Conservation Act 1999.

While there is strong evidence of population growth in what is considered to be a western subpopulation, there is less evidence that supports similar growth in what is considered to be an eastern subpopulation. The evaluation of any population growth, however, is hampered by the lack of systematic data from the eastern subpopulation where information available is predominantly opportunistic in nature.

Systematic surveys and opportunistic data collection of the south-western population is showing that as the species recovers, habitats used for calving and nursing are expanding. They also suggest that some population parameters are becoming more variable and may be changing. To ensure that the national Southern Right Whale Conservation Management Plan, which is used in decision-making, is informed by contemporary and updated information there is a need to:

1. Ensure that the long-term time series of relative population abundance and population parameters estimated for the western subpopulation continue to be updated and processing of photo-identification data is enhanced;
2. Ensure that reproductive areas that are recognised nationally as Biologically Important Areas (BIAs) are updated as the species recovers;
3. Develop methodologies that enable the utilisation of historical datasets that have been unable to be included in these estimations due to their opportunistic nature and;

4. Assess movements, migratory corridors and offshore distribution to improve industry-associated risk assessments, and elucidate contemporary population structure between the eastern and western subpopulations;

This project aims to address the above priority areas through four separate, but interconnected subcomponents. It will, in addition, undertake a consultative process with relevant Commonwealth and State management agencies, the broader research community working on SRWs and the NESP (through the Marine and Coastal Hub and the Threatened and Migratory Species and Threatened Ecological Communities Cross-cutting Initiative) to identify future research priorities for development and implementation across 2024, 2025 and out years of the NESP. This will ensure that further work conducted under the NESP is informed broadly, connects with (and potentially leverages) research conducted by other agencies and delivers targeted information required by conservation plans in place across Commonwealth and State jurisdictions.

Subcomponent 1: Population monitoring of the western population of southern right whales

Aerial surveys of SRWs have been conducted along the coast from Perth (Western Australia) to Ceduna (South Australia) since 1993, as part of a long-term monitoring program of the species. Data collected have been used to estimate relative abundance, population trends, and reproductive parameters of the western subpopulation. They have provided the majority of information available to the conservation management and recovery plans on the population trajectory of the species post commercial whaling. The same aerial survey methodology as previously used in NESP projects (A7, 1.22, 1.26) will be applied across August 2023 and 2024, with photos collected and associated metadata uploaded to the national catalogue of photos used for identifying SRW individuals and tracking those individuals through time, the Australian Right Whale Photo-Identification Catalogue (ARWPIC). Key population metrics for the western subpopulation will be calculated on the basis of mark-recapture information derived from multiple sightings of individuals (based on photo-identification), contributing to the determination and updating of long-term population trends.

Large numbers of photo-identification images are collected every year through these annual surveys as well as land-based monitoring (e.g. Head of Bight) and opportunistic datasets in the eastern region (e.g. Victoria, NSW). Currently, matching of individuals from these images to generate mark-recapture datasets occurs within ARWPIC using a code-based manual comparison framework that requires a significant time investment. Existing open source artificial intelligence image recognition algorithms have been applied to North Atlantic right whales through the platform Flukebook (<https://www.flukebook.org/>) and preliminary work has been undertaken to test the feasibility of these to Australia's datasets. This subcomponent will further this initial work by refining the open source algorithm used by Flukebook and developing tools to provide an interface with ARWPIC to automatically integrate images and associated image metadata into the catalogue. This will increase efficiencies in processing photo-identification images, fast-tracking transfer of data required for estimating population parameters. Further, it will expand the accessibility of ARWPIC to data contributors such as the land-based surveys conducted at the Head of Bight, opportunistic sightings collected through State government agencies (e.g. Right Whale ID) and formal and informal sightings gathered by citizens by simplifying cross-matching and upload processes.

Subcomponent 2: Southern right whale aggregation area assessment

Progress in updating the status of SRW aggregation areas for national recognition as Biologically Important Areas (BIAs) is variable across regions within Australia, with some region's analyses of information on their utilisation not having been updated in well over a decade. In particular, the region east of Ngari Capes Marine Park within Flinders Bay, and eastward to Esperance in Western Australia still need to be re-evaluated.

This subcomponent of the project will take a highly collaborative approach to build on previous work that has contributed to updating aggregation areas (Project 1.22) by:

1) Collating and processing existing opportunistically collected photo-identification images, and conducting targeted surveys to expand photo-identification information in data-poor locations. This work will include:

- Processing of citizen science images collected by the community group South Coast Cetaceans in the Albany to Hopetown region (south coast WA) collected between the 1990's and 2022 and will be collected across 2022 and 2024.
- Processing of photo-identification images planned to be collected by the citizen science and research groups Western Whale Research and Southwest Whale Ecology Study (SouWEST) in Ngari Capes Marine Park (southwestern WA) between 2022 and 2024.
- Conducting vessel surveys in the eastern region of Flinders Bay (beyond the previously surveyed area falling within Ngari Capes Marine Park) and collecting and processing photo-identification images planned in 2023.
- Conducting four aerial surveys during the 2024 season in the Esperance region and processing photo-identification images collected.

2) Conducting within region matching of individuals based on images processed in 1) above to estimate minimum abundance, residency, site fidelity, and connectivity.

3) Supporting the upload and curation of photo-identification images into ARWPIC that have been collected across key aggregation areas utilised by the eastern and western subpopulations.

This subcomponent will provide key information on the habitats utilised by SRWs off WA required for updating BIAs utilised in Commonwealth conservation management and recovery plans for the species and the degree of connectivity between habitats utilised by the western subpopulation, which is essential for estimating population parameters relevant to the whole subpopulation. In addition, it will support actualisation of ARWPIC across both Australian subpopulations.

Subcomponent 3: Expanding utilisation of southern right whale datasets for estimation of national population parameters

Observations of marine species, including southern right whales, have rapidly diversified over the last decade with increasing numbers of observations collected either through citizen science programs or opportunistically by agencies and/or citizens and then submitted into public databases such as the ARWPIC. In some regions, such as the south-east of Australia, opportunistic observations are the only data streams available for monitoring SRWs.

The utility of these datasets for inclusion in population abundance analyses and the determination of population parameters is currently limited, largely because they do not meet the statistical assumptions of many analytical approaches available. As a result, opportunistic observations are largely only currently used qualitatively within research applications. The inability to utilise these datasets to establish biological and population parameters undermines current conservation management plans where measuring and monitoring population recovery are central measures of success of those plans. Developing methods that allow for the utilisation of opportunistic datasets would expand the information required by conservation management plans, substantially improve the ability to determine the effectiveness of those plans and provide for the first time, particularly for the eastern population, important metrics for the species.

Following on from previous NESP projects (A13,1.29), this component of the project will further the development of integrative methods that will allow for the combination of opportunistic observations with more formally collected observations (e.g. systematic surveys) into statistical approaches for estimating population parameters. It will do this by progressing the methodologies identified from

Project 1.29, particularly those associated with estimating distributions, densities and habitat utilisation from presence only data and applying these to SRWs as a test case utilising those datasets generated through NESP project A13. The outputs from this component of the project will provide a framework that can be applied to expand the datasets available for estimating population estimates, rates of change and connectivity. This will enhance the applicability of data collected nationally and progress the attainment of understanding of both the eastern subpopulation and the population at a national scale.

Subcomponent 4: Movements, connectivity, and population identity of southern right whales at the boundary of the eastern and western subpopulations

Encounter Bay (South Australia) is currently recognised nationally as an emerging aggregation area, but in recent years an increase in the number of whales suggests the area should be reclassified as a small aggregation (Kemper et al. 2022). This aggregation is located at a midway point between the two recognised subpopulations, but the area is considered part of the South-East Marine Region in the Marine Bioregional Plans. Recent photo-identification matching indicates movements of whales between Encounter Bay (and other aggregations) to/from western and eastern regions. Over 20% of whales sighted in Encounter Bay between 2006-2022 have been re-sighted in shelves of the eastern region, including Western Bass, Bass Strait, South-East and Tasman (Gilmore et al., unpublished data). However, this result is possibly downward biased given that most of the photo-ID effort has focused on western aggregations and the South-West Marine Region (e.g., Smith et al. 2021; Charlton 2017; Charlton et al. 2019). A review about the occurrence of southern right whales in Encounter Bay by Kemper et al. (2022) recently suggested that more research needs to be done to clarify whether the aggregation should be considered part of the western or eastern management group, and to confirm where the boundary of the sub-populations is located. The Commonwealth conservation management plan for the species identifies a priority objective of understanding the movements and migration pathways of individuals, as well as the nature and degree of difference between the two subpopulations. Current understanding of the population structure is based on genetic studies completed approximately a decade ago, and utilised low power DNA markers and small sample sizes (e.g., Carroll et al. 2011; Carroll et al 2015); thus, a re-assessment is warranted.

This subcomponent will use animal movement modelling, spatial risk analysis and genomics to advance understanding of coastal connectivity and offshore distribution, industry-associated risks, and population structure. It will include vessel-based satellite tag deployments on unaccompanied adults, biopsy sampling of all age classes (except calves), and photo-identification of individuals within Encounter Bay. Tagging will focus on unaccompanied adults because they are expected to move more frequently along southern Australia and are more likely to be exposed to interactions with marine industries. Although the focus of southern right whale research has mainly been on reproducing females, unaccompanied adults represent an important component for the recovery of the population as they represent adults and sub-adults soon to be recruited into the reproducing population. The lower number of unaccompanied adults observed in the South-West Marine Region in recent years (e.g., 2020, 46% UAs to 54% Cows, or 23% UAs if cows and calves are considered; Smith et al. 2021) is of concern, and research effort should be put toward a better understanding of this population class. Data derived from tags deployed will be used to model whale movements, occupancy and behaviour of this population class, and combined with spatial data on anthropogenic stressors to assess risk to these whales using a spatial risk analysis framework. Genomic analyses will be conducted to identify subpopulations that sampled individuals belong to, and re-assess stock structure and connectivity across Australia and with New Zealand, in collaboration with University of Auckland researchers and utilising their genomic dataset for comparison. Movement data and biopsy subsamples will also be made available to complement other satellite tagging and isotopic studies in southwestern Australia (Macquarie University) and New Zealand (University of Auckland) focusing on movements of southern right whales to their foraging grounds.

Outputs from this subcomponent will update information and extend maps in the Commonwealth species profile and threats database, update maps of BIAs for use in marine parks management

(south-west and south-east networks) and for updating the species conservation management plan. Information of whale locations and timing in southern Australia can also be used by marine industries for their risk assessments, and by the tourism industry. Consultation with Traditional Owners focused on cultural values and knowledge will expand partnerships to manage Sea Country and promote sustainable use and species recovery, as well as enable Indigenous whale stories to be shared with the public.

Indigenous consultation and engagement

Indigenous engagement and collaboration 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 largely a Category 3 project (i.e. for sub-components 1, 2 and 3) for Indigenous partnerships. Category 3 projects involve opportunities for communication. Sub-component 4 of this project is Category 2 for Indigenous partnerships as it will provide opportunities for communication and collaboration.

As part of subcomponent 1, 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.

Indigenous consultation by those involved in subcomponent 2 is ongoing with respective regions in which long-term photographs of southern right whales have been collected, and has included meetings, one-on-one consultation, and training and education opportunities. Continued Indigenous consultation and engagement through these established pathways will be a key aspect of the work undertaken, and will include the most suitable mode for Indigenous partners (meetings, workshops, email, and/or phone). In addition, as the new regional representative corporations continue to develop in WA (currently underway), further knowledge sharing and capacity building opportunities will be identified.

As part of sub-component 4, workshops will be held with local Indigenous groups and Traditional Owners in South Australia to understand their knowledge about Sea Country and the cultural significance of southern right whales within the study region, and to exchange information on the study aims and findings. Signage and/or installations of Aboriginal stories about whales will then be jointly developed at key sites (Kangaroo Island and Encounter Bay, SA).

The project team will implement a collaborative approach to the project where the early stages will focus on building shared understanding about reciprocal benefits of the project. Where these exist, we will work under established agreements that clearly sets out the purpose, benefits and responsibilities of any collaborative partnership, where these do not exist we will establish new research agreements. If there is agreement to share cultural knowledge we will also establish an Indigenous cultural and intellectual property (ICIP) agreement. The project team will seek free, prior and informed consent from collaborating Indigenous organisations (or other relevant cultural authority) as part of any agreement associated with this project. The project team will work closely with collaborating Indigenous organisations to identify and develop appropriate research outputs for communicating the findings of this research to Indigenous people.

Location of research

At which spatial scale is the project working	National <input type="checkbox"/>	Regional <input checked="" type="checkbox"/>	Local <input type="checkbox"/>
Location(s) – gazetted region /place name	<p>Subcomponent 1: Aerial surveys of southern right whales are regional in scale and will be conducted across two States from Perth (Western Australia) to Ceduna (South Australia) along the south-west Australian coastline (~1 nm off the coast).</p> <p>Subcomponent 2: Vessel and aerial surveys of southern right whales will be conducted within season within Flinders Bay and Esperance region in WA (respectively).</p> <p>Subcomponent 3: is a desktop exercise that will be carried out at the CSIRO Marine Laboratories in Hobart, Tasmania. The spatial scale of the datasets to be utilised by this subcomponent will be dependent on data access, but will most likely span national temperate waters.</p> <p>Subcomponent 4: Vessel-based fieldwork will take place at the Encounter Bay Marine Park, South Australia, encompassing the base of the Fleurieu Peninsula to the north-eastern coast of Kangaroo Island and the Coorong. However, satellite tagged whales are likely to move long distances and tracks will potentially cover areas of Victoria, Tasmania, Western Australia and the Southern Ocean.</p>		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	<p>Subcomponent 1: Project management will be undertaken at Murdoch University on the lands of the Wajuk-Noongar people. The aerial surveys will be undertaken within the coastal waters (~1 nm from shore) in Sea Country of the Wajuk-Noongar, Pinjarup, Kaniyang, Wardandi, Bibbulman, Minang, Goreng, Wudjari, Ngatjurnay, Morning and Wirangu peoples.</p> <p>Subcomponent 2: Project management and much of the image processing will be undertaken on the lands of the Wajuk-Noongar people. The aerial surveys will be undertaken within the coastal waters (~1 nm from shore) in Sea Country of the Wudjari people and the vessel surveys within the coastal waters (~1 nm from shore) in Sea Country of the Bibbulman peoples.</p> <p>Subcomponent 3: is a desktop exercise that will be carried out at the CSIRO Marine Laboratories located in Nipaluna, Lutrawita, land of the Muwinina Palawa. The spatial scale of the datasets to be utilised by this subcomponent will be dependent on data access, but will most likely span national temperate waters.</p> <p>Subcomponent 4: Fieldwork will take place at Ngarrindjeri Sea Country, but whales will potentially move into the Sea Countries of Kurna, Barngaria, Wirangu, Tjaljraak, Nyungar, and Minang/Menang Noongar peoples.</p>		

Analyses of large and	Delay of data analyses,	Unlikely	Moderate	Low	All data collection and analyses will be done by
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complex datasets turn out difficult/problematic.	and/or reduced quality of outputs.				people with proven experience in animal modelling, spatial risk analysis and genomics. Equipment and software will be tested prior to analysis, and data backups frequently made.
Low community engagement.	Delayed/negligible engagement, lower quality of outputs.	Unlikely	Moderate	Low	Indigenous rangers and local citizen scientists are involved with workshops and signage/installation. Approach is culturally appropriate.
Ineffective engagement with Indigenous organisations, and failure to obtain free, prior and informed consent for collaborative research	Damage NESP/partner reputation	possible	moderate	medium	The project team's approach to Indigenous engagement will be guided by the Hub's Indigenous partnerships strategy. Project team will work closely with the Hub's Indigenous facilitator and knowledge broker to plan and implement an effective approach.

Project 3.16: Delineation and estimation of the Maugean skate population in Macquarie Harbour, Tasmania

Project description

Project summary

This project will use next generation genetic sequencing and novel imaging survey tools to delineate and estimate the size of the Macquarie Harbour Maugean skate population to inform conservation strategies. The endangered Maugean skate is now only found in Macquarie Harbour, which has a long history of environmental degradation, and recent research suggests that the population may be declining. However, our current abundance estimation tools are inadequate to determine population status and a new method is needed. There is also a need to investigate the evolutionary potential of the Maugean skate to adapt to the changing environmental conditions. This research addresses these needs.

Project description

Maugean Skate (*Zearaja maugeana*) are the only known estuarine specialist skate species and have one of the most restricted ranges of any extant elasmobranch. The species has been classified as Endangered under the Australian *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act) and the *Tasmanian Threatened Species Protection Act (1995)* based on its likely 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 [1]. However, a recently completed NESP funded project found that Maugean skate are now effectively absent from Bathurst harbour [2], suggesting that most, if not all, of the remaining skate now live in Macquarie Harbour. In 2021, the Maugean skate was listed as one the 100 priority species under the Australian Government's Threatened Species Strategy, Priority species have been selected to help focus the efforts of the Australian Government and partners on threatened species recovery actions.

Unlike the world heritage protected Bathurst Harbour, Macquarie Harbour has a long-documented history of anthropogenic impacts that have resulted in considerable degradation of the environment. Recent work on the Maugean skate in Macquarie Harbour has shown clear signs of population stress and detrimental impacts of the degraded environment [3]. These findings highlight the inherent vulnerability of micro-endemic species (range is restricted to one or a few specific locations) and an urgent need to prioritise research and conservation action across what is likely to be the last remaining population for the species, Macquarie Harbour. This project will use next generation genetic sequencing and novel imaging survey tools to delineate and estimate the size of the Maugean skate population in Macquarie Harbour to inform urgently needed conservation strategies for the species.

Developing and implementing conservation strategies requires delineation of populations, i.e., investigation of population structuring (e.g., discrete sub-populations within a population). In the Macquarie Harbour Maugean skate population, this was originally attempted with DNA barcodes and microsatellites [4]. Both these markers showed that the species has very low genetic diversity; with no diversity detectable in over three thousand base pairs surveyed from the mitochondrial genome, low average microsatellite heterozygosity (an indicator of genetic diversity) and no overall population structure [4]. With a view to improving the power of detecting fine-scale population structuring and investigating the evolutionary potential of the Maugean skate to adapt to changing environmental conditions in Macquarie Harbour, we will employ a two-pronged approach both of which involve Next

Generation Sequencing strategies: 1) whole nuclear (i.e., using DNA from the cell nucleus) genome (the complete set of DNA in an organism) typing and 2) developing a high-resolution dataset of genome-wide single nucleotide (a single DNA building block) polymorphisms (SNPs – pronounced snips), which are the most common type of genetic variation in a species. This approach will also inform adaptive management strategies such as captive breeding, and translocations of lineages from one geographical region to another. Note that we are applying for a 'Threatened Species Initiative' grant (<https://threatenedspeciesinitiative.com/>) for the whole genome approach, as Maugean skate are on their species list for support, while the SNPs approach is part of this application. In particular, using over 250 Maugean skate tissue samples already collected, we will use SNPs to undertake a genome-wide population genetic study to detect fine-scale genetic structure in the Macquarie harbour population. Importantly, this will be used for the identification of differentiated lineages, including those with deleterious alleles (one of two or more versions of a DNA sequence at a given genomic location) and those with adaptive potential.

Skates have been shown to be inherently more vulnerable to declines caused by habitat disruption and fishing than most other elasmobranchs (sharks, skate, and rays), however, a significant number of species remain data deficient [5]. One of the biggest challenges to the management of endangered and vulnerable species is the ability to obtain reliable estimates of the size and structure of a population. Unfortunately, methods for population monitoring that are based on the capture, tagging and recapture of individuals require a vast effort (particularly for rare or endangered species), the gear used for capture can often be susceptible to size or sex biases, and the process carries additional risks to the animals (i.e., handling stress, post release mortalities).

Long term (> 12 years) fisheries-independent catch data from research gill netting has shown concerning shifts in the size structure of the Maugean skate population in Macquarie Harbour. However, due to the cryptic nature of the species and the challenging environmental conditions in the harbour, existing population estimates remain highly uncertain, with no current way to provide robust assessments of the relative changes to the population over time. For species like the Maugean skate, genetic-based abundance estimation tools can be used, however, they require a certain level of genetic diversity to work, which is not supported by current knowledge [4], noting, however, that the genetic portion of this project will address this issue. Additionally, along with posing a potential risk to the health of captured skate, since 2019 the netting collection method is no longer reliably capturing skate, even when they are known to be present, which creates biases in any estimates that rely on the skate's capture (i.e., tag and recapture methods, including genetic methods). As such abundance estimation methods not based on capture are required.

Despite being a shallow estuary, the physiochemical profile of Macquarie Harbour results in conditions that more closely resemble deep sea habitats (i.e., low light penetration and low seasonal variability of environmental conditions in waters below 10m). The seafloor is largely composed of very fine sediments which are easily disturbed and remain suspended for an extended period. These traits restrict the usefulness of traditional video-based survey techniques such as towed video, or remote baited underwater cameras.

Technological developments in acoustic imaging (sonar) and real-time 3-D scanning using light detection and ranging (LiDAR), have resulted in improved sensors that may provide the fine scale detail necessary for identifying organisms reliably [6, 7, 8]. Likewise, advances in deployment platforms such as tow sleds, AUVs and ROVs offer the means to effectively deploy the new sensor technology for the purpose of population monitoring studies. Development of these approaches could result in a cost-effective way to survey at risk, data-deficient species that are currently not logistically feasible, providing a valuable tool for management and conservation.

Both sonar, in particular adaptive resolution imaging sonar (ARIS, see [8]), and LiDAR based methods offer significant advantages over traditional visual methods in low visibility, high turbidity settings like Macquarie Harbour. Accordingly, both ARIS and LiDAR technologies are currently being trialled by

IMAS as potential monitoring/abundance estimation alternatives for Maugean skate and are showing significant promise. However, an important part of using these novel imaging tools is their integration into an adequate platform, including the need for additional sensors, as well as optimisation of survey protocols. Furthermore, these devices provide a data rich output that requires the development of pre- and post-processing pipelines to be used effectively. Accordingly, before these tools can be used to estimate relative Maugean skate abundance, there is an important need to undertake this integration, and development stage. This project will conduct these important integration, optimisation, and data pipeline steps to the point that a developed population survey tool(s) is available for routine use.

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5. Siskey, M., et al. (2019). Skating on thin ice: Identifying the need for species-specific data and defined migration ecology of Rajidae spp. *Fish and Fisheries* 20 (2): 286-302.
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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 3 project for Indigenous engagement. Category 3 projects communicate and share results with relevant Indigenous organisations.

The NESP Marine and Coastal Hub (southern node) is undertaking broad-scale engagement with Tasmanian Aboriginal communities to improve understanding about the NESP, the Hub and funded research projects. Engagement will include discussion on current projects with the view to identifying 'interested Indigenous organisations' that would like to continue or deepen engagement on specific projects. This is an important step in this project as cultural connections to the Tasmanian Wilderness World Heritage Area (TWWHA) are shared across a range of Indigenous groups in Tasmania.

This project is focused on delineation and estimation of Maugean skate populations in Macquarie Harbour, Tasmania, part of the TWWHA. 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'. Broad-scale engagement will focus on the Tasmanian Aboriginal Centre, Tasmanian Regional Aboriginal Communities Alliance (TRACA), Aboriginal Heritage Council, Aboriginal Land Council of Tasmania and Aboriginal Heritage Tasmania

(AHT) within the NRE Tasmanian Government. More targeted consultation and engagement about the project objectives, opportunities for greater involvement in the project and the research outcomes will be targeted to 'interested Indigenous organisations' (i.e. those with specific interests in this project). Note that AHT will have moved to Department of Premier and Cabinet to form the Aboriginal Affairs Division by commencement of this project if successful). Updates and consultation with the Aboriginal Heritage Council will be facilitated by AHT.

Location of research

On-ground work will be in Macquarie Harbour (Fig. 1) Western Tasmania, and is local in scale, as this is now the only known location of the Maugean skate.

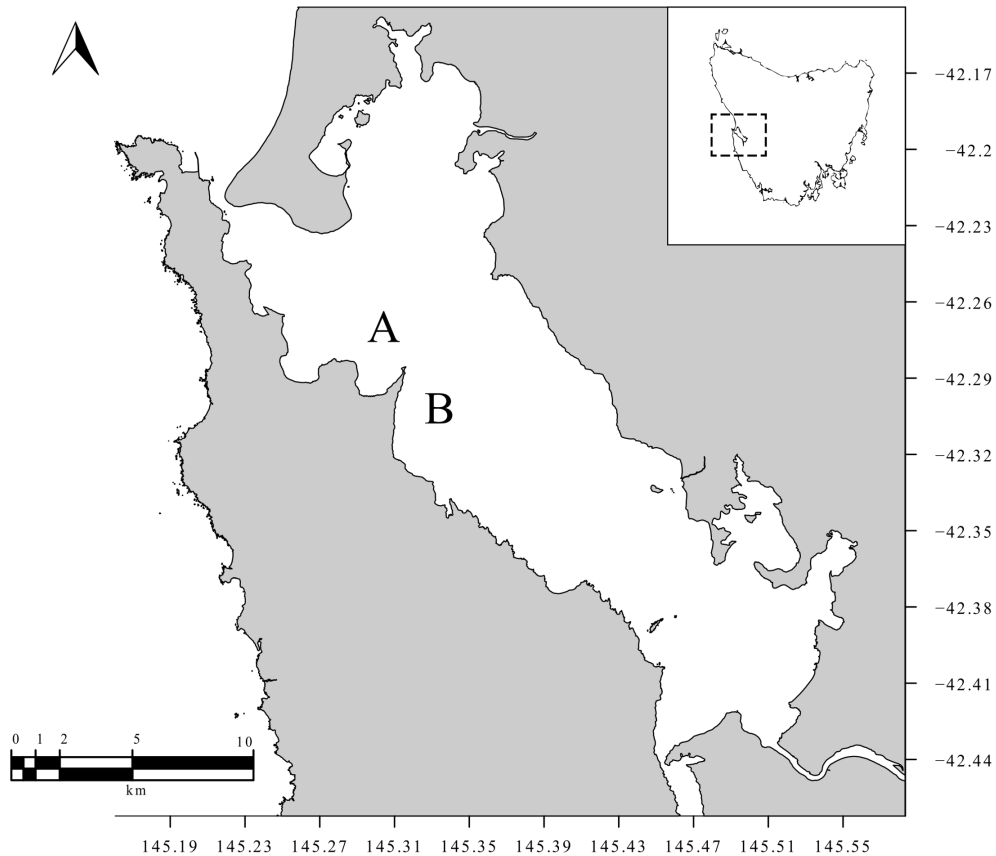


Fig. 1: Macquarie Harbour, Tasmania. Table Head (A) and Liberty Point (B) have traditionally been the sites of greatest Maugean skate abundance. These sites will also be used in this proposed study.

Project 3.17– Locating Unidentified Reef and Habitat Features in the Northern Australian Seascape

Project description

Project summary

This project will map the reefs of the northern Australian seascape, from central Western Australia, through to western Cape York in Queensland. Reefs are hotspots of conservation as they provide habitat for numerous marine species but are poorly mapped for much of northern Australia. This project will deliver datasets of reef boundaries, satellite imagery optimised for the marine environment, and geomorphic and benthic habitat maps for shallow clear reefs based on improvements to the Allen Coral Atlas. These products are targeted at assisting in the planning and evaluation of coastal development in northern Australia, helping to ensure that sensitive high value habitats are identified and considered in development proposals. This project will use satellite imaging techniques to map this region based on methods consistent with existing reef mapping of the Great Barrier Reef, Torres Strait, and the Coral Sea.

Project description

The economic development of northern Australia is a priority for the Australian Government and presents substantial opportunities for development in agriculture, mining, and energy. Reef areas are of high conservation value as they are home to numerous marine species. It is therefore important to know where reefs are to be able to assess if they are affected by the receiving waters of industrial developments.

In northern Australia there are still a significant number of reefs yet to be discovered and mapped and there is no existing dataset that consistently covers this region. This leads to the risk that these important habitats are not considered in coastal and offshore development proposals or are only discovered late in the process.

This project aims to develop datasets that will allow the identification of reef features across the northern Australian seascape from Western Australia, Northern Territory through to western Cape York in Queensland, with the primary goal of ensuring that the boundary of all known reefs and as many as possible new reef features are mapped.

While there is some existing knowledge of reefs, such as the Allen Coral Atlas (UQ), GA Geodata topo250k, GA bathymetry surveys and AHO marine charts, each have significant limitations, in either spatial coverage, accuracy, availability or compatibility with reef boundary mapping in eastern Australia.

In this project we will use remote sensing to map the reef features using a workflow optimised for detecting reefs in both clear water and turbid waters, combining and enhancing existing workflows developed by AIMS and UQ teams.

The primary project outputs will be:

- **Reef boundary mapping focused on comprehensive coverage of reef features** to ensure reliable flagging of reef features in environmental assessments. The approach will be consistent with existing mapping in GBR (GBRMPA), Torres Strait (AIMS, TSRA) and Coral Sea (AIMS) to enable the creation of a national database of tropical reefs.

- **Improved habitat maps based on the Allen Coral Atlas along the coastal regions** – this will provide greater spatial and taxonomic detail than the reef boundary mapping but won't be as comprehensive in its spatial coverage. The habitat maps will be limited to shallow regions and clearer water. Improvements will be achieved by improved satellite imagery (switching from PlanetLabs to Sentinel 2 satellites), the creation of additional training and validation data and an improved global mapping framework.

AIMS will be primarily responsible for the delivery of the reef boundary datasets, based on techniques established in mapping Torres Strait and Coral Sea. UQ will primarily be responsible for improving the habitat mapping based on their experience in developing the Allen Coral Atlas. Both primary project outputs will use a shared high-quality satellite image mosaic optimised for mapping reefs and habitats, virtual field work and collation of relevant datasets and literature.

Marine Optimised Satellite Imagery

Clear satellite imagery is key to reef boundary and habitat mapping. In this project we will use the Google Earth Engine to extend existing workflows developed by AIMS and UQ to produce a satellite image composite mosaic for the northern Australia seascape that is optimised for viewing the marine benthos. This imagery will then be used for both the reef boundary digitisation and the habitat mapping. This imagery will also be published as a value-added product that will assist other research, planning and managing the Australian marine environment.

Reef Boundary Mapping

The goal of the reef boundary mapping is to support the assessment process of northern development by enabling rapid and accurate identification of high value habitats, such as reefs, that might be affected by developments that impact the coastal waters. A secondary goal is to map offshore reefs to ensure that there is consistent coverage over the whole northern Australian seascape, and with existing reef boundary mapping in the GBR, Torres Strait and Coral Sea. The broad coverage of this dataset will help facilitate an understanding of the connected nature of these habitats, providing context for Australian Marine Parks and coastal ecosystems.

Reef boundaries map the outer deepest edge of a reef enclosing all the habitats that make up a reef. They are then classified based on their structure and likely habitats, providing a proxy for their relative conservation value. The reef boundaries also represent named places (such as Hardy Reef (19-135)), assisting in the communication of places within the marine environment. In this project mapped reefs will be allocated permanent identifiers, similar to those used in the GBR, to act as a stand in for feature names.

The boundaries of the reef features are digitised using a semi-automated approach with extensive review and checking against multiple satellite images and existing data sources (bathymetry, nautical charts, etc.) to ensure all existing known reefs are included along with newly discovered reefs. This project will provide a progression of information about shallow reefs. In highly turbid environments we may only be able to determine a reef's presence and not exact shape. In progressively clearer and shallower conditions we will be able to accurately map the boundaries and in still clearer conditions map the sub-reef scale habitats.

The mapping approach for reef boundary mapping used in this project will be an extension of that used in the Parks Australia funded project in the Coral Sea marine park. We will extend the methods developed for the Coral Sea to better deal with the challenges of turbid waters and adapted to handle the greater variety of reefs across the northern seascape.

We expect the number of new reefs to be discovered to vary significantly across different sections of the coastline. A preliminary investigation indicated 100's of new fringing reefs in the Kimberley region and approximately >10 in the Gulf of Carpentaria.

Habitat Mapping

The Allen Coral Atlas (<https://www.allencoralatlas.org>) is an initiative to map geomorphic zonation and benthic habitats of shallow coral reefs globally, completing the first version in 2021. The mapping framework integrates high resolution satellite imagery with physical attributes (depth, slope, waves), reference samples for training and validation through machine learning and object based contextual editing. The habitat mapping focuses on benthic habitats that can be distinguished from satellite imagery (Coral/Algae, Microalgal Mats, Rock, Rubble, Sand, Seagrass). The accuracy of the habitat mapping is dependent on the clarity of the water, quality of the satellite imagery, the quality of the physical attributes and the amount of training data for a given area. The first version was not optimised for conditions across northern Australia.

This project will enhance the habitat mapping for the northern Australian seascape by upgrading the satellite imagery to clearer imagery, significantly increasing the amount of training data used in the mapping process, and an improved global mapping framework.

While the primary focus of this project is on reefal areas, seagrass is another key coastal habitat that can be affected by coastal development. The existing Allen Atlas includes seagrass as a mapped habitat however its coverage is limited to reefal areas. As a value-added component of this project, we will expand the seagrass mapping to all inshore shallow environments where seagrass is visible from remote sensing. We will incorporate existing (NESP MaC 1.13) and new in-situ seagrass survey data to improve the machine learning model used to map these areas. This will result in a more comprehensive coverage of key inshore habitats, provide estimates for seagrass in areas where there is little existing in-situ field data, and provide a mechanism for remotely monitoring these habitats in the future.

Map validation

Due to the enormous area being mapped it is impractical to ground-truth this area within the scope of this project. We will instead rely on compiling virtual field validation data from existing local scale habitat data and high-resolution image sources, both aerial and underwater, such as Squidle+, Reef Life Survey, YouTube drone and underwater imagery and government aerial image archives. This information will then be used to train those preparing the maps, and a portion of the data reserved for validation and accuracy assessment of the final products.

Scope and limitations

The mapping technique used will be optimised for mapping reefs in turbid waters and will allow us to detect reefs in areas where traditionally they couldn't be mapped. However, since the satellite imaging technique relies on favourable conditions occurring in the historic satellite image record the technique will generally be limited to reef features shallower than 20 - 30 m and is more likely to miss features in highly turbid environments. We cannot guarantee to detect all reefs and the maps will not be suitable for navigation.

To highlight this limitation, we will produce a map indicating our confidence in the level of detection of reef features across each region. We will also indicate our confidence in the mapping of each reef feature.

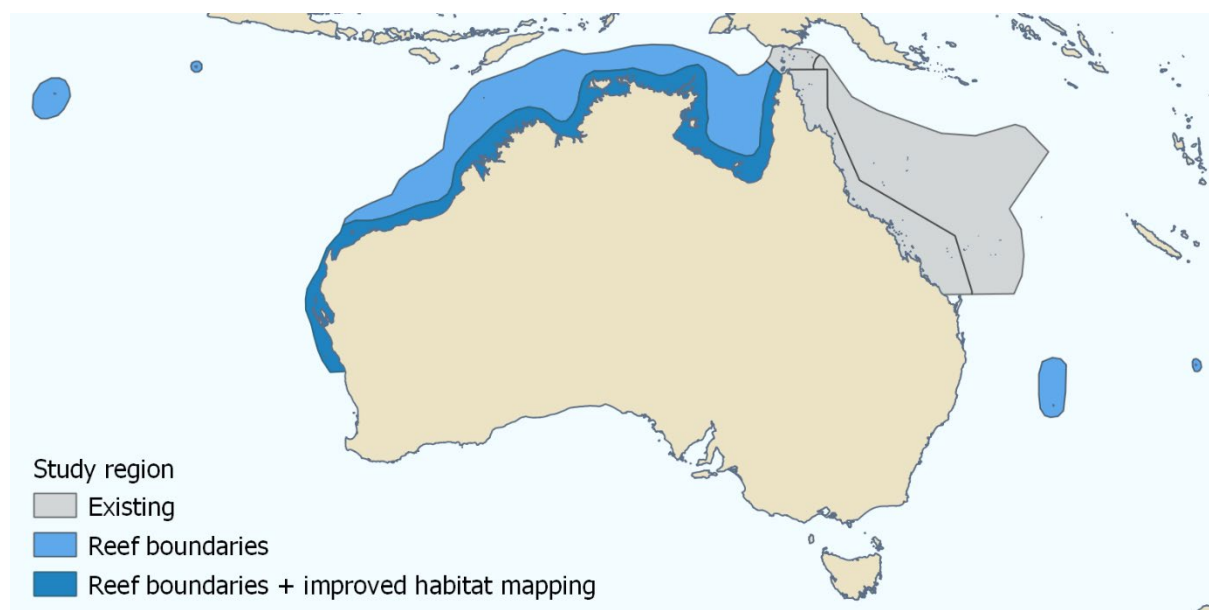
The collating of the reef names, in particular Indigenous names of reefs, is outside the scope of this project due to the time required to do this properly. It is envisioned that collating reef names could be a future project undertaken by the community facilitated by the open reef boundary dataset produced in this project.

Indigenous consultation and engagement

This project is category 3 for Indigenous consultation and engagement. The project team acknowledges and understands the importance of working with Traditional Owners of Sea Country and the positive contributions that two-way knowledge systems can make to science outcomes.

Underpinned by best global practice standards, approaches such as the AIMS Indigenous Partnerships Plan and separate Policy outline our clear commitment to engage with Traditional Owners of Sea Country.

The project team will work closely with the NESP Indigenous Knowledge Broker and AIMS Indigenous Partnerships team and NAILSMA to develop an approach to ensure that the TO and Indigenous ranger groups have access to the maps, and to leverage regional TO forums to communicate the project findings. We recognise that Traditional Owners are the custodians of Indigenous Cultural and Intellectual Property (ICIP). To ensure that Traditional Owners rights to ICIP are respected we will only record and use ICIP with the free, prior and informed consent of Traditional Owners.



At which spatial scale is the project working	National	Regional	Local
	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Location(s) – gazetted region /place name	Desktop work: Townsville, Brisbane Impact areas: Gulf of Carpentaria, Arafura Sea, Timor Sea, Shark bay, Houtman Abolhous Islands, Ningaloo coast, Pilbara coast, Kimberley coast, Joseph Bonaparte Gulf, Rowley Shoals, Scott Reef, Lord Howe Island, Norfolk Island, Cocos Keeling Island, Christmas Island		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	Ningaloo, Bilybara coast (Pilbara), Burrup Peninsula (part of Dampier Archipelago), Ayangkidarrba (Groote Eylandt)		

Project 3.18 – Robust citizen science for reef habitat assessment in support of management

Project description

Project summary

By mobilising tourism vessels and thousands of citizens, the Great Reef Census (GRC) has demonstrated that citizen-based infrastructure can undertake reconnaissance of hundreds of reefs and garner private donor support. While these data are already used by managers, there remain core scientific questions regarding the acquisition, quality, and optimisation of such data for reef management. Here, we create a robust approach to citizen science that can be scaled up to reefs generally. Specifically, our project will (1) maximise the quality of data on key habitats by combining machine and human learning (in partnership with Dell Technologies) while conducting a rigorous testing of data quality, (2), operationalise a field deployment strategy that maximises the value of citizen data for management and mapping and (3) provides annual maps of reef state and ecological importance that feeds into decision-making by marine managers. It specifically responds to MAC Hub priority research areas 2023 (citizen science and/or new technologies in assessing condition and status of marine habitats and species).

Project description

Australia's coral reefs are vast ecosystems and their management requires multiple types of information. Monitoring of reef state is conducted mostly by scientific agencies. Yet, a number of management needs do not require such high technical expertise. In many cases, large-scale field reconnaissance is required to help ground-truth habitat maps, map Sea Country, or identify whether a reef is in an early versus late stage of recovery. It is here that citizen science can play a crucial role that complements other activities.

The Great Reef Census (GRC) commenced in 2020, led by Citizens of the GBR in collaboration with UQ, JCU, GBRMPA, and a scientific steering committee with representatives from UTS and UTas (<https://greatreefcensus.org/>). Dozens of citizens have participated on tourism boats and taken seascape photographs on more than 300 reefs. Thousands more citizens have served as 'virtual surveyors' and processed the photographs (e.g., 33,000 images were analysed by 6000 virtual surveyors in 50 countries in 2020). Clearly, there is an appetite from citizens and a willingness among donors to fund annual campaigns to generate large scale reconnaissance. It is now timely to invest in the science so that the value of this human resource can be maximised. There are two primary objectives that collectively deliver a robust operational capability for citizen science on Australia's reefs and address the problems facing marine managers.

1) Maximise the quality of citizen data

Citizens take seascape photographs and in the first iteration of GRC, we began by asking citizens to delineate the boundaries of individual corals. This was laborious and not ideal so the first goal of the NESP project is to reduce the burden on analysts by incorporating Artificial Intelligence (AI). We are partnering with Dell Technologies on the use of AI and pilot data suggest that it has the power to resolve common coral shapes. The NESP project will allow us to extend far beyond the initial pilot work and create a shared AI/human approach that combines the strengths of both approaches. For example, AI is capable of recognising shapes of corals but the human eye is likely to be better at resolving whether the coral is living vs dead, as this requires cognition of subtle changes in colour and

texture. Further, AI can be used to screen the many thousands of images and aid the human experience by sorting photos into those with similar characteristics. This allows people to specialise in one type of reef at a time, which may improve consistency of interpretation.

The overall aim is to maximise the accuracy of mapping key coral groups of management concern: table *Acropora*, branching *Acropora*, massive corals, others. These corals are particularly important for ecosystem functioning and highly vulnerable to crown-of-thorns starfish predation. We will explore the combination of citizen training, image segmentation and recognition from AI, and visual interpretation that achieves maximum accuracy for these reef habitat types. The hybrid human/AI methodology will be embedded within a revised web portal that citizens use for photo-interpretation.

End users, such as GBRMPA, need to justify their use of any data source and it is imperative that GRC undertakes and publishes a validation of its data. This will happen under the NESP project and begin by using images from the 2022 Census, which immediately precedes the start of the project. Validation data will also be collected by Yirrganydji Sea Rangers and it is expected that additional data will be collected at Ningaloo Reef, through existing invitations from tour operators. Outcomes from the 2023 validation exercise will inform the training given to 'virtual surveyors' from thereon. Validation will then be repeated in 2024 to evaluate whether the improved training and AI methods developed in 2023 lead to practical improvements in data accuracy. Outcomes will be published and shared with end users through face-to-face discussions.

Working with end users from GBRMPA (CoTS control, compliance), we will then co-design appropriate sampling designs for multiple management objectives, several of which have already been identified through discussions with GBRMPA: mapping community types, identifying key source reefs for larval dispersal, categorising reefs into major health states. For example, applications concerned with the ecological importance of reefs as sources of recovery may only need to resolve reef state in 10% increments of coral cover. Habitat mapping applications might have lower thresholds of accuracy as this is more concerned with identifying one of several community types. Designs will be published as a Standard Operating Protocol for the use of citizen data for each management application.

2) Planning to maximise the value of data

Once an appropriate sampling design has been established, we ask "where to sample?". A valuable data point is one where there is both considerable uncertainty in reef state and that clarification of state will strongly influence decisions that are taken. This need has been discussed with GBRMPA, and is particularly relevant where the management action (e.g., CoTS control) can only be performed at a limited number of sites (currently 150-200). The project will focus on at least three existing management needs. A) Ground-truthing maps of predicted reef community type. The mapping itself is out of scope and is a separate GBRMPA/ UQ project led by co-investigator Roelfsema. But Census data can be targeted to provide ground-truthing where community type matters such as locating anchoring and mooring locations (a GBRMPA request). B) Identifying ecologically important reefs that help replenish coral populations that have been damaged by recent bleaching. Such reefs are included in planning for CoTS control and we have discussed the inclusion of such reefs as part of GBRMPA's compliance program. Specifically, where two reefs have similar risks of poaching but one has greater tactical ecological importance, it might be prioritised for patrol. C) Planning of restoration activities, which currently use existing maps of reef geomorphology but would benefit from knowing the state of the reef and its community type (i.e., there is no point restoring reefs with modest cover). This issue has been discussed with GBRMPA and several on-going restoration initiatives and complements activities under the Reef Restoration and Adaptation Program (an additional end user).

We will create a methodology that enables management, citizen science organisers, and community monitoring groups to plan where data acquisition can be most influential. The methodology will be available as a 'how to' guide targeted towards two audiences. The first is technical and will include full methodologies and appropriate R or Matlab code. The second, is less technical and will describe key

outcomes as heuristic ‘rules of thumb’ that can be applied without statistical modelling. Outcomes will improve community reef reporting, the use of habitat maps for vulnerability analysis, anchoring and restoration, the identification of ecologically important reefs, and enhance community engagement.

The sampling and survey designs will be implemented by GRC in all three years of the project, albeit in a preliminary form in year 1 as the frameworks will still be under construction. The project will provide at least three output maps annually that support on-going management needs under the CoTS control program but we expect the applications to extend to include use in planning compliance patrols. The maps are:

- (a) ecologically-important reefs for supporting coral recovery,
- (b) ground-truthed verifications of reef community types (for vulnerability assessment, restoration),
- (c) current reef state that updates ecological model projections with field observations from GRC, GBRMPA Reef Health and Impact Surveys (RIS), and AIMS monitoring.

Maps (b) and (c) also have value in reinforcing the engagement of citizens as they will have the opportunity to trace their individual contributions on the websites. It is also important to point out that GRC complements existing programs by visiting reef locations that are not already represented yet also achieving good representation with a minimum of three sites per reef.

Tools will be hosted on two websites that will significantly outlive the project: greatreefcensus.org which is supported by Citizens of the GBR and marinespatialecologylab.org/resources which is supported by the University of Queensland.

We will attempt to quantify some of the ecological, social, and cultural benefits of the NESP project. Ecological benefits will be estimated in terms of improved coral cover on the GBR. To do this we will simulate the impacts of CoTS control strategies with and without data inputs from Census. Census data help guide CoTS control by (a) highlighting the vulnerability of individual reefs to infestation (e.g., if they have many palatable corals) and (b) helping identify and then target ecologically important reefs that help corals recover on damaged reefs. We will evaluate how adding such field data improves the effectiveness of control, resulting in healthier reefs. The ecological models needed to do this were developed under an earlier NESP and are currently being improved under the CoTS Control Innovation Program (CCIP). The analysis will also compare the cost-effectiveness of collecting these data using a citizen-based model to alternative options.

Social benefits will be measured by quantifying the number and international diversity of citizens acting as virtual surveyors. They will be using the NESP-funded photo-interpretation approach and be able to view their results on the interactive map interface. Global engagement is important for dispelling the widespread ‘myth’ that the ‘GBR is dead’.

Cultural benefits are likely to occur through the NESP-supported validation activities that partner with Traditional Owners. For example, Yirrganydji Rangers undertook Census on eight of their reefs in 2021 and identified 4 for further study because of their exceptional health. ICIP permitting, we will report on changes in the perceived importance of Sea Country as a result of citizen surveys.

The project complements four previous NESP projects: NESP4.5, 4.6, NESP2 1.29a, and CoTS IPM. It also complements RTP investments into Reef Indicators, CoTS control, and Reef Restoration. Alignment to 2023 Priority Areas:

Natural capital to support economic & social values	Engaging local and global citizens on reef assessment helps mitigate the inaccurate view that the 'reef is dead'. This brings economic benefits to tourism. Inclusion of citizens increases the efficiency and wise use of resources for managing the reef. By increasing the number of reefs sampled (using citizens), decisions are improved because uncertainty has been reduced (e.g., locations of ecologically important reefs).
Improving Indigenous futures	Increasing the opportunities for First Nations people to assess their Sea Country creates greater inclusiveness, will improve decision-making, and may help people realise aspirations to protect the integrity of Sea Country
Innovation in monitoring & decision-making	Rigorous assessment of how citizens can contribute to ecosystem monitoring and the project provides an explicit framework for prioritising where such assessments can best support decisions: i.e., where uncertainty is high and field verification will influence decisions.

Indigenous consultation and engagement

This project is a category 1 for Indigenous consultation and engagement. The Great Reef Census team is primarily based in Cairns and is working in partnership with the Yirrganydji Land and Sea Rangers (Dawul Wuru Aboriginal Corporation), who lead the GRC survey reefs in their Sea Country as part of the Census. Our approach combines all three categories of the MaC Indigenous Partnerships Strategy: communication, collaboration and co-design. This will continue throughout the project, and we describe the approaches to achieving all three elements – usually simultaneously - below.

The GRC is an integral part of the Reef Cooperative, a program co-designed with Dawul Wuru Aboriginal Corporation around the Kul-Bul principle of incorporating Traditional Owner knowledge with current know-how. It has a strong focus on Indigenous Ecological Knowledge sharing and is led by a Yirrganydji Cultural Reef Officer. The program is funding Dawul Wuru Aboriginal Corporation for capacity building and employment for an Education Officer and the scale up of a First Nations led education program. This is an important vehicle and one of its functions considers Indigenous cultural and intellectual property (ICIP) where project outputs are discussed with Elders and board directors for approval. In this project, that will include items like the use of Census data collected by Rangers and on Sea Country in scientific publications. Indeed, we fully anticipate the opportunity to co-author at least one scientific publication with Rangers while also providing training in the scientific process.

The GRC is currently developing a relationship with the neighbouring Gunggandji Land and Sea Rangers, who will be surveying reefs within their TUMRA regions this year, with the aim of their inclusion in the Reef Cooperative program.

The 2021 GRC included a 'Reef Women' expedition, where women Rangers from the Torres Strait Regional Authority (TSRA) utilised and participated in research for their own projects on board the expedition. There is now a collaboration on a TSRA led expedition in the Torres Strait and the process of confirming the ICIP for GRC photo surveys taken on Torres Strait reefs is currently underway and will inform how this NESP project proceeds in that area.

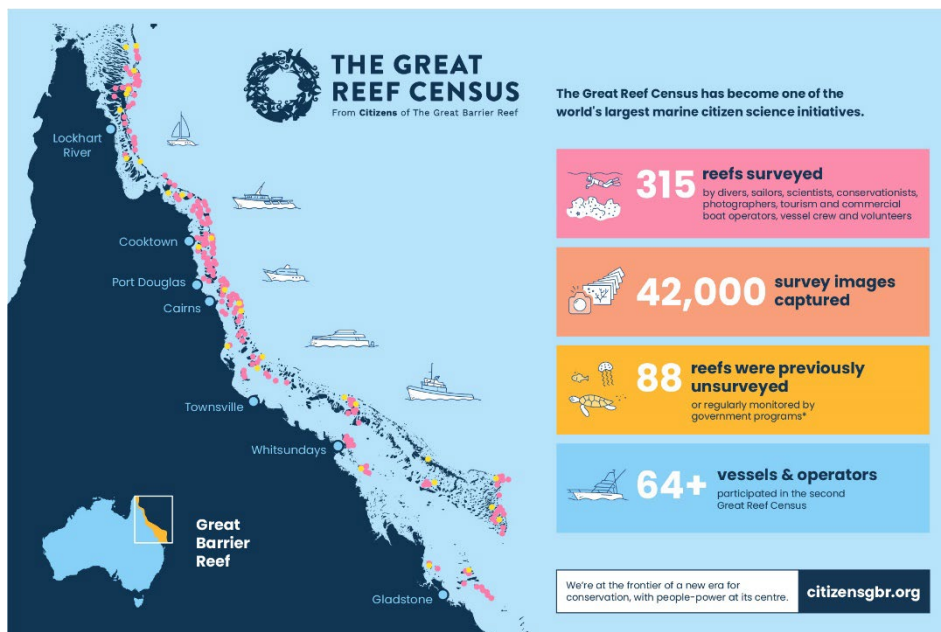
The planning of three GRC expeditions this year is also underway focusing on Princess Charlotte Bay, Wreck Bay and the Hardline Reefs. The Citizens team are already communicating with TUMRA coordinators in these areas to develop relationships, inform them of the expeditions and identify any areas of collaboration to help them achieve their research aspirations. This approach will be pursued throughout the NESP project.

As detailed above, the GRC has communicated and collaborated with Traditional Owners across the Great Barrier Reef, with the goal to co-design expeditions to realise common outcomes. We recognise that Traditional Owners are the custodians of Indigenous Cultural and Intellectual Property (ICIP). To ensure that Traditional Owners rights to ICIP are respected we will only record and use ICIP with the free, prior and informed consent of Traditional Owners.

Location of research

The research will primarily occur in Queensland but we have begun early discussions with Department for Biodiversity, Conservation and Attractions in WA as well as tourism operators, regarding trials at Ningaloo Reef. The ability of the GRC to operate in WA depends not only on engagement from government, communities, and tour operators, but also philanthropists. At this stage, we plan to explore whether the needs of DBCA can be met – at least in part – through citizen science. This will require continued relationship building and be informed strongly by results of the project; particularly data quality. To that end, the majority of project activities will take place in Queensland but we anticipate some piloting of methods at Ningaloo.

The GRC responds to a number of end user needs and the locations vary accordingly, depending on recent impacts of bleaching and cyclones and the current stage of CoTS outbreaks. Indeed, one of the advantages of the citizen science model is that data can be collected wherever needed and the project will be making important advances on how to prioritise such locations. A map of 2021 sites is included below.



GRC expeditions primarily take place between October – December each year. Existing data will be analysed, at least in the first year of the project and many of these come from the Swains region, Ribbon reefs, far northern GBR, Capricorn Bunkers.

At which spatial scale is the project working	National	Regional	Local
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Location(s) – gazetted region /place name	<p>Example, Yirrganydji rangers surveyed 8 reefs in the Sea Country including Jorgensen, Pixe, Nicholas, Onyx, Spur, Breaking Patches, Oyster, Upulo reefs. Four of these were considered urgent priority for local research.</p> <p>Additional sites anticipated include Fitzroy island, Green island, and Moore Reef with Gunggandji Rangers, Princess Charlotte Bay with Lama Lama Rangers, and Wreck Bay with Wuthanthi Rangers.</p>		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	Yirrganydji, Gunggandji, Lama Lama, Wuthanthi		

Project 3.19: Addressing Kakadu's strategic marine research needs

Project description

Project summary

The Indigenous-owned lands of Kakadu National Park are World Heritage-listed and globally significant. The natural and cultural values of Kakadu are at risk from a range of threats that will intensify over time. To prioritise the management of these threats, there is a pressing need to develop a Kakadu research strategy. The NESP Resilient Landscapes Hub have already committed a project within RP2022 to work with Traditional Owners and Park managers to develop a research strategy for Kakadu National Park. Investment from the NESP Marine and Coastal Hub in RP2023 will value-add to this existing project and enable the inclusion of marine and coastal issues into this research strategy. This project will deliver a research strategy that will provide guidance on both *what* research needs to be done and *how* it should be conducted in Kakadu. The Kakadu Indigenous Research Committee (KIRC) has been operating successfully for the past 5 years and the park has been the location for several Indigenous-led research projects that demonstrated best-practice approaches for collaborative research.

Project description

This project will use Kakadu National Park as a case study to demonstrate how NESP research can support management of protected places. The project aims to bring together *Bininj/Mungguy*, Parks Australia, the Kakadu Research and Management Advisory Committee (KRAMAC) and KIRC with the 4 NESP hubs and cross-cutting initiatives to:

- support KIRC to update *Bininj/Mungguy* research priorities and Kakadu research protocols
- develop a draft research strategy for Kakadu National Park that includes short-term and longer-term research priorities and updated research protocols based on desktop review and targeted workshops
- facilitate meetings to co-design a set of NESP projects that address Kakadu research priorities and which will collectively form the NESP Kakadu Flagship.

Strategic priorities for the Kakadu research strategy.

A systematic, risk-based approach will be used to bring together the existing information about the park's values, the threats to these values and critical knowledge gaps. This would provide a comprehensive list of strategic research priorities that would be a key part of the Kakadu research strategy and help to ensure that the Parks Australia plan delivers and supports collaborative research that addresses key knowledge gaps. An initial desktop collation and review process will be complemented by targeted workshops on agreed themes. Some of these workshops could be run in collaboration with other relevant NESP hubs and cross-cutting initiatives. This process will be led in collaboration with members of KRAMAC and key Parks Australia science/leadership staff. This component will be completed by September 2023 and will build on work to identify short-term priorities for NESP research in Kakadu.

Develop a draft Kakadu research strategy

This project will work with *Bininj/Mungguy*, Parks Australia, KRAMAC and KIRC to develop a draft Kakadu research strategy. This draft will include the strategic research priorities and the updated research protocols, as well as any relevant information from the review of the *An-gerregen* strategy (Kakadu's key cultural heritage management strategy). The draft strategy will be provided to Parks Australia for wider consultation and finalisation before seeking endorsement of the Kakadu Board of Management.

This component will be completed by December 2023.

Co-designed NESP flagship projects

This project will provide resources to facilitate a series of meetings/workshops between relevant NESP researchers and a range of Kakadu research users. The project team will work closely with the Kakadu Indigenous Research Coordinator to ensure engagement with *Bininj/Mungguy*. These workshops will focus on co-designing research projects with *Bininj/Mungguy* and Parks Australia, and will identify NESP researchers to address research priorities identified through the process outlined above. The outcome will be a coordinated set of research projects designed to address critical research needs to manage Kakadu and operating under agreed research protocols. It will also include agreed processes for providing coordinated approaches to communicating and sharing research findings and regular evaluation of research activity done in collaboration with KIRC.

Indigenous consultation and engagement

This project is a Category 1 (Indigenous Partnerships Strategy) project. The research strategy will include consultation, co-design and collaboration with *Bininj/Mungguy* people. Our end-user engagement strategy is to engage early, encourage participation and collaboration, and ensure dissemination of project information. This project is being initiated following a resolution from the Kakadu Board of Management which has a majority of Indigenous members. This project will be co-lead by a member of KIRC and a NESP researcher. The project will be overseen by a steering committee made up of members from KIRC and KRAMAC. The project will be co-designed with KIRC. A specific aim of this project is to support KIRC to update *Bininj/Mungguy* research priorities and to update Kakadu research protocols. These activities are all aimed at empowering *Bininj/Mungguy* in Kakadu to have a strong voice in setting the Kakadu research agenda and determining how research should be conducted within Kakadu. The project will resource the operation of the KIRC including payment of the members. Approaches will follow the relevant sections of the "Our Knowledge, Our Way guidelines". The project will attain Human Research Ethics Committee approval as required for any research work conducted on country with Aboriginal and Torres Strait Islander Peoples. This requires us to:

- Abide by the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) [Code of Ethics for Aboriginal and Torres Strait Islander Research](#) and "[A Guide to applying The AIATSIS Code of Ethics for Aboriginal and Torres Strait Islander Research](#)"
- NHMRC [Ethical conduct in research with Aboriginal and Torres Strait Islander Peoples and communities: Guidelines for researchers and stakeholders \(issued August 2018\)](#)
- Attain free, prior and informed consent from the relevant TOs where the research work will be conducted.
- Develop a Research Project Agreement with TOs which will include:
 - Opportunities to develop a communication network between the science team and Traditional Owners and Indigenous communities to exchange and share updates on the project throughout the project.
 - Employment opportunities for members of Indigenous communities.
 - Payment for TOs time where appropriate.
 - Opportunities to attend in person presentations and/or information webinars about the research work.

- Returning results to the TOs in an accessible medium and format negotiated with them.
- Data co-ownership and access, including establishing an ICIP agreements.

Benefits will be agreed upon with Traditional Owners once the project has been approved. In the short term, Indigenous collaborators will be paid for their involvement as members of the project team and offered co-authorship and appropriate acknowledgement on all publications and reports arising from this project. Potential benefits from the outcome of this project include increased recognition of Indigenous priorities in research strategies and plans for Kakadu National Park, and greater involvement in, and more equitable outcomes from, future research undertaken in Kakadu.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

Kakadu National Park, Northern Territory – local scale.

At which spatial scale is the project working	National <input type="checkbox"/>	Regional <input type="checkbox"/>	Local <input checked="" type="checkbox"/>
Location(s) – gazetted region /place name	Kakadu National Park, Northern Territory		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	Gagudju, Bininj and Mungguy are the language groups of Aboriginal Traditional Owners who live on Kakadu.		

Project 3.20 - A National Approach to Indigenous Engagement in Australia's Blue Carbon and Environmental Markets

Project description

Project summary

We propose to coordinate a national Indigenous engagement approach for Blue Carbon and where appropriate include discussions on other Environmental market projects. This process will capture the wide-ranging rights and interests of Indigenous peoples and communities across jurisdictions and ensure empowerment in the Blue Carbon market. A key output from this research will be a document that outlines leading practice Indigenous engagement principles learned through a process of consultation with key Indigenous groups across Australia. It will be submitted to the Commonwealth government alongside proposed new Blue Carbon methods to enable efficient implementation that is ethical and in accord with leading practice principles of Indigenous engagement. The Blue Carbon market provides an opportunity for Indigenous community economic gain amidst complex legislation, tenure, resource ownership and co-benefits that haven't been investigated in detail. Projects for the proposed Ungulate Method (Project 3.8) will occur on Aboriginal-owned land and mixed tenure where Indigenous people hold significant values and interests. Ensuring, Indigenous peoples rights, equity, and that principles of free, prior, and informed consent, are at the fore front of projects, leading practice Indigenous engagement is essential. We note that the legislative framework for the Blue Carbon market and how it relates to Indigenous peoples is different to other emerging environmental markets and it is likely to inherently limit the outcomes of this project.

Project description

Blue Carbon and Environmental markets, and their related environmental policy are rapidly evolving to meet National carbon reduction targets. In Australia, they're emerging markets with great potential to improve carbon sequestration and restore biodiversity and cultural values. However, swift market growth infers the potential for perverse outcomes without proper regulation and processes implemented alongside. Corresponding regulation and processes are not yet in place to ensure Indigenous engagement is conducted in a legitimate, respectful, and empowering manner.

A discussion paper will present issues regarding Blue Carbon and Environmental market implementation in Australia as it relates to Indigenous peoples and appropriate engagement processes. Mapping of the Indigenous coastal estate (for Blue Carbon) will also be conducted to provide clarity around resource discussions. Legal advice regarding tenure, agreements, and regulations to protect and prioritise the rights and interests of Indigenous peoples will underpin a document on leading practice Indigenous engagement principles.

Consultative workshops will be held with Traditional Owner bodies and native title advisory services to investigate Indigenous coastal Blue Carbon rights. This research will inform a workshop report and a set of Principles that will be reviewed by participants. 'The principles' will be embedded into the leading practice guidelines for seeking free, prior and informed consent of Indigenous communities for Blue Carbon projects in the coastal zone.

There is a risk that Indigenous tenure and Blue Carbon data is not secure and, if not compiled and validated, is at risk of being lost or becoming privately commercialised. Such free and independent

data is critical information for building capacity in Indigenous communities and rangers establishing Blue Carbon projects and aspiring to engage in the Blue Carbon market. Through establishing a consistent engagement process, coastal Indigenous communities are better able to understand habitat health in a both-ways knowledge framework and apply adaptive management to species and resources in their sea country. This project will address these problems by:

- Mapping tenure of Blue Carbon resources with a focus on Indigenous land, rights, and interests.
- Compiling and synthesizing Indigenous tenure related to Blue Carbon resources data into a publicly available spatial database (eAtlas) to create a permanent reference.
- Review Indigenous Carbon Industry Network Best Practice Free, Prior and Informed Consent Guidelines for Seeking Consent of Indigenous Communities for Carbon Projects (2020) with a view to extend application of guidelines to coastal, intertidal and oceanic zones and biodiversity values.
- Co-design leading practice guidelines with Traditional Owner groups, Native title bodies, and Indigenous representative bodies on Indigenous Engagement in the Australian Blue Carbon and biodiversity markets.
- Interpret and report on workshop findings, including providing advice on establishing engagement options and leading practice guidelines and options for regulatory improvement to empower Indigenous peoples in these markets.

Blue Carbon and Environmental markets are rapidly emerging as significant opportunities to empower Indigenous groups in the management of the environment and this opportunity can only be realised with a strong foundation of Indigenous engagement.

Decisions regarding the implementation of Blue Carbon and Environmental market projects on lands and seas where Indigenous peoples have rights and interests need to be underpinned by appropriate, lawful, and accurate information. There is a risk that a poorly informed implementation phase for these markets may disadvantage and disempower Indigenous peoples and see commercial operators with a greater capacity for capitalising on these markets, developing a strong position.

As a signatory to the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), Australia has committed to actions that support Indigenous peoples. Of relevance to this project are several Articles within the Declaration including which support Indigenous peoples have the right to participate in decision-making in matters which would affect their rights, through representatives chosen by themselves in accordance with their own procedures, as well as to maintain and develop their own indigenous decision-making institutions.

Australia is required to take effective measures and, where appropriate, special measures to ensure continuing improvement of economic and social conditions for Indigenous peoples. The Articles noted below from the UNDRIP are directly relevant to this project. The Commonwealth government will hence be delivering to its commitments under this Convention.

Article 26: 1. Indigenous peoples have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired. 2. Indigenous peoples have the right to own, use, develop and control the lands, territories and resources that they possess by reason of traditional ownership or other traditional occupation or use, as well as those which they have otherwise acquired. 3. States shall give legal recognition and protection to these lands, territories and resources. Such recognition shall be conducted with due respect to the customs, traditions and land tenure systems of the indigenous peoples concerned.

Article 27: States shall establish and implement, in conjunction with indigenous peoples concerned, a fair, independent, impartial, open and transparent process, giving due recognition to indigenous peoples' laws, traditions, customs and land tenure systems, to recognize and adjudicate the rights of indigenous peoples pertaining to their lands, territories and resources, including those which were traditionally owned or otherwise occupied or used. Indigenous peoples shall have the right to participate in this process.

Article 28: 1. Indigenous peoples have the right to redress, by means that can include restitution or, when this is not possible, of a just, fair and equitable compensation, for the lands, territories and resources which they have traditionally owned or otherwise occupied or used, and which have been confiscated, taken, occupied, used or damaged without their free, prior and informed consent.

Article 29: 1. Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources. States shall establish and implement assistance programmes for indigenous peoples for such conservation and protection, without discrimination.

The cultural, commercial, and ecological values of lands eligible for projects may be at risk of poor management and outcomes if appropriate engagement is not conducted. Building capacity with Indigenous groups for future engagement in Blue Carbon and Environmental markets is essential given the traditional custodianship of coastal resources throughout much of Australia. Furthermore, many coastal Indigenous groups have local knowledge and local access to remote locations.

A discussion paper focusing on Blue Carbon and Environmental market issues and Indigenous ownership and engagement will be developed to provide the necessary background to the guidelines. Legal advice regarding tenure, agreements, and regulations to protect and prioritise the rights and interests of Indigenous peoples will underpin the proposed guidelines. Mapping of the Indigenous coastal estate will also be conducted to provide clarity around resource discussions.

A consultative workshop will be held with traditional owner representative bodies and native title advisory services to discuss Blue Carbon and Environmental market rights, Indigenous-centred social licence to operate, Indigenous decision-making processes, Indigenous peoples' priorities and aspirations, place-based relationships, social and economic opportunities, resources and networks, risk mitigation, FPIC and conditions for consent.

Discussion around these topics will be captured in a workshop report and a set of Principles will be developed from the workshops and reviewed by participants. The Principles will be embedded into the Guidelines for engaging with Indigenous Communities for Blue Carbon and Environmental Market Projects in the Coastal Zone.

The research is applied and will be undertaken with local/regional partners and the information will be collated in a format consistent with existing public data and easily incorporated into future mapping. We will:

6. Work with end-users including Traditional Owners (as well as Aboriginal Corporations, Indigenous land and sea management groups and native title representative groups), government, management agencies, and research agencies to identify data available for spatial synthesis of Indigenous tenure in Blue Carbon ecosystems. Bilingual maps will be produced if agreed to by the Traditional Owner partners.
7. Partner with Traditional Owners, Indigenous communities, rangers and other regional partners to co-develop, and report on Blue Carbon market engagement processes. Consultation workshops will include development of engagement methods that enable co-design processes.
8. Co-develop Indigenous community engagement methods that can be applied in the national Blue Carbon market.
9. Create a publicly available synthesis of Blue Carbon resources that regard Indigenous peoples interests and rights in a format compatible with the eAtlas interface. Data and metadata will also be available with downloadable GIS shapefiles.
10. Report back to end users/Traditional Owners/ranger groups/communities for each consultation region through on country meetings, community brochures, mapping products, and reports.
11. We will identify gaps through this research and identify where and how future consultation should occur to be more inclusive of other Environmental markets (and socio-cultural markets).
12. Noting the primary focus of this project is Blue Carbon, our team recognises that emerging Environmental Markets with yet to be defined policies or clear consultation/engagement process carries risk to the effective and fair engagement of Indigenous peoples and the ability for them to benefit. Therefore, in the interests of leading practice Free, Prior and Informed

consent principles, it is important that independent resources (not limited to NESP) are dedicated to supporting Indigenous Peoples engagement in emerging Environmental Markets, such as Biodiversity Markets and Nature Repair Markets, as the policies and regulations develop.

13. It is likely that some principles and elements of the engagement practice developed for the Blue Carbon project will be relevant and applicable to other Environmental Markets and we will identify these. However, dedicated resources are necessary for consulting on other emerging Environmental Markets and should be sought given the difference in geography, policy, and regulation.

The leading practice guidelines and 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:

- Essential knowledge of the location and composition of key Blue Carbon assets across Australia to develop long-term monitoring plans and target data gaps for future surveys.
 - *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>
 - Input into State & Commonwealth development/EIS and dredge management plan assessments considering impacts to Blue Carbon.
-
- Data, metadata and spatial layers created will be secured on a CDU server perpetually.
 - Metadata and final spatial layers will be submitted to eAtlas to be held perpetually.
 - Peer-reviewed open access publications.
 - Consultation reports for each regional consultation and final report will be publicly available on the NESP, CDU, ICIN and eAtlas websites.

Is this a cross-hub project?

Yes. NESP Resilient Landscapes Hub.

This project will support policy development, market implementation, and management and regulatory processes to protect Australia's marine assets through:

- Enabling a clear and appropriate process for engagement with Indigenous peoples on Blue Carbon projects in Australia.
- Conducting research where outcomes can be used for environmental assessment of development proposals.
- Supporting Indigenous-led management of Blue Carbon assets (Blue Carbon, mangroves, saltmarsh etc.).
- Guide Best Practice agreement making and consent practices that recognise Indigenous rights and interest in Blue Carbon.

The outputs from this project will be relevant and transferable at some level to the terrestrial environment for future support of alternative economies for Indigenous communities.

Does this project contribute to a cross-cutting initiative?

Yes. It will be relevant to the Resilient Landscapes – Threatened and migratory species and ecosystems cross-cutting initiative. It will provide information on the possible economic value of seagrass, mangroves and other coastal habitats of importance and the species which inhabit them and leading practice engagement with coastal Indigenous peoples.

Indigenous consultation and engagement

Which Three-category approach the project meets	Communicate	Collaborate	Co-design
	☒	☒	☒

Our project is a Category 1 (Indigenous Partnerships Strategy) project for Indigenous consultation and engagement. Indigenous engagement will include consultation, co-design and collaboration with Indigenous traditional owners and custodians, communities and organisations to ensure both-ways sharing of knowledge and information.

Our end-user engagement strategy is to engage early, encourage participation and collaboration, and ensure dissemination. Workshops will be held in early 2023 to further discuss the potential for partnership, approach, scope, and opportunities for co-support including additional sources of funding to value-add to the methods.

This project will be conducted collaboratively and with full consent by Traditional Owners. Traditional knowledge and Indigenous Cultural and Intellectual Property (ICIP) will be managed following established standards (Our Knowledge Our Way Guidelines). Where agreements exist, we will work under established agreements that clearly sets out the purpose, benefits and responsibilities of any collaborative partnership, where these do not exist we will establish new research agreements. If there is agreement to share cultural knowledge we will also establish an Indigenous cultural and intellectual property (ICIP) agreement.

The project team will seek free, prior and informed consent from collaborating Indigenous organisations (or other relevant cultural authority) as part of any agreement associated with this project. The project team will work closely with collaborating Indigenous organisations to identify and develop appropriate research outputs for communicating the findings of this research to Indigenous people. We plan co-authorship of publications with Traditional Owners where they want to share their data and knowledge.

Project outcomes and resources will be shared, where approved, with Indigenous collaborators and end users across the survey area through eAtlas (eatlas.org.au), community brochures, project reports and presentations at community workshops.

Each activity will attain Human Research Ethics Committee approval as required for any research work conducted on sea country with Aboriginal and Torres Strait Islander Peoples. This requires us to:

- Abide by the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) [Code of Ethics for Aboriginal and Torres Strait Islander Research](#) and “[A Guide to applying The AIATSIS Code of Ethics for Aboriginal and Torres Strait Islander Research](#)”
- NHMRC [Ethical conduct in research with Aboriginal and Torres Strait Islander Peoples and communities: Guidelines for researchers and stakeholders \(issued August 2018\)](#)
- Attain free, prior and informed consent from the relevant TOs where the research work will be conducted.
- Develop a Research Project Agreement with Indigenous groups which will include:
 - Opportunities to develop a communication network between the science team and Traditional Owners and Indigenous communities to exchange and share updates on the project throughout the project.
 - Employment opportunities for members of Indigenous communities.

- Payment for TOs time where appropriate.
- Opportunities to attend in person presentations and/or information webinars about the research work.
- Returning results to the TOs in an accessible medium and format negotiated with them.
- Data co-ownership and access, including establishing an ICIP agreements.

The following opportunities will also be available:

1. Co-authorship – opportunities for co-authorship will be available and encouraged for Traditional Owners and Indigenous groups from each region and sea country being reported.
2. Co-ownership of Intellectual Property.
3. Capacity building/training – Guidelines will be co-developed with Indigenous traditional owners and Indigenous representative bodies. This will enable an opportunity for Indigenous peoples to understand the Blue Carbon market and opportunities. This is crucial to provide equity in the Blue Carbon market.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National	Regional	Local
	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Location(s) – gazetted region /place name	This project spans coastal Australia. Workshops and meetings will be established around regional hubs.		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	All national coastal Indigenous representative bodies and corporations		

Project 3.21 – Identifying priority datasets of relevance to the Gippsland declaration area and pathways for their use in guiding decision-making

Project description

Project summary

Australia has entered a phase of rapid development of offshore renewable energy (ORE) with one declaration area and one notice of proposal to declare an area for ORE infrastructure announced in late 2022 and early 2023 respectively. There is an immediate need to ensure that assessment and regulatory processes can access relevant information on species protected under environmental legislation comprehensively and efficiently, to ensure that decisions are evidence based, gaps in understanding are identified and future research and monitoring is directed to fill those gaps. This project will undertake a rapid exploration of information on a priority subset of species identified by the Department of Climate Change, Energy, Environment and Water (DCCEEW) and the National Offshore Petroleum Safety and Environment Authority (NOPSEMA) identified as critically endangered or endangered under the Environment Protection and Biodiversity Conservation Act 1999 in relation to the Gippsland declaration area. The project aims to 1) identify datasets and information sources relevant to these priority species; 2) identify the level of accessibility of these datasets and information source; 3) based on the outcomes of 2), evaluate the utility of information identified for assessments required to be undertaken by DCCEEW and NOPSEMA; and 4) identify what activities would need to be undertaken to improve the accessibility and utility of datasets and information sources not currently accessible in useable formats. This project does not intend to duplicate the efforts already being undertaken by NESP project 3.3 in identifying information on marine ecosystems nationally and producing an inventory of recognised best practices for monitoring, mitigation and management of interactions and impacts that can be applied from installation to decommissioning, to be delivered in March 2024, but will fast-track some of the information that can be incorporated into project 3.3.

Project description

The offshore renewable energy (ORE) sector is rapidly developing in Australia's Commonwealth and State waters with the declaration of an infrastructure area off Gippsland, Victoria occurring in late 2022 (Figure 1) and a notice of proposal to declare an infrastructure area off the Hunter, New South Wales announced in early 2023. Several other regions have also been identified as priority areas for assessment for area declaration (see <https://www.dcceew.gov.au/energy/renewable/establishing-offshore-infrastructure>).

There are several Commonwealth and State and Territory agencies responsible for administering the licensing and regulation of infrastructure projects, including assessing environmental management plans associated with infrastructure activities under Commonwealth and State or Territory legislation. These agencies rely on a strong scientific evidence base to support decisions made under key legislation and to determine effective regulatory processes. Building this scientific evidence base requires efficient and timely access to quality environmental data that are able to be applied effectively for legislative and regulatory processes.

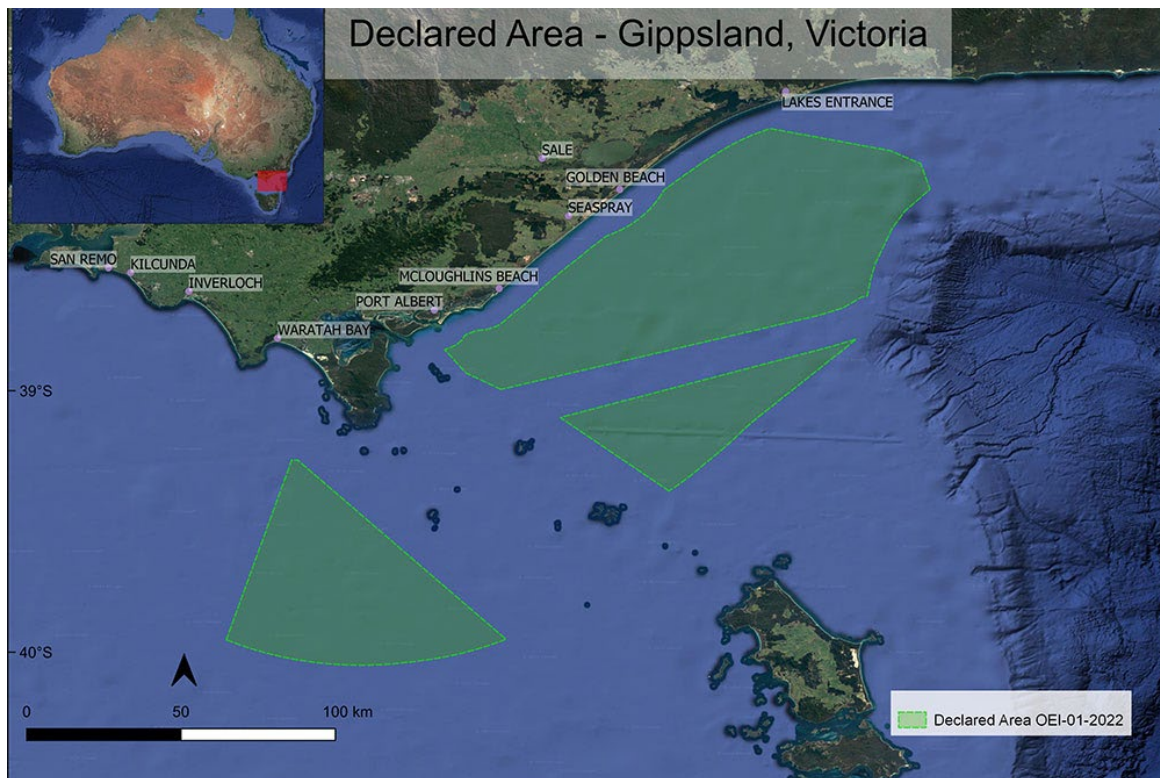


Figure 1. Declaration area for offshore renewable energy off Gippsland, Victoria.

A number of species protected under the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) are known to occur throughout the region of the Gippsland declaration area and have the potential to interact with ORE infrastructure during construction, operations and decommissioning. Given the fast pace at which the sector is developing there is an urgent need to identify information on species likely to interact with ORE infrastructure that can assist in supporting assessment of ORE activities, guiding monitoring programs required to be undertaken by proponents (including assessment of cumulative effects), identifying mitigation and management measures for reducing interactions and associated impacts and informing future research programs for filling knowledge gaps.

The NESP Marine and Coastal (MaC) Hub is currently coordinating the delivery of a nationally focused inventory of existing information on ecosystem components, including oceanography, seabed biogeomorphology and interacting species and habitats. This information collation exercise also includes gathering information on potential impacts of ORE infrastructure from installation through to decommissioning and recognised best practice standards for monitoring. The project “Guiding research and best practice standards for the sustainable development of Offshore Renewables and other emerging marine industries in Australia” (NESP MaC Hub project 3.3), initiated as part of the NESP MaC Hub 2023 Research Plan, will be delivered in March 2024.

Within the context of the time scale of delivery of project 3.3. and the broader focus of this project, Department of Climate Change, Energy, Environment and Water (DCCEEW) and the National Offshore Petroleum Safety and Environment Authority (NOPSEMA) have identified the need for a rapid assessment of information available for the Gippsland declaration area specifically and for a subset of species that are listed as critically endangered or endangered under the EPBC Act (Table 1). This represents the species considered to be potentially at greatest risk to ORE activities. In association, a number of data and information needs for supporting the assessment, monitoring, mitigation and management of interactions between this subset of species with ORE infrastructure

have been identified. These fall into two broad categories: 1) baseline conditions and long-term reference datasets and 2) methods and techniques for monitoring, mitigation and management of interactions and impacts.

While some information on this priority subset of species is available in the public domain, there is much that is either embedded in the scientific literature, detailed in grey literature, held privately or is in the form of datasets that are yet to be fully analysed. Further, while some datasets might be publicly available, they may not be in formats that are easy to access or be used by those agencies responsible for administering the licensing and regulation of ORE infrastructure projects.

This project will use networks established by the NESP MaC Hub under project 1.20 (<https://www.nespmarinecoastal.edu.au/project-1-20/>) and 1.29 (<https://www.nespmarinecoastal.edu.au/project-1-29-3/>), as well as those already established by CSIRO and the NESP, to bring together various streams of research of relevance to the subset of priority species identified by DCCEEW and NOPSEMA. This will be primarily facilitated through a workshop, also involving relevant section of DCCEEW and NOPSEMA, with the aim of 1) identifying datasets and information sources relevant to these priority information areas; 2) identifying the level of accessibility of these datasets and information sources, 3) evaluating their utility for assessments required to be undertaken by DCCEEW and NOPSEMA and 4) identifying what activities would need to be undertaken to improve the accessibility and utility of datasets and information sources not currently accessible in useable formats.

In this respect the project will provide additional information than that being delivered by project 3.3, in that it will provide an evaluation of the “readiness” of information and involve an expert elicitation process to identify information, data and data products that are not currently in the public domain and identifiable through a broad-scale inventory process.

Following the workshop, a report will be prepared for Commonwealth, state and territory managers outlining the outcomes from the workshop and identifying a set of recommendations for improving the utility of knowledge already collected and key knowledge gaps that can be used to inform further research planning by the NESP, and via other funding sources. This includes providing guidance to DCCEEW, NOPSEMA and the NESP MaC Hub and its partners on where resources could be directed in 2024 and beyond, to improve the accessibility and utility of datasets and information sources not currently available to assessors and regulators in useable formats. The outcomes provided in the report will be presented via a briefing to DCCEEW, NOPSEMA and state agencies, to be hosted by the NESP MaC Hub. In association, the project will establish a bibliography of research papers, reports and datasets, including their location and key contact points for reference and use by DCCEEW and NOPSEMA. Where available, metadata records will be included with each bibliographic record. This bibliography will be useful for identifying knowledge gaps on the priority subset of species that can then be used to guide monitoring programs and directed research efforts across the declaration area.

Table 1. Priority species identified by DCCEEW and NOPSEMA in association with the Gippsland declaration area.

Common Name	Scientific Name
Birds, shorebirds and seabirds	
Amsterdam Albatross	<i>Diomedea amsterdamensis</i>
Australian Gould's Petrel	<i>Pterodroma leucoptera leucoptera</i>
Curlew Sandpiper	<i>Calidris ferruginea</i>
Far Eastern Curlew	<i>Numenius madagascariensis</i>
Grey-headed Albatross	<i>Thalassarche chrysostoma</i>
Mongolian Lesser Sand Plover	<i>Charadrius mongolus mongolus</i>
New Siberian Islands Red Knot	<i>Calidris canutus piersmai</i>
North-eastern Siberian Red Knot	<i>Calidris canutus rogersi</i>
Northern Royal Albatross	<i>Diomedea sanfordi</i>
Orange-bellied Parrot	<i>Neophema chrysogaster</i>
Swift Parrot	<i>Lathamus discolor</i>
Shy Albatross	<i>Thalassarche cauta</i>
Southern Giant-Petrel	<i>Macronectes giganteus</i>
Tasmanian Wedge-tailed Eagle	<i>Aquila audax fleayi</i>
Yakutian Bar-tailed Godwit	<i>Limosa lapponica menzbieri</i>
Cetaceans#	
Blue whale	<i>Balaenoptera musculus sp.</i>
Southern right whale	<i>Eubalaena australis</i>
Humpback whale	<i>Megaptera novaeangliae</i>

#In addition, other whale species such as sperm whales (*Physeter macrocephalus*) and humpback whales (*Megaptera novaeangliae*) have been identified as important species for gathering baseline information on abundance, distribution and habitat utilisation by DCCEEW and NOPSEMA. Other threatened cetaceans include the fin whale (*Balaenoptera physalus*) and sei whale (*B. borealis*), both of which are identified as vulnerable under the EPBC Act. For the purposes of this project, humpback whales will be included in addition to the subset of cetaceans already identified by DCCEEW and NOPSEMA, based on high population recovery and in association, likelihood of interactions with ORE infrastructure in the Gippsland region. National information on sperm whales, fin whales and sei whales, including information from the Gippsland region, will be captured under project 3.3.

In achieving these deliverables, the project will be complementary to the current NESP MaC Hub project 3.3, and assist in fast-tracking the inventory being developed by project 3.3 with respect to the subset of priority species identified by DCCEEW and NOPSEMA specific to the Gippsland declaration area.

Indigenous consultation and engagement

Indigenous engagement and collaboration 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 Hub's Indigenous Partnerships Strategy. This project is a Category 1 project for Indigenous partnerships. Given the scope and the short timeline for the project, the project will focus on opportunities for communication of outputs and knowledge sharing, with engagement in the project workshop by Traditional Owners of relevance to the Gippsland declaration area facilitated through the NESP.

The project recognises the importance of working with Traditional Custodians of Sea Country and the positive contributions that two-way knowledge systems can make to ensuring that the project workshop captures important values and knowledge and identifies knowledge gaps of relevance to Traditional Custodians. Outputs from the workshop will be co-designed with workshop participants and through a review process in the development of the report to ensure that it is respectful of their ownership of knowledge and their customs and conveys these appropriately.

Location of research

The table below describes the scale at which the project will be working, and the location/s where the majority of the project research will be conducted.

At which spatial scale is the project working	National <input type="checkbox"/>	Regional <input checked="" type="checkbox"/>	Local <input type="checkbox"/>
Location(s) – gazetted region /place name	Gippsland declaration are (see Figure 1)		
Aboriginal or Torres Strait Islander nation or traditional place name(s)	Proposals for offshore renewable energy infrastructure are presently being considered in areas aligned with the following Traditional Owners: <div style="margin-left: 40px;"> Gippsland Eastern Victoria Furneaux Island group </div> This list may change throughout the project as the NESP Hub facilitates engagement with Traditional Owners on behalf of the project.		