National Environmental Science Program

Marine and Coastal Hub research plan 2024 – Attachment B project plans

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Project 4.1 – Coastal seagrass of the Gulf of Carpentaria: building knowledge and capacity as a foundation for long-term monitoring

Project type: Hub research project	
Cross-cutting initiative:	Not directly but indirectly to both the Threatened Species and the Protected Places initiatives.
Project start date: 01/02/2024	**Project end date**: 11/12/2026
Project leader details:	Name: Catherine Collier Organisation: TropWATER, James Cook University Name: Alex Carter Organisation: TropWATER, James Cook University Name: Natalie Waller Organisation: Carpentaria Land Council Aboriginal Corporation Name: Mark Hogno Organisation: Carpentaria Land Council Aboriginal Corporation

Project description

Project summary

The Gulf of Carpentaria has a globally significant seagrass habitat, supporting dugongs, green turtles, and commercially important fish and prawns. Key to managing impacts to species in these habitats, including indirect impacts through land use within southern Gulf catchments, is reliable data on seagrass distribution and how it changes over time. Achieving this requires large-scale mapping and a ranger-led seagrass monitoring program. This project will map intertidal seagrass habitats from the western boundary of the Nijinda Durlga (Gangalidda) and Thuwathu/Bujimulla Indigenous Protected Areas to the Bynoe River near Karumba. This mapping focuses on data-deficient regions along the mainland coastline of the southern Gulf. Surveys will be co-designed and undertaken with rangers. New technologies for monitoring using drones will be collaboratively tested in key locations for ongoing monitoring of coastal habitats by rangers. This will value-add to surveys being conducted around Mornington Island and the Gilbert River in 2023 and contribute towards the development of a regional baseline of seagrass for the Gulf of Carpentaria.

Project description

Seagrass habitats in the Gulf of Carpentaria are exposed to potential threats from water extraction and grazing in the adjacent catchments and gulf plains, fishing (e.g., trawling and illegal netting), and tourism (e.g., recreational fishing). Climate variability (including floods and heat waves) also threatens the ecological services that seagrass habitats provide, such as blue carbon, nutrient absorption, sediment stabilisation, food for iconic species, and habitat for fisheries, migratory birds and waders. Concern over the health of dugong and green turtles has prompted seagrass monitoring as a key action in the Nijinda Durlga (Gangalidda) Indigenous Protected Area Management Plan and Thuwathu/Bujimulla Indigenous Protected Area Management Plan.

Little is known about seagrass habitats along the extensive Gulf of Carpentaria coastline within Queensland. Data on seagrass distribution across this range is patchy (from very broad-scale surveys) and outdated, as few large-scale mapping surveys have been undertaken. Such baseline data, and ongoing monitoring, is critical information for the Carpentaria Land Council Aboriginal Corporation (CLCAC) and First Nations communities aspiring to manage their sea country.

This builds on a foundation of other NESP-funded projects and support from funding partners to document the benthic habitats of the Gulf of Carpentaria. A data synthesis (NESP 3.1) of the available seagrass spatial data in the GBR, Torres Strait and the Gulf of Carpentaria collected from 1982-2022 was recently published and is available to the public (Carter, McKenna et al. 2023). The benthic habitat data gaps identified included the southern Gulf of Carpentaria coastline from Karumba to the Northern Territory border. Data for this region is several decades old and was not comprehensively collected or as precise as is possible today owing to the scale of the original surveys and the technology available at the time (e.g. no GPS). There were also large areas that were not surveyed at all. Data and outputs from this project will update this data synthesis for the Gulf of Carpentaria region by using the same methods and focusing on data-deficient areas. Other related projects are contributing towards this goal for the Gulf of Carpentaria, but none of these will include the vast area between Karumba and the NT border. These other related projects include:

- mapping projects in several locations, including the Gilbert River region south towards Karumba (NESP2 MaC 1.13) and the Karumba Port long-term monitoring funded by Ports North and led by Michael Rasheed (JCU) both neighbouring the proposed survey area to the east.
- mapping intertidal habitats on Mornington Island in 2023 (DCCEEW) neighbouring the proposed survey area to the north.

- mapping critical habitat in Yanyuwa Sea country in 2022 on the Northern Territory side of the southern Gulf of Carpentaria (neighbouring this survey area to the west) in NESP 1.12, DCCEEW and NT Ranger Grants.

This project will conduct contemporary baseline mapping of intertidal seagrass habitats from the western boundary of the Nijinda Durlga (Gangalidda) and Thuwathu/Bujimulla Indigenous Protected Areas to the Bynoe River near Karumba. Intertidal seagrass monitoring will also be established in high-priority and accessible areas. This will enable First Nations communities to better understand habitat health in a both-ways knowledge framework and apply adaptive management to species and resources in their sea country. Monitoring is also vital for assessing the environmental impact of future developments and impacts, and climate variability. This project will address these problems by:

1. Mapping 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, First Nations communities, rangers, management agencies, industry, and researchers to assess change.
3. Co-design mapping and monitoring methods with Gangalidda Garawa Rangers, Normanton Rangers and scientists with guidance from Traditional Owners, including utilising novel technology such as drones.
4. Interpreting and reporting on survey findings, including co-developed options for ongoing monitoring that can be implemented by Gangalidda Garawa Rangers and Normanton Rangers.
5. Co-funding a PhD that contributes to understanding condition and resilience of tropical Australian seagrass.

Growing a strong and sustainable future for residents of the Gulf of Carpentaria 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. Furthermore, rangers have local knowledge and local access to remote northern Australian locations.

The surveys will be undertaken by Gangalidda Garawa and Normanton Rangers in collaboration with scientists from JCU. The information will be collated in a format consistent with existing seagrass spatial data. We will:

1. Work with Traditional Owners and research users, including government and management agencies (DCCEEW, DES), to identify: (1) priority areas for surveys, (2) potential for co-investment in surveys, and (3) how data streams from new technologies (e.g. drones) can feed into decision-making.
2. Co-design, conduct and report on baseline seagrass surveys. Survey methods will include the use of a helicopter to assess the extent, abundance and species composition of intertidal seagrass (Figure 1). We will use the same methods as previous and ongoing projects (e.g. in Torres Strait, Queensland ports, Great Barrier Reef habitat mapping, Limmen Bight, Yanyuwa IPA, South East Arnhem Land IPA) to ensure consistency in methods and comparability of data.
3. Co-develop and conduct seagrass monitoring methods that can be used by rangers in remote areas, including applying new technology, in particular drones (Figure 1). Drones will be used to examine the extent of seagrass using orthomosaics and low-altitude spot checks in high-priority areas to determine abundance and diversity.

4. Develop a Research Project Agreement and data sharing agreements through consultation with CLCAC and Traditional Owners (detailed in the Indigenous Consultation and Engagement section). This will include discussion and reaching agreement on:
    - Public release of reports with summary data included.
    - Raw data accessibility, such as through the e-Atlas portal.
    - Integrating data into regional data sets to enable knowledge sharing with Traditional Owners throughout the Gulf of Carpentaria and allow predictive modelling for seagrass.
    - Production of bilingual maps.
5. Report back to Traditional Owners and research users through on country meetings (Normanton and Burketown), brochures, maps, and reports.

Figure 1. Helicopter (left) and drone (right) being used to survey seagrass.

Reference

Carter, A., S. McKenna, M. Rasheed, H. Taylor, C. van de Wetering, K. Chartrand, C. Reason, C. Collier, L. Shepherd, J. Mellors, L. McKenzie, N. C. Duke, A. Roelofs, N. Smit, R. Groom, D. Barrett, S. Evans, R. Pitcher, N. Murphy, M. Carlisle, M. David, S. Lui, T. S. I. Rangers and R. G. Coles (2023). "Seagrass spatial data synthesis from north-east Australia, Torres Strait and Gulf of Carpentaria, 1983 to 2022." Limnology and Oceanography Letters.

Prior Relevant Research

Project	**Details**
NESP 3.1, 3.2.1, 5.4, NESP2 MAC Project 1.13: Seagrass mapping synthesis. Led by Alex Carter, Rob Coles, Skye McKenna and 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 and data-deficient areas.
NESP 3.5 and TSRA: Assessment of key dugong and turtle seagrass resources in north-west Torres Strait Led by Alex Carter and Michael Rasheed (JCU)	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 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)	Benthic habitats were mapped in the southern Gulf of Carpentaria (NT) in collaboration with li-Anthawirriyarra Rangers and NT Parks.

Led by Catherine Collier and Alex Carter (JCU) and Rachel Groom (CDU)	
Mabunji Aboriginal Corporation and NESP2 MAC Project 1.12: Mapping critical habitat in Yanyuwa sea country (2021-2023)	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.

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

Project/Research/Work	**How our project links to other research**
CLCAC projects include: Green turtle resilience on the Wellesley Islands with CSIRO Sawfish sampling and tracking in the southern Gulf Future projects planned for dugong, dolphin, and documentary on the cultural values of the Gulf Reef networks.	Traditional Owners have a strong interest in assessing and conserving the environmental values of the Gulf region, to assist in future protection of marine and riverine environments. This will form one of the critical pillars that will demonstrate the importance of seagrass meadows in the Gulf for supporting diverse marine environments, and assist in building protections against further agricultural development, mining or commercial fishing operations in future years. It is hoped this data will be invaluable for supporting a review of protected areas, e.g. the Gulf of Carpentaria Marine Park review due in 2026.
NESP2 3.10: Partnerships and novel technologies of improved dugong research Led by Chris Cleguer (JCU), Holly Raudino (DBCA), Rachel Groom (CDU)	This project will utilise genetic methods to understand how individuals and populations of dugongs mix and move in the Gulf of Carpentaria.
NESP2 MaC Hub RP2024 proposed Project 4.6 Led by Rachel Groom (CDU)	This project will survey locations of dugong abundance which can be linked to seagrass given this is the food source. Both projects will work with the same TO's and have some overlap in key research staff.
NESP2 Project 3.5: Supporting regional planning in northern Australia: Building knowledge, skills and partnerships for understanding seagrass distribution. Led by Alex Carter and Catherine Collier (JCU), Rachel Groom (CDU), and Kathryn McMahon (ECU)	This project will map seagrass habitats across northern Australia (QLD, NT and WA) through targeted mapping expeditions in data-deficient regions. It will strengthen relationships with coastal communities, build on existing knowledge 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.
NESP2 Project 1.12 Mapping critical habitat in Yanyuwa and Marra sea country (DCCEEW,	The southern Gulf of Carpentaria is an area rich in biological diversity, with dugongs and turtles moving throughout the region. Data on habitats from these areas (South East Arnhem Land IPA and Marra and Yanyuwa sea country) can be used for understanding the extent and resilience of habitats

NTG, Parks Australia, NT Ranger Grants) (2023) South-East Arnhem Indigenous Protected Area seagrass mapping (2022-2023, proposed for 2024) Led by Catherine Collier and Alex Carter (JCU) and Rachel Groom (CDU)	and their dependent species in the southern Gulf of Carpentaria more broadly, and vice versa. 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.
Karumba Port long-term monitoring funded by Ports North and led by 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.

The spatial data produced for this project will provide:

1. Information needed to implement the Nijinda Durlga (Gangalidda) and Thuwathu/Bujimulla Indigenous Protected Area Management Plans. Specifically, for the Actions:
    - Dugong
    - Turtle
    - Pollutants
    - Baseline data
2. Essential knowledge of the location and composition of key environmental assets in the southern Gulf of Carpentaria to develop long-term monitoring plans.
3. A foundation to assess risk from water quality, water extraction and other environmental impacts, tourism, fishing, climate change, etc.
4. *Environmental Protection and Biodiversity Conservation Act 1999* matters of national environmental significance, e.g. threatened species or listed marine and migratory species.
5. Understanding dugong and marine turtle habitats, including migratory corridors.
6. Support the objectives of *Australia's Strategy for Nature 2019-2030*. https://www.australiasnaturehub.gov.au/national-strategy
7. Future modelling of seagrass distribution, values, resilience and connectivity.
8. *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.
9. Input into State & Commonwealth development/EIA/EIS and dredge management assessments considering impacts to seagrass.
10. A foundation for blue carbon accounting.

The spatial data may also be made 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, subject to conditions outlined in the research and data agreements that will be developed.

Project 4.2 – Assessing dugong distribution and abundance in the southern Gulf of Carpentaria

Project type: Hub research project	
Cross-cutting initiative:	Yes. Threatened and migratory species and threatened ecological communities. Protected place management
Project start date: 01/02/2024	**Project end date**: 11/12/2026
Project leader details:	Name: Dr Rachel Groom Organisation: Charles Darwin University Name: Dr Chris Cleguer Organisation: James Cook University

Project description

Project summary

Aboriginal ranger groups, Traditional Owners of the southern Gulf of Carpentaria (sGoC), scientists, Queensland, Northern Territory and Commonwealth government representatives will co-design and implement a program that enables a contemporary cross-border understanding of dugong populations and other marine megafauna. The dugong program comprises three parts: 1) Dugong population genetics, 2) a standardised aerial survey in the sGoC, and 3) Indigenous-led drone surveys of marine megafauna hotspots. The collaborative approach will enable contemporary data on abundance, distribution and genetic population structuring to inform local and regional conservation management actions. In combination with other NESP investments in Qld and WA, this program will have applied consistent approaches to dugong population assessment across three states. This program directly responds to the national priorities of conserving, protecting and sustainably managing biodiversity through research and information management.

Project description

There are multiple pressures impacting dugong (*Dugong dugon*) populations in Australia, including, but not limited to, extreme weather events, which reduce available food, commercial fishing, and unsustainable hunting. These pressures have had an apparent population-level impact on the east coast (Marsh et al. 2019, Cleguer et al. 2023). While the same pressures occur across much of northern Australia, the abundance and distribution data are not current. Traditional Owners have raised concerns in the sGoC about the abundance of dugongs and green turtles; a response to these concerns is limited and potentially misleading without current data. Given the remoteness of the northern Australian marine environment, it is important that local communities are provided with the means of undertaking, or at least participating in, future population monitoring. A partnership approach to collecting up-to-date dugong population estimates and developing a long-term, Indigenous-led monitoring strategy is required to inform conservation management decisions by Traditional Owners and government agencies. The project will provide a contemporary assessment of the sGoC dugong population and the abundance and distribution of marine megafauna. We will actively engage with sGoC coastal Traditional Owners and rangers to better inform them of the monitoring activities and conservation status of dugongs in the Gulf. Further, we will co-design monitoring strategies with coastal ranger groups to establish more robust engagement and locally informed conservation strategies.

It has been 15 years since the last cross-border dugong aerial survey in the sGoC and Traditional Owners have raised concerns about the apparent low number of dugongs in their sea country and the need for improved management. We are better positioned to respond to these concerns with new dugong abundance and distribution data from aerial surveys. Furthermore, concerted efforts are being made to understand the broader context of dugong conservation. Several important changes have occurred since the 2007 aerial survey that can improve the management of dugongs. These include a new availability bias correction factor for dugongs in the Gulf - which has improved population abundance estimates of dugongs; Commonwealth and NT marine parks have been gazetted, more Indigenous Protected Areas have been established, comprehensive seagrass mapping has occurred; an IUCN Important Marine Mammal Area (IMMA) has been identified in the sGoC, and Indigenous-led sea country planning and management is underway.

More recently, the GoC has been subjected to significant flooding, which has likely reduced available seagrass foraging habitat; this has the potential for population-level impacts. Multiple pressures on the GoC dugong population and their sensitive life history characteristics render them vulnerable to

decline. Traditional Owner groups in the GoC want greater engagement in managing dugongs and green turtles, and this project supports that aspiration robustly and collaboratively.

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

Work with end-users, including Traditional Owners (Aboriginal Corporations and ranger groups), government, management agencies, and research agencies to identify: (i) priority areas for surveys, (ii) potential for co-investment in surveys, and (iii) data available for spatial synthesis to inform risk-based management.

Partner with Traditional Owners, Indigenous rangers, and other regional partners to co-design, co-conduct, and co-report on dugong surveys in target areas. Survey methods will include fixed-wing aircraft and drones for assessing the distribution and abundance of dugongs.

We will use the same methods as previous and ongoing projects (e.g., in Torres Strait, Great Barrier Reef, Kimberley coastline (2022), NT-wide survey (2015), NT-GoC (2014,2019) to ensure consistency in methods and comparability of data.

Bilingual maps will be produced if the Traditional Owner partners agree to this.

Co-develop dugong monitoring methods that can be used for long-term monitoring by rangers in remote areas, including applying new technology such as drones.

Facilitate discussion on dugong genetic sampling, analysis, and results.

Create a publicly available data layer of dugong and other marine megafauna in the sGoC in a format compatible with the eAtlas interface. Data and metadata will also be available with downloadable GIS shapefiles.

Report back to end users/Traditional Owners/Ranger Groups/communities for each survey region through on-country meetings, community brochures, mapping products, and reports.

Attain CDU Human Research Ethics Committee approval as required for any research work conducted on sea country with Aboriginal and Torres Strait Islander Peoples. FPIC and a Research Project Agreement, as detailed further in the Indigenous Consultation and Engagement section, will form the basis of our project engagement.

Prior Relevant Research

Project	Details
NESP 3.1, 3.2.1, 5.4, NESP2 MaC Project 1.13: Seagrass mapping synthesis. Led by Alex Carter (JCU), 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 can inform our understanding of historical and current seagrass presence and the likelihood of dugong distribution. This can assist in optimising the survey design.
Limmen Marine Park (Commonwealth) and Limmen Bight Marine Park (NT) (2021-2022) Led by Catherine Collier, 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, which can assist in optimising the dugong aerial survey.
NESP2 MaC Project 1.20: An inventory of dugong aerial surveys in Australia. Led by Chris Cleguer (JCU) and Helene Marsh (JCU)	Inventory of all aerial surveys undertaken in Australia to assess dugong presence, habitat use, abundance, and distribution. Inventory of literature reference and data accessibility. Insights into methods of abundance and trends estimation and spatial modelling.
NESP Project 3.2: Improving historical estimates of abundance and distribution of dugongs and large green turtles in western and central Torres Strait.	Abundance estimates of dugong and large green turtles were quantitatively improved, which has supported follow-on studies in the sGoC.

NT Gulf of Carpentaria Aerial Survey (2014 and 2019); NT-Qld Gulf of Carpentaria Aerial Survey (2007) and dugong telemetry tagging (2018)	Abundance estimates from these aerial surveys will allow for trend analysis across years in the NT. Additionally, the dugong dive profile data acquired through telemetry and depth loggers will allow locally relevant correction factors to be used for estimating dugong abundance in the sGoC.

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

Project/Research/Work	How our project links to another 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, Alex Carter (JCU) and Rachel Groom (CDU)	The southern GoC is rich in biological diversity with dugongs and turtles 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 with 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 knowledge sharing. Spatial data will be formatted so that results from these surveys are comparable. We will seek permission to include data from this project to help predict dugong distribution in the Gulf of Carpentaria.
Planned NESP2 MaC project 4.6 on dugong in Kimberley led by DBCA/ISWAG/JCU	This project will work with the dugong team to investigate maximising the synergies of the two projects, including dugong genetics across northern Australia.
Partnerships and novel technologies for improved dugong research NESP MaC Hub Project 3.10 (led by Chris Clegeur (JCU))	This project will collate, test and adapt new technologies and explore and develop methods that can be used and applied by non-experts. In collaboration, scientists, managers, and Indigenous rangers will develop drone and plane-based aerial photography protocols; utilise and refine artificial intelligence systems to count dugongs from aerial images; explore the feasibility of remote measurement of size and body characteristics; compare and align old and new survey methods; use genetic methods to understand how individuals and populations mix and move; and develop an Indigenous community-led monitoring program in the Kimberley region. This project has limited operational funding, and this dugong project will enable greater reach to community groups in the southern Gulf of Carpentaria and funding for the analysis of samples and the development of partnerships.
Karumba Port long-term monitoring. Funded by Ports North. Led by 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) and provide insight into dugong distribution and abundance.

How the Research will be Applied

The research will be applied in Indigenous-led decision-making in sea country regarding dugong (and green turtle) use, protected area planning, and supporting government agencies in supporting conservation actions for dugongs. The spatial data produced for this project will be publicly available to guide environmental and cultural decision-making and on-ground action, including:

- Essential knowledge of the abundance and distribution of key marine megafauna values in the GoC to develop long-term monitoring plans, conservation action, 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., listed threatened, listed marine and listed migratory species.
- Understanding dugong and marine turtle habitats, including migratory corridors, data to inform Biologically Important Areas

Support the objectives of *Australia's Strategy for Nature 2019-2030*.
https://www.australiasnaturehub.gov.au/national-strategy

Future modelling of dugong and seagrass distribution, resilience, and connectivity.

- *Recovery Plan for Marine Turtles in Australia* (2017). The need to acquire up-to-date foraging habitat information has been identified to inform management of this listed threatened species.
- Input into State & Commonwealth development/EIA/EIS assessments considering impacts on dugongs, green turtles, and their habitats.
- Assessment and planning for spatial management arrangements, e.g., Dugong Protected Areas and Indigenous-led management areas. This will include spatial management in the Gulf of Carpentaria to reduce interactions of Commonwealth Listed Threatened and Listed Migratory Species in the Gulf of Carpentaria.

Data, metadata, and spatial layers created will be secured on a CDU/JCU server and made publicly available through online repositories. Metadata and final spatial layers will be submitted to eAtlas. Peer-reviewed open-access data publications and survey reports for each IPA/Sea Country/region, and the final report will be publicly available on the NESP, TropWATER, CDU, and eAtlas websites.

Project 4.3: Unbroken whispers – The ripples connecting sea kin

Project type: Hub research project	
Cross-cutting initiative:	No
Project start date: 1/3/2024	**Project end date**: 1/3/2026
Project leader details:	Name: Jodi Edwards Organisation: University of Wollongong
Cross-hub contact details:	Name: Chels Marshall Organisation: University of Tasmania

Project description

Project summary

Knowledge, in all its forms, is key to effectively protecting and recovering threatened and migratory whales and dolphins. Indigenous ecological knowledge (IEK) is what has guided Indigenous peoples through many uncertain climate and ecological fluctuations, it has also been used as part of protected area and species management for many thousand years. Recently IEK has shown to huge potential to contribute to our understanding threatened and migratory whales and dolphins, but this knowledge has not been collated, analysed or properly considered. Consequently, there is an absence of Indigenous perspective and use of cultural knowledge informing the protection and recovery of EPBC listed threatened and migratory species. This Indigenous-led project will identify, collate and share (where appropriate) the relational context of human and kin, and looking at the metaphysics of cultural knowledge as they relate to cetaceans (as cultural keystone species) and related species (primary and secondary keystone species) and the connections between land, sea and sky.

The project will develop and test and model Aboriginal concepts such as being, knowing, identity, time, and space and relational complexities in conservation and management that can be applied more broadly around the coast of Australia. It will set a unique precedence for connecting Indigenous stories and relational metaphysics nationally and internationally to understand whole systems thinking in relation to existence metaphysics between species and habitual space with intent of deepening the understanding of cultural values. Research themes will be grouped into four categories, Cultural, Environmental, Social, Technical, all of which intersect and overlap in various ways and are held in place by the ancient cultural practice of sustainability. End-user engagement is focussed in the following areas: Indigenous communities and organisations and government agency research end-users.

Project description

Over the last 238 years, resident and migratory marine species occurring in Australia have endured a diverse range of pressures. These pressures have intensified with the continuing increase of human population, technology, the ongoing impact of development in marine and coastal environments, along with escalating extraction of marine resources. Moving into the future with unknown effects of human induced climate change, green and blue economies, and alternate energy sources, these pressures are not expected to decrease.

For some species this has resulted in significant population declines, habitat loss and ecosystem dysfunctions that need to be understood to support and rebuild populations, ecosystems and their environs. Whales and dolphins are among these species, and as a result, many have been listed as threatened under the EPBC Act and many related State legislations. They are also listed as migratory species. As we look to the decades ahead, these species will most likely have to contend with new, and in some cases intensifying pressures as humans pursue a growth and productivity agenda within the marine environment.

Knowledge, in all its forms, is key to effectively protecting and recovering threatened and migratory whales and dolphins. Scientific knowledge is being used effectively to inform understanding of population status, trends and habitat use. Indigenous Ecological Knowledge also has huge potential to contribute to our understanding of threatened and migratory whales and dolphins, a key problem at this stage is this knowledge has not been considered, collated or analysed. There is an absence of Indigenous perspective and deficiency of cultural knowledge for protecting and recovering EPBC listed threatened and migratory species. A recent review of the EPBC Act asserted Australia's environmental law was not working for the environment, business or the community for a range of

reasons, including that Traditional knowledge is not valued or considered adequately, promoting a – culture of tokenism.

Description of research

Whales and dolphins are culturally significant species for many Aboriginal nations, families and individuals, particularly in southeast Australia. The importance of our sentinels is documented in many stories embedded in land/sea scapes, portrayed in song and dance, displayed in rock art, contemporary artworks and are totemic species. These knowledges have been passed and shared from generation to generation by our Cultural Custodians to younger generations, land/sea caretakers/managers and to those relocating to the area. Between the stories shared, the historical knowledges they contain, and wrapping them in aspects of cultural science lies the keys to unlocking a better understanding of how our Ancestors understood rational complexities, related to, and integrated relational attributes to culture and protected these species and their habitats, with understandings of ecological dynamics including their migratory patterns and inter and intra species relations.

The research, whilst in its infancy, will provide a strategy that can be applied more broadly around the coast of Australia and set a unique precedence for connecting Indigenous stories and relational metaphysics nationally and internationally. The research themes will be grouped into these four categories, Cultural, Environmental, Social, Technical, all of which intersect and overlap in various ways, and they are held in place by the ancient cultural practice of sustainability. Research will also provide opportunities to weave Indigenous knowledge with relevant knowledge generated in the western science system. Together these knowledges provide a more comprehensive knowledge base than either can alone.

Through Ancient Coastlines (changes in sea levels) and adaptation —the resilience of Aboriginal people across Australia including surrounding islands to remain connected across the Sea through song lines and migration routes of species such as cetaceans, can be seen. The research can demonstrate the interconnected and wholistic understanding and experience Indigenous people have of Country that is commonly only understood on the surface and/or misunderstood by broader society, including non-Indigenous researchers and government.

Draped in cultural traditions of the Ancient ways of story sharing, song and dance this project will be inclusive of a continuum of knowledge conceived by our Ancient Ancestors metaphysically handed down by our cetaceans to Elders then passed to young people through research outputs. These outputs will positively inform policy development, implementation and review in a way that works towards a sustainable future, supported by equitable processes and outcomes in the future Cultural governance of our Sea Country and our threatened and migratory species.

How research will be undertaken

The approach to the project will include the following components:

- Establish Indigenous Cultural Connections Reference Group: to assist the Aboriginal Researchers with cultural and spiritual protocols and leadership of the project. The group will consist of knowledge holders who uphold a vested interest in the connectedness of Aboriginal people to continue their traditional roles in modern days and changing times relating to kin of sea country.
- Desktop analysis: An initial review will be undertaken to assess the success and application of Indigenous Marine Mapping on a global and national scale. A desktop assessment will then be undertaken to include the assessment of Anthropological, ethno anthropological, historic records and documents, oral history. A component also included is the review of language and complexities in story associated with the identified marine habitats, species and other relevant associations.
- Co-design workshops: On-Country gatherings will be co-designed with the research participants during Co-Design Workshops. Co- Design Workshops will be hosted online and face to face and be structured as a collaborative exploration of ideas and decision- making spaces.

- On-country gatherings: On-Country Gatherings will be held with participating Indigenous communities. Gatherings will be between 2-4 days long and consisted of artistic workshops, yarning circles and on-Country learning. The workshops will be video recorded.
- Analysis and sharing insights from research: This stage of the project will focus on bringing the project threads together to generate insights from woven Indigenous knowledge. Two eye seeing will also be provided by weaving Indigenous knowledge with western science knowledge.
- Work with Indigenous communities to collaboratively develop and capture five case studies that *focus on the relational complexities of cultural values and interactions between sea kin*

Why research is a priority

The proposed project aligns strongly with the three overarching narratives that have emerged from the Hub's research themes, they are:

- Improving Indigenous futures
- Innovation on monitoring, evaluation and decision making
- Natural capital supporting economic and social values

Research also contributes to Australian Government priorities for Closing the Gap and the Nature Positive Plan. The Australian Government recognises that First Nations peoples' participation in management of land and sea is crucial to environmental outcomes. Improving protection of First Nations cultural heritage and increasing opportunities to integrate and value First Nations' knowledge and participation in managing Australia's heritage and environment are important first steps (*Nature Positive Plan: better for the Environment, better for business 2022*[1]).

End-user engagement

End-user engagement is focussed in two areas: primary focus is Indigenous communities and organisations (see section on Indigenous participation and inclusion) and government agency research end-users.

Engagement with research end-users from targeted government agencies will occur at several stages throughout the project. The scoping stage of the project has been informed by engagement with policy makers from DCCEEW (eg. Migratory Species Section). The project will also build in engagement mechanisms to ensure these end-users understand what the project is seeking to achieve and out-reach in the mid-stages of the project to communicate progress. The final stages will include engagement to communicate research findings and explore opportunities for understanding and applying Indigenous knowledge for the protection and recovery of threatened and migratory species.

[1] https://www.dcceew.gov.au/environment/epbc/publications/nature-positive-plan

Project 4.4: An Indigenous-led approach to advance health and wellbeing of Tebrakunna Country, Coastal Plains nation, North-east Tasmania

Project type: Hub research project	
Cross-cutting initiative:	Yes • Protected places management • Threatened and migratory species and threatened ecological communities • Climate adaptation
Project start date: 1/03/2024	**Project end date**: 1/03/2026
Project leader details:	Name: Mark Harriss, Rebecca Hope Organisation: MTWAC Name: TBA Organisation: University of Tasmania
Cross-hub contact details:	Name: Emily Flies (Sustainable Communities and Waste Hub) Organisation: University of Tasmania Name: Vanessa Adams (Resilient Landscapes Hub) Organisation: University of Tasmania Name: Jenny Styger (Climate Systems Hub) Organisation: University of Tasmania

Project description

Project summary

This research is an Indigenous led co-designed project between Melythina Tiakana Warrana Aboriginal Corporation (MTWAC) and the University of Tasmania spanning all four NESP Hubs. It is focusing on Healthy Country Planning (HCP) processes at *Tebrakunna* as the Coastal Plains Nation are re-connecting to Ancestral land and sea Country. Through MTWAC's strategic direction, key priorities and areas of interest there is a core focus on concepts surrounding healthy Country and healthy people that will develop throughout the project and contribute to the HCP for MTWAC.

MTWAC aims to be a sustainable organisation, manage culture and heritage, and contribute to healing and wellbeing and broader community engagement. To achieve these priorities, through MTWAC-led HCP processes, Western scientists will work closely with MTWAC, including Indigenous Researchers within this community, *Tebrakunna* Country Ranger Program and HCP Facilitators. The project will assess priority values, targets, threats and viability of land and sea of *Tebrakunna* Country. We will determine within budget and time constraints where efforts will be best targeted to improve and protect the health of Country and people at *Tebrakunna*. Monitoring and evaluation, including of the wellbeing of people and Country, through measurable, community-developed goals and strategies will improve capacity and employment opportunities of MTWAC and the *Tebrakunna* Rangers.

Project description

Problem statement

Aboriginal Australians are the oldest continuing culture in the world. Like many Indigenous cultures around the world, their identity and wellbeing are deeply entwined with that of nature within Country. However, colonisation and dispossession have removed/displaced many Aboriginal people from their Ancestral lands, interrupting Indigenous land management, fragmenting the transmission of cultural and ecological knowledge, and having cascading negative impacts on the health of Country and people. Tasmanian Aboriginal people are progressively reclaiming their culture, language, knowledge, sovereignty, practices, and their relationship with nature.

Tebrakunna Country is a highly significant and special place for Tasmanian Aboriginal people and is the Ancestral land to which most Tasmanian Aboriginal people trace their ancestry. It is a relatively remote part of Australia that has been subject to agriculture and mining activities and is undergoing significant and progressive changes in land and sea use (e.g. land-based wind farming, offshore windfarms, tourism, increasing calls for protected areas). It is also part of the South-east region of Australia known for its importance for migratory species and as one of the global hotspots for ocean warming. This warming has seen the introduction of pest species such as the long-spined sea urchin, *Centrostephananus rodgersii* which are creating extensive sea urchin barrens in the marine environment, devastating both culturally and economically significant resources that depend upon these environments (e.g. shells used by our women for cultural 'shell stringing' practices, and abalone). In this project, MTWAC will identify the cultural connections of the Coastal Plains Nation to *Tebrakunna'*s land and sea Country and how these changes are affecting wellbeing of the MTWAC and the wellbeing of *Tebrakunna* Country.

Description of research

This project will target research to support MTWAC's strategic approach for healthy Country and healthy people in *Tebrakunna* Country. Research will support the HCP Process for *Tebrakunna* Country led by MTWAC. The collaborative approach will develop tools to assess wellbeing benefits of connection with Country/on-Country activities and how spiritual, emotional, physical, social- economic and environmental changes are impacting wellbeing. Research will support the advancement of priority management, research and monitoring needs for improving health of *Tebrakunna* Country and wellbeing of Coastal Plains Nation, including the early steps required to move toward establishing and

or informing a Sea Country IPA designed to protect cultural values. It would have the additional benefit of building capacity of MTWAC rangers to improve and monitor the health of *Tebrakunna* Country.

As aligned with MTWAC's strategic priorities of being a sustainable organisation, managing culture and heritage, healing and wellbeing and community engagement, researchers will work closely with MTWAC to:

- Support MTWAC to develop their HCP Processes through Indigenous led workshops with stakeholders, including compiling relevant environmental, cultural and social data to complete assessments of the targets, threats and viability of *Tebrakunna* Country and the wellbeing of the Coastal Plains Nations through a staged approach across time and place as capacity of community strengthens and joint management of other areas is established.
- Develop a framework and tools for understanding the wellbeing benefits of on-Country programs in adapting to changing environments.
- Support development of a strategic approach to their research and monitoring priorities for healthy Country and healthy people.
- Build capacity to support MTWAC's aspirations in developing skills and other opportunities e.g. environmental monitoring and assessment.

This project includes budget, resources and research capacity to deliver research outputs and outcomes for the Marine and Coastal Hub (see below). The project also includes budget, resources and research capacity to coordinate NESP research of all four NESP Hubs (see below) with MTWAC for the duration of the project. The aim is that through this project the four NESP Hubs will implement a joined-up and coordinated approach when working with MTWAC.

The **Marine and Coastal (MaC) Hub** will, through the MTWAC led HCP processes, support the identification of priority values and threats to the Sea Country of *Tebrakunna,* including coastal wetlands. This will include an assessment of targets defined within the HCP. We will identify collaborative opportunities to advance priorities and address gaps in capacity (e.g. training opportunities in sea Country management for *Tebrakunna* Country Trainee Rangers), including through this project where possible given budget and time constraints. The project will also provide opportunities in sea Country assessment, monitoring and implementation of priority community needs in caring for sea County through connections to Country, species of significance and the Ancient coastline and land bridge. It will also contribute to adaptation to climate change, an understanding of issues such as microplastics impacts to cultural food sources and increasing development of land and sea based renewable energy infrastructure through strengthening future support of MTWAC gaining and/or informing a Sea Country Indigenous Protected Area in the north-east.

The **Resilient Landscapes (RL) Hub** would contribute to monitoring support of HCP Processes and *Tebrakunna* Country trainee rangers Tafe Units and associated program and planning to meet objectives of re-establishing a cultural burning program at *Tebrakunna.* This will include building on cultural knowledge and practice already returned to Country in the past few years to demonstrate improvements in biodiversity and regenerative vegetation outcomes. The recent years have seen regeneration of areas because of removing cattle, returning access of land to MTWAC/ returning people to place. Improvements have been seen since the return of cultural burning, including the regeneration of environmentally and culturally significant target species of flora and fauna. This will also likely contribute to bushfire risk reduction through addressing accumulated fuel loads since colonisation and adapting to future climatic pressures in the area. Understanding of these impacts will be delivered through project 3.17 within the Resilient Landscapes Hub (Improving environmental outcomes on conserved and managed lands).

The **Sustainable Communities and Waste (SCaW)** Hub will contribute to the development of a community wellbeing framework and tools. Improvements in wellbeing since returning to *Tebrakunna* Country have been expressed within the community. SCAW will assist in facilitating on-Country workshops with MTWAC to develop through a co-designed wellbeing framework, culturally-appropriate

methods and tools to assess wellbeing. These methods and tools can then be used for capacity-building and to examine the wellbeing through a Strength-based Approach. This component of the project will be delivered through project IP01.02.01 within the Sustainable Communities and Was Hub (Nature Connection: Indigenous led project on Nature Connection.

The **Climate Systems Hub (CS Hub)** will contribute at various stages of the project when information on climate pressures is required, and will involve various representatives from the Hub that are specialists in the different areas such as terrestrial climate projections, sea level rise, ocean warming and storm events. The CS Hub is working with MTWAC to develop a seasonal cultural calendar for *Tebrakunna* Country. This component of the project will be delivered through project CS4.3 (ConservationAdapt project) and project 2.5 (Regional guide for climate action) within the Climate Systems Hub.

End-user engagement

End-user engagement is focussed in two areas: the primary focus is MTWAC (see section on Research description and Indigenous participation and inclusion), the secondary focus is DCCEEW.

Engagement with DCCEEW will occur at several stages throughout the project. The scoping stage of the project has been informed by engagement with policy makers from DCCEEW (e.g. Science Partnerships Section and Oceans and Wildlife Branch). The project will also build in engagement mechanisms to ensure these end-users understand what the project is seeking to achieve and out-reach in the mid-stages of the project to communicate progress. The final stages will include engagement to communicate research findings and explore opportunities for applying MTWAC knowledge to protect their cultural heritage and protect and recover culturally important species and habitats.

Project 4.5– Developing an Integrated Pest Management Framework for Feral Pigs in Coastal Environments

Project type: Hub research project	
Cross-cutting initiative:	Yes Threatened and migratory species and threatened ecological communities Initiative
Project start date: 01/02/2024	**Project end date**: 11/12/2026
Project leader details:	Name: Dr Justin Perry Organisation: NAILSMA

Project description

Project summary

Feral pig populations are recognised as a current and future threatening process across most of northern Australia's species and ecosystems. They severely impact 1) threatened species, such as marine turtles, with up to 90% of egg and hatchling mortality attributable to feral pig predation, 2) culturally important places and 3) coastal wetlands, leading to increased greenhouse gas emissions. To date, feral pig control efforts across northern Australia are small-scale. What data we have suggests pig populations remain high, despite the significant annual investment in control, and there is currently no published evidence that quantifies a predictable relationship between control activities that reduce feral pig populations and the reduction of impacts in different habitat types. A new approach is needed. Integrated Pest Management (IPM) is a well-established approach to pest management in agricultural contexts and, over the last decade, has been successfully adapted for and applied to protecting biodiversity from invasive pest species. The aim of the project is to develop an IPM approach for effective feral pig control for biodiversity and cultural values protection, in coastal wetlands and ecosystems in northern Australia. The science-based IPM approach, informed by workshops with stakeholders and experts, will be implemented in up to three case study areas, principally by Indigenous Land and Sea management organisations and their partners, with data-driven analysis of effectiveness and recommendations for future evolution of the Strategy. This project addresses the Australian Government's national environmental priorities through mitigating impacts on threatened species, innovation in monitoring and increasing the participation and capacity of Traditional Owners and stakeholders.

Project description

Feral pig (*Sus scrofa*) populations are recognised as a current and future threatening process across most of northern Australia's species and ecosystems. Feral pig predation on a wide range of native species is well documented, including marine and freshwater turtles, frogs, lizards, annelids and 'ground nesting' birds (Heard et al., 2021; TAP, 2017). Of particular concern are their impacts on marine turtles, namely, the flatback (*Natator depressus*), olive ridley (*Lepidochelys olivacea*), hawksbill (*Eretemochelys imbricata*) and green (*Chelonia mydas*), with up to **90%** of egg and hatchling mortality attributable to feral pig predation (Nordberg et al., 2019; Whytlaw et al., 2013). The feral pig threat abatement plan (TAP), prioritises research and management to mitigate impacts on nationally threatened species such as these (TAP, 2017)

Feral pigs directly impact culturally important places, habitats, and species. In contrast to traditional harvest practices regulated by the frequency and timing of ceremonies and seasons, which contributed to sustainability of populations of target species, pig predation is unrelenting and non-discriminatory. This is threatening not just for the persistence of species but the ability of Aboriginal and Torres Strait peoples to continue traditional cultural harvesting practices.

Feral pigs are opportunistic omnivores and switch diets according to food availability (Barrios-Garcia & Ballari, 2012). In northern Australia, this translates to an increase in activity around billabongs and watercourses during the dry season (Corbett, 1995). Very few pigs are found more than 2 km from water, particularly in the dry season (Hone & Atkinson, 1983). Feral pigs are in their highest densities on coastal wetlands leading to extensive late dry season damage that includes disturbance of soil exposing roots and plant material (Bengsen et al., 2014). This disturbance regime has been linked to increased greenhouse gas emissions (O'Bryan et al., 2022). Currently, there is no published evidence that quantifies a predictable relationship between control activities that reduce feral pig populations

and the reduction of impacts in different habitat types. This makes it very challenging to understand how much investment is required and where effort should be applied to reduce feral pig impacts.

Feral pig control efforts across northern Australia are currently piecemeal, small-scale and what data we have suggests pig populations remain high despite the significant annual investment in control. Feral pigs are uniquely challenging to manage. Populations rapidly recover following control with more than 70% of the population needing to be removed annually to retain reduced populations. A failure to manage this challenging pest costs an estimated 87 million dollars per year (AgEcon, 2021).

A new approach is needed. Integrated Pest Management (IPM) is a well-established approach to pest management in agricultural contexts and, over the last decade, has been successfully adapted for and applied to protecting biodiversity from invasive pest species. A prominent example is the successful use of IPM principles and surveillance approaches for control of outbreaks of a coral predator (crown-of-thorns starfish - CoTS) on the Great Barrier Reef. IPM aims to achieve the most efficient and effective control of the pest given the available resources and ecological and logistic considerations. The successful adaptation of IPM concepts to the marine environment required an understanding of ecological process and dynamics of the crown-of-thorns starfish and a multidisciplinary research strategy (Westcott et al., 2020).

Conservation agencies across State and Territory jurisdictions have expressed a need for an effective science-based approach to feral pig control that can be applied across scales (TAP, 2017). The challenge here is to empower local communities and land managers to lead feral pig management whilst being able to scale the impacts through wise use of resources in an integrated approach. This project addresses the Australian Government's national environmental priorities through mitigating impacts on threatened species, innovation in monitoring and increasing the participation and capacity of Traditional Owners and stakeholders (TAP, 2017). The aim of the project is to develop an IPM approach for effective feral pig control for biodiversity and cultural values protection, in coastal wetlands and ecosystems in northern Australia.

This project is directly addressing research gaps and priorities in the Pig Threat Abatement Plan (TAP, 2017) and the National Feral Pig Management Action Plan Research, Development and Extension Plan (RD&E) (https://feralpigs.com.au/wp-content/uploads/2023/11/NFPAP-RDE-Plan-stakeholder-consultation-November-2023.pdf).

The Feral Pig TAP prioritises research projects that develop new control tools and models for feral pig management. This project is directly addressing this research priority through the practical implementation and testing of scalable integrated pest management with the express purpose of developing associated management and monitoring tools. This project will work with active feral pig control programs to value add their investment in control by integrating research and monitoring activities that directly inform their efficacy. We will focus on nationally threatened species and ecological communities impacted by feral pigs in tropical coastal ecosystems. Specially, our work will extend research into the protection of threatened marine turtles from feral pigs (Eastoe et al., 2023; Nordberg et al., 2019). Our proposal is inherently participatory and includes workshops, research and monitoring activities with land managers that are conducting feral pig management in different jurisdictions, tenures and habitat types. Our approach requires the social barriers for feral pig control to be incorporated into the framework and as such meets the second research priority in the TAP (social research in barriers for pig control). The TAP suggests that regional reviews of priority areas for feral pig control is required nationally. Our proposal will establish a framework for prioritising control that incorporates local, regional and national values. Our project will include the development and implementation of standardised monitoring tools that will support a more organic growth in the reporting of feral pig management activities that also offer feedback to managers at appropriate scales. The development of management plans suitable for different locations is highlighted as a priority in the TAP. In this project we expect the framework we are proposing, along with the associated monitoring tools, to supersede discrete management plans and instead offer a continuous adaptive management approach that can operate at multiple scales.

Our approach will be to harness a wide range of stakeholders and collaborating research institutions, including Traditional Owner groups, to mine current data, management experience and expert opinion on feral pig impacts and management effectiveness. A series of inception workshops will be held to establish an IPM research framework for feral pig control that will guide further investment into areas identified as data-deficient, for example, methodologies for surveillance and control. The resulting multi-disciplinary research strategy will inform and refine management actions to improve the coordination and performance of the feral pig control activities in coastal and floodplain regions of northern Australia for biodiversity protection. The research-informed IPM approach will then be implemented in up to three case study areas, with data-driven analysis of effectiveness and recommendations for future evolution of the Strategy.

Feral pig management programs have historically aimed to reduce pig populations with an assumption that this approach will reduce impacts on important values. However, previous programs have been dominated by control activities (such as aerial culling, trapping and baiting) with limited resourcing for monitoring the impact of control on defined values (Perry et al., 2021). This has led to ongoing investment in feral pig control with limited evidence of success. In projects where impacts on values have been explicitly quantified, broadscale landscape impacts were limited questioning the efficacy of existing approaches (Perry et al., 2021). There are some notable exceptions, such as reductions in feral pig depredation of marine turtle nests (Nordberg et al., 2019). In this case, successful impact was related to intensive local control of individual populations adjacent to turtle nest beaches and barriers placed on nests rather than broadscale aerial culling (Perry et al., 2019).

NESP researchers conducted the first comprehensive cross-disciplinary research project on feral pig impacts on ecological and cultural values in northern Australia (Perry et al., 2021). This project collaborated with Indigenous Land and Sea management organisations in the Archer River Basin, Cape York (Aak Puul Ngantam and Kalan Enterprises) who had identified the management of feral pigs as a significant threat to natural and cultural values on their land. Researchers quantified the relationship between feral pig damage and terrestrial invertebrates (J. C. Marshall et al., 2020), the efficacy of fencing (Negus et al., 2019), impacts on freshwater ecosystems (Waltham & Schaffer, 2021), terrestrial vertebrates (Perry et al., 2021), marine turtles (Nordberg et al., 2019), cultural values (Perry et al., 2021), the distribution of impacts by waterhole type (Glanville et al., 2023) and the efficacy of aerial control (Perry et al., 2021). This project provided some insights into the impacts of feral pigs and the effectiveness of control but highlighted a significant research gap in the relationship between control methods and impacts on multiple values (Perry et al., 2021). Specifically, there is no published relationship that quantifies the relationship between proportional reduction of feral pig populations and environmental impacts. As such, there is no evidence that investment in feral pig population reduction has associated benefits for different environmental and cultural values. This highlights the importance of conducting applied research that demonstrates the methods, monitoring and operational management tools required to effectively reduce feral pig populations, maintain the reduced populations over time and accurately quantify the impact on environmental values of the reduced threat, especially threatened ecological communities and species (TAP, 2017). By combining investment into feral pig management with investment into research, this project aims to bridge the gap between management and research to identify a framework for ongoing management at appropriate scales.

Recent conferences, such as the National Feral Pig Management conference in Cairns (June 2023) provided a comprehensive overview of significant investment into feral pig control activities across the nation (https://feralpigs.com.au/wp-content/uploads/2023/06/National-Feral-Pig-Conference-2023-proceedings-final.pdf). The conference included presentations on a successful feral pig eradication program on Kangaroo Island, South Australia (Korcz, 2023), successful management of feral pigs for the protection of marine turtles on Cape York Peninsula (Eastoe et al., 2023), government controlled

and funded national scale management of feral pigs with limited success in the United States of America (VerCauteren et al., 2023) and the challenges and efficacy of broad scale management of feral pigs in terrestrial habitats in New South Wales and Queensland in preparations for disease outbreaks (L. Marshall et al., 2023). These control and research programs focussed on broad scale management at national, state and regional scales and demonstrated a significant gap in successful frameworks for both understanding and controlling feral pigs at different scales and for understanding and protecting different values in variable habitat and land use types. The Kangaroo Island work demonstrated that it is possible to eradicate pigs locally when re-establishment is geographically constrained (Island ecosystems). This work demonstrated that in a discrete isolated site (Kangaroo Island) at scale (200,000 hectares) eradication is expensive (>$2 million), requires consistent effort (5 years) and rigorous monitoring is required (ongoing continuous monitoring using cameras, public sightings and aerial surveillance). Another presentation highlighted research that explored local eradication of feral pigs in connected terrestrial ecosystems in northern NSW (L. Marshall et al., 2023). This research exposed a gap in our knowledge in managing feral pig's reinvasion following control in terrestrial ecosystems. Given the successful eradication on Kangaroo Island, theoretically, feral pig sounders (breeding groups) could be locally eradicated to protect high value assets. Population recovery could be constrained if several overlapping sounders were controlled with buffer zones established to limit reinvasion pathways. However, this is theoretical, research is required to understand feral pig behaviour and population dynamics in natural, connected landscapes following extensive control aimed at local eradication. An additional complexity for maintaining reduced populations in connected terrestrial landscapes is the threat of human mediated population recovery (usually pig hunters establishing populations for more convenient hunting). The research focus has largely been on the local eradication of feral pigs but has not quantified the relationship between control success and ecological impact.

Research and management activities in this project will address both the ecological and social constraints into successful ongoing feral pig control and establish a comprehensive framework for evaluating the impacts of feral pigs on specific values. Feral pigs are an ideal study species here as they are highly fecund so reinvasion processes can be quantified within the project period. Our area of interest (tropical coastal ecosystems) are also well suited to this research as they are ephemeral systems that respond rapidly when feral animal pressure is removed (Perry et al., 2021).

If the aims and objectives of the feral pig threat abatement plan (TAP, 2017) and National Feral Pig Management Action Plan are to be achieved, applied research is required to be able to guide land managers in the best ways to manage feral pig impacts in their context. To do this, a systematic research and management program needs to be established at several pilot sites that reflect the constraints of management. We need to establish the essential knowledge base at spatial scales that are meaningful for management and test the research within a working feral pig management program with explicit metrics of success for well-defined values.

The applied research will enable decision support processes to be developed that will enable informed investment in control at appropriate scales with well-defined expected outcomes. The aims of this project mirror those of the CoTS program where scaling of impact occurred from local scale management (e.g. at a particular reef) embedded within a decision support model that met larger scale objectives (control of CoTS across the Great Barrier Reef) (Westcott et al., 2020)Here, we expect local feral pig management actions to meet national objectives through wise guidance of local management actions.

This project is important to establish a systematic and iterative approach to managing feral pigs. To date, there is no accepted method for successfully managing feral pigs and their impacts on biodiversity and agricultural values. Species and ecological systems impacted by feral pigs are both culturally important (Ens et al., 2015) and vital to the integrity of coastal and floodplain ecosystems. The Australian Government's Nature Positive Plan aims to reduce and repair threats to biodiversity by 2030. To achieve this ambitious goal, the management of ubiquitous invasive species such as feral pigs will be essential. As evidenced by the history of CoTS management, the management of

challenging invasive species requires a strategic approach, with appropriate and accessible tools and empowerment of local people to lead management activities. In the absence of an alternative approach that acknowledges and incorporates the substantial challenges of managing feral pigs, values will continue to be impacted.

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

This project will require several research phases to establish the data that will underpin a decision support tool that is accurately parameterised with location and seasonally specific data. This will include

- **i)** undertaking autecological studies of feral pigs at a variety of scales and contexts
- **ii)** defining values impacted on by feral pigs in each region,
- **iii)** developing and testing of management strategies at local and regional scales and
- **iv)** integration of ecological, social and infrastructure constraints into a decision support tool.
- **v)** Communication and scaling impacts

The scope of this project is coastal wetlands and beaches in northern Australia. The project will not explicitly seek to identify impacts or test management on freshwater wetlands and ecosystems.

i) Feral pig ecology and behaviour

A critical input into building a functioning decision support tool is to have detailed spatio-temporal data on feral pig movement and habitat use. These data enable accurate predictions to be made of how an action is likely to influence a population and the associated pressure on habitat values ((Glanville et al., 2023).

This project will assess and summarise current data and knowledge (including Traditional Knowledge) of feral pig life cycle attributes, distribution, dispersal and seasonal habitat preferences. We will do this through workshops with experienced wildlife management practitioners, Traditional Owners and through a systematic review of published and grey literature. This information will be workshopped to inform a modified IPM algorithm to identify knowledge gaps and uncertainty of existing data.

Additional pig ecology research will be conducted in case study locations during the project. The exact details of where and what will depend upon the outcome of the above review and consultation process but are likely to involve satellite-tracking, aerial surveys and remotely operated cameras to quantify baseline populations and categorise the population structure (total number, age and sex class distribution, occupancy).

ii) Defining values impacted on by feral pigs in each case study region.

At each of the case study regions we will work with Traditional Owners, researchers and land and sea managers to identify and quantify feral pig impacts on specific values. We will conduct a literature review to collate and categorise potential or known impacts on values in the area of interest and generalise these impacts to similar contexts to identify the utility of knowledge across northern Australia (i.e. how representative are the values and impacts). We will conduct a baseline survey of impacts across the coastlines and coastal wetlands at each case study site that focuses on the area where management interventions will be applied. Interviews will be done with Traditional Owners on Country at the case study sites to identify expected outcomes from management prior to any management activities occurring. A subset of the defined values will be selected to test the efficacy of control methods over time and a robust operational monitoring program will be developed with the Indigenous Land and Sea management organisations to quantify change.

iii) Developing and testing management strategies at local and regional scales including testing and selecting surveillance methods.

A critical part of the IPM approach is to understand the effectiveness of management activities in the context of the environmental constraints in time and space and the expected impacts on values. This project will experimentally apply common management strategies at the case study sites in a constrained area of interest. We expect each of the case study sites to reflect the average home range of feral pig sounders (around 30km), with two adjacent territories left un-managed to monitor changes in behaviour and reinvasion. Various control methods will be applied as appropriate (e.g. baiting, trapping, ground shooting, aerial shooting), and populations will be assessed following control to measure changes in population. At the same time the behaviour and movement of adjacent populations will be monitored to identify reinvasion by nearby populations versus repopulation by the animals not controlled. The selected values will be monitored in the management zone and in the adjacent unmanaged areas to enable value indicators to be regressed against population change.

iv) Integration of ecological, cultural, social and infrastructure parameters into an IPM approach supported by a management decision support tool.

The IPM approach will be applied to two/three sites where feral pig management is being undertaken. The approach (including surveillance and control) will be regularly upgraded and adjusted to improve efficiency and effectiveness of control. The selected values will be monitored to quantify the positive or negative impacts of the control methodology. This project will conduct the underpinning research to inform the development of a decision support tool. We will convert research outcomes into practical summaries that will inform management and monitoring methods. We aim to establish the architecture of an operational tool within the project period, however, we expect development and testing of an IPM decision support tool will require further development once operational challenges are exposed during this project.

v) Communication and scaling impacts.

This project is collaborating with the National Feral Pig Action Plan. The NFPAP has allocated 50k cash contribution to this project to support the scaling of regional collaboration. This funding will be used to resource the NFPAP Indigenous advisory panel (IAP) to widen the scope of participation in the IAP and develop communications materials for land managers suitable to guide management activities, monitoring and reporting. The NFPAP Research, Development and Engagement (RD&E) plan prioritises impact monitoring and informed strategic control. We will summarise project outputs under these broad headings and utilise the NFPAP national network of demonstration sites, website, and IAP to widely share the summary materials and integrate activities into the National implementation of the plan.

Communication materials will be developed to suit a broad range of end users. This will include local feral pig management practitioners such as Indigenous rangers and co-ordinators, state and territory government agencies responsible for feral pig management, regional organisations (such as NRMs) investing and supporting feral pig management and National Government agencies investing in feral pig management activities to reduce threats to priority species and ecosystems (TAP, 2017). In addition to communications materials, this project will also explore the development of useful operational tools (such as data collection applications and data management processes that provide direct feedback to guide continuous improvement of management activities) that enable research to be converted into management action.

The project will engage with government agencies and Indigenous land and sea management organisations throughout the project, We will provide advice and evidence to support the development of feral animal management strategies and operational frameworks that can be scaled across different tenures and jurisdictions. We are collaborating with the National Feral Pig Action Plan and the Department of Agricultural Fisheries and Forestry with the express aim of using research outcomes to inform management of feral pigs nationally with a specific emphasis on the use of the NFPAP feral pig management demonstration sites and DAFFs national investment in Indigenous ranger programs in northern Australia to manage feral pig impacts. This project aims to provide a tangible pathway to

achieve the aims of the feral pig threat abatement plan (TAP, 2017) through deep collaboration with agencies and organisations that are investing in feral pig management.

Details of related prior research, if relevant

This project will leverage the successful implementation of an IPM and decision support tools for crown-of-thorns Starfish (Westcott et al., 2020) and the control data and stakeholder networks thus far developed under the National Feral Pig Action Plan. The project lead is convener of the scientific committee of this action plan.

Feral pig impacts and control efficacy in northern Australia have been explored in a previous NESP project (Perry et al., 2021). This research explored biodiversity impacts from feral pigs and included exclusion experiments. This research identified the importance of categorising waterholes within wetlands to reduce confounding habitat-specific seasonal factors on biodiversity impact from feral pigs that were not universal at the wetland classification scale (Glanville et al., 2023). This research also identified important cultural waterhole classification approaches incorporating ecosystem service theoretical frameworks (Perry et al., 2021)

There is a wide range of research on feral pig movement ecology, population dynamics, habitat use and distribution, management efficacy, population dynamics, seasonal diet and surveillance methods that we will leverage to generalise our research within the existing knowledge base.

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

The project will link to work undertaken within the Resilient Landscape Hub for protection of threatened species and communities. It is also relevant to the Climate Hub adaption approaches for species protection in the face of climate change.

The project is relevant for the NESP MaC Hub large feral animal cluster of projects which includes projects 3.9 (led by Justin Perry and NAILSMA) focused on evaluating the logistic and capacity requirements for Indigenous groups to participate in large-scale feral pig control, 3.8 (UQ led, focused on estimating the carbon benefits that can be derived from feral pig control), 3.20 (CDU led – increasing capacity for Indigenous groups to participate in carbon markets) and 3.7 (JCU led – barriers to coastal and marine habitat restoration). These projects expose networks and partnerships across sectors and disciplines that will greatly enhance the project outcomes.

Summary of how the hub expects the research will be applied to inform decision-making and on-ground action.

Success is the development of a workable IPM feral pig control framework that is agreed to by most stakeholders, including Traditional Owners. The IPM will be tested by Land and Sea managers in an operational setting.

The approach will be steadily implemented and refined over the three years through the NESP MaC Hub funding, with research needs continuously identified and updated. Flexibility within the Hub management framework will allow the project to be annually updated as new information becomes available. The feral pig IPM program will inform and assist the implementation of feral pig control actions across Northern Australia. There will be three case studies of effectiveness where feral pig control is currently being undertaken, incorporating significant input and activity from local Indigenous Rangers.

Beyond the project, it is anticipated that State and Territory jurisdictions in partnership with World Heritage Management Authorities and on-ground implementation organisations will continue to use and upgrade the IPM approach to enable effective management of feral pigs for biodiversity protection at scale. The implementers of the National Feral Pig Action Plan are heavily involved in this project,

and it is anticipated the outcomes will be widely disseminated through that network. The MaC Hub knowledge broker will produce synthesis products for use by the Department of Climate Change, Energy, the Environment and Water in communications, as well as other stakeholders.

Project 4.6 – Developing Traditional Owner community-led dugong monitoring in the Kimberley region

Project type: Hub research project	
Cross-cutting initiative:	Yes. Threatened and migratory species and threatened ecological communities. Protected place management
Project start date: 01/02/2024	**Project end date**: 11/12/2026
Project leader details:	Name: Christophe Cleguer (lead) Organisation: James Cook University Name: Dean Mathews and Daniel Oades (co-leads) Organisation: ISWAG Name: Holly Raudino (co-lead) Organisation: Department of Biodiversity, Conservation and Attractions (WA)

Project description

Project summary

Dugong are a keystone species with considerable ecological and cultural value across northern Australia. In the Kimberley region of Western Australia, dugongs have been identified as one of the top priorities to monitor in an effort to ensure the population is maintained and traditionally harvested in a sustainable manner. This project aims to have Traditional Owners and ranger groups across the Kimberley use cost-effective and culturally appropriate approaches to (1) fill knowledge gaps on the dugong's population structure and connectivity at a range of spatial and temporal scales and (2) monitor the animals' presence, density and habitat use in areas that are ecologically and culturally important to the local community and state and federal managers. This program directly addresses the national priorities of conserving, protecting and sustainably managing biodiversity through research and information management.

Project description

Problem

The dugong (*dugong dugon*) plays a crucial ecological and cultural role as a mega-herbivore and serves as a significant food source in the traditional harvest of northern Australia. However, our current understanding of dugong abundance and distribution in the Kimberley region is limited to a single baseline broadscale aerial survey conducted in 2015 and 2017 (refer to Bayliss and Hutton 2017; also see Cleguer and Marsh 2023 for survey inventory and data accessibility). Conducting large-scale aerial surveys in remote locations like the Kimberley is a highly expensive, risky, and logistically complex endeavour, particularly when considering the need for long-term, continuous monitoring required for population trend analysis. Moreover, these surveys often fall short in providing valuable information regarding population structure and connectivity, both of which are crucial for effective regional dugong management. Thus, alternative methods are sought where local communities can monitor dugong presence and abundance at a local scale in a cost-effective way, as well as participate in regional assessments on the dugong population structure and connectivity at a range of spatial and temporal scales.

Years of collaboration with the Kimberley's Indigenous Saltwater Advisory Group (ISWAG) and the recent launch of a 10-year plan for sea turtle and dugong conservation (Turtle and Dugong Initiative) in the Kimberley region by ISWAG have underscored the necessity of a cooperative approach that bridges Western Science and Traditional (Indigenous) Knowledge. This approach aims to ensure the sustainability of dugong populations in Kimberley waters while also supporting Indigenous livelihoods, culture, and traditional practices.

Our project aims to rectify the aforementioned knowledge gaps and challenges by applying alternative innovative research tools to increase scientific knowledge on dugongs in support of management and fostering collaboration between scientists, the Kimberley region's Traditional Owners, and ranger groups. We will employ complementary methods to large-scale aerial surveys, providing insights into local-scale dugong presence, density and habitat utilisation at key sites within multiple sea countries. The aim will be to build a big picture of dugong distribution, population structure, and regional connectivity while working together to build capacity that will sustain long-term monitoring and joint management.

This project will expand upon Activity 3 and Activity 5 in NESP Mac Hub Project 3.10. Activity 3 is conducting a genetic-based connectivity study for dugongs across their entire range in northern Australia, but there is an identified gap in genetic samples from the Kimberley that requires filling.

Activity 5 used an engagement process to identify specific needs and priorities of Kimberley Traditional Owners for culturally appropriate management of dugong and saltwater country identified during the engagement process in Activity 5 of NESP Project 3.10.

The current proposal has three main areas of activity for the project:

Activity 1. Development of a community-led program to monitor dugongs at the local scale using small drones: NESP MaC Hub Project 3.10 Activity 5 revealed a strong interest from ISWAG in training community members to conduct dugong surveys using small drones in key ecological and cultural areas throughout the Kimberley. This will allow country managers and Indigenous rangers to build capacity for saltwater country management on their native title lands. Off-the-shelf drones have been shown to be suitable for monitoring this species at a fine scale in northern WA in the adjacent Pilbara region (Cleguer et al. 2021) but have yet to be applied for this purpose in the Kimberley. ISWAG members have expressed interest in upskilling rangers to be able to monitor dugongs using drones. This aligns with their aspirations under the Turtle and Dugong Initiative and various management and healthy country plans. This would also provide key information to feed into the hunting guidelines that are being developed by the saltwater groups in the West Kimberley. Further, if successful, it could be incorporated into ongoing efforts to monitor dugongs under the current Joint Management of the marine parks with WA State government. In recent prioritisation processes between the WA Department of Biodiversity, Conservation and Attractions, Yawuru, Bardi Jawi and Mayala, dugongs have been listed among the top priorities for monitoring. This project will provide the support needed in the Kimberley to develop a network of local dugong monitoring activities to inform regional management and conservation of the species. While NESP Project 3.10, Activity 5 provided seed funding to begin this process, funding from that project will only cover the costs of training ranger groups across the Kimberley. Additional funding is required to develop and implement post-training monitoring efforts, as well as to appoint a community-led coordinator who will oversee the work and act as a liaison with scientists. This will ensure that this monitoring technique becomes embedded in Healthy Country work plans and management. Our team will endeavour to also link this project with other NESP-funded projects focusing on seagrass habitat mapping across the Kimberley.

Activity 2. Assessment of the dugong population structure and connectivity across the Kimberley: Activity 3 of NESP Project 3.10 provides co-funding for a PhD study (2023-2026) focusing on dugong population structure and connectivity across northern Australia. Whilst that study can perform the analysis of samples, there is a need for a locally-based coordinator to help facilitate the collection, curation and sharing of dugong tissue samples from various Indigenous communities across the Kimberley. In this project, we seek funding to support an Indigenous coordinator representing the communities' priorities and questions on connectivity of dugong populations that can be answered through genetic analyses.

Activity 3. Understanding the movement and habitat use of dugongs at the individual level and at a range of spatial and temporal scales:

Large-scale connectivity studies through genetics and local-scale monitoring via drone surveys provide important data to estimate local abundance as well as large-scale connectivity, however, such studies often lack the temporal resolution necessary to discern the reasons for local and regional redistribution of populations, which is crucial for the interpretation of monitoring data, as well as the design of surveys in the first place.

The objective of Activity 3 is to use telemetry tracking devices to understand how dugong distributions change over diel, tidal and seasonal scales to support both the design of monitoring protocols and to provide data relevant for the spatial management of dugong populations. This approach will provide a complementary tool to both drone monitoring and genetics. Especially in the case of the Kimberley,

where some of the largest tides in the world and drastic seasonal changes between the dry- and monsoon seasons are expected to result in changes in nearshore animal distributions.

GPS-linked satellite tags will be used to understand both localised movement as well as regional dispersal over periods of weeks/months. Acoustic telemetry will be utilised to understand localised movements over months/years, initially in the Roebuck Bay-Broome area.

Support through the WA Department of JTSI has provided an opportunity to commence this work by funding fieldwork costs and purchase of tags. However, some crucial funding gaps remain, specifically related to staff time for the analysis of data, Indigenous ranger engagement in fieldwork and planning, as well as aerial support to efficiently locate dugong herds for tagging. Furthermore, the establishment of an acoustic array in Roebuck Bay, funded through the Integrated Marine Observing System coastal infrastructure initiative (IMOS) and maintained by Murdoch University (MU), provides an opportunity to study dugong distributions over extended temporal scales to inform management actions by the Yawuru/DBCA joint management body. It is hoped that the array will be regionally expanded in collaboration with TOs in the future to enable long-term regional tracking of dugong.

Research plan

The research will be undertaken as follows:

Overall: support ISWAG in the creation of a community-based coordinator (CBC) position to support Activities 1 and 2 and, to some degree, Activity 3 (complementary funding for this position being secured in the JTSI project). The coordinator will be responsible for liaising with teams of scientists and members of the community across the Kimberley to co-organise training activities, workshops, fieldwork, data analysis and reporting.

<u>Activity 1. Development of a community-led program to monitor dugongs at the local scale using small drones:</u>

Train ISWAG members in the use of small-drone survey methods for local dugong mapping. This training program will encompass both theoretical and practical components, including site selection, data processing techniques, mapping methodologies, developing flight plans and conducting training drone surveys.

Following the training, an additional day will be allocated for trainees to brainstorm and apply their newfound knowledge in the field, specifically by defining the objectives of their future drone surveys, selecting survey locations, and determining survey frequency. It is important to note that the exact survey frequency may be challenging to establish until the training is completed, and partners involved have a clear understanding of the capabilities and limitations of drone surveys. This aspect is covered under the funding secured in Project 3.10.

Work with end-users, including ISWAG members, government, management agencies, and research agencies to identify priority areas for local dugong drone surveys, and opportunities for future co-investment in surveys.

Partner with ISWAG to co-design the small-drone surveys (site locations, seasonality of surveys etc.) and ensure that ISWAG members have the capacity to take ownership over the implementation of the surveys, including the data processing, mapping and reporting. The small drone survey method will be inspired from Cleguer et al. (2021)'s work developed in the Exmouth Gulf and the Pilbara region.

Bilingual maps of dugong distribution (as well as that of other species of marine megafauna detected in the imagery) will be produced if agreed to by the Traditional Owner partners.

Create a publicly available data layer of the distribution of dugongs and other marine megafauna across the Kimberley in a format compatible with the eAtlas interface. Data and metadata will

also be available with downloadable GIS shapefiles (which may be buffered) as appropriate from both a cultural and specially protected species point of view.

A likely add-on / project risk mitigation application of local dugong drone mapping work will include the use of the same drones to collect baseline information on dugong morphometrics and body condition. Development of this method is starting in early 2024 via a NESP-JCU funded PhD scholarship. For example, if there is an insufficient number of dugongs in one of the survey sites, the drones could be used to collect photographs of the few dugongs present in the area for body measurements.

Activity 2. Assessment of the dugong population structure and connectivity across the Kimberley:

Liaise with the CBC to develop a research agreement between ISWAG and scientists to certify that each party understands expectations and to provide protection for organisations and communities involved in the research and for researchers and research institutions, especially with regard to sample and data sharing.

Develop a standardised protocol, kits and hands-on training for the sampling of dugong tissues.

Liaising with rangers, the hunting community and providing guidance in the collection of samples and ensuring the appropriate and safe storage of samples to optimise the viability.

Report back to end users/Traditional Owners/ranger groups/communities via communication means and products that they request, e.g. on country and/or online meetings and community brochures.

Activity 3. Movement and habitat use of dugongs at the individual level and at a range of spatial and temporal scales in one key location:

Undertake collaborative fieldwork with Yawuru Traditional Owners to tag dugongs in Yawuru Sea Country.

Analyse dugong movement in relation to diel, tidal and seasonal scales.

The complementary funding sought in this project to appoint a post-doc will mean that the post-doc will also contribute to multiple NESP activities in this project.

Why is the project a priority

In Australia, the dugong is a Matter of National Environmental Significance because it is listed as a migratory and marine species under the Environment Protection and Biodiversity Conservation Act. The dugong is also listed as Vulnerable under the Nature Conservation Act 1992 (Qld) and at a global scale (Marsh and Sobtzick, 2019).

Australia is a signatory to several international agreements that define its obligations to protect dugongs, including the Convention on Migratory Species and its Memorandum of Understanding on the Conservation and Management of Dugongs and their Habitats throughout their Range (Dugong MOU). Signatories to the Dugong MOU agree to cooperate to restore or maintain a favourable dugong conservation status.

As the only surviving member of the family Dugongidae (Marsh et al. 2011), the dugong is a species of high biodiversity value. Anecdotal evidence suggests that dugong numbers have decreased throughout most of their range (Marsh and Sobtzick, 2019), which is the basis for their global listing.

Significant populations persist in Australian waters, which are now believed to support most of the world's dugongs.

Sea turtles and dugong hold significant cultural and conservational significance in the Kimberley region. This project falls within ISWAG's 10-year plan for turtle and dugong conservation. The plan is led by Indigenous saltwater managers across the Kimberley region. Sea turtles and dugongs are facing threats to their habitats both in the Kimberley and around the world. Dugongs are culturally significant to all relevant Native Title groups and are high on the priority list of Healthy Country and marine park management plans for those groups. Beyond being a primary food source over the years, the traditional knowledge of this species is immense.

The Kimberley region has for many years remained one of the last near-pristine coastal environments in the world. With sea temperatures increasing, the health of Kimberley marine habitats, such as coral reefs, is being impacted by climate change. The impact these changes have on the dugong populations is currently not well understood across the Kimberley and the current data is insufficient, making it difficult for managers to assess their conservation status confidently in their sea countries. This project will greatly increase the capacity of Indigenous Rangers to monitor their dugong populations.

Details of related prior research

Project	Details
NESP2 3.10 A partnership approach to filling key knowledge gaps on dugongs in northern Australia using novel technologies (ongoing, Cleguer, Groom, Raudino)	Five activities (aerial imagery work in the GBR, aerial survey of Shark Bay-Ningaloo-Exmouth Gulf, development of drone-based methods to assess the body condition of dugongs, dugong genomics across northern Australia) contributing to addressing key dugong knowledge gaps across northern Australia. Transversal to the activities described below is a strong partnership approach with Traditional Owners and members of the wider community.
NESP2 1.20: An inventory of dugong aerial surveys in Australia (Cleguer and Marsh 2023)	Inventory of all aerial surveys ever undertaken in Australia to assess the presence, habitat use, abundance and distribution of dugongs. Inventory of literature reference and data accessibility. Insights into methods of abundance and trends estimation and spatial modelling.
WAMSI Project 1.2.5: Integrating Indigenous knowledge and survey techniques to develop a baseline for dugong (*Dugong dugon*) management in the Kimberley (Bayliss and Hutton 2017)	Abundance and distribution of dugong (aerial surveys), movements and diving behaviour (telemetry tracking), integrating Indigenous and scientific knowledge of dugongs.

Links to other research

Project/Research/Work	How our project links to other research
JTSI (MU-led)	Integrating ecological, social and cultural values of WA's coastal waters: the case of Yawuru Nagulagun (Roebuck Bay)
Integrated Marine Observation System (IMOS)	IMOS Acoustic Tracking – Coasts & Estuaries Initiative, Lead Rob Harcourt Macquarie University
E02165 Advancing new tech to improve dugong research (JCU-led)	Research to trial and improve telemetry tags, drone specs and genetic tools to improve dugong research

E02166 Enhancing Dugong AI (JCU-led)	Research to advance AI to detect marine megafauna with a focus on dugongs

Summary of how the hub expects the research will be applied to inform decision-making and on-ground action

The research will address key priorities identified by ISWAG in the Turtle and Dugong Initiative, Marine Park management and Healthy Country Plans. It will support Indigenous-led decision-making in sea country regarding dugong use, and provide an evidence base for indigenous, state and federal government-protected area planning. It will also support government agencies in supporting conservation actions for dugongs.

Data, metadata, and spatial layers created will be secured on a server with ISWAG, DBCA and James Cook University (JCU) perpetually and made publicly available through online repositories as appropriate. Telemetry data will both be stored on JCU, IMOS and Murdoch servers, as well as with Nyamba Buru Yawuru, following the development of a data management plan. Metadata and final spatial layers will be submitted to eAtlas to be held perpetually. The DNA samples collected by DBCA/ISWAG will be owned by ISWAG and shared with JCU to support a PhD study. The details of data sharing and use will be developed as part of a research agreement between DBCA/ISWAG and JCU. Activities related to the JTSI project (dugong tracking) have an existing multi-part collaborative agreement that will be adhered to as part of this research.

Project 4.7 – Development of regional modelling and risk assessments to inform offshore renewable decision-making.

Project type: Hub research project	
Cross-cutting initiative:	Yes Threatened and migratory species and ecological communities Protected places management
Project start date: 04/03/2024	**Project end date**: 10/12/2026
Project leader details:	Name: Keith Hayes Organisation: CSIRO Data61

Project description

Project summary

The project aims to: a) demonstrate the application of species-specific population dynamics models, and whole-of-ecosystem models, to estimate the impacts and risks of installing new offshore wind infrastructure in Australian waters; and, b) through these demonstrations develop a shared understanding between the NESP MaC Hub and key stakeholders within the Department of Climate Change, Energy, the Environment and Water (DCCEEW) and other relevant agencies such as the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), of the approaches, methods and data required to conduct risk assessment for resident, static and migratory species that could be impacted by the development of offshore renewable energy (ORE) in Australia. The project will use the recently declared Gippsland region as a case study, together with the 12 ORE impact pathways identified by DCEEW, to contextualise the quantitative modelling and cumulative risk calculations that will be performed. Finalisation of project scope and deliverables are to be discussed at a proposed meeting of key DCCEEW and NOPSEMA research-users in late January prior to completion of the project workplan.

Project description

Problem statement

Offshore renewable energy generation is expanding rapidly as the world transitions towards clean energy sources. Australia has abundant, high-quality, offshore wind resources in many locations (Briggs *et al*., 2021) and the federal government has recently declared two areas on the continental shelf suitable for ORE development -- the eastern Bass Strait and Hunter regions, with a further two areas offshore of the Illawarra and Portland regions currently undergoing public consultation. Further areas on the west coast are also expected to be declared.

The installation of ORE facilities in Australian waters will simultaneously create novel risks (e.g., turbine collisions) while augmenting (e.g., acoustic disturbance and vessel strikes) or changing (e.g., commercial and recreational fishing) the distribution of existing pressures that threaten marine habitats and associated species, particularly migratory and threatened species such as birds, marine mammals, sharks and rays. Quantifying the cumulative effects of offshore wind farms adding to and changing the existing pressures faced by marine species, at whole of life-cycle relevant scales, will require a shift towards assessment methods that acknowledge ecological connectivity within a more holistic, regional/sea-basin scale perspective (UN Global Compact, 2021). This shift will require consideration in the way that relevant guidance material (such as NOPSEMA's guidance on environmental plans https://www.nopsema.gov.au/node/531) is typically implemented.

A methodology for probabilistic, cumulative, risk assessment for resident and static environmental values has already been developed by CSIRO and applied to new coal seam gas and coal mine operations (Hosack *et al.*, 2017). Cumulative probabilistic risk assessment for migratory species, however, is significantly more difficult and will require innovative risk assessment approaches. The individual components of the necessary methodology, however, are well established and proven albeit in different contexts. The innovation occurs in the overall risk assessment design, guided by the incorporation of stakeholder and Indigenous cultural values into a Problem Formulation stage, and in the use of two different modelling strategies – a species-specific and a whole-of-ecosystem approach – employed in a complimentary fashion.

Similar species-specific and whole of ecosystem methods to address ORE risks are being considered in the USA and Europe (for example Marchand *et al*., 2022). We cannot, however, simply adopt approaches developed overseas as they will not match the Australian context, both in terms of the ecosystem and species involved, but also the policy frameworks, objectives and expectations.

Description of research

Risk assessments comprise three core components: (i) hazard identification, (ii) exposure and effects analysis; and (iii) risk estimation (Renn, 2008) (Fig. 1). These components are usually preceded by a description of the stakeholder values that are perceived to be threatened by the activity or activities in question and concluded by an assessment of monitoring needs and risk mitigation strategies.

Stakeholder and cultural values

The project will focus on the species identified by DCCEEW as priorities for the Gippsland declared area. The project will rely on the outcomes of NESP project 3.21 to identify relevant datasets and any associated impediments to access and re-use. The project may use the outcomes of NESP project 3.3 to help identify relevant cultural values. The Indigenous component of project 3.3 is detailing the Indigenous communities that are likely to intersect with the declaration areas and identifying any Sea Country Plans, cultural mapping, etc. that may hold relevant information. The project will not undertake detailed participatory values mapping with local Indigenous communities but will use this type of information if it is made available. Where possible the project will also draw upon other potentially relevant projects in the NESP hub's 2024 and 2025 research plan, including connecting Indigenous values of cetaceans across south-eastern Australia (project 4.3) (see Fig. 2).

Hazard identification

The potential impacts associated with offshore renewable energy generation in Europe and the USA have already been extensively documented (Galparsoro *et al*., 2022), and 12 critical impact pathways have been recently identified by the Australian federal government (DCCEEW, 2023). This project proposes to contextualise the approaches it proposes by formulating each of these impact pathways within the Problem Formulation methodology that develops testable risk hypothesis (Raybould, 2006), within the context of the declared Gippsland OEI area. The project will introduce the department to the objectives and methods of Problem Formulation, from a regional, rather than individual development, perspective. The problem formulation stage will inter alia re-formulate each of the impact pathways identified by DCCEEW into causative chain of events that link pressures -- new, augmented, amended or existing -- to clearly defined harmful outcomes on the species and habitats identified by the department and other stakeholders, and importantly identify what parts of this chain are most readily observed in order to (in)validate risk predictions, and how this chain of events can be most readily interrupted by new or existing risk mitigation strategies.

Exposure and effects assessment – key species

Many of the 12 critical impact pathways identified by the department – such as collisions between turbines and birds (or between vessels and marine fauna), the effects of underwater noise and electro-magnetic fields on sharks, rays and marine mammals, and the displacement of these fauna due to the noise, light or the physical presence of new infrastructure – will require species-specific exposure and effects assessments. Species-specific exposure assessments should be informed by existing information such as Biologically Important Areas (BIAs), data sets such as those identified under NESP projects 3.3 and 3.21, and where necessary additional expert opinion, to identify important breeding, over-wintering or foraging areas and migration pathways for birds, marine mammals, sharks and rays, with a focus on priority threatened species identified by DCCEEW for the Gippsland region. Information generated in projects 3.3 and 3.21 will be important to evaluate the specific local, regional and international data that is relevant to this objective (see Fig. 2). Both of these projects will be completed during the early part of the project. In addition, projects 4.8 and 4.9 will provide additional new information on blue whales and southern right whales that will inform the assessment of risks (Fig. 2).

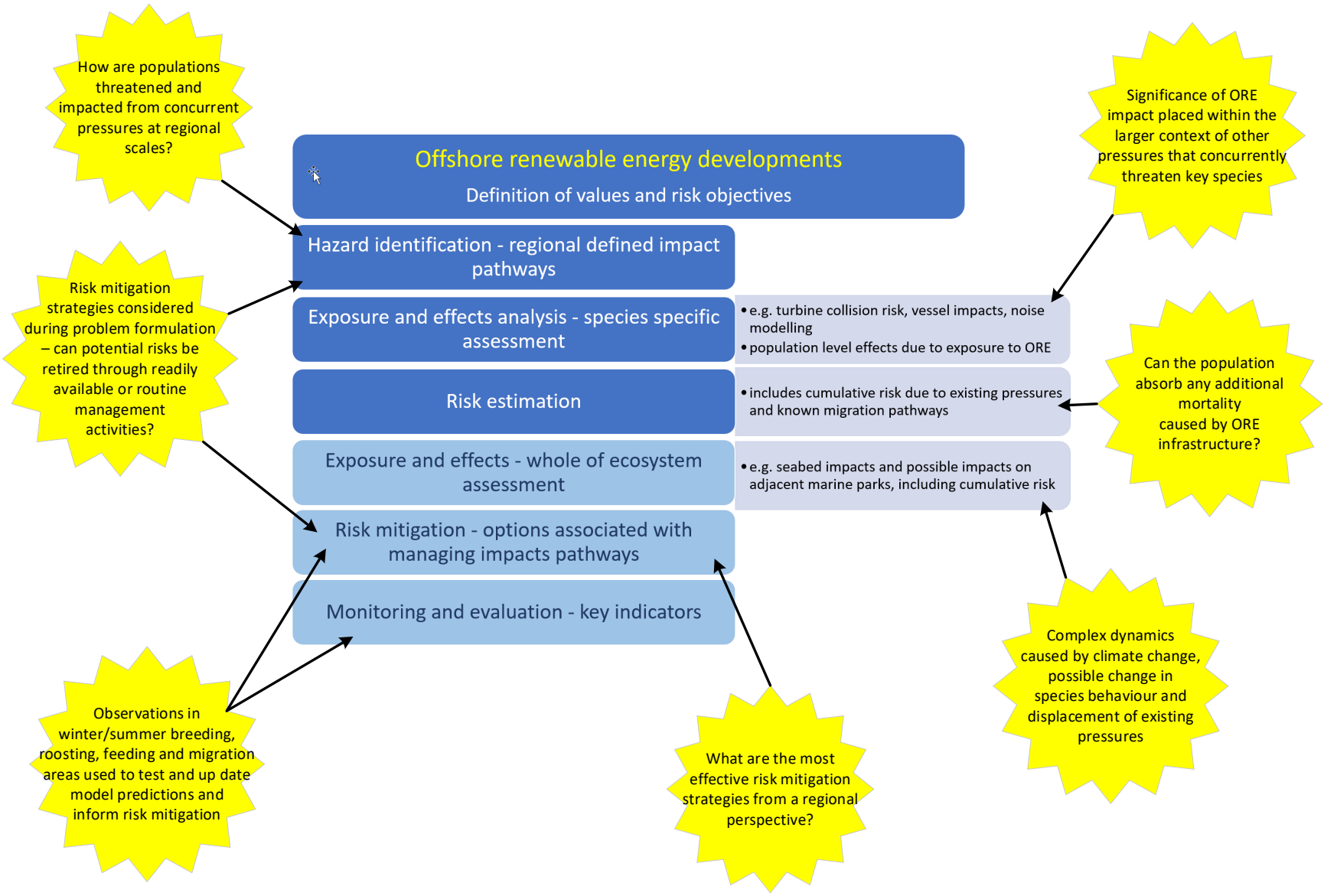

Fig. 1 Components of risk assessment process and key questions and information considered during the steps

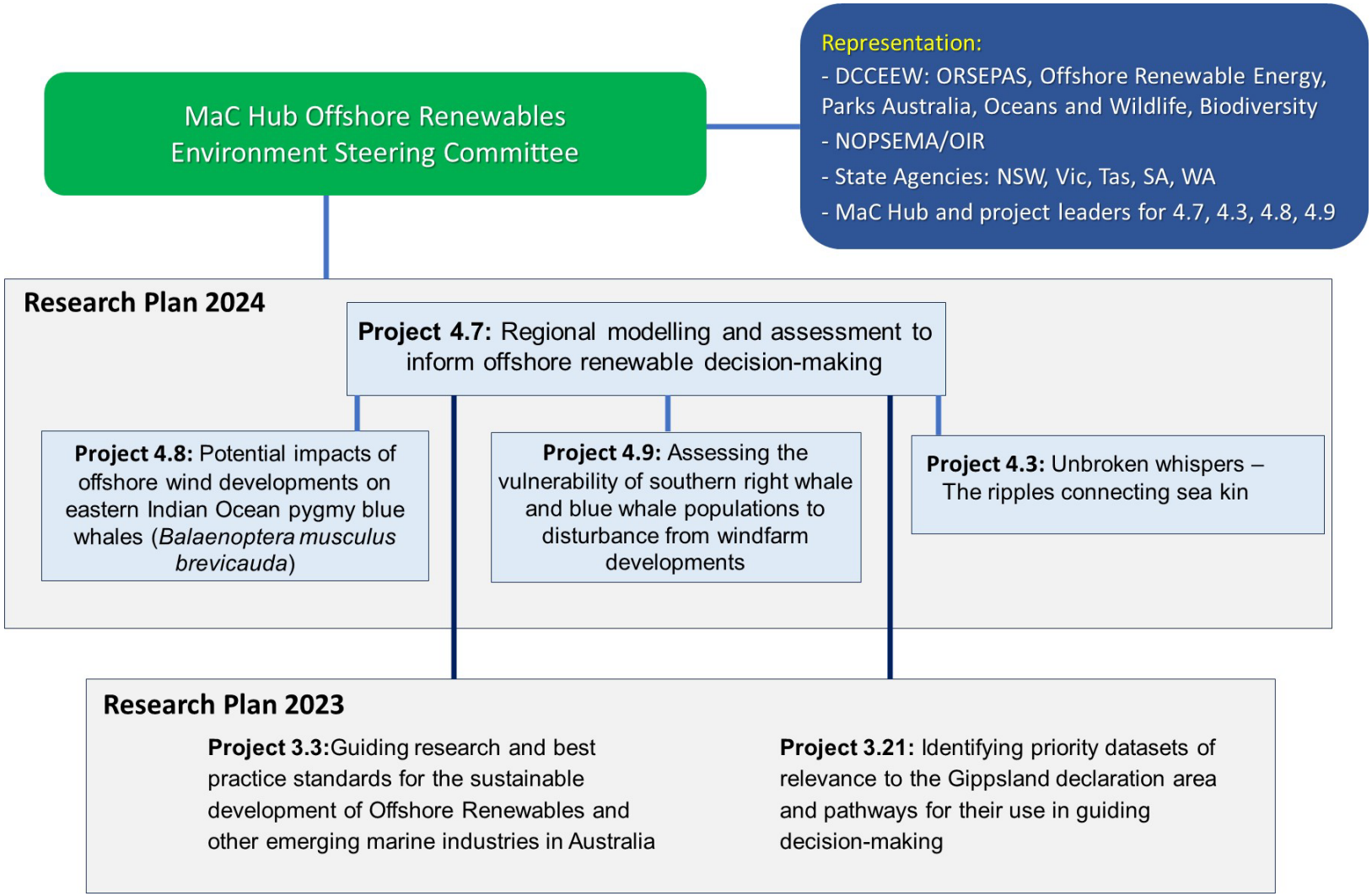

Fig. 2 Description of projects within RP2023 and RP2024 relevant to offshore renewable energy that will contribute to information to support assessment and modelling within the project, and relationship to proposed ORE program steering committee. This steering committee will be supported by the Hub executive.

Quantitative exposure assessments will require models such that can predict the probability of animal presence and density through time (e.g., Patterson *et al*., 2008) and accurately reflect observed behavioural shifts associated with BIAs. These models will need to predict movements of animals through proposed OEI areas and parameterise the likelihood of encounter with infrastructure and potential behavioural changes that are relevant to population sustainability and individual animal welfare concerns. Quantitative effects assessment will require species-specific turbine collision risk (e.g., Masden and Cook, 2016), vessel impact (e.g., Womersley *et al*., 2022), noise propagation (e.g., Erbe *et al*., 2012) and impact models (e.g., Pirotta *et al*., 2018), for example, to estimate morbidity or mortality attributable to offshore wind farms. World-leading expertise on marine noise has been included in the project team to ensure the best available information is applied to these assessments. Project 4.9 will also provide an important contribution to the understanding of collision risk.

Contingent on DCCEEW support, the project will develop an agreed number of population models for key threatened and migratory species, building wherever possible on existing models (for example Grey Nurse Sharks under NESP project 3.13) to estimate the population level effects of the mortality or morbidity following exposure to the impact pathways associated with offshore wind farms. To assess the cumulative risks to long term recovery and sustainability, these population models must be developed at a scale that reflects the breeding, over-wintering and foraging and migration regions of each species to assess the population-level consequences when the mortality/morbidity caused by impacts with, or avoidance of, offshore wind farms is added to the mortality/morbidity experienced by the population (e.g., Butsch and Garthe, 2017) because of existing pressures such as climate change, land-use changes, or the effects of feral and non-native species.

Exposure-effects assessment – whole of ecosystem

Some of the 12 impact pathways identified by the department – such as the effects of physical presence on hydrodynamics and sediment transport, including seabed disturbance and loss of/harm to benthic habitats, and the multiple pathways leading to possible impacts on Australian Marine Parks (AMPs), are best addressed through a whole of ecosystem approach to exposure/effects assessment, in collaboration with, the MaC Hub RP2024 project 4.20.

The project will use new or existing regional-scale hydrodynamic models to parameterise the physical components of a whole-of-ecosystem (WoE) model, such as Atlantis (Fulton *et al*., 2019), and will use the WoE model to predict the effects of displacing other activities (particularly commercial and recreational fishing), the trophic effects that may occur due to the attraction of fish and other fauna to offshore infrastructure, and the whole of ecosystem effects of regional (or site-specific) pressures such as the construction and operational footprint of wind energy generation (e.g. noise effects, increased traffic servicing installations etc) in combination with climate change effects on oceanic wind and heat properties and major circulation patterns.

The geographical scope of the WoE model will reflect the entire life cycle of key species and will be designed to combine the effects of new, amended or existing pressures to identify possible non-linear, super-additive or antagonistic responses in critical ecosystem components. Its spatial and temporal resolution will likely be coarse, at least in parts of the model domain, but it will examine finer scales in the immediate area of the ORE leases. The project envisages that the WoE model will help quantify cumulative effects and inform the structure and parameterisation of the species-specific population models, for example by identifying possible changes to foraging or migration behaviour due to changing ocean circulation patterns caused by the combination of climate-change and local-scale impact of ORE infrastructure. Moreover, the combined set of models provides greater weight of evidence (across a broader set of spatial-temporal scales) around potential effects on the key species.

Risk estimation

The project proposes to employ a suite of different models to estimate the cumulative risks associated with new ORE infrastructure. This is because cumulative exposure and effects assessments require

multiple types of models that facilitate learning, methodology formulation and decision support. The spatial scope and resolution of these models will be determined by the proposed location of offshore wind farms and the behaviour over the entire life cycle of the species potentially at threat, thereby incorporating all relevant breeding, foraging and over-wintering locations (in terrestrial, coastal and marine environments) and migration pathways between these locations.

The project's species-specific population models will estimate population-level impacts on threatened and migratory species will be deliberately designed to: (i) assist decision making; and (ii) be readily tested against empirical observations. These models will be as simple as possible while still being able to incorporate uncertainty and be updated with monitoring data (e.g., Dennis and Ponciano, 2014). Typically, these models will evaluate population change and distribution of individual species. These models can be used to test the likely effect of management decisions or data-collection and monitoring schemes. This is likely to be a joint approach whereby these models can be considered alongside (or even nested within) the broader outputs of the whole of ecosystems models.

The whole of ecosystem model will focus on the potential (non-linear, compounding) effects that may cascade through food-webs due to changes in physical or biological processes. This provides regional and long-term context to assessments and will assist in identifying synergistic effects where risk mitigation has an enhanced return on investment. It also creates a testbed for how well species-specific models will inform decision making (i.e., when they are/are not reliable, and what kinds of contextual information can be used to increase reliability and reduce uncertainty or potential biases). This approach to the use of whole-of-ecosystem models is widespread in fisheries and has been used to good effect in cumulative effects assessment in Norway to understand the effect of cumulative pressures, help structure regional plans and design monitoring schemes that ultimately reduce costs versus a proponent-by-proponent, development-by-development approach (Hansen *et al*., 2019).

Risk mitigation and monitoring

The objective of post-assessment monitoring is to track the state and response of key species, natural assets and the broader state of the ecosystem. Through this monitoring, data can be used to test the risk hypotheses made during the problem formulation phase, and thereby (in)validate the risk predictions made by the risk assessment (i.e., to check whether the assessment is matching reality and is thus reliable as a basis of decision making).

The project's population dynamic models will be used to determine the ongoing monitoring requirements at a species-specific level. These models will be developed so that they can: (a) be informed by existing monitoring data; (b) inform and be updated by future monitoring data; and (c) be used to evaluate management and mitigation response to ORE and other relevant stressors on the population. By explicitly identifying gaps in the knowledge of critical population impacts, the models will also be useful for prioritisation of future research within the NESP or other research programmes.

Monitoring strategies should address the direct and indirect pressures and key ecosystem indicators identified by the whole of ecosystem model, and the monitoring design should be informed by the key locations, timing and scales identified by this model. Such a monitoring scheme will allow for transparent evaluation of whether risk mitigation is indeed reducing cumulative effects and conserving stakeholder and cultural values. Furthermore, any monitoring should be designed to complement the monitoring in development for AMP management effectiveness.

The project will discuss the feasibility of development-specific risks mitigation strategies, such as changes in design, judicious placement of structures and scheduling of activities, and the imposition of operational constraints, with DCCEEW and NOPSEMA within the project's first year. This is important because it may allow certain risks to be retired (https://tethys.pnnl.gov/risk-retirement) and thereby help inform the scope of any subsequent cumulative risk assessment. The effect of potentially costly but feasible strategies, when applied at individual or regional scales, can be quantified using the modelling components described above. Importantly, the whole-of-ecosystem modelling components

can also be used to test the effects of whole-of-life cycle, area-wide, mitigation strategies such as managing introduced species within breeding habitats or changes to marine park zones, which may have greater population-level benefits than risk mitigation strategies applied to ORE infrastructure.

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Project 4.8–Potential impacts of offshore wind developments on eastern Indian Ocean pygmy blue whales (*Balaenoptera musculus brevicauda*)

Project type: Hub research project	
Cross-cutting initiative:	No
Project start date: 01/03/2024	**Project end date**: 28/02/2025
Project leader details:	Name: Luciana Cerqueira Ferreira Organisation: Australian Institute of Marine Science Name: Michele Thums Organisation: Australian Institute of Marine Science

Project description

Project summary

Pygmy blue whales (*Balaenoptera musculus brevicauda*) are listed as Endangered under the Environment Protection and Biodiversity Conservation Act (EPBC 1999), and their distribution and Biologically Important Areas (BIAs) overlap with areas proposed for offshore renewable energy (ORE) development in Western Australia, South Australia, Victoria, and potentially NSW. This project will quantify (largely from telemetry data) the distribution and location of areas of residency (e.g., foraging) for eastern Indian Ocean pygmy blue whales, where these overlap with proposed ORE developments, and assess the potential impacts of these developments to the species in addition to existing impacts from other anthropogenic activities (see Table 1 for terminology). Project outputs, including spatial products and raw data, will be made publicly available and we will also identify future research and associated data collection needs. These project outputs will assist government, regulators, proponents, and other stakeholders in the assessment and mitigation of ORE projects to this threatened species.

Project description

The offshore renewable energy (ORE) sector is rapidly developing in Australian waters with several areas proposed for development off southwest and midwest Western Australia, the Bass Strait region in Victoria, and the Hunter region in New South Wales. As such, Commonwealth (and State) agencies responsible for licensing and regulation under environmental legislation (e.g., EPBC Act) urgently require scientific evidence-based data and information to support decision-making, and to drive efficient regulatory processes for this newly developed industry. In July 2023, DCCEEW published their guidance document for impact assessment of ORE developments indicating the statutory requirements under the EPBC Act in addition to key environmental factors considered pertinent to ORE. These included appropriate consideration for potential cumulative effects, and avoidance of overlap with biologically important areas for listed threatened and migratory species (DCCEEW 2023). Additionally, the NOPSEMA Research Strategy 2023-2025 indicates the need for improved understanding on species, processes and industry activities to support impact and risk assessment as a primary goal for the agency (NOPSEMA 2023).

In Australia, blue whales (*Balaenoptera musculus*) are listed as Endangered under the EPBC Act and various Acts in State waters. The pygmy blue whale (*Balaenoptera musculus brevicauda*) is one of two recognised blue whale subspecies in the Southern Hemisphere. The blue whale's conservation listing in Australia makes it subject to a National Recovery Plan under the EPBC Act (Commonwealth of Australia 2015) and spatial areas of importance to pygmy blue whales have been identified therein, known as "Biologically Important Areas" (BIAs) (Figure 1). BIAs are areas where biologically important behaviour occurs such as calving, foraging, resting or migration (Commonwealth of Australia 2015). The BIAs were defined largely by using the limited empirical data, scientific literature, and personal field experience of experts. Since their publication in 2015, more data have been collected (Figure 1) and the BIAs for blue whales are now under review.

The eastern Indian Ocean sub-population of pygmy blue whale is known to migrate between Australia and South-East Asia offshore of Western Australian, South Australia and Victoria (Double et al. 2014, Möller et al. 2020, Thums et al. 2022). The species has inter-annual foraging sites within Australian waters off the Bonney Coast and Perth Canyon (Double et al. 2014, Möller et al. 2020), where BIAs have been delineated (Figure 1). But foraging movement behaviour, identified in satellite tracking data from slow speed and high number of turns (so called milling or area-restricted search) and increased time spent in areas, also occurs at other places along their migration route (Möller et al. 2020, Thums et al. 2022). The pygmy blue whale distribution, including migration routes and foraging locations overlap with areas subject to oil and gas exploration and extraction, fishing and shipping activity

(Commonwealth of Australia 2015, Thums et al. 2022, Ferreira et al. In press), exposing whales to potential impacts of vessel strike and underwater noise which can elicit behavioural and physiological responses, and deterrence from feeding, with potential consequences to fitness of individuals and populations. In addition, the pygmy blue whale distribution also overlaps with proposed ORE development sites (located in State and Commonwealth waters) (Figure 1) potentially exposing the species to cumulative threats across their distribution in the future. NESP Marine and Coastal Hub's key end users (DCCEEW, NOPSEMA) identified pygmy blue whales as a priority species for understanding potential impacts, and specifically, the need for data on their distribution and foraging areas in relation to ORE developments (DCCEEW 2023, NOPSEMA 2023). Here, we propose to assess the spatial overlap between ORE proposed and declared areas and pygmy blue whale distribution (including areas of high residency such as for foraging) and undertake a cumulative impact analysis as has been done in the north-west of Australia (Ferreira et al. In press).

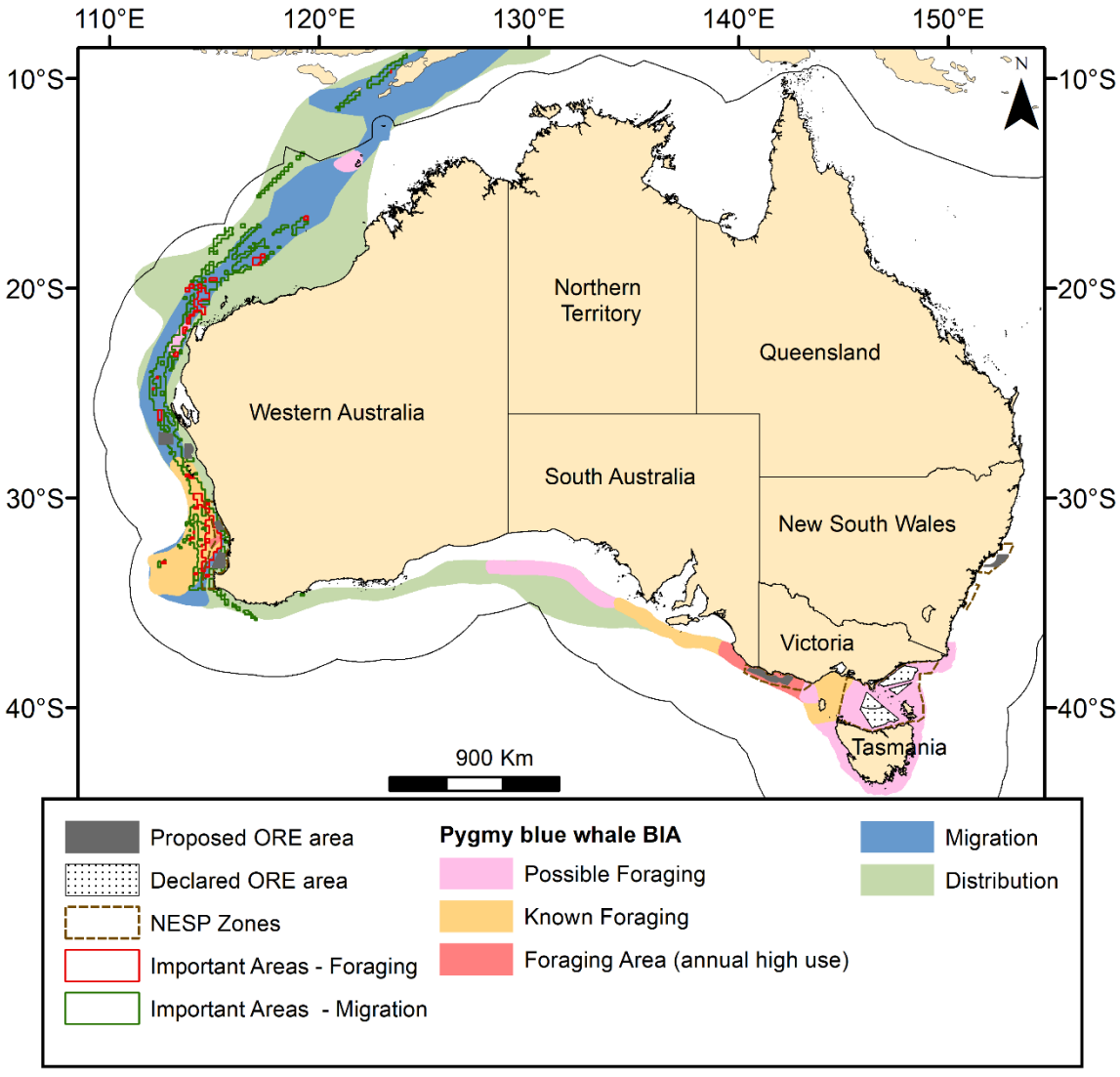

Figure 1. Overlap of distribution and Biologically Important Areas for pygmy blue whales (Commonwealth of Australia 2015) Most important areas for foraging and migration as defined by quantitative analysis of satellite telemetry data by Thums et al. (2022) and proposed offshore renewable energy development areas. NESP zones are NESP priority areas in relation to ORE.

A first step to this objective is data on the pygmy blue whale distribution and areas of high residency. While the BIA's are currently being reviewed (as stated above) and may be available in time, the polygons developed from the BIA process do not provide relative importance across the distribution. This information is critical for the proposed cumulative impact analysis. Relative distribution, that we refer to as occupancy, will be quantified based on the methodology developed by Thums et al. (2022) using satellite tracking data available from that work (including from Double et al. 2014). We propose to include new satellite tracking data recently collected by AIMS (2022-2023) and other existing datasets from our project partner, AAD and Flinders University (Möller et al. 2020) (Table 2), to calculate relative distribution across southern (and Western) Australia, encompassing all current ORE development areas. Occupancy will be calculated for the entire known (for which we have data) Eastern Indian Ocean pygmy blue whale distribution as well as by splitting the dataset into foraging and migratory movement behaviours. This will be done by applying a state-space model and move persistence model to the satellite tracking data (Jonsen et al. 2019).

Relatively low move persistence is obtained when residency in an area is higher and is indicative of behaviours such as foraging (but also potentially resting and reproduction) whereas relatively high move persistence generally represents more transitory (and less resident) behaviour indicative of migration. Although this compilation will be the largest sample size of satellite telemetry for this sub species (n=38), it is still relatively small (Sequeira et al 2019), and so the resulting spatial outputs may not be completely representative of all areas used by the species that may overlap with ORE areas. For this reason, we aim to compile auxiliary data sources such as aerial surveys and marine mammal observer (MMO) data (Table 2) held by researchers and industry. These data can be used to determine whether our distribution calculated from satellite tracking data is representative and if the supplementary datasets are made available and are of sufficient breadth and quality, we will attempt to create supplementary distribution maps for the species with these data. In addition, we will use the outputs of spatial models (Ferreira et al. 2023) which have identified the drivers of distribution and predicted foraging and migration habitat suitability across their range to ensure representative spatial coverage.

Core areas of occupancy for foraging and migrating whales will be quantified and be overlaid with spatial data of pressures (shipping, existing oil and gas activity, proposed ORE) and associated threats (habitat loss, displacement, vessel strike, underwater noise) identified by NESP Project 3.3 in a cumulative impact assessment framework (see Table 1 for terminology). An impact score will be calculated as the spatial overlap of pygmy blue whale occupancy with the intensity of a specific threat weighted by the species' vulnerability to that threat, and then summing across all threats and mapping the cumulative score in space.

Projects 4.8 will provide additional new information on blue whales that will inform the assessment of risks that is a key objective of project 4.7. These project links are outlined in Fig 2 and will be a key point of discussion at the proposed program workshop in late Jan.

Overarching project objectives include:

1) Assessing spatial overlap between the ORE proposed areas and the eastern Indian Ocean pygmy blue whale distribution, core foraging and migration areas and revised BIAs and Australian Marine Park (AMP) boundaries to determine vulnerability across these important spatial management units;

2) Performing a cumulative impact analysis (e.g., impact = the effects of a threat to the individual, taxa and/or population) of ORE proposed areas that overlap with the eastern Indian Ocean pygmy blue whale distribution, core foraging and migration areas and overlaying BIAs and AMPs as above;

3) Identifying reference areas, which are areas with low cumulative impact score that may serve as suitable control sites for monitoring impact of ORE developments.

This project is a partnership between the Australian Institute of Marine Science and Flinders University and leverages considerable previous investment from industry, the Australian Marine Mammal Centre (Australian Antarctic Division), AIMS and Flinders University in the tagging and tracking of pygmy blue whales in Australia. The project represents exceptional value in the context of value-adding to existing data to directly address a national problem. Project outputs and raw data (where approvals are obtained) will be made publicly available through NESP MaC Hub to enable them to be used by DCCEEW, NOPSEMA and State regulators to inform their impact assessment of ORE developments. Similarly, proponents will have access to these products to be used during their impact assessments and mitigation planning for proposed activities.

Table 1. Definition of terminology

Terminology	Definition
Pressure	Spatial layer related to an activity or infrastructure that is associated with one or multiple threats (for example: shipping)
Threat	Threat is a stressor, action or event that causes harmful effects that may impact the environment and species (strike, underwater noise, chemical pollution). A pressure may be associate with multiple threats (for example: shipping is associated with strike, underwater noise, artificial light, and pollution)
Vulnerability	The degree to which a species is susceptible to harm from exposure to a pressure or threat. A vulnerability score will be assigned to each pressure and used to determine impact.
Impact	The effects of a threat to an individual, taxa and/or population (strike = injury, death; noise: behavioural changes; chemical pollution= health condition).
Cumulative impacts	Account for the cumulative effect of multiple threats co-occurring in space and time
Risk	Risks are the likelihood × the consequence of the impact but taking mitigation into consideration. As proponents for ORE development have yet to do their impact assessment process to provide information on mitigations, we will not include risk in this analysis, but it could be included in a later stage.
Occupancy	Measure of use within species distribution calculated as the proportion of time and proportion of tagged individuals in each grid cell.
Core areas	Area within distribution with highest values of species occupancy encompassing the top 50% of the cumulative frequency distribution. Akin to the 50% utilisation distribution (UD) as the minimum area in which the animal has 50% probability of being found.
Habitat suitability	Predicted suitable habitat derived from modelling the relationship between environmental data and whale presence (probability of occurrence).

Table 2. Details of datasets identified and considered for the analysis.

Data type	Spatial extent	Number of datasets	Data owner	In hand and permission to use	Comments
Satellite tracking	Western Australia	17 tracks	AIMS	Yes	
Satellite tracking	Southern Australia	13 tracks	Flinders University	Yes	
Satellite tracking	Western Australia	9 tracks	AAD	Yes	
Marine mammal observer data	Australia EEZ		AAD	No	Request has been sent to Virginia Andrews-Goff
Marine mammal observer data	Australia EEZ		Industry	No	Request has been sent
Aerial survey	Bonney region		Peter Gill	No	Local extent, however, potentially enough data for small scale local maps (P. Gill has been contacted)
Aerial surveys	Perth Canyon		Curtin University	No	Limited data and extent in area with good coverage by tracking data
Aerial survey	Geographe Bay		Chris Burton	No	Geographe Bay – too close to shore

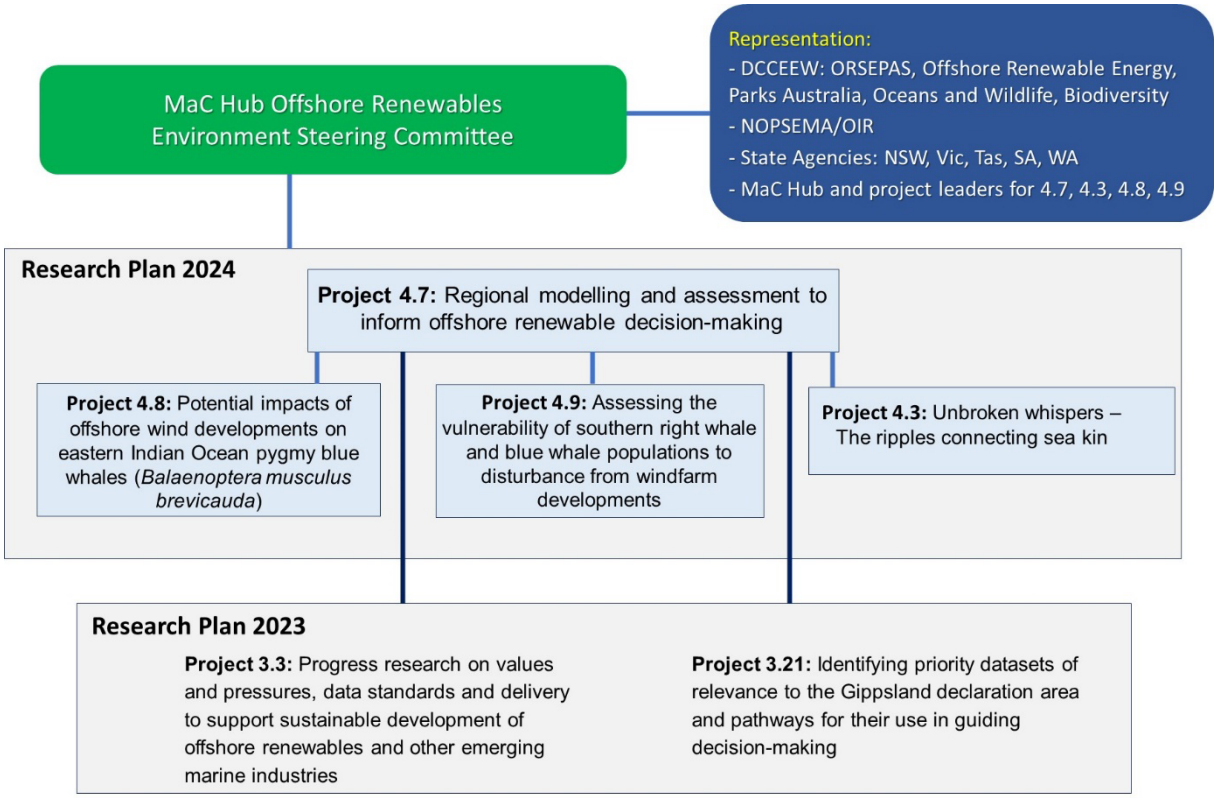

Figure 2. Description of projects within RP2023 and RP2024 relevant to offshore renewable energy that will contribute to information to support assessment and modelling within the project, and relationship to proposed ORE program steering committee. This steering committee will be supported by the Hub executive

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Project 4.9 – Assessing the vulnerability of southern right whale and blue whale populations to disturbance from windfarm developments.

Project type: Hub research project	
Cross-cutting initiative:	Yes Threatened and migratory species and threatened ecological communities
Project start date: 01/03/2024	**Project end date**: 28/02/2025
Project leader details:	Name: Associate Professor Rebecca Dunlop Organisation: University of Queensland

Project description

Project summary

The proposed project will use available data (where possible) to develop an **interim** PCoD model for blue whales (*Balaenoptera musculus*) and southern right whales (*Eubalena australis*), to determine the likelihood of a population level impact of one, or multiple, wind farm developments off the Australian coast. Where data is not available, expert elicitation will be sought. A precautionary approach will be taken with any model assumptions noting a range of values will be included. Outcomes will also provide a first-pass risk analysis of the likelihood of population-level negative impacts on blue whale and right whales exposed to wind farm construction noise.

Project description

The increased exploitation of renewable energy, such as the development of offshore windfarms, are not impact free. The construction, and operation, of large wind turbines generate both impulsive, and low-frequency noise. Noise is defined as sound that impairs reception of signals of interest or that affects an animal in a way that disrupts normal behaviour (Richardson et al. 1995). Given marine mammals are reliant on their acoustic environment to feed, breed, and therefore survive, the effects of man-made noise on marine mammal populations have received increasing public and scientific attention.

There have been several proposed wind farm development sites along the Australian coastline, e.g., the Gippsland region in Victoria https://www.dcceew.gov.au/about/news/on-your-marks-gippsland-go. However, these sites likely overlap with feeding and breeding areas for two vulnerable cetacean species, the southern right whale and blue whale. Both have been listed as under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as “endangered” and, as such, the blue whale has a conservation management plan (Blue Whale Conservation Management Plan - DCCEEW) and the southern right whale has a recovery plan (Conservation Management Plan for the Southern Right Whale: A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999 2011-2021 - DCCEEW). Given the role of regulatory bodies such as NOPSEMA (National Offshore Petroleum Safety and Environmental Management Authority) is to act as independent expert regulators for the environmental management for offshore petroleum and greenhouse gas storage activities in Commonwealth waters, any anthropogenic impacts of underwater noise cannot be inconsistent with statutory recovery plans for these species.

It is difficult to minimise potential threats without first understanding 1) if there is a threat, 2) to what extent this threat may impact the population in question, and 3) the consequences of any impact for population recovery. On the one hand, ceasing all potentially threatening activities, such as windfarm developments, will meet the anthropogenic threat objective for the long-term recovery of each species. On the other, it is important that renewable energy developments are supported as they play an important role in the Australian government’s commitment to net zero by 2050 and are likely to help mitigate the effects of climate change on these species. Understanding the potential for impacts to impede the recovery of a species will be required for impact assessments under the EPBC Act. Once this information is gathered, it can then be used to determine the likelihood of a population-level impact, and therefore identify if there is a threat to population recovery. Considering this, the following project proposes a risk-based modelling approach to determine the likelihood of population-level impacts that could result in population decline and therefore impede species recovery in southern right whale, and blue whale, populations. The study will first focus on two key areas:

- Portland
- Gippsland

The “Population Consequences of Disturbance (PCoD)” model is a framework with which to relate the response of individuals to a potential stressor to changes in population dynamics via changes in

individual health (National Research Council 2005). If fully parameterized, the PCoD framework allows a comprehensive, population-level, evaluation of the impact of disturbance-inducing activities. A fully parameterized PCoD model involves the use of multiple datasets that determine the behavioural/physiological response of individuals within the species to the disturbance, the energetic consequence of this response, changes in their health, the subsequent change in vital rates, and finally, link these to forecast potential changes in the population dynamics. However, models are time-consuming and expensive to fully parameterize meaning there are very few available in the scientific literature. Considering this, the proposed project will use available data (where possible) to develop an **interim** PCoD. This method has been developed and used by regulators internationally to assess the potential impacts of offshore wind developments (e.g., https://hub.jncc.gov.uk/assets/0c3f5dc2-2433-446c-9203-7757a0ef4a2b - Joint Nature Conservation Committee, UK Government advisor, impact of wind developments on harbor porpoises in British and Scottish waters). Following their methodology, this project will use a decision pathway for each whale species (right whale and blue whale), for each proposed wind farm development area, to determine vulnerability of the population to the activity. Given this is a desk-based project, it is a cost-effective project way of consolidating available data, and as well as informing which data gaps are most crucial to fill.

The workflow comprises of a series of questions concerning the overlap of the population with the likely disturbance-inducing activity. Specifically, the temporal and spatial overlap of the animals within the population and the activity are considered, along with the likely proportion of the population that will be exposed to the activity or activities, the probablity of repeated disturbance, the reproductive strategy of each population, and the “life stages” the population will be in whilst exposured to the activity (e.g., feeding, pregnant, lactating). The results of these questions will then be used to create a risk likelihood of negative population-level impacts.

To be able to address the questions, key parameters are identified, and emperical data are sourced to create these parameters. The first step of this project will liase with the “NESP Hub data wrangler” to source and consolidate available emperical data as well as develop any data user agreements. In the absence of emperical data, and given this will be a desk-top study only (with no inclusion of a data collection phase), an interim population consequences of disturbance model approach will then be used to generate an initial risk forecast. This interim forecast can then be later updated with emperical data when it becomes available (iPCoD; King et al. 2015; Figure 2.) Where there are emperical data gaps, expert eliciation can be used to estimate various parameters. Parameters, either from emperical data, or expert elicitation, are then incorporated into a population-level model. All parameters are included (e.g., population size and probability of disturbance, exposure time, exposure severity etc) as ‘best estimates’ along with measures of uncertainty, which constitute the upper and lower confidence bounds. In addition, a sensitivity analysis is included, to indicate how sensitive the model is to changes in these parameters as they vary within the uncertainty. If the model is highly sensitive to the parameter, even small changes will produce quite different results. Therefore, the sensitivity of the model to each parameter variation helps to identify which parameters should have uncertainty bounds minimised as much as possible, and therefore where future research should be directed. A second sensitivity analysis will identify which parameter, if changed, will have the most impact on the model outcome. This will help direct mitigation measures. For example, if the identified parameter is the risk of hearing damage, then mitigation measures to lower this risk will have the most impact on population forecasts.

Model outputs will be used to predict spatio-temporal cumulative impacts of the proposed activity or activities at a regional scale. Note, the inclusion of measures of uncertainty and a sensitivity analysis within the outputs allows for an informed precautionary approach when end users engage with the results as well as inform the best and most appropriate mitigation measures should the activity proceed. Given the focus on anthropogenic noise as the disturbance, the benefits of the project are not limited to offshore renewable energy proposals and will also be relevant to decommissioning activities, oil and gas activities and carbon capture and storage activities.

Finally, given other researchers are currently developing agent-based models, collaborations with these researchers will be developed throughout the project. Outcomes of this project can be used to inform and improve agent-based models, and outcomes of agent-based models can be used to improve disturbance models developed. For example, Dunlop (et al. 2021) combined an agent-based model, with a disturbance model, to predict the effect of a seismic survey on a humpback whale population. Specifically, a disturbance model was used to predict the mean aggregate disturbance, and the probability of multiple disturbances, for southerly migrating humpback whales when migrating through a seismic survey zone (Dunlop et al. 2021). The results of the disturbance model were then combined with an agent-based model. The agent-based model informed the disturbance model at an individual level, the disturbance model informed the agent-based model at a population level. By developing a collaborative and informed approach within this project scope, Australia's commitment to clean energy can be upheld without impeding its commitment to the recovery of the blue and right whale.

Projects 4.9 will provide additional new information on blue whales that will inform the assessment of risks that is a key objective of project 4.7. These project links are outlined in Fig. 1 and will be a key point of discussion at the proposed program workshop in late Jan.

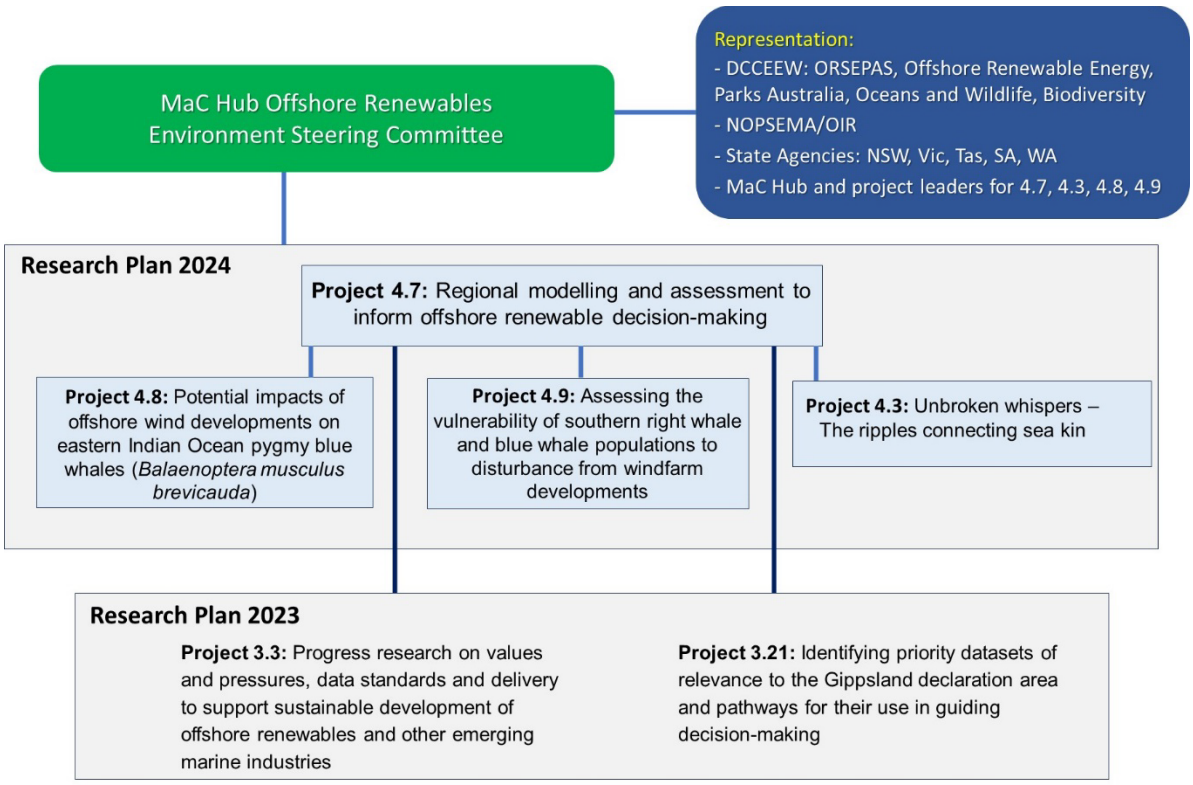


Figure 1. Description of projects within RP2023 and RP2024 relevant to offshore renewable energy that will contribute to information to support assessment and modelling within the project, and relationship to proposed ORE program steering committee. This steering committee will be supported by the Hub executive

Project 4.10 - De-risking nature repair activities in Australian coastal and marine ecosystems

Project type: Hub research project	
Cross-cutting initiative: No	Yes Threatened and migratory species and ecological communities
Project start date: 01/03/2024	**Project end date**: 10/02/2026
Project leader details:	Name: Megan Saunders Organisation: CSIRO Name: Nathan Waltham Organisation: JCU Name: Rebecca Morris Organisation: University of Melbourne

Project description

Project summary

Scaling up marine and coastal restoration and nature-based solutions (NbS) (“nature repair”) in Australia is necessary to achieve national and international commitments to biodiversity and climate change mitigation and adaptation. The goal of this project is to guide coastal marine nature repair in Australia at scales relevant to help meet national targets. The project has three aims: **Aim 1** update a stocktake of the coastal and marine restoration and NbS activities which have occurred in Australia. **Aim 2** Develop the evidence-base to de-risk coastal and marine nature repair. **Aim 3** scope a forward-looking coordinated framework to support continued implementation of investments in nature repair of Australia’s coastal and marine ecosystems. The research will be conducted using primarily desktop methods supplemented with new empirical research. Addressing these aims is required to move forward beyond uncoordinated efforts to achieve effective seascape-scale interventions that support the Nature Positive Plan and international targets.

Project description

Problem statement. Coastal wetland, estuarine, and marine habitats in Australia have suffered degradation and loss over the past two centuries due to cumulative pressures. The Australian Government Nature Positive Plan outlines a range of goals that will require targeted and coordinated research into restoration of our coastal and marine estate to meet national and international biodiversity and climate change mitigation targets. To achieve these goals there is a need to 1) compile the evidence needed to derisk investment into marine and coastal nature repair, and 2) provide a science-based approach to inform restoration investment options. Without a national framework that is coordinated, shared, supported, evaluated and promoted, our ability to meet these targets will be difficult or impossible.

Description of research. There is increasing interest in marine and coastal nature repair in Australia. The National Marine Science Plan 2015-2025 identifies restoration and eco-engineering as priorities for future investment to support the burgeoning Blue Economy. The Nature Repair Market was recently announced as part of the Nature Positive Plan of the Commonwealth Government of Australia. The market, which is anticipated to become operational at the end 2024, will offer a voluntary trading scheme for biodiversity credits achieved through nature repair actions. Nature Repair can be achieved through ecological restoration, rehabilitation, and Nature-based Solutions (NbS), which include a suite of interventions aimed at initiating ecological recovery, supporting biodiversity, and provision of ecological functions and services. Recent investment into marine and coastal nature repair includes the Australian Government Ecosystem Restoration Fund and Blue Carbon Ecosystem Restoration Grants, and expanding investment through non-government organisations, such as OzFish and The Nature Conservancy’s Reef Builder program.

Decision makers and investors into restoration and NbS need robust information to guide investment. For example, the types of nature repair actions that can be taken, under what contexts they are applicable, and the level of confidence that the actions can achieve stated objectives (“succeed”). Project investors also need to know the risks and liability that they take on by engaging (or not engaging) in nature repair – with risks spanning legal, engineering, environmental, and socio-economic dimensions. While there have been many nature repair projects implemented in Australia, and a range of research programs that have been funded by state and federal government (for example NESP, see below), there is no comprehensive synthesis of information which outlines the evidence for nature repair outcomes (ecological, environmental, economic, or social), and the risks related to these actions. This leads to barriers or delays in implementation, and large uncertainty into outcomes, which ultimately limits capacity to invest in the environment and the people who rely on it.

Recent research funded by NESP has developed a strong base from which this proposal builds. NESP Marine Biodiversity Hub Project B1 and E5 explored the role of marine restoration in Matters of National Environmental Significance (McLeod et al). For Project E5 the authors compiled information on restoration methods for seagrass, kelp, shellfish and saltmarshes; it did not attempt a quantitative assessment of the effectiveness of restoration methods. This research led to the initiation of the Australian Coastal Restoration Network (ACRN), and which hosts the ACRN database.

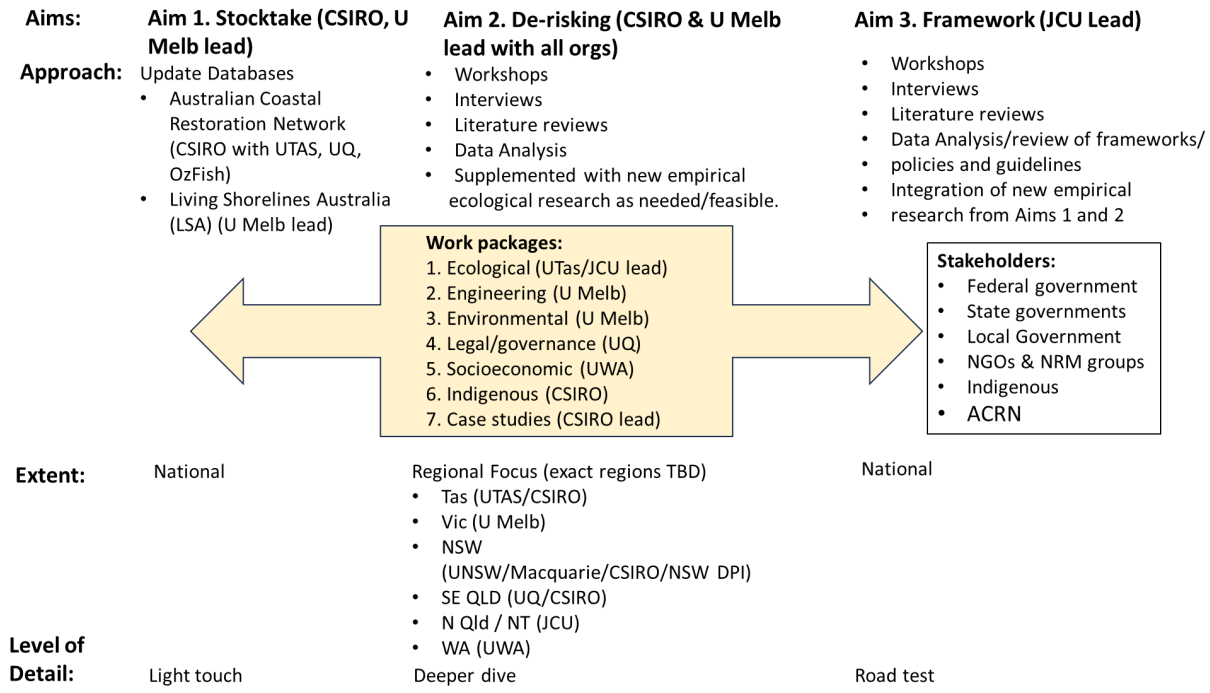
More recently the NESP Marine and Coastal hub has invested in projects on restoration and NbS. NESP MAC Project 1.6 assessed the state of marine and coastal restoration in Australia and developed 10 guiding principles in “A roadmap to coordinated landscape scale coastal marine restoration” (Saunders et al. 2022). NESP MAC Project 1.7 “Towards a consolidated and open-science framework for restoration monitoring” developed guidelines aimed at improving co-ordinated and open-science monitoring for restoration (MacDougall et al. 2022). NESP Earth Systems Hub Project 5.9 and NESP MAC 1.10 developed guidelines for, and a national inventory of, Nature-based solutions for coastal hazard protection (Morris et al. 2022); importantly, information on evidence for outcomes of NbS were not compiled in this work. NESP MAC 3.7, currently in progress, aims to identify barriers to marine and coastal restoration focussing on three thematic areas: Legal and governance barriers to restoration, Barriers to uptake and adoption of NbS by the Engineering sector, and barriers to participation for Indigenous communities (Waltham et al. in progress).

Recent symposia, such as the Australian Coastal Restoration Network symposia in May 2023, and sessions at the AMSA conferences in 2022 and 2023, demonstrated a wealth of marine restoration research occurring in Australia – this means there is a community of actors on call to deliver a coordinated large-scale program of marine and coastal restoration. However, the extent of the activities which have been untaken are not sufficient to position Australia to meet national and international targets, and a framework to guide future investment is needed.

Recent efforts to develop databases of information about completed projects for restoration (Australian Coastal Restoration Network (ACRN) Database) and Nature-based Solutions (Living Shorelines Australia) provide a strong basis from which to understand the types of nature repair activities occurring, however, there are significant gaps in the information available from these assets. The databases are outdated, and are lacking data, which was not published or otherwise accessible, since data are held in institutional repositories, if available at all, given that funding for monitoring is generally short term. Therefore, the databases require updating. More importantly, there is a lack of synthetic quantitative information on ecological, environmental, or socioeconomic outcomes of restoration and NbS, and it is not currently possible to predict the effectiveness of nature repair activities, to assess the scope of work which has been done at regional – national scales, or to have easy access to information on the types of risks that nature repair assumes. Ecological synthesis research captures broad trends and proves useful to both research and practice. For instance, global scale research which quantified the costs and feasibility of coastal marine restoration has achieved high scientific impact, as evidenced by high citation rates, and has been referenced in many policy documents (Bayraktarov, Saunders et al. 2016. 709 cites, Google Scholar 4 Dec 2023).

The proposed project is timely, relevant, and builds on expertise and strengths of the project team. The regional approach which will be assumed (see Aim 2 below) aligns with the regional priorities of the Australian government in the Nature Positive Plan, and the scale of the Natural Resource Management groups who commonly implement nature repair. CIs Saunders and Waltham lead the Australian Coastal Restoration Network, and Morris is a national leader in marine Nature-based Solutions. Members of the project team bring nationally recognised expertise in the thematic areas of this research, including legal & policy barriers to restoration (Bell-James, Shumway), developing economic accounts for the DCCEEW blue carbon program (Rogers), evaluation of ecological outcomes (Strain, Ling, Waltham), and Indigenous engagement (Fischer).

The proposed consists of three aims which be addressed using desktop-based methodologies (synthesis of existing data, workshops) supplemented with new empirical data.



Aim 1. Update the stocktake of marine and coastal restoration and NbS activities in Australia. (CSIRO, University of Melbourne lead)

Rational: In order to make the most informed decisions about how and where to conduct nature repair it is essential to have access to information about where and how projects were conducted in the past, what their objectives were, and whether there is information on outcomes. Two relevant datasets exist [1) the Australian Coastal Restoration Network (ACRN) database of restoration projects (https://www.acrn.org.au/) and the Living Shorelines Australia (LSA) database on NbS for coastal hazard protection (https://livingshorelines.com.au/)]. However, they are outdated (ACRN was updated in 2018) and are limited in scope.

Approach: We will update the inventory of existing national databases on marine Nature Repair in Australia (ACRN, LSA) which are available online. At the national scale, a 'light touch' approach will be taken, eg, identifying projects which have publicly available information or through working with agencies such as state governments who have organisational repositories of project level data, and reporting basic project level information (eg, location, habitat, restoration approach, etc). More comprehensive information will be obtained for regional case studies (see Aim 2).

Activities:

- Desktop review of available literature.
- Work with project partners and networks, including state agencies, NGOs and Natural Resource Management groups, to elicit information from their archives (see Aim 2).
- Update the existing online repositories for the ACRN and LSA databases.

Out of scope

- comprehensive update of the costs and effectiveness of all projects.

Aim 2. Develop the evidence-base to de-risk coastal marine nature repair. (CSIRO, JCU, University of Melbourne lead)'

Rational: A major barrier to implementation of restoration and NbS is that **taking action poses risks** which may be more or less well understood or palatable for decision makers. The risks include **unclear evidence for outcomes**, which leads to low predictability of the ecological, social, or economic outcomes of restoration and NbS, as well as **risks related to implementation** with respect to legal, engineering, environmental, socio-economic, and Indigenous cultural perspectives. For instance, from a legal perspective, agencies installing structures need to accept liability for those structures in perpetuity. From a governance perspective, nature repair poses particular risks in protected areas such as Ramsar sites. From an engineering perspective, installing living shorelines for coastal hazard protection poses risks that structures won't meet engineering goals. From a socio-economic perspective, risks include damage to relationships and social license to operate and wasted resources. From an environmental perspective, climate change poses a risk to long term outcomes. From an Indigenous perspective, many groups do not currently have resources and capacity to engage in restoration despite interest in doing so.

Approach: The research will build off Aim 1 and research conducted in NESP MAC 1.6 and 3.7 to conduct a more thorough examination of the evidence for effectiveness and risks of nature repair for particular regions/methods/and/or projects. **This aim will be addressed through thematic work packages: 1) Ecological; 2) Engineering; 3) Environmental; 4) Legal/Governance; 5) Socioeconomic; 6) Indigenous, and 7) Regional case studies.** The work packages will be led by disciplinary experts within the team and will explore aspects of evidence for outcomes and/or risks, as appropriate for the specific work package.

Activities: (CSIRO, JCU, U Melb lead with contributions from all)

- Initial workshop(s) to define:
    - What restoration & NbS activities, habitats and regions are in scope.
    - Metrics and indicators of evidence for outcomes and "success" for each work package and align to datasets from Aim 1&2. This will build off work in NESP MAC Project 1.7.
    - Knowledge needs for risks component for each work package and align to datasets from Aim 1&2.
- Follow up workshop(s) to gain feedback on results and socialise the project outcomes.

Work package 1 - Ecological (JCU/UTAS lead with contributions from all)

- Identify projects from ACRN and Living Shorelines Australia databases for which there are suitable ecological data available for detailed evaluation.
- Identify key gaps in the evidence base, and then collect primary data to fill one or more gaps. Scope TBD but will provisionally occur in Tasmania and North Qld in alignment with cash contributions and requests from UTAS and JCU. The information should be transferable across habitats and be relevant to Nature Positive Plan.
- Identify indicators of success, with input from relevant DCCEEW sections (eg. Environment Information Australia)
- Outline ecological risks relevant to ecosystems.

Work package 2 - Engineering (U Melb lead)

- Conduct follow up interviews on engineering outcomes with the project proponents of Living Shorelines Australia database.
- Synthesise information on engineering risks and liabilities.

Work package 3 - Environmental (U Melb lead)

- Conduct follow up interviews on environmental outcomes of NbS with project proponents of Living Shorelines Australia database.
- Synthesise existing information on environmental outcomes of restoration projects.
- Conceptualize climate change risks to restoration and NbS

Work package 4 - Legal/governance (UQ)

- Synthesise/collect new information on legal/governance risks and liabilities (UQ)

Work package 5 - Socioeconomic (UWA)

- Conduct desktop review of socio-economic outcomes, risks and liabilities of nature repair.

Work package 6 - Indigenous (CSIRO)

- Compile culturally relevant and appropriate information on 1) marine and coastal nature repair and 2) the value proposition for partnering with researchers.
- Share the material with project partners with the aim of upskilling in cultural engagement.
- Conduct a pilot approach to reciprocal knowledge sharing with select Indigenous communities using the materials developed.

Work package 7 – Case study(s) (CSIRO lead)

- Define case studies which will include a regional and/or habitat and/or nature repair action focus – with needs to be identified through consultation with research users.
- Case studies will be designed to intersect with WP1-6, and the intent is that some should align with Australian Government Blue Carbon Ecosystem Restoration Grants projects.
- Regional case study regions will allow us to identify the number of projects in multiple habitat types in a region, how many have monitoring, and what proportion show evidence for outcomes.
- While the scope of the case studies is TBD, we have regional expertise in all Australian states and those personnel will help to identify suitable projects in scope for Aims 1 & 2.
    - Tasmania (UTAS, CSIRO)
    - Victoria (U Melbourne)
    - New South Wales (UNSW, Macquarie)
    - Southeast Queensland (UQ, CSIRO)
    - North Queensland & NT (JCU)
    - Western Australia (UWA)
    - South Australia (Uni Adelaide)
    - National (OzFish)

Out of scope: Extensive new empirical research on outcomes of restoration.

Aim 3. Scope what a National coordinated framework needs to include to effectively guide nature repair for marine and coastal ecosystems in Australia (JCU Lead)

Rational: For Australia to meet its international commitments we will need to conduct a step change in the scale of restoration and NbS implementation. **A coordinated framework is needed to outline the steps that decision makers should take in determining where and how to invest in nature repair**, that if collectively adopted across the country, in a coordinated fashion, will deliver a consistent and efficient approach toward nature repair investment, with meaningful impact. Evidence of this coordinated approach can be seen in similar large programs overseas – e.g., Restore America's Estuaries.

Approach: We will scope out what a national coordinated framework to guide marine nature repair needs, which will be designed through a coordinated workshop program among the ACRN members and focused departments and personal involved in the restoration business. While the exact scope needs will be co-developed with government agencies and ACRN end users, it could provisionally include guidance on: (i) how decision makers can articulate their objectives for investing in nature repair; (ii) how to identify what types of restoration or NbS activities are most likely to deliver those objectives; (iii) spatial suitability of different restoration and NbS activities; (iv) the risks and liabilities that will need to be addressed when preparing to invest; (v) the platforms that can assist in prioritising investment in nature repair projects; (vi) requirements for Monitoring, Evaluation, and Reporting (MER); (vii) how co-design with Indigenous communities or Indigenous owned restoration projects should be supported. The basis here is to pay particular attention to how decision making varies across spatial scales, from local to national, when assigning funding investment rounds, as well as concepts of multi-habitat seascape scale restoration. Indigenous leadership and involvement will comprise a distinct component of the framework.

Activities:

- Integrate conclusions from Aims 1 and 2.

- Review the Nature Positive legislation reforms and work with DCEEW to align the framework accordingly.
- Evaluate successful scaled restoration from international programs, such as Restore Americas Estuaries (RAE) and Marine Ecosystem Restoration in Changing European Seas (MERCES) to identify the key elements that were taken to lead to large-scale implementation.
- Review existing frameworks (e.g. QLD Values-Based framework) to identify how they could apply at national scales.
- Workshop and potential for a working group to scope and design the framework.
- Identify and link to existing decision support platforms and technical guides required for decision makers to implement the guidance steps.
- Identify knowledge gaps or tools required to assist with implementation of the guidance steps.

Out of scope: Extensive new empirical research on outcomes of restoration (data and information from Aims 1 and 2 will be used as part of this Aim); spatial prioritisation; development of platforms/tools.

Links to other research and/or the work of other hubs

The project has strong synergies with research conducted in the Climate Systems Hub. “Climate-effective management for threatened species and protected places” is developing a database of climate adaptation approaches, and particularly where there are intersections with restoration and NbS. “Oceans and coasts: connecting climate variability and extremes across scales” is developing up to date climate forecasts which intersect with the environmental risks component of this project. The NESP Climate Systems Hub – cross hub project to develop a biodiversity knowledge and adaptation platform for climate adaptation may provide a suitable outlet to communicate findings from the project.

How the hub expects the research will be applied to inform decision-making and on-ground action.

The research has been identified as a priority by our end-users in Commonwealth and State Governments. As the Nature Repair Market develops and the restoration Targets for the Kunming-Montreal convention are decided upon, our primary end-users in DCCEEW will require the most up to date synthesised data on nature repair learnings and latest research and development in the field. This will help to de-risk investment decisions as there will be less uncertainty in outcomes. This will ultimately lead to better social, economic and environmental outcomes achieved for reduced cost.

Project 4.11 – Scaling-up long-term seagrass restoration in the Cocos (Keeling) Islands

Project type: Hub research project	
Project start date: 1/02/2024	**Project end date**: 11/12/2026
Project leader details:	Name: A/Prof Michael Rasheed Organisation: James Cook University

Project description

Project summary

There is an urgent community-driven need to develop appropriate seagrass restoration approaches at scale for the Cocos (Keeling) Islands (CKI). Fast-tracking larger-scale restoration research is required to prevent imminent collapse and functional extinction of seagrasses at CKI due to past disturbance and current green turtle grazing pressure. This project builds on pilot studies to design and establish a network of larger-scale turtle exclusion areas where locally appropriate restoration approaches can be refined. At the same time, this will provide “seagrass refuges” to initiate recovery, monitor ecological effects, and provide for future restoration efforts. The project has been co-developed with the CKI community and Parks Australia, addressing their highest research priority identified in the newly established Cocos (Keeling) Islands Marine Park. The project will provide an action plan for ongoing interventions and strategies to future-proof local seagrasses and support seagrass-dependent species, such as green turtles and fish, in the long term.

Project description

Dramatic declines in seagrass meadows have been documented in the Cocos Keeling Islands (CKI) between 2006 and 2018. The decline coincides with a range of cascading and cumulative impacts, including dredging for a new port facility, episodic die-off events associated with high temperatures and calm conditions and subsequent turtle overgrazing. This resulted in more than 80% of the estimated 18.77 km^2 of previously mapped seagrasses being lost. These meadows are culturally important for the Cocos Malay community and provide regionally significant foraging grounds for green sea turtles.

This substantial seagrass loss is a major management concern for Parks Australia and has alarmed the local community, impacting their traditional subsistence fisheries and the health of the green turtle population. More recently, together with the community, Parks Australia has identified a need for research on how to restore the seagrasses as their highest research priority within the newly established CKI Marine Park (Sea Country Solutions Report 2022[1]).

In response, an initial project to investigate potential seagrass restoration approaches was established by the research team, through the Indian Ocean Territory (IOT) Marine Parks program funding administered by Parks Australia. The team has conducted initial work to identify and establish small-scale restoration trial sites. However, initial observations have revealed the situation is worse than anticipated, with the seagrass system nearing the point of collapse and unable to recover naturally due to grazing pressure. Local seagrass extinction is likely without key interventions and research to find solutions.

Grazing pressure by green turtles has been identified as the current major contributing factor in the ongoing seagrass decline and prevention of seagrass recovery (Buckee et al. 2021). This relationship has been confirmed through an 18-month pilot study that used small exclusion cages to prevent turtle grazing with seagrass within cages recovering. Results from surveys in April 2023 funded by Parks Australia have revealed that seagrass meadows throughout the entirety of the lagoon have been grazed to the point where there is less than 1% cover within the remaining footprint. Additionally, reports of increasing turtle mortality and evidence of poor health have been recently documented (Whiting pers. comm.), indicating flow-on effects of seagrass decline on this priority conservation species.

Once seagrass ecosystems undergo regime shifts to alternate states (e.g. bare sediments or algal-dominated systems), they are much more ecologically challenging and expensive to rehabilitate and sometimes, rehabilitation is not possible at all. Turtle overgrazing in other Indian Ocean atolls (e.g. Lakshadweep archipelago) has resulted in the functional extinction of seagrasses, loss of associated ecosystem services and an inability to recover, even after turtle populations have declined. These findings necessitate bringing forward the restoration research program originally planned to follow on from the IOT Pilot Restoration study and implement larger-scale experimental turtle exclusion and restoration areas before local seagrass populations and donor meadows are lost.

[1] https://parksaustralia.gov.au/marine/files/iots/CKI-Conservation-Action-Plan.pdf

How the research will be undertaken

Our team of leading tropical seagrass restoration practitioners, in partnership with local community organisations and staff, and under the guidance of the established CKI seagrass restoration expert panel, will establish a network of larger-scale (~400 m^2) seagrass protection areas, in which turtles are excluded, to provide refuge for, and promote recovery of, existing remnant seagrass meadows at CKI. Exclusion areas will vary in size, construction, depth, seagrass community composition and sediment types and location within the CKI lagoon. Successful restoration approaches identified in the CKI Restoration Pilot Program, using small 1.5 x 1.5 m exclusion areas, will be scaled up within these larger restoration sites, beginning in March 2024. These larger enclosure areas will be at a scale that allows for restoration that will be self-sustainable in the longer term and provide sufficient refuge areas for seagrass to ensure seagrass survival in CKI and a source of propagules for future expanded restoration and natural recruitment. We will use an iterative approach, with the best locations and exclusion methods combined with the most successful restoration techniques, refined in years 2 and 3 to develop an effective ongoing plan. The final location of the seagrass protection areas and barrier installation will be informed through broad stakeholder and community consultation in the initial stages of the project with the team holding stakeholder workshops in CKI in February 2024 and ongoing consultation on-island, from the locally based research partners at Cocos Marine Care and Parks Australia. Construction of the seagrass protection areas will use eco-barrier construction similar to that deployed as a barrier to exclude sharks from swimming beaches in WA. The construction of these is designed so that fauna cannot get entrained and use a mesh/grid size of approximately 25 x 25cm to allow the majority of smaller fish and animals free passage (for a similar design, see: https://www.globalmarineenclosures.com/aquarius-barrier-gen-2).

These larger-scale restoration experiments will have a dual role: (1) providing key research into appropriate approaches for tropical seagrass restoration at scale and valuation of returned services, including Blue Carbon, and (2) critically, they will serve as a network of seagrass “refuges” to avoid the worst outcomes from local seagrass extinction ensuring there are ongoing viable seagrass areas within CKI. At the restoration sites key water quality parameters including light (PAR) and temperature will also be assessed using in situ benthic loggers to examine the impact these may be having on seagrass restoration and recovery at the sites.

Complimenting the restoration trials will be investigations of nursery approaches and a local seagrass restoration research scale nursery if required to support the exclusion work. This will utilise existing on-island aquaculture facilities and investigate approaches to propagate the local seagrass species, acting as a potential source of propagules and approaches for future restoration efforts.

Details of related prior research

This work builds on the research team’s pilot seagrass restoration work that has been conducted at CKI over the past two years. These initial studies have provided proof of concept showing the removal of herbivory pressure at small scales results in a return of seagrass functionality. To narrow down the transplantation and restoration techniques that will be most suitable and effective for the local seagrass species and ecosystem, the team has established sites with small 1.5 x 1.5m exclusion cages. At these sites, a range of seagrass transplantation techniques have been examined in areas free of herbivory and those exposed to herbivory (control sites). These studies feed into this larger-scale program and provide evidence to support this approach. The smaller scale work will continue through to the establishment of the larger exclusion studies as part of this NESP project, with some elements associated with fine-tuning of transplanting techniques at small-scale sites continuing during the first year of the NESP project.

The JCU TropWATER Seagrass Ecology Group have successfully carried out megaherbivore exclusion experiments to understand how green turtles and dugong structure seagrass meadows elsewhere in tropical Australia, as part of Australian Research Council research in the GBR and also in the Torres Strait as part of previous NESP project 1.14 (Scott et al., 2020, 2021a, 2021b and York et al., in prep). The team is also conducting large-scale tropical seagrass restoration research projects on the east coast of Australia, including work on the same suite of species that occur in the CKI.

The Sea Country Solutions (SCS) team have been working with the local CKI community and Cocos Marine Care since 2021 to explore the relationship between turtle grazing and seagrass health and recovery at the atoll. These initial studies show a significant increase in seagrass cover (shoot count, blade length and overall per cent cover) within areas that exclude turtles compared to unprotected areas (SCS, unpublished). This project led to the CKI Pilot Restoration Programme, which includes a

lagoon-wide seagrass monitoring program to establish benchmark cover (at the Marine Parks' establishment) and track changes in seagrass density and distribution over time. Outcomes from this program will inform ongoing seagrass monitoring and enable adaptive management at the atoll.

Project 4.12 – Protecting valuable shoreline mangroves of northern Australia

Project type: Hub research project	
Cross-cutting initiative:	Yes – Climate Adaptation
Project start date: 1/02/2024	**Project end date**: 11/12/2026
Project leader details:	Name: Norman C Duke Organisation: James Cook University

Project description

Project summary

The mass death (~80 km^2) and dieback of shoreline mangroves around the Gulf of Carpentaria (GOC) and across northern Australia in 1982 and 2015 was a wake-up call to the vulnerability and immense importance of marine coastal ecosystems like mangroves. It is essential that we fully understand the circumstances surrounding such catastrophic events, the environmental triggers identified, and what we might do to restore the damage while also preventing future occurrences. In response to the 2015 mass dieback event (the world's largest such recorded event), the NESP commissioned an Emerging Priority project that utilised aerial surveys to assess the extent of the dieback along the entire Gulf of Carpentaria coastline. It is proposed to resurvey GOC shorelines for their current condition whilst taking the opportunity further to devise a well-considered and fully costed rapid response plan that will include innovative preventative management outcomes for the longer-term sustainability of threatened but highly-valued coastal marine ecosystems of northern Australia.

Project description

In 2015-16 a significant portion, >6% of mangroves along 2,000 km of Australia's northern coastline (specifically the Gulf of Carpentaria (GOC)), were lost to a mass dieback event (Duke et al. 2017; 2020a,b; 2021; 2022), along with their considerable ecosystem benefits like seafood production, shoreline protection, plus carbon sequestration and storage (Duke 2020; 2022). Subsequent investigations under NESP funding in 2017-2019 identified coincident climatic conditions associated with the dieback (Duke et al. 2020a,b). There has been little follow-up work to further examine recovery, along with the longer-term consequences for ecosystem services of the region.

The cause was attributed to unusually extreme oscillations in mean sea level coincident with extreme ENSO conditions (Abhik et al. 2021; Bergstrom et al. 2021; Gauthey et al. 2022; Chung et al. 2023). Specifically, extremely low sea levels over at least 6 months, associated with severe El Nino conditions, appear to have caused mangroves to die from a lack of inundation and wetting during the long dry season (Duke et al., 2022). It is important to better understand the circumstances surrounding the catastrophic events that occurred in 2015 and 1982 and whether any triggers were identified. There is also the question of what can be done to restore the damage, while also preventing/minimising future occurrences. Such knowledge is required by environmental managers to enable their best-considered responses and possible intervention to help mitigate/alleviate damage caused by such episodic damaging events. The response options available to managers and policymakers differ significantly starting with the scale of effective implementation at local, national or regional jurisdictions.

A primary question is whether a proposed mitigation effort is likely to succeed, or whether such intervention might even make matters worse. Recent examples include the often, ill-considered practice of planting of mangrove propagules without consideration of prevailing existential threats (Zimmer et al. 2022). The answers to such questions need to be addressed by appropriate research to provide the best-possible understanding of the cause(s) of damage, its persistence, and the key drivers. For the GOC mass mangrove dieback, the earlier project with NESP (Duke et al. 2020a,b) effectively described and quantified the damage to shoreline mangroves of the GOC in 2015 along with the cause (summarised by Duke et al. 2022). Importantly though, that study derived an environmental stress index (the Sea Level Stress Index) that defined a threshold environmental trigger level beyond which, forest damage was lethal. It was notable that threshold values were exceeded in areas of mass death (~80 km^2) of shoreline mangroves around the Gulf of Carpentaria (GOC) and across northern Australia in 1982 and 2015. The NESP project findings (see references below, listing multiple, independent research findings) further demonstrated important differences between recovery rates from sublethal damage, compared to non-reproductive canopy resprouting. The latter was

understandably more rapid compared to recovery from lethal damage requiring a lengthy period of seedling reproduction, forest re-establishment and tree growth. Recovery from lethal damage was reported to take around 15-20 years for canopy reformation and closure following the 1982 loss event. It is essential that we now know whether the 2015 dieback recovery is comparable. It seems that environmental conditions in recent decades have changed considerably since 1982. For example, a recent evaluation of severe tropical cyclones in GBR waters of NE Australia have increased in number and intensity to cause significantly greater damage to mangrove ecosystems there (Duke et al. 2024).

A second series of questions explore the environmental values and benefits, in view of ongoing pressures and risks of accumulative damaging events like severe tropical cyclones and major flooding – as well as the more extreme ENSO events. The questions revolve around the repeated and accumulative damage caused, and how these events influence recovery. There is a point where ecosystem recovery cannot be sustained under such ever-increasing damage.

The challenge for managers is to determine whether any intervention is likely to succeed. What are the relative costs involved in doing nothing, compared to doing something like habitat restoration, or the prevention of future occurrences, or both? Our plan is to assist with these and other questions, including evaluating the costs involved in mitigation works to prevent/minimise future damage and losses with the value and benefits derived from the shoreline mangrove ecosystems of northern Australia.

Our plan combines existing data with acquired additional updated observations from the resurvey of the condition of mangrove shorelines of the GOC and nearby. A first aim is to identify existing drivers of change, consolidate our assessment of the cause, and evaluate current risks. Secondly, we will devise and evaluate a well-considered response plan for achieving successful management outcomes with longer-term sustainability of the vulnerable, but highly-valued, coastal marine ecosystems of northern Australia. As set out in Figure 1, the program will achieve these outcomes in three component groupings, including: the updated monitoring of shoreline mangrove condition, the implementation of restorative measures to improve habitat resilience, and our development of an innovative rapid response management plan for minimising future occurrences of unusually severe mangrove dieback, as seen in 2015.

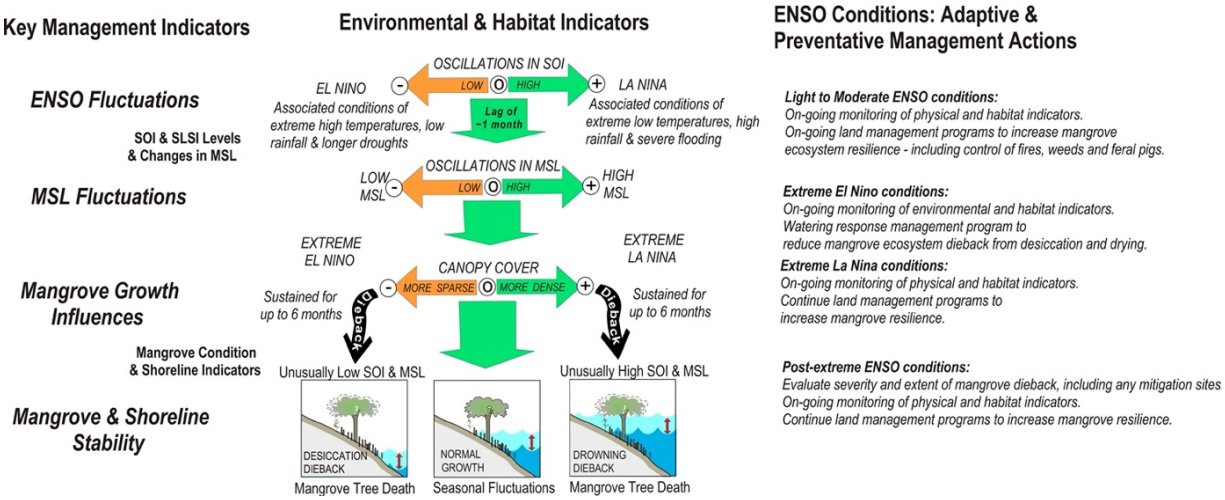


Figure 1. Program proposed for the adaptive and protective management of tropical mangroves threatened by extreme ENSO events (Duke et al., 2022).

PROJECT COMPONENT GROUPINGS

Monitoring Current Shoreline Condition, Extant Drivers, and Ecosystem Benefits

1) We will re-map the shoreline mangrove vegetation of the Gulf of Carpentaria (GOC) showing their current condition in 2024-2025. This will show mangrove dieback areas of 2015, along with areas of recovery, poor condition, or no recovery. These findings will be made whilst comparing areas of subsequent (accumulative) damaging events of severe tropical cyclones (category 3 or more), and large floods.
2) We will conduct aerial resurveys of GOC shorelines previously surveyed in 2017 and 2019, planned for 2024-2025. Our assessment will describe the extant condition of habitat, enabling quantification of key drivers of shoreline change throughout the region, the severity of change, and the longer-term trends. This will be aided by the development and implementation of AI interpretation of survey imagery for more efficient scoring of shoreline condition indicators.
3) We will conduct transect monitoring of the 8 GOC field transects, first measured in 2018, planned for 2025-2026. The transect measures of forest condition and demography will enable quantification of stand growth and recovery, as well as direct measures of standing woody biomass, and sequestered carbon. These measures will be used for comparative measures of the loss of habitat and carbon from prior instances of damage. Our assessment will include comparisons of 2015 damaged areas affected and unaffected by subsequent severe tropical cyclones. We will test the idea that such accumulative impacts retard recovery, leading to possible ecosystem collapse. It would be beneficial to identify key threshold tipping points.
4) We will make an assessment of the influences of changes in the shoreline of the GOC, including spatial and temporal variations in the rates of rising sea levels, plus the ENSO-driven oscillations in extreme high and low sea level events. These data will be gathered from at least three port sea level recording stations in the GOC region.
5) We will update previous NDVI green fraction monthly time series plots showing canopy changes in key mangrove sites in the GOC from 1987 to 2024-2026. These data will usefully quantify seasonal cycles in mangrove canopies, along with longer-term changes, and specific instances of abrupt canopy damage and subsequent recovery. A key aim is to compare changes at two indicative mangrove ecotones, being at the seaward shoreline edge, and the upper edge of the shoreline zone. Our aim is to show how changes at these ecotones describe the differing influences of respective drivers of change, including rising sea levels, drought and the ENSO sea level influences of unusually extreme highs and lows. We note that mass dieback events in 1982 and 2015 correlated with 6-month periods of extremely low sea levels during exceptionally severe El Nino events.
6) We will assess severe tropical cyclones and severe weather events in the GOC in regard to their cumulative pressures/damage to the condition of shoreline mangroves. This will include quantification of habitat losses from damage events, and potential savings with preservative management.
7) We will evaluate blue carbon levels in damaged and undamaged shoreline mangrove stands of the GOC using data from shoreline surveys, field transects, and green fraction time series. This will include quantification of carbon losses from damage events, and potential savings with preservative management.

Improving Shoreline Habitat Resilience to Preserve Threatened Mangroves

Based on the aerial survey, we will be able to prioritise areas recommended for on-ground mitigation. Undertaking significant mitigation works is not part of this project but the information we collect will enable us to scope potential mitigation works.

1) We will assess on-ground mitigation works to monitor, protect and sustain mangrove areas deemed vulnerable and /or damaged. The aim is to increase the resilience of shoreline mangroves, minimising their damage during damaging events, and assisting their more rapid recovery.
2) Findings from the aerial surveys and field investigations listed above will inform this program to identify and quantify hotspot sites for prioritisation in mitigation, clean-up and restorative works.

3) Mitigation works will be scoped and where possible small-scale trials will be undertaken for evaluative purposes. This may well, include collaboration with relevant Indigenous rangers and budget has been allowed for this. The exact nature of the ground works will be decided upon in consultation with the respective ranger groups. However, it is expected that mitigative measures to be considered will include prevention of grassland fires, works to reduce exotic weeds, removal of rubbish, removal of abandoned fishing nets, and the removal of feral pigs.
4) Our overall aim is to minimise the agents causing damage to mangrove areas, particularly those bordering upland supratidal vegetation. The migration of mangroves into this higher elevation zone is critical to successful mangrove retreat and their longer-term survival as sea levels rise. The steady relocation of this ecotone is at great risk as ever-more rapid sea level rise forces the establishment of seedling stands at higher and higher elevations. This project will identify and quantify the current shifts in this supratidal ecotone, and the longer-term relocation of the mangrove zone upland.
5) We are aware of Indigenous ranger concerns about piles of dead timber in mangrove areas damaging recovery from the 2015 dieback event. We plan to discuss this matter as a specific option for operational works in consultation/collaboration with each of the Indigenous ranger groups in the southern GOC area. The piles of dead timber (from the 2015 dieback event) are piled up and washing across the tidal zone. As this occurs, seedlings and surviving trees have been scoured and swept away. Based on the planned aerial survey to be conducted in 2024-2025, any areas of current concern will be located and prioritised for restorative mitigation works.

Environmental Monitoring and Preventative Management to Preserve Threatened Mangroves

1) Environmental monitoring (SOI, rainfall, sea level) will be conducted in collaboration with Indigenous rangers in the southern GOC. This will include regular determinations, monitoring and identification of the threshold trigger value of the Sea Level Stress Index (SLSI). The threshold value of the SLSI will be applied as an ‘alert-to-action’ trigger for initiation of a Watering Response Program.
2) The Watering Response Program involves the watering of trees considered to be dehydrated and at the limit of survival should no water be supplied otherwise. The justification for this premise is founded in the findings of the previous NESP project (references below). The Watering Response concept has been promulgated in a peer-reviewed PLOS Climate journal article (Duke et al. 2022). We consider this plan to be the only mitigation works proposed to date, likely to sustain shoreline mangrove stands threatened by such extreme dehydration and lack of tidal inundation. Such conditions were recorded during the previous prolonged severe El Nino periods with extremely low mean sea level (MSL) conditions when tidal waters were unable to wet upper zone mangroves for six months during the dry season.
3) Our plan is to fully cost the rapid response application in this innovative Watering Response Program. In view of the previous project findings, there appears to be at least one month’s notice before mangrove dieback and death occurs. This is based on a lag between the Southern Oscillation Index (SOI) and MSL recorded along shorelines of northern tropical Australia. When emerging extreme conditions are detected in the SOI, the response team, along with local Indigenous rangers, can be mobilised with pre-arranged equipment for aerial spraying of water across nominated vulnerable upper-shoreline mangrove zones. While it is considered that only one application would be necessary, this will be tested if the situation arises.
4) An integral part of the Watering Response Program will be supplemental monitoring of the success or otherwise of the program deduced from both satellite surveillance plus field and aerial monitoring of mangrove canopy condition. The cost of the plan will be considered an offset in terms of the potential losses of habitat and carbon versus the cost of doing nothing.
5) While the Watering Response Program is for future occurrences beyond 2026, we will consider the feasibility of conducting trials should the opportunity arise. Should mangroves be threatened by unusually severe El Nino conditions during the program, we will conduct informative, experimental field trials to test the Watering Response Program methodology.

Such trials would most likely be conducted in an accessible area like Karumba in Queensland subject to fitting within the current budget.

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Project 4.13 Mapping and characterising Australia's tropical shellfish reefs

Project type: Hub research project	
Cross-cutting initiative:	Yes, indirectly, as an important ecosystem for species. Threatened and migratory species and threatened ecosystems Initiative
Project start date: 01/05/2024	**Project end date**: 11/12/2026
Project leader details:	Name: Professor Rod Connolly Organisation: Griffith University

Project description

Project summary

This project will assess the current status of tropical oyster (also called shellfish) reefs across Northern Australia. A combination of satellite imagery, community consultations facilitated by OzFish and The Nature Conservancy, and Traditional Owner Knowledge will be used to develop a comprehensive map of past and present oyster reefs and underpin DCCEEW assessments of future protection and restoration needs. Full assessments of reef condition at selected sites will be used to develop rapid assessment methods suitable for estimating oyster populations, supported biodiversity, habitat preferences and settlement substrates to inform future management, monitoring, and conservation status of tropical oyster reefs.

Project description

Shellfish reefs are biogenic habitats created by dense aggregations of oysters and/or mussels. These habitats provide important ecosystem services, including shoreline stabilisation, water filtration, nutrient assimilation, and the provision of habitat for marine life, including harvested fishes and crustaceans.

Destructive and unsustainable harvesting coupled with pollution, disease and coastal development have destroyed 85% of temperate oyster reefs globally, making them one of the most imperilled marine ecosystems and triggering worldwide restoration action. Shellfish reefs are sometimes referred to as the “temperate equivalent of coral reefs”, but this description is misleading as shellfish reefs are now known to also occur throughout the tropics. Compared to other coastal and estuarine habitats (i.e. mangroves and seagrass), shellfish reef research is in its infancy due to their eradication before living memory. To date, research has been concentrated in wealthier countries (United States, Europe and southern Australia) which are mostly temperate, which has resulted in the exclusion of tropical shellfish reefs from global and national assessments.

Very little is known about tropical shellfish reefs and very few have been characterised globally, while to date, none have been characterised in Australia. Major knowledge gaps include which species are reef-building, habitat ranges, thermal tolerances, and quantified ecosystem services. Climate change will potentially impact reefs in the far north by creating conditions too hot for reefs to thrive and southern distribution shifts of more commonly studied species, such as *Saccostrea glomerata* (Sydney rock oyster), have already been documented in Australia. Although declines have been documented in the tropics, the past and present extent of tropical shellfish reefs remains largely unknown, a knowledge gap that presents a significant barrier to the management and protection of these tropical wetland habitats.

Several tropical species present significant opportunities for the expansion of aquaculture in the tropics and are harvested in other parts of the world. Opportunities are currently being explored by the Qld Department of Agriculture and Fisheries; however, our current limited understanding of species-specific eco-physical requirements and distributions presents major challenges to the industry.

From the few studies globally, tropical shellfish reefs are considered to function differently to temperate shellfish reefs in several ways, for example, in the triggers for growth and spawning, and face different environmental challenges. It is, therefore, inappropriate to inform management decisions for tropical shellfish reefs based on their temperate counterparts.

This project will assess the current status of tropical shellfish reefs and determine whether there is a need for their protection and restoration. Given the lack of historical records in remote regions of northern Australia, the inclusion of local fishers (through OzFish) and Traditional Owners and their knowledge of past and present shellfish reefs is critical to this project. We will characterise a variety of known and newly known (from the project) shellfish reefs across the tropics to understand species-specific habitat niches and eco-physical requirements. This information will be key to informing future management, developing baselines against which future conservation and restoration targets can be measured, and allowing for the expansion of shellfish aquaculture in the tropics.

The database developed from this project will be made available in two ways: 1. as an open dataset (subject to any limitations requested by Traditional Owners) on a publicly available data repository such as Pangaea, and 2. via an 'app' coded to allow easy access to summarised data and imagery.

How the research will be undertaken

Present reefs: The location and distribution of oyster reefs will be identified using a three-part strategy: 1. satellite imagery (Sentinel II, Qimagery and other suitable sources), 2. consultation with Traditional Owners from around the tropical Australian coastline, and 3. by collaborating with local fishers facilitated by OzFish and The Nature Conservancy. Data collection and collation will use an OzFish app that includes photos by locals, assess whether sites are "reefs", and information including reef size and primary settlement substrate.

Past reefs: The distribution of reefs historically will be informed by TO knowledge, intergenerational knowledge and photos from recreational fishers, and archived newspaper articles from the National Library of Australia Trove database, which has been used as a proxy for past distributions of shellfish reefs in temperate Australia.

Characterisation (full assessment): Several large reefs will be fully characterised in the field to develop an understanding of the ecology and benefits of oyster reefs in the tropics. Full assessments will include site characteristics (location within the coast/estuary, air and water temperature ranges, salinity, tidal flow), area and numbers of reefs via aerial footage (drone) or underwater drone/boat sounders for subtidal reefs, live oyster densities, identification of reef-building species (using recently developed cost-effective molecular tools when necessary), quantifying associated invertebrates and measuring fish use with automated camera rigs.

Rapid assessment: Those full assessments will be used to select a subset of easy-to-use measures that citizen scientists can make for rapid yet robust assessments at other sites, during and after the project (see e.g. Coen and Luckenbach 2000 "Developing success criteria and goals for evaluating oyster reef restoration). Rapid assessment methods and outcomes will develop patch definitions and condition thresholds/classes in line with current guidelines for listed ecological communities to assist with identifying when a tropical reef would be characterised as a functioning ecological community and protected under the EPBC Act if nominated and assessed as threatened.

Native Flat Oyster and Sydney Rock Oyster reefs of southern and eastern Australia are currently being assessed under the EPBC Act and should be assessed as Critically Endangered based on research by Gillies and colleagues. These assessments do not include reefs found in the tropics, however, and there is a need to understand past and present distributions to include tropical oyster reefs in EPBC assessments.

This project will build upon a component of NESP Marine Biodiversity Hub project B4 Shellfish reef habitats: a synopsis to underpin the repair and conservation of Australia's environmental, social and economically important bays and estuaries project. Due presumably to a lack of information, tropical Western Australia and the Northern Territory were not included in that report. A summary was included for tropical Queensland, but the information about shellfish reefs is, we now know, incorrect in many respects, especially about shellfish species identifications.

For example, recent work by Richardson and colleagues quantified the global diversity of reef-building oysters and conservatively estimated that tropical regions contain over four times more reef-building species than temperate regions, with many of these species still undescribed. McDougall and colleagues recently published a guide to intertidal oysters in Queensland (using molecular tools for accurate identification), which revealed an unexpectedly high diversity of oysters within the *Saccostrea* genus (which includes the reef-building Sydney rock oyster, *Saccostrea glomerata*), as well as several undescribed species. These studies have confirmed that there are currently undescribed reef-building oysters in the Queensland tropics, and this is likely to also be the case in the Northern Territory and Western Australia. Obtaining ecological and spatial knowledge of tropical oyster reef systems will be an important precursor in assessing their conservation status and potential for restoration.

In summary, we expect this research to be applied to decision-making and on-ground action in the following ways:

1. Provide a data repository of the distribution and characterisation of tropical shellfish reefs to support DCCEEW assessments of conservation needs.
2. Develop rapid assessment methods that can be easily used by TOs and citizen scientists to assess remnant shellfish reefs and monitor restored shellfish reefs in tropical waters.

Project 4.14 – Enhancing monitoring approaches to evaluate the abundance, life history and critical habitats of the endangered Australian sea lion

Project type: Hub research project	
Cross-cutting initiative:	Yes. The project addresses both the Threatened and Migratory Species and Threatened Ecological Communities, and Protected Place Management missions, which are led by the Resilient Landscape and Marine and Coastal Hubs, respectively.
Project start date: 04/03/2024	**Project end date**: 27/03/2026
Project leader details:	Prof Simon Goldsworthy Partner A Project Lead (SA) Adelaide University/SARDI Dr Holly Raudino Partner B Project Lead (WA) Department of Biodiversity, Conservation and Attractions Dr Jennifer Lavers Esperance Tjaltjraak Native Title Aboriginal Corporation

Project description

Project summary

This project aims to improve the monitoring and inform the management of the endangered Australian sea lion (ASL) *Neophoca cinerea*, which has declined in numbers by over 60% in the past four decades. The goal is to develop cost-effective methods for acquiring abundance data from under-surveyed regions impacted by fisheries bycatch and other pressures, apply drones to enhance monitoring at suitable breeding and haul-out sites, develop efficient techniques to process and analyse demographic data so that survival and reproductive success estimates from a microchipped population at Seal Bay can be routinely updated, and continue to deploy underwater cameras on sea lions to identify and understand critical habitats and risks. Findings from these activities will under-pin the National Recovery Team conservation efforts, in line with the Australian Government's Threatened Species Action Plan and Healthy Country plans. The project has been developed and co-designed with three Indigenous partners who will be responsible for delivering different components of the project.

Project description

Problem statement and priority

The Australian sea lion (ASL) is Australia's only endemic pinniped. Populations have declined drastically (>60%) over the last 40 years to extremely low levels, leading to its endangered status. Known threats to the species include fisheries bycatch, disease, pollution, entanglement in marine debris, and climate change. Improving our understanding of the species' abundance, life history and critical habitats is essential for evaluating these threats and guiding recovery actions but is incredibly challenging due to the species' unique life-history and breeding biology, longevity, demersal foraging behaviour and occupancy of remote breeding habitat. This project aims to develop cost-effective approaches to monitoring ASL abundance, life history and critical habitats, which are all key elements required to understand threats and inform recovery actions. The project addresses priorities identified in the draft ASL Recovery Plan, Conservation Advice, and by end-users (State Governments, Healthy Country managers), and will support implementation of the objectives of the Threatened Species Action Plan (TSAP). Project data will provide critical information to inform the Recovery Team's decision making and develop clear recommendations to the Australian Government for actions to best improve population trajectories of ASL in line with TSAP objectives.

How research will be undertaken

Broadly, this project aims to improve the methodologies to evaluate and monitor key aspects of ASL population abundance, life history and critical habitats and to fill current knowledge gaps that are essential for informing recovery actions. Four priority areas have been identified to address the MaC Hub Priority Research Plan 2024 for ASL:

1) Survey Recherche Archipelago (WA): The Recherche Archipelago represents ~35% of breeding colonies in WA, yet there is a lack of current data on abundance, and the timing of breeding among the known breeding sites. This has made it difficult to evaluate trends for this sector of the population, but also the population as a whole. Given that demersal gillnet fisheries still pose a major threat here, contemporary abundance data is integral to evaluating and managing bycatch and other impacts on this population.

Regular helicopter surveys will be undertaken across the Recherche Archipelago to assess the status of breeding sites, identify new breeding sites, and determine the breeding chronology at each site. Surveys undertaken at the end of the breeding season will be used to determine the pup production for each breeding site and enable at least one (and up to two) surveys (given that breeding seasons are about 17-18 months apart). At least one static camera with the ability to continuously record and

transmit data remotely will be installed at a key site to identify breeding status. This will facilitate the planning and timing of surveys to get the most accurate pup counts.

2) Drone surveys of key ASL breeding and haul-out sites (WA and SA): Drones will be used to provide baseline abundance data of ASL at suitable haul-out and breeding sites. This will be particularly important in WA to identify sites where drones can be applied for ongoing monitoring of pup abundance given the remoteness and difficulty to access of sites. During the helicopter-based surveys (above), sites will be evaluated for their suitability to be surveyed by drone in the future. Drone surveys will be validated by on-ground counts to account for visibility biases where pups are not available for detection due to habitat i.e., in caves, under rocks, ledges and vegetation. Different sensors will be trialled depending on site selection, habitat (vegetation, island topography) and animal abundance including photogrammetry, forward scanning infra-red (FLIR), thermal imaging and 3D-ranging (LiDAR). Methodologies will be tested to ensure adequate image resolution to differentiate between species, as fur seals are common at some sea lion breeding sites. The potential application of a correction factor that accounts for availability bias will be assessed and its applicability between sites will also be evaluated. It is likely that site-specific (and daily temperature specific) correction factors will be required.

3) Streamline Seal Bay demographic analysis (SA): The long-term microchipping program at Seal Bay provides the only source of demographic data for the species. Because of the species' unique life-history, data being collected have been critical as they provide basic knowledge about the species' population demography (survival, age of first breeding, breeding success, longevity) essential to informing conservation actions. While these data have been collected for 20 years, survival and reproductive success analyses are complex and time consuming to undertake, and consequently, have been undertaken infrequently (i.e., twice). Life-history data, however, underpins the development of population models to understand demographic changes in response to threats and actions, and could assist species recovery. We propose to streamline data extraction, checking, filtering, formatting and analytical steps to facilitate more regular reporting of population vital rates (e.g., at the end of each breeding season), so data can be routinely examined and used to update population models needed to evaluate risk, cumulative impacts, and recovery actions.

4) Deploy sea lion cameras to determine key habitats: This component will build on NESP Project 2.6 which has been highly successful in showcasing the diversity of habitat use and foraging behaviour of ASL. State-of-the-art underwater cameras, along with tracking devices and accelerometers were trialled as part of this pilot study. Devices were attached to adult female ASLs at two colonies. They were deployed and recovered multiple times, with no equipment losses, so the equipment is still in-hand. The cameras revealed amazing insights into the diversity of habitats used by sea lions, their foraging behaviour, and the first direct evidence of social learning of foraging habit in any pinniped. Linked with the tracking devices and accelerometers, they also allowed us to identify key sea lion habitats, assess their ecological value and further understand their unique relationship with, and dependency on benthic ecosystems.

Having this equipment available and having refined field and analysis techniques necessary for data collection and processing, represents an opportunity. Each deployment so far has provided new and unique information, refining our understanding of the critical at-sea phase of sea lion life. The plan is to progress this success with further deployments at Seal Bay, a major breeding site that is relatively easy to access and for which much collaborative data are being collected, and at other key island sites off the western Eyre Peninsula, in Warungu Country to broaden inter-colony comparisons and further develop First Nations engagement opportunities. Further deployments at Seal Bay will provide a greater understanding of the level of within-colony, inter-individual variability in habitat use and foraging strategies, while deployments at different sites off the western Eyre Peninsula will progress knowledge on the variability of habitat use and foraging behaviour among colonies. The core objectives of the sea lion camera component of the project are to:

i) identify key sea lion habitats, assess their ecological value and further understand their unique relationship with, and dependency on benthic ecosystems;

ii) provide new information on the movement and habitat use of sea lions to inform species risk assessments, including threats from fisheries interactions;

iii) evaluate the extent to which existing management measures (e.g., marine reserves) provide protection of key sea lion habitat;

iv) provide novel datasets that will aid and complement other MaC Hub projects, map continental shelf seabed habitats across southern Australia; and

v) provide opportunities for Aboriginal rangers to gain experience in sea lion field work and research and use the engaging underwater video footage to educate and inspire sea-Country connection with sea lions.

Results will improve our understanding of the requirements of, and threats to sea lion populations and support future conservation actions to recover the species. Project data will also provide critical evidence to support the assignment and delineation of 'foraging' Biologically Important Areas (BIAs) for ASL. Importantly, it also advances links with First Nations people, and their sea-Country connection with the sea lions and, through media opportunities, engages the public.

How research will be applied to inform decision-making/on-ground action
Each project objective contributes essential data and insights that directly inform conservation decision-making and on-ground actions.

Survey Recherche Archipelago: helicopter surveys will provide contemporary data on breeding chronology and sea lion abundance in the Recherche Archipelago, a crucial but under-studied region potentially impacted by demersal gillnet fisheries. This research will be used to evaluate population trends, assess threats, and make informed decisions about conservation actions.

Drone surveys: the application and suitability of drones to survey breeding colonies and key haul-out sites will be further developed through this project. Research results will be critical to guiding decisions relating to the design and resourcing of the long-term monitoring of the species.

Streamline Seal Bay demographic analysis: streamlined analysis of demographic data being collected from the Seal Bay population will facilitate more regular reporting of population vital rates. The provision of up-to-date demographic data will provide capacity for these data to inform species recovery efforts and assess the impact of threats, including cumulative impacts.

Deploy sea lion cameras: footage from underwater camera deployments will identify and map critical sea lion habitats and assess their ecological importance. Research results will support the designation of 'foraging' Biologically Important Areas (BIAs) for ASL and help identify and contextualise threats in key habitats. Analyses of data will contribute to Commonwealth and SA Marine Park objectives through the understanding of habitats and opportunity for public appreciation of the marine environment in marine parks.

Project outputs will address key priorities identified by the ASL Recovery Plan, Conservation Advice, and end-users, as well as support implementation of the objectives of the Threatened Species Action Plan (TSAP) and support Healthy Country/Sea Country Plans. Project data will provide critical information to inform the National ASL Recovery Team and develop clear recommendations to the Australian Government for actions to improve population trajectories of ASL in line with TSAP objectives. Outcomes of this research will also inform ongoing long-term monitoring of the ASL through relevant State government departments.

Project 4.15 – Grey Nurse Shark Aggregations

Project type: Hub research project	
Cross-cutting initiative:	Yes Threatened and Migratory Species and threatened communities Initiative
Project start date: 01/03/2024	**Project end date**: 01/04/2025
Project leader details:	Name: Russell Bradford Organisation: CSIRO Name: David Harasti Organisation: NSW DPI Name: Emma Westlake Organisation: CSIRO

Project description

Project summary

The grey nurse shark (*Carcharias taurus*) has been protected in Australian Commonwealth waters since 1996 (DoE, 2014). Although historically distributed across southern Australia (Last and Stevens, 2009), in October 2001 the grey nurse shark was listed as two separate populations with different protection listings under the EPBC Act of 1999: Critically Endangered in eastern Australia, and Vulnerable in Western Australia (DoE, 2014).

Grey nurse sharks (GNS) tend to aggregate at specific sites along migration routes. There are currently 19 identified key aggregation sites along the eastern seaboard. A key aggregation site is defined as a site consistently occupied by five or more GNS throughout the year (Otway et al. 2003). Recent observations indicate that this definition requires revision to account for factors such as seasonal movements and to be applicable to the Western Australian population.

This project aims to collate existing information on key aggregation sites and 'new' sites where GNS have been found to gather (both in eastern and western Australia). This information will be used to refine the definition of key aggregation site and develop criteria to allow assessment of new sites at a separate workshop to be convened by DCCEEW. This project will also investigate potential sites in Victoria where the least amount of information is available.

Project description

The grey nurse shark (*Carcharias taurus*) is divided into two populations in Australia, with the eastern population listed as Critically Endangered and the western population listed as Vulnerable under the EPBC Act. A recent study found that the eastern grey nurse shark (GNS) population was growing at a rate of 3-4% per annum (Bradford et al., 2018).

During the implementation of the NESP 3.13 project "Eastern grey nurse shark population abundance and trend", it was identified through the research implementation and community engagement that there are several sites where grey nurse sharks have been observed that are not listed as aggregation sites, and hence, have no legal protection placed on those sites. For the eastern GNS population, these sites are located in Queensland, New South Wales, and potentially Victoria. In Western Australia, four potential aggregation sites are known but data on numbers and seasonality are sparse and preclude assignment as "key aggregation" sites at this point in time.

Previously (Otway et al., 2003) defined a "key aggregation site" as one where five or more GNS were consistently found throughout the year. Although this definition has served well, there is new information indicating that the definition should be revised and that clear and unambiguous criteria be determined in order to categorise new potential aggregation sites based on measurable criteria (e.g., seasonality and shark abundance).

The MaC Hub SC has supported the development of a project on GNS prioritising research to:

1. Develop a rigorous and defensible definition for "key aggregation sites" with appropriate selection criteria to identify a key aggregation site.
2. Investigate recently identified sites to assess potential inclusion as key aggregation sites.

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Otway NM, Burke AL, Morrison NS & Parker PC (2003). Monitoring and identification of NSW critical habitat sites for conservation of grey nurse sharks. *New South Wales Final Report Series No. 47*. NSW Fisheries Office of Conservation, Nelson Bay, NSW.

Description of research

An indicative budget from the Hub was in the order of $140,000. Following extensive consultation with relevant researchers and DCCEEW (the Department), it was clear that the indicative budget was inappropriate for the scope of the project and research requirements, especially to deliver on point two. Assessing potential new aggregation sites would involve extensive fieldwork which would not be covered by the proposed funding, and therefore this project can be regarded as the initial component of a more comprehensive research program subject to further funding.

The Department (Marine Species Conservation Section) has agreed to investigate separate funding for a workshop where relevant stakeholders will gather to develop a contemporary definition for a key aggregation site and the appropriate criteria to be able to classify new sites. However, it will be important to bring researchers together before that workshop in order to collate existing data in preparation for the workshop.

Categorising new sites cannot occur prior to the revised definition and criteria being developed. It is highly likely that the new criteria will include an assessment of occupancy (i.e., transient, seasonal, annual, year-round occupancy); existing data is insufficient to categorise already identified sites that may become key aggregation sites. In addition, there are potential sites in waters outside of Queensland state waters, NSW, and Victorian state waters that will require further investigation. To address this, the project will:

1. Following the identification of new sites that may meet the definition of an aggregation site, the project will draft up a plan for future research priorities that would inform the classification of these new sites (both state and Commonwealth waters). This plan may include preliminary costings but note that costings would not be accurate beyond the life of this project.
2. Funding would be used for on-ground activities to investigate Victorian waters in more depth as these waters are the least investigated. The funding would include training and equipment for Indigenous Joint Management Rangers while partnering with the project team.
3. Funding would be used to purchase two Innovasea acoustic release receivers and to cover vessel charter costs to gather data on seasonal use of the Barwon Banks, located in Commonwealth waters off Queensland where divers have reported seeing 35-40 grey nurse sharks including several pregnant females.
4. Funding will be used to support an initial survey, using BRUVS, of a potential GNS aggregation site off NSW which is in waters at/exceeding safe diving depths.
5. Review of data on the western population of GNS distribution/catch rates (to be confirmed).

GNS aggregation sites are not well-known or identified in Victorian waters. This may be due to seasonal changes in their abundances and a lack of dedicated survey effort in GNS habitat. Previously, GNS have been observed on baited remote underwater video systems (BRUVS) at Wilsons Promontory in Gippsland, Victoria (Ierodiaconou, unpubl. data). Thus, we will complete dedicated surveys at several sites in Gippsland. A combination of eDNA, Remote Operated Vehicle (ROV), and BRUVS will be used to identify potentially suitable habitat and presence of GNS. These surveys will be conducted in partnership with the traditional custodians of the region through the GLaWAC Joint Management Ranger program. This is proven technology which the project team have been using for over 10 years.

In addition to completing surveys in Gippsland, local community engagement will be key to identifying potential aggregation sites and areas where GNS have been observed (to be undertaken by Deakin University). For this engagement, we will create information packets and flyers and meet with local

dive operators, fishing operators, and freediving clubs to solicit information and encourage information sharing when GNS are observed.

Grey nurse shark have been reported at the Outer Gibber region within the Commonwealth Hunter Marine Park. Funding within this proposal will allow for an initial BRUV survey of the reef to determine if GNS are present. If GNS are present, a dive team will survey the region.

Barwon Banks, off Queensland in Commonwealth waters, has been reported to be a possible aggregation site. However, divers do not survey the area consistently and, at present, there is only one acoustic receiver located at that site. Funding from this project will provide the opportunity to expand the number of receivers at Barwon Banks, with the aim of examining the extent of usage through detections of acoustically tagged GNS. This is only a preliminary start, and it is unlikely that data will be recovered within the lifespan of this project. In other words, funds will be used to instal receivers at some key locations where recent evidence suggests there may be a previously unrecognised aggregation of GNS. The data, however, are unlikely to be analysed as part of this project as the project duration is too short to accomplish this. However, the data will be used at a later time to inform on new aggregation sites. Noting that an aggregation requires animals to be present across years, not just in one year.

A number of potential western GNS aggregation sites have been identified in Western Australian waters. Funding under this proposal would be used to review the available evidence and determine a plan for future investigation (GNS are not currently a priority in WA). In addition, Western Australia will be doing a desktop investigation of existing data to see if there are regions which may require further investigation as well as being involved in developing a common definition for a GNS aggregation site.

Project 4.17– Supporting recovery and management of migratory shorebirds in Australia

Project type: Hub research project	
Project start date: 01/02/2024	**Project end date**: 11/12/2026
Project leader details:	Co-lead: Professor Richard Fuller Organisation: University of Queensland Co-lead: Professor Marcel Klaassen Organisation: Deakin University Co-lead: Dr Tatsuya Amano Organisation: University of Queensland

Project description

Project summary

Coastal Australia is home to 37 regularly occurring migratory shorebird species, with many protected areas including Ramsar sites designated on the basis of shorebird populations. Many migratory shorebirds are declining rapidly, and hence the focus of conservation efforts at multiple levels of government in Australia and overseas. Excitingly, after decades of decline, many of Australia's migratory shorebird populations are now showing improving trends (NESP MaC Project 1.21 - Australia's Coastal Shorebirds: Trends and Prospects). However, we do not understand why the birds' populations are stabilising, or how these gains can be converted into genuine population recovery to previous population levels. This project will combine analyses on more than a million observations of shorebirds banded in Australia with a comprehensive database of management actions to (i) create an annually updatable dashboard providing the key shorebird population parameters of reproductive output and survival, (ii) build a comprehensive database of conservation management actions for migratory shorebirds, indicating which actions are known to benefit reproductive output and survival, and (iii) create a shorebird management handbook that can be used by practitioners to guide action across Australia and around the East Asian – Australasian Flyway. Outputs will support DCCEEW's international obligations in relation to Ramsar wetlands, the Convention on the Conservation of Migratory Species (CMS), bilateral migratory bird agreements with Japan (JAMBA), China (CAMBA) and the Republic of Korea (ROKAMBA) as well as feed directly into developing the new incarnation of the Australian Government's Wildlife Conservation Plan for Migratory Shorebirds. Results have a pathway for regional and local implementation through BirdLife Australia's Migratory Shorebirds Conservation Action Plan.

Project description

The project has three parts. First, we will estimate reproductive output and survival for a number of migratory shorebird populations around Australia (Aim 1). Next, we will build a database of management actions that have been undertaken for shorebirds in the East Asian – Australasian Flyway, including an assessment of whether each action is actually effective in increasing reproductive output or survival (Aim 2). The project will culminate in the production of a shorebird management handbook, containing practical guidance on implementing evidence-based actions that are known to benefit the reproductive output and / or survival of shorebirds (Aim 3).

Aim 1: Create an annually updated dashboard providing estimates of reproductive output and survival

Population numbers are determined by reproductive output and survival. These two population-dynamic parameters are key in describing the health status of populations as well as in guiding conservation management. Prof Marcel Klaasen's team at Deakin University will build a tool allowing annual estimation of reproductive output and survival from shorebird banding data.

For up to 40+ years, the citizen-science organisations Australasian Wader Studies Group (AWSG), Queensland Wader Study Group (QWSG) and Victorian Wader Study Group (VWSG) have caught and banded more than half a million migratory shorebirds with Australian Bird and Bat Banding Scheme (ABBBS) bands. The banding included providing some birds with individually coded leg-flags, allowing observers along the flyway to recognise these birds and submit over half a million sightings. In recent years, Marcel Klaassen and Aaron Spence from Deakin University have brought the data from AWSG and VWSG and some of the data from QWSG and other shorebird banding groups along the flyway together in an online portal (www.birdmark.net). Moreover, this multi-lingual portal invites bird enthusiasts and professionals from across the flyway to submit their sightings of coded leg-flags, leading to a recent boost in submitted data to the portal, each observation being rewarded with a full account of the individual history of the birds observed. The portal provides data on 73 migratory and

resident shorebird and tern species, with detailed insights on the number of birds banded, where and when, and on the routes and phenology of their migrations. However, these data are also highly useful for population-dynamic analyses, notably for the estimation of annual survival and breeding success for a range of distinct non-breeding populations in SE, E, and NW Australia.

For at least 11 migratory shorebird species with differential conservation statuses, ecologies and migration strategies (i.e., Bar-tailed Godwit, Curlew Sandpiper, Greater Sandplover, Great Knot, Grey-tailed Tattler, Red Knot, Red-necked Stint, Ruddy Turnstone, Sanderling, Sharp-tailed Sandpiper, Terek Sandpiper) sufficient banding and resighting data has now been amassed to allow estimation of accurate annual juvenile percentages (an index of reproductive output) and survival of each species at one or more non-breeding sites across the country. We will conduct the survival analyses using Bayesian population analyses adapted from Kéry and Schaub (2011) using WinBUGS14, and R within RStudio, an approach with which we have ample hands-on experience (e.g. Schofield et al. 2020; Galtbalt et al. 2022; Ross et al. 2023).

While created as a portal to facilitate data collection, storage, maintenance and dissemination for the AWSG and VWSG, www.birdmark.net is also providing a platform for and services to other national and international banding groups, including QWSG. Our analyses will principally be conducted using AWSG, QWSG, and VWSG data. Yet, through this exercise we also hope to motivate other banding groups along the flyway to allow integrating their data into future analyses beyond the life of this project, and ultimately create a dashboard that can monitor the demographic status of Australia's migratory shorebirds on an ongoing basis.

Preliminary analyses of the AWSG and VWSG data suggest some intriguing possibilities. Site fidelity during the non-breeding season tends to be very high amongst migratory shorebirds, as exemplified for Curlew Sandpiper in Figure 1, where site fidelity appears to be extremely strong, except for two sites within Roebuck Bay, WA. This means that after combining the Roebuck Bay sites, there is potential to estimate population dynamic parameters for seven locations (not including likely additional sites from Queensland once QWSG data is being included). For one of the sites (Yallock Creek, Victoria, depicted in purple in Figure 1), we conducted a tentative survival analysis using only capture and recapture data, i.e., excluding resighting data of engraved leg flags, and distinguishing between juvenile and adult survival that were assumed to be constant and variable across years, respectively (Figure 2A).

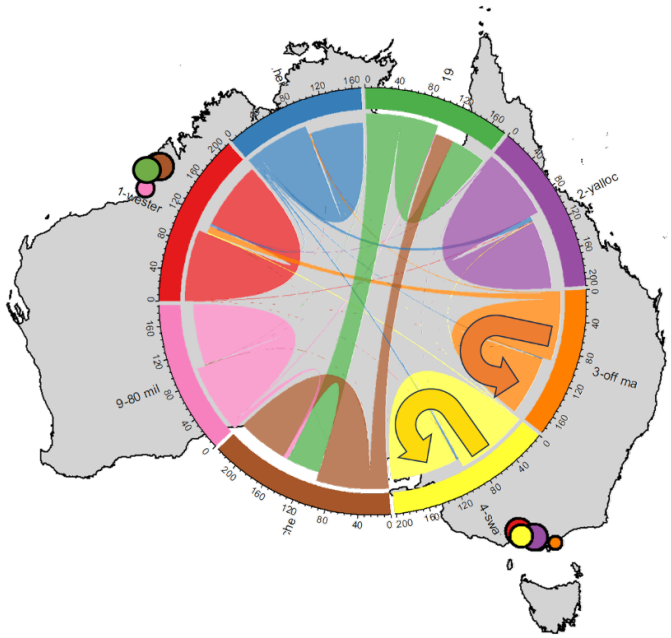

Figure 1. Site fidelity trends in Curlew Sandpipers captured since 1974 at eight sites across SE and NW Australia using AWSG and VWSG data only. The circular visualisation shows high site fidelity across all sites except two within Roebuck Bay in WA (depicted in green and brown). Conservative estimates of Curlew Sandpiper site fidelities are shown whereby the width of each arc indicates the standardised number of birds first captured at each site (100%; base of arrow, closest to outer ring), and where they were recaptured or resighted again on the following occasion not considering observations in the same year unless a change in site was made (head of arrow, further from outer ring).

This tentative analysis was accompanied with an analysis of annual recruitment of Curlew Sandpipers across all five Victorian sites (Figure 2B). The two analyses suggest that survival of adult Curlew Sandpipers has declined, while reproductive output has increased, indicating that at least for this species in this part of Victoria, management efforts may need to focus on enhancing the survival of adult birds. This is the sort of finding we will link to the conservation evidence database developed in Aim 2.

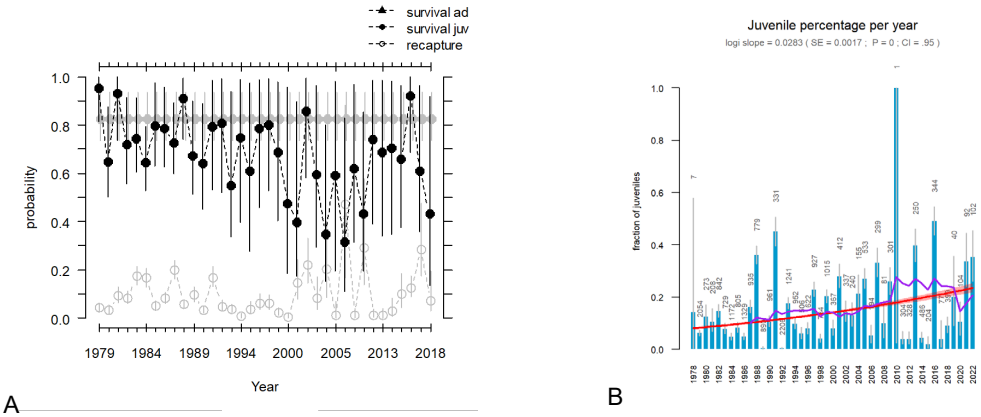

Figure 2. Adult Curlew Sandpiper survival is declining (A), but breeding success is increasing (B), suggesting that management in Australia needs to focus on actions that enhance survival of adult birds.

The tool providing the annual estimates of survival and reproduction of the 11 selected migratory shorebird species across their major non-breeding sites in Australia will be implemented within www.birdmark.net. Our project will develop the technical infrastructure allowing for a straightforward annual updating of the analyses. These contemporary analyses will be freely accessible. AWSG, QWSG, and VWSG have provided their support to the development of this tool with the use of their data.

Aim 2: Compile a comprehensive database of conservation management actions for migratory shorebirds

Led by Dr Tatsuya Amano's and Professor Richard Fuller's teams at the University of Queensland, we will create a comprehensive database of conservation management actions that have been undertaken for migratory shorebirds in the East Asian – Australasian Flyway. Here, a conservation management action is defined as an intervention that was put in place to protect, manage, restore or reduce impacts of threats to migratory shorebirds or their habitats, or control or mitigate the impact of a threat to migratory shorebirds or their habitats. Examples range from protected area designations and enhanced hunting regulations to water flow regime management and feral predator control. Rather than create something new, we will identify and adopt an existing standard threat and management action typology, perhaps that used by the IUCN for Red Listing assessments.

We will systematically search for and compile scientific studies that test the effectiveness of conservation management actions for migratory shorebirds in the East Asian – Australasian Flyway, first by screening two existing databases. The Conservation Evidence database (https://www.conservationevidence.com/), stores over 8,000 English-language studies testing the

effectiveness of conservation actions for a wide range of species and ecosystems, and the TranslatE project database (Amano et al. 2021; https://translatesciences.com/) stores 1,234 non-English-language studies testing the effectiveness of conservation actions mainly for birds, mammals, and amphibians. The search for relevant studies on those databases will be conducted using appropriate keywords, such as shorebirds, waders, or each species name and country or region name.

As the most recent studies stored in the two databases are those published in 2011 (Conservation Evidence) and 2020 (TranslatE), respectively, we will also conduct exhaustive searches for relevant English-language literature published after 2011, and relevant non-English-language (those languages spoken within the East Asian – Australasian Flyway, such as Chinese. Japanese, Russian, and Korean) literature published after 2020. The search will be based on the protocol for discipline-wide literature searching, established and adopted for the development of the Conservation Evidence database (Sutherland et al. 2019), and also used for the development of the TranslatE project database. Discipline-wide literature searching involves first identifying literature sources that are likely to contain relevant information, and manually scanning titles and abstracts (or summaries) of every document in those sources. In this project, we will focus only on peer-reviewed journals that are already screened by the two databases as literature sources. For the non-English-language literature searches, we will develop international collaboration with native speakers of relevant languages, following the method adopted by Amano et al. (2021).

From each of the studies identified, we will extract and record information, such as bibliographic metadata, study species, study site location, the type of the conservation management action, study design, and details of the effectiveness of the action in relation to improving reproductive success or survival. The information will be stored as a concise summary in an open access database, following the Conservation Evidence database format (e.g., see: https://www.conservationevidence.com/individual-study/937).

Next, we will estimate the benefits of the identified conservation actions for increasing reproductive output or survival, by surveying practitioners who have undertaken the actions, along with a range of other shorebird experts. We will adopt an approach based on the Delphi method, established and successfully used by the Conservation Evidence project (Sutherland et al. 2021). We will organise an online workshop / survey to ask, for each conservation action, experts to read the summarised evidence on its effectiveness, and then score to indicate their assessment of:

- Effectiveness: 0% = not effective, 100% = highly effective
- Certainty of the evidence: 0% = no evidence, 100% = high quality evidence; complete certainty
- Harms: 0% = none, 100% = major undesirable effects.

Actions are then categorised based on the median score from all the experts' assessments (Figure 3). We hope to conduct this expert elicitation in at least 1-2 languages beyond English to enable broader participation along the Flyway. Aim 2 will give rise to a comprehensive evidence synthesis of what works (and just as importantly, what doesn't work) for shorebird conservation management in Australia and around the East Asian – Australasian Flyway.

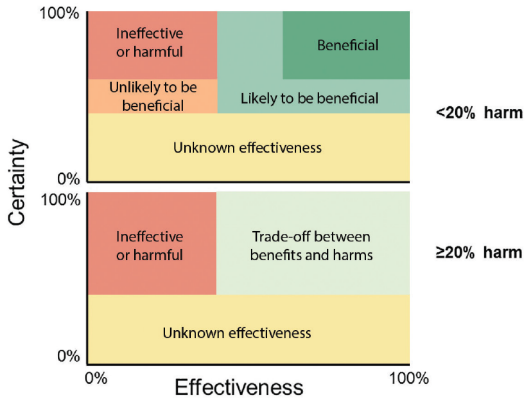

Figure 3. Categories of effectiveness of a management action, based on a combination of effectiveness and certainty, scored by experts. Based on Sutherland et al. (2021).

Aim 3: Create a shorebird habitat management handbook that can be used by practitioners

Emerging from the analyses in Aim 1, and the identification of the most effective management actions in Aim 2, we will produce a practical shorebird habitat management handbook, building on the recent roosting habitat guide produced by Jackson & Straw (2021). This will provide an enduring and practical resource that can be used to help stimulate management action for shorebirds based on the best available science, and also the vast practical experience that managers have collectively built up around the Flyway. A key component of the Handbook will be a high level summary of the characteristics of successful recovery/management actions, in as practical form as possible.

The handbook will be distributed widely and freely, and socialised via a number of online workshops. For a wider distribution, we will attempt to find resources enabling translation of the handbook into relevant languages spoken across the East Asian – Australasian Flyway, such as Chinese, Japanese and Korean, e.g., using the Google Translation Hub, or by securing other funding.

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Project 4.18 – Indigenous Ranger-led monitoring of threatened sawfish in the southern Gulf of Carpentaria

Project type: Hub research project	
Cross-cutting initiative:	Yes Threatened and migratory species and threatened ecological communities Initiative
Project start date: 1/2/2024	**Project end date**: 11/12/2026
Project leader details:	Name: Richard Pillans (Lead) Organisation: CSIRO Environment Name: Simon Booth (Co-Lead) Organisation: Carpentaria Land Council Aboriginal Corporation

Project description

Project summary

This project will partner scientists with First Nations Ranger groups to assess population abundance, distribution and by-catch survival for sawfish species in the southern Gulf of Carpentaria. This project will develop capability in First Nations Ranger Groups that will directly assist with developing baseline status and trends for sawfish species in Australia (including the largetooth sawfish *Pristis pristis,* which is a priority species: https://www.dcceew.gov.au/sites/default/files/documents/threatened-species-action-plan-2022-2032.pdf). Developing sampling and monitoring capability within First Nations Ranger groups in the southern Gulf of Carpentaria will increase the number of tissue samples for close kin mark recapture (CKMR) population estimates, potentially reducing the present reliance on the fishing industry to collect samples, and ultimately enable sawfish population trajectories to be measured.

This project addresses the following Action Plan priorities for *Pristis pristis*: establish baseline status and trend, identify sustainable bycatch rates, measure trajectory, work closely with First Nations people, develop new tools and incorporate First Nations knowledge.

The Problem

There are currently no estimates of sawfish abundance (population baseline data) in Australia. Current research (also NESP-funded) is focussing on using the genetic technique - close kin mark recapture (CKMR) to estimate adult abundance using tissue samples collected primarily by the commercial fishing Industry. In the Queensland Gulf of Carpentaria, more than 75 % of commercial fishers have been provided with sampling kits. The uptake of kits was lowest in the southern Gulf. Low uptake of kits in the southern Gulf, combined with uncertainty around the ramifications of recently-announced net-free zones could result in fewer samples coming from this important region. The southern Gulf has the highest fishing effort and historically had the highest catch rates of sawfish in the Gulf of Carpentaria (Peverell, 2005), so it is important that capacity to collect tissue samples is developed in that region.

By developing capacity of First Nations Ranger Groups, this project will establish a program that will enable the collection of sawfish tissue samples to directly assist with developing baseline status and trends for sawfish species in the Gulf of Carpentaria and that could be the model for other regions in Australia.

The Carpentaria Land Council Aboriginal Corporation (CLCAC) has identified sawfish as a priority species for research due to growing concern about their conservation status in the southern Gulf of Carpentaria. Due to several Traditional Owner groups expressing concerns regarding the abundance, distribution, health and impact of commercial fisheries on sawfish populations across their combined freshwater and sea country, the CLCAC approached the NESP and CSIRO to develop capability that will enable them to undertake sawfish research in the southern Gulf of Carpentaria. Traditional Owners have noted their experience of a reduction in observations of sawfish in the marine environments of the Gulf over the last 50 years. This, combined with a planned review of the Commonwealth Gulf of Carpentaria Marine Park in 2026, and a review of current trawl operations and inshore net and line fishing permits, has culminated in the Traditional Owners expressing the desire to collect robust data to inform planning and decision-making with aims to protect sawfish populations.

The Land and Environment Program within the CLCAC undertakes management activities that enhance the protection and management of natural resources and cultural assets on country for the long-term benefit of Traditional Owners and communities. This Program is considered one of the most effective and well-resourced Indigenous Land and Sea Programs of its kind in Australia, in terms of skill levels of employees and delivery of services. CLCAC have considerable experience with the delivery of on-ground research projects and are well-established with the skills and resources for on-ground delivery of research programs. The combined capability across the teams spans 35 Ranger positions (including 10 coxswains), 10 vessels from 3.7 meters to 7.5 meters and a fleet of 13 four-wheel drive vehicles dedicated to the CLCAC Land and Environment Program. To enable CLCAC to undertake sawfish research, this project will undertake a training program that will enable fishery-independent sawfish surveys (and tissue collection) as well building capacity for CLCAC to undertake

independent surveys of their country.

The CSIRO project team will facilitate capacity building of four Ranger teams within the CLCAC Normanton, Gangaliida and Garawa (Burketown), Wellesley Islands and Ngumari Waanyi (Gregory) to undertake sawfish surveys in the Southern Gulf. The training will build the skills of the Rangers to undertake sawfish surveys to collect tissue samples, distribution data and satellite tagging on CLCAC sea country. Tissue samples collected will contribute directly to the current NESP Sawfish project 3.11 "Multi-fishery collaboration to assess population abundances and post-release survival of threatened sawfish in northern Australia", which is focused on working with the commercial fishing industry. These samples will be used to obtain baseline estimates of sawfish population status required to monitor population trends.

A key outcome of long-term significance from this project will be to build capacity within four Indigenous Rangers groups for monitoring sawfish and other Threatened, Endangered and Protected Species (TEPS). This will be achieved through collaboratively co-designing the proposed sawfish research project with Traditional Owners to ensure understanding of project concepts whilst considering and incorporating Traditional Ecological Knowledge. Through this process, the project team will build the capability and on-ground skills to ethically, and in a culturally respectful manner, obtain the best-practice data required to inform spatial management and sustainable fisheries practices into the future.

The integrated role of Indigenous Land and Sea Rangers undertaking sawfish surveys, is crucial in areas with lower commercial industry participation. Beyond the clear benefits of empowerment and capability enhancement through co-design, involving Traditional Owners in the collection of this data will improve the capacity of the project to collect data over larger spatial scales, resulting in a more comprehensive sawfish abundance and distribution dataset, which can be used for Marine Park Planning and Fishery Management.

The Queensland Government is currently reviewing management of the inshore gillnet fishery. This is likely to include spatial closures and effort reduction through licence buy-back efforts. The CLCAC have made a submission to the consultation round regarding proposed net-free areas, concerns regarding increased commercial operations in the Gulf region following the east coast closures, and the desire to access commercial licences for PBC's to hold and support Indigenous enterprise with access to the inshore (N3) fishery during this process. The aim would be for communities to fish these licences to generate revenue and obtain food. By training up CLCAC Rangers in how to safely deal with sawfish and other TEPS captured as bycatch, as well as how to record data required for sustainable management, this project would ensure that Rangers can support, and in-turn train Indigenous licence holders to actively contribute to the data collection process required for sustainable fisheries management.

Description

Despite concern that commercial fisheries operations are impacting sawfish populations, estimates of sawfish abundance, catch rates and post-release survival are limited for the Gulf of Carpentaria. Sawfish are nationally and internationally recognised as being at risk from fishing activities, with all four sawfish species having experienced dramatic population declines and reduced geographic range in recent years. Recovery of these populations is anticipated to take several decades (Brewer et al., 2004). While northern Australia is one of the last global strongholds for all four sawfish species once found globally, there is insufficient data to assess their population status. The paucity 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.

The current NESP sawfish project (MaC Project 3.11 - Multi-fishery collaboration to assess population abundances and post-release survival of threatened sawfish in northern Australia) is focused on obtaining tissue samples from commercial fisheries in northern Australia and is therefore heavily reliant on support from industry to provide samples. If sufficient tissue samples and associated data on size and sex are obtained from commercial fishers, estimates of adult abundance for all four sawfish species will be possible. In addition to tissue sampling, sawfish captured as bycatch in commercial fisheries have also been tagged with satellite tags to estimate post-release survival. With assistance

from industry to date, 40 sawfish have been tagged with satellite tags across the Northern Territory, Queensland and Commonwealth fisheries. The project is progressing well, with more than 75% of license holders in the NT, QLD and commonwealth fisheries provided with sampling kits. However, uptake of kits is lowest in the southern Gulf of Carpentaria, a region with the highest commercial fishing effort and historically (based on estimates in Peverell, 2005 – data that is more than 20 years old) had the highest catch rates of sawfish based on data provided by the commercial fishing industry between 2000 – 2002. Karumba is the epicentre of commercial fishing in the Gulf of Carpentaria, and the level of mistrust in research and management is highest in this area, which may explain the lower uptake of sampling kits.

The Federal Environment Minister recently announced that by mid-2027, all gill nets will be removed from the Great Barrier Reef Marine Park https://minister.dcceew.gov.au/plibersek/media-releases/tackling-risks-reef. Net-free areas in the Gulf of Carpentaria are also being proposed. There is uncertainty around the nature of net-free areas in the Gulf of Carpentaria, and commercial fishers are nervous about the implications this will have. While these decisions have nothing to do with the current NESP project, the uncertainty and anger amongst the fishing industry have the potential to damage relationships between research and industry. This could result in a situation where fishers who have been participating in sawfish tissue collection are reluctant to or refuse to contribute samples. Since the ability to estimate sawfish abundance is entirely reliant on a large number of tissue samples, reduced industry participation is a concern.

Training Indigenous Ranger groups in key areas to undertake sawfish surveys and collect tissue samples may be a way of ensuring that we are able to collect sufficient tissue samples in areas with lower commercial uptake in current NESP Project 3.11 (as a result of attitudes in Kurumba and due to changes in attitudes resulting from the proposed net-free zones in the Gulf of Carpentaria).

Indigenous Ranger groups across northern Australia can play an immensely important role in collecting tissue samples and associated data from sawfish captures. However, there is currently limited capacity for many Ranger groups to undertake this without guidance and on-ground support.

To combat these issues, the objectives of this project are:

- CSIRO, CLCAC and NESP will co-design a project that will aim to provide training to CLCAC Rangers with the short-term aim for the Rangers to independently collect research data. This training will enable four Ranger groups to undertake fishery-independent surveys of sawfish in the Southern Gulf of Carpentaria. Tissue samples collected during these surveys will be used in the current NESP Sawfish project to develop estimates of sawfish abundance that can inform sustainable bycatch rates.

This project will develop capability within four Indigenous Ranger groups to undertake scientific surveys for sawfish that will involve species identification, correct handling practices, collecting tissue samples for genetic analysis and deploying satellite tags to obtain data on post-release survival and movement. This data will be influential in addressing a key knowledge gap in sawfish ecology for the Gulf; through a gain in understanding of movement and habitat usage, which is fundamental for management across these large spatial scales and understanding the role of marine parks and fisheries management in improving sawfish sustainability.

Data collected in this project will also help address critical knowledge gaps required to inform spatial closures and commercial net fishing effort reductions that were tabled in the recent press release (https://minister.dcceew.gov.au/plibersek/media-releases/tackling-risks-reef)

In addition to developing capacity for CLCAC to undertake sawfish surveys and collect data to inform estimates of sawfish abundance in northern Australia, this project also aims to develop capacity for CLCAC to further contribute to the Gulf of Carpentaria Inshore Finfish Fishery working group and play an active role in collaborative enforcement operations in partnership with state and commonwealth fisheries regulators. Many of the CLCAC Rangers have completed formal qualifications in government compliance and investigations and have sound capacity in maritime operations to support this project.

Project 4.20– Delivery of science to support the implementation of a National Marine Park Management Effectiveness system

Project type: Hub research project	
Cross-cutting initiative:	Yes Protected Place Management
Project start date: 1 March 2024	**Project end date**: 31 December 2026
Project leader details:	Name: Piers Dunstan Organisation: CSIRO

Project description

Project summary

Parks Australia is implementing a management effectiveness framework for Australian Marine Parks (AMPs). This system will support the management of 48% of Australia's EEZ. The Marine and Coastal Hub has supported the development of Parks Australia's (PA) Management Effectiveness (ME) system. The ME system is designed to allow Parks Australia to test the effectiveness of the Australian Marine Park (AMP) system and ensure that AMPs are effectively and appropriately managed. PA have identified priorities for research to assist in the implementation of the ME system, to identify scientific outputs needed for network management and adapt to new issues in the marine environment through the Australian Marine Parks Science Plan. This project will deliver several of the key science needs identified in the plan and will draw on the combined expertise of the partners and scientists within the Marine and Coastal Hub to generate the outcomes which build onto extensive work previously delivered. The project will deliver the following four outputs required for the 2028 National AMP management plan review:

Output 1: Test effectiveness of management arrangements through the development of monitoring protocols for tier 1 & 2 priority monitoring sites to assess management effectiveness.

Output 2: Address emerging and increasing activities and pressures through improved knowledge transfer system, workflows for values and pressures assessments to enhance understanding of the status of AMPs, including the identification and characterization of the pressures and activities impacting them.

Output 3: Identified and defined impacts and management options for emerging industries.

Output 4: Increasing Parks understanding of the entire system, integrating AMPs data and approaches across different jurisdictions and agencies, and fostering collaborations to create this product.

Project description

Parks Australia has developed an adaptive management approach to the Australian Marine Parks. A key part of this is testing the effectiveness of management arrangements and understanding emerging and increasing pressures and activities that may potentially impact park values. This will allow Parks Australia to take an evidence based adaptive management approach to Australian Marine Parks. This project will deliver the science necessary to meet these challenges. Monitoring priorities were established through the MAC Hub project 1.3 (Support for Parks Australia’s Monitoring, Evaluation, Reporting and Improvement System for Australian Marine Parks) and MB Hub project D7 (NESP Hub support for Parks Australia’s Monitoring, Evaluation, Reporting and Improvement System for Australian Marine Parks) and SS2 (Interpreting pressure profiles (Synthesis project)) and from enabling projects in Themes D&E in the Marine Biodiversity Hub.

Parks Australia's adaptive management approach to AMPs needs updated scientific information and data to support the effective management of marine park values, to understand emerging and increasing pressures, and to identify potential impacts on park values. To test the effectiveness of management and whether zoning arrangements are appropriate, Parks Australia will require additional information on the status and trends of natural values and pressures. This project will provide the required scientific knowledge, where possible, to address these challenges systematically to ensure the successful implementation of the adaptive management approach.

Description of research

Test effectiveness of management arrangements: Developing the monitoring protocols needed to test management effectiveness for the tier 1 & 2 priority monitoring site.

To ensure the completion of monitoring activities at priority long-term locations in a fit for purpose and rigorous manner, the development of monitoring protocols for each of the 40 target areas is essential. These protocols will facilitate data collection and analysis that can be compared at a national scale, thereby enabling a consistent understanding of the status of each network. Parks Australia will utilize these protocols when commissioning monitoring activities. To develop the protocols the project will use the outputs of MAC Hub Project 2.3 to assign values of condition to monitoring priorities and identify appropriate indicators. It will establish a knowledge transfer process for pressure indicators to facilitate effective monitoring, linked to the road map produced by Project 2.3. The project will collaborate with Parks Australia to address the questions outlined in the science plan monitoring plan and identify appropriate thresholds for each indicator in consultation with Parks Australia to ensure alignment with management objectives.

The monitoring protocols will consist of:

- Site-Specific Monitoring Plans: Develop detailed monitoring plans for each location, specifying the monitoring design to measure expected changes in natural values and ecosystem components towards the desired state. This includes defining the methods, frequency, timing, and expected analytical approaches.
- Inventory of Existing Data and Survey Methods: Compile information on existing data and survey methods, along with the sampling locations, for each long-term monitoring site. This will ensure a comprehensive understanding of the available resources and ensure the data collected previously can be integrated into any new monitoring.

- Where Parks Australia already has established relationships with Traditional Owners, the monitoring protocols will capture the established priorities and approaches that have been developed through existing partnerships with Parks Australia. This will occur in Limmen, Roebuck and Kimberly AMPs. Project 4.21, “Assessing the key natural values within priority temperate Australian Marine Parks to evaluate management effectiveness” is building partnerships with Traditional Owner groups for Geographe, South West Corner and Beagle AMPs. The protocols will capture this emerging partnership and the engagement will be led by the project leaders for project 4.21, who are also part of this project.

Address emerging and increasing activities and pressures: Critical science needs to improve knowledge transfer and understand the status of AMPs and the pressures and activities acting on them.

We will provide Parks Australia with updated and improved information on natural values and likely pressures which will improve decision making and provide robust data streams for the reviews of management plans due to begin in 2026.

- Implement key recommendations related to the ME framework for the marine data landscape roadmap from Mac Hub project 2.3. As the recommendations become clear from project 2.3, these will be incorporated into the design of the project.
- Develop knowledge transfer systems to provide information on AMP natural values and pressures (such as commercial and recreational fisheries). This will include a workflow and data agreements with holders of pressure data sets to maintain information flow to PA.

- Update Natural Values Ecosystem to version 3 and work with Parks Australia to describe a process for continued updates. Update reefs map with data produced by MAC Hub project 2.1[2] plus other relevant projects.

- Process for updating KNVs.

- Develop methods to assess absolute risk of activities that occur within and around AMPs to identify key intervention points to maintain values within AMPs. This will be done for 3 AMP networks, SW, SE and TE. This will assist is developing a better understanding of cumulative pressures on AMP natural values and key natural values and provide key information to support assessments and to ensure that identified performance measures can be met. This will utilise existing end to end ecosystem models (such as Atlantis) to develop risk-based metrics on the potential impacts of new developments, linked to ecosystem structure and the existing activities that occur. The approach will explicitly address the ecosystem components identified in Parks Natural Values Common Language (NVCL). This will also allow the risks of new activities to be appropriately assessed and will be coordinated with the MAC Hub proposal on "Development of regional modelling and risk assessments to inform offshore renewable decision-making". This project will provide the capability to create the ecosystems models and the project developing offshore wind risk assessment will provide the capability to elicit the impacts of wind and other emerging pressures.

Identification and characterisation of impacts and thresholds for emerging industries, such as space industry or offshore renewables.

- Using the methods developed above to assess absolute risk, describe a process that can be used to update activity risks for AMPs. This will be designed so that it can be applied after project end when needed. This element will also be coordinated with the MAC Hub proposal on "Development of regional modelling and risk assessments to inform offshore renewable decision-making".

- A test case for this approach will be offshore wind that are spatially adjacent to AMPs.

    - Identify potential impacts of offshore wind installation and operation on adjacent AMP natural values and key natural values. These may include noise, sediment, and toxic materials.

    - Identify facilitated impacts of offshore wind installation and operation on AMP natural value and key natural values. These may include the displacement of existing activities into AMPs.

- Identify where additional applications of this approach may be necessary such as decommissioning of marine artificial structures, and carbon storage developments.

Development of whole of systems understanding where AMPs data and approaches can link with different jurisdictions and agencies and collaborating to develop synthesis.

Work with Parks Australia, State and Territory Marine Park/Fisheries managers and scientists to identify where there are opportunities to link ME approaches and improve shared scientific understanding. This could include:

- State marine parks that sit adjacent to Australian Marine Parks

[2] Project 2.1 – Mapping temperate continental shelf seabed habitats

- State marine parks with adequate zoning arrangements allowing testing of management effectiveness
- State marine parks where sufficient data are available for indicators that line up with those being examined in the adjacent marine park
- State ME programs that are well-established and appropriately resourced;
- The agencies that hold this data are willing to be involved and co-invest in this analysis.
- This will be developed in tight collaboration with Parks Australia.

This will be developed more fully with Parks as part of the MPA Science and Management Effectiveness Working Group, which include state and commonwealth Park Managers. A report summarising the links between state and commonwealth management will be produced.

Project 4.21 – Assessing the condition of natural values within priority temperate Australian Marine Parks to evaluate management effectiveness.

Project type: Hub research project	
Cross-cutting initiative:	Yes, Protected Place Management
Project start date: 01/03/2024	**Project end date**: 10/02/2026
Project leader details:	Name: Jacquomo Monk (Project and East lead) Organisation: IMAS, University of Tasmania Name: Tim Langlois (South-west lead) Organisation: UWA Oceans Institute and School of Biological Sciences, The University of Western Australia

Project description

Project summary

Parks Australia is launching a management effectiveness framework for Australian Marine Parks (AMPs), covering 48% of Australia's Exclusive Economic Zone. Key to the success of this framework is robust biological and ecological data to assess management performance. The project will collect data to measure natural value trends to allow for evaluation of management performance at various levels on the continental shelf regions of four AMPs, selected based on previous partnerships between Parks Australia and NESP. This project aligns with Parks Australia's science plans, supporting adaptive management and addressing emerging threats. It follows best practices in marine sampling and monitoring protocols to systematically collect data that will offer trusted scientific evidence for decision-makers, aiding in effectively safeguarding the ecological integrity of these marine ecosystems.

Project description

Parks Australia's Management Effectiveness approach for AMPs requires monitoring data to test management arrangements, evaluate emerging pressures, and identify potential impacts on park values. The current lack of scientific data impedes effective management strategies. Thus, this project will systematically address these challenges, providing the necessary monitoring data to inform the management effectiveness approach.

In developing this project, we consulted with Parks Australia to further refine the 12 identified AMPs to a subset of six key temperate AMPs in the continental shelf region. We selected three AMPs from the SW network, two from the SE network, and one from the TE network (Table 1). These AMPs were chosen from the proposed long-term monitoring locations in Parks Australia's draft Science Plan as they provide biogeographic coverage across southern Australia as well as include the ability to evaluate zone effectiveness, assess different ecosystems and species relevant to management, understand potential impacts of emerging pressures (such as offshore renewable energy), and capture the impact of climate change. These priorities cover a variety of zoning types and both established and emerging activities, all aimed at testing the management effectiveness of the selected AMPs. Importantly, most of these AMPs have at least one time step to support the establishment of robust ongoing monitoring.

It is important to note that the available NESP budget limits the project to completing only four of the six identified AMPs. We are seeking additional funding in 2026 to support activities in the remaining two AMPs. The exact AMPs will be finalised once the final Science Plan is released and the successful OMP grants are announced, to ensure that there is no duplication of effort.

A steering group will be formed for both this project and *4.20 Delivery of science to support the implementation of an Australian Marine Park Management Effectiveness system*' to provide advice and ensure they remain aligned to PA Management Effectiveness program. The group will consist of representatives from collaborating partner institutions and Parks Australia. The group will be formed in consultation with Parks Australia during the inception meeting of this project in March 2024.

At each chosen AMP, monitoring gear will be deployed following standards outlined in the existing NESP field manuals and following the protocols to be developed in the MaC Hub project 4.20 '*Delivery of science to support the implementation of an Australian Marine Park Management Effectiveness system'*. At present, a suite of gear types that will capture quantitative data on demersal fishes (BRUVs & ROVs), mobile invertebrates (Pots & Traps), sessile invertebrates, seagrass and macroalgal communities (ROVs & Drop cameras) present within these AMPs.

This project aligns with Parks Australia's science plans, supporting adaptive management and addressing emerging threats. The project will deliver time critical outputs required for the 2028 National AMP management plan review.

Output(s) to be delivered

1. Four main outputs will be achieved with this project:

- Collection of state and trend of natural values and pressures for identified Tier 1 and 2 priority monitoring locations, including updated science products for natural values and ecosystems.
- Testing the effectiveness of reporting on the condition and trend of natural values and pressures in Australian marine parks. This testing will be informed by two research programs: RP22 (*2.3 Improving knowledge transfer to support Australian Marine Park decision making and management effectiveness evaluation*), led by Keith Hayes, and RP24 (*4.20 Delivery of science to support the implementation of a National Marine Park Management Effectiveness system)*, led by Piers Dunstan.
- Improved information on the management implications of analysis and evaluation for Parks Australia's management effectiveness system, which could potentially include off-park areas.
- For Wadandi Country – we will collaborate delivery into the Cultural Reports planned in the Undalup Association led “Ni Kidji Gnangkaa Boodja – Listening to Mother Country” funded project. That is designed to provide Cultural guidance in marine and coastal planning, management and protection across Wadandi Watturu Boodja, including both the Geographe and South-west Corner Marine Parks.

Table 1. Details on the ecosystems and potential indicators for the six focal temperate water AMPs. EP – park adjacent to emerging pressure (OR - proposed offshore renewable), ZE – opportunity to test zoning effectiveness, CC – opportunity to track and support resilience in face of climate change, MR – ecosystem, pressure, species of management relevance) * Not included in current NESP budget with additional funding is being sort (costing presented in Appendix A).

Proposed Year	Australian Marine Park	Ecosystem type	Gear types	Focal indicators	Justification
2024	Geographe	Shallow reefs Seagrass and shelf unvegetated sediments	BRUV, drop camera, pot, trap	Habitat forming vegetation and sessile inverts, demersal fish, mobile invertebrates	EP-OR, ZE, CC, MR
	Beagle	Mesophotic rocky reefs, shelf unvegetated sediments	BRUV, ROV	Habitat forming sessile inverts, demersal fish (including sharks)	EP-OR, CC, MR
2025	SW Corner	Mesophotic rocky reefs and rariphotic reefs	BRUV, drop camera, pot	Habitat forming vegetation and sessile inverts, demersal fish, mobile invertebrates	EP-OR, ZE, CC, MR
	Hunter	Mesophotic rocky reefs and rariphotic reefs	BRUV, ROV	Habitat forming sessile inverts, demersal fish	EP-OR, CC, MR
2026*	Abrolhos	Mesophotic rocky reefs and rariphotic reefs	BRUV, drop camera, pot	Habitat forming vegetation and sessile inverts, demersal fish, mobile invertebrates	EP-OR, ZE, MR
	Tas Fracture	Rariphotic reefs	BRUV, ROV, pot	Habitat forming sessile inverts, demersal fish, mobile invertebrates	ZE, MR

Project 4.22 - Environmental concentrations of emerging contaminants in coastal stormwater

Project type: Hub research project	
Cross-cutting initiative:	No
Project start date: 01/03/2024	**Project end date**: 28/02/2025
Project leader details:	Name: Martina Doblin and Justin Seymour Organisation: University of Technology Sydney **National Outfall Database** Name: John Gemmill Organisation: Clean Ocean Foundation

Project description

Project summary

Australia's Waste Policy Action Plan, Threat Abatement Plan for the impacts of marine debris and Australia's One Health Master Action Plan all refer to the need for emerging pollutants to be incorporated into contaminant guidelines. Scoping study 1.16 determined there is a clear and consistent need for data on environmental concentrations of contaminants of emerging concern (CECs) and an assessment of their impact on ecological communities. Project 2.4 focused on wastewater outfalls in different coastal settings - this extension will determine the concentration of emerging pollutants in coastal stormwater. The extension to Project 2.4 will also continue to collate, analyse and maintain the information from Water Treatment Authorities on outfall flows, pollutant concentrations and loads presented annually within the National Outfalls Database. Further details on project deliverables and key knowledge gaps are proposed to be discussed at a meeting of key DCCEEW research-users and water contaminants experts in early February 2024, funded directly by the Mac Hub.

Project description

Australia's Waste Policy Action Plan, Threat Abatement Plan for the impacts of marine debris and Australia's One Health Master Action Plan all refer to the need for emerging pollutants to be incorporated into contaminant guidelines. To build an evidence-based understanding of the environmental concentrations of these contaminants and their ecological significance in Australian coastal waters, Project 2.4 was co-designed with end-users to determine environmental concentrations and potential ecological effects at selected wastewater treatment plant outfalls. In 2023, end-users stated a need for improving the temporal and spatial resolution of the current project.

Project 2.4 used outputs of oceanographic simulations and other information to identify a small set of locations for sampling that are representative of a range of receiving water contexts. Spatial surveys of contaminants of emerging concern (CECs) in water and sediments were undertaken, timed during the dry period to limit the potential for stormwater inputs. An implicit assumption of the sampling design was that stormwater also contains CECs and could confound the assessment of contaminants in wastewater. Furthermore, our spatial surveys around wastewater treatment plant (WWTP) outfalls were conducted only once. In view of this, the problem being addressed in this extension project is to determine the concentration of emerging pollutants in coastal stormwater, and in WWTP effluent on a seasonal basis.

We will address this problem in two key locations: Gamay (NSW) and Glenelg (South Australia). These are the same locations sampled in Project 2.4 (with a focus on WWTPs), so that we can determine the comparative concentrations of CECs at stormwater locations.

1. Gamay (Botany Bay) in New South Wales
In consultation with NSW Department of Planning and Environment and Sydney Water, the project team will collect water and sediment samples from a range of sites in Gamay (e.g. within Towra Point Nature Reserve, swimming and fishing sites used by the Gamay community and at Foreshore Beach, known as the dirtiest beach in Sydney (Beachwatch, State of the Beaches Report, NSW Department of Planning and Environment). At each site, water and sediment samples will be collected at fixed distances away from the stormwater drain outlet or beach in the case of controls, similar to the design of Birrer et al. (2021; doi:10.3389/fmicb.2021.66117). The project team is also engaging with Gamay Rangers and La Perouse Local Aboriginal Land Council with the view to involving them in the project (see Indigenous engagement section).

We will quantify contaminant levels in both water and sediment samples using the same techniques used in Project 2.4. Briefly, concentrations of CECs such as pharmaceuticals (i.e. antibiotics), will be quantified using HPLC and mass spectrometry approaches (LC-MS, ICP-MS). Microplastic (<5 mm)

concentrations and characteristics (e.g. fragment/fibre) will be measured using best-practice techniques including visual inspection and infrared spectroscopy (FTIR). Physico-chemical data at sampling sites, including temperature, salinity, dissolved oxygen, chlorophyll a, dissolved nutrients and metals, will also be collected.

Potential marine ecological impacts will be examined by investigating the responses of microbial assemblages within the water column and sediment samples. Microbes are excellent diagnostic sentinels for impact because of their fast generation times and highly sensitive metabolisms, meaning that they can be employed as sensitive indicators of impact. We will employ ecogenomic approaches, including next generation sequencing to define the composition of microbial assemblages and use quantitative PCR approaches to quantify antimicrobial resistance genes. In addition to these genomic analyses, we will quantify populations of microbes using well-established flow cytometry protocols.

The project team will work collaboratively with all relevant Indigenous organisations (Gamay Rangers, La Perouse Local Aboriginal Land Council, South Australia First Nations Sea Country Research Alliance), to communicate project progress and communicate the research results in a respectful and culturally appropriate way. This will likely involve providing a project summary/fact sheet at the outset of the project and a presentation/written update after sampling, and following sample analysis.

2. Glenelg beach area in South Australia
Together with our partner, SA Water, we will collect WWTP effluent during different seasons to determine the concentration of CECs. These samples will then be delivered to the University of Adelaide (microplastic analyses) and shipped to the University of Technology Sydney to complete other CEC analyses.

If weather conditions permit, our partner SA Water will also deploy an autosampler to capture a high-resolution time-series of water samples during a stormwater event from urban beaches within St Vincents Gulf, South Australia (e.g. Glenelg, Brighton Beaches). This will provide a unique opportunity to assess contaminant dynamics during rainfall events but is dependent on the weather conditions that are forecast to be very dry in 2023-2024. Contaminant levels will be quantified using the approach described above. A table of analytes that will be tested is found in Appendix A.

National Outfall Database

A complementary aspect of this project includes the continued collection and reporting of Wastewater Treatment Plant discharge data in the National Outfalls Database for 2022/2023. Additional data on proposed capital works /license variations/technology/ by water treatment authorities will also be integrated into the database with their permission. The project will seek to use pre-existing HUB assets from NESP (1.0) wherever possible with a view to provide continuity with NESP2.0 in future years.

In order to connect the reporting of known contaminants through this mechanism to the field studies outlined above, we will also engage data providers within the states and territories to determine whether they would be interested in assisting with sample collection for a future project, and whether there are any planned infrastructure upgrades. Such plans would then help to prioritise where before-after control-impact (BACI) studies could be conducted that would determine the effectiveness of WWTPs in removing regulated contaminants as well as CECs.

Governance

A Project Steering Committee will be set up to provide a mechanism for regular communication between end-users, contributors and researchers. It will be comprised of members from DCCEW, NSW DPE, Sydney Water, SA Water, the Gamay Rangers, and UTS.

Outcomes

Overall, the various components of the project will increase the spatial and temporal sampling of CECs in coastal environments, and hence advance our understanding of the concentrations of these pollutants and provide information on the scale and significance of the issue. It will also deliver a fuller picture of the ecological footprint of contamination that will help decision-makers scope the research needed to determine guideline values.

The project outcomes have relevance for the management of state and Commonwealth marine parks around areas of human amenities, viability of coastal restoration projects in areas receiving stormwater inputs, protection and management of Ramsar-listed wetlands in urban settings such as Gamay (Botany Bay, NSW), and is fundamentally important to Indigenous communities who rely on a healthy environment to maintain their cultural practices.

Project 4.23 – Environmental DNA for measuring offshore marine biodiversity: what can DNA in water collected from the RV Investigator tell us?

Project type: Hub research project	
Cross-cutting initiative:	No
Project start date: 1/3/2024	**Project end date**: 10/2/2025
Project leader details:	Name: Bruce Deagle Organisation: CSIRO, Hobart

Project description

Project summary

Using environmental DNA (eDNA) found in seawater to get a snapshot of the species present in an area is an emerging technology with diverse applications in marine ecosystem monitoring. In this project we will collect a large eDNA dataset during the Southeast Australian Marine Ecosystem Survey (SEA-MES). The eDNA samples will be taken from the RV Investigator throughout the water column at offshore sites stretching from Tasmania to NSW, including sites within the South-east Marine Park Network. The voyage includes parallel collection of biodiversity data using a suite of conventional methods (nets, cameras, and acoustics) will allow us to assess how eDNA compliments these approaches. The project will provide a new baseline and unique eDNA-based perspective on the biodiversity of the region. It will also allow for evaluation of eDNA sampling methods and guidance for design of effective, scalable, and non-extractive biomonitoring tools for marine ecosystems.

Project description

Environmental DNA (eDNA) is genetic material that is found in the environment. In marine ecosystems eDNA is ubiquitous in seawater, and it comes from everything from bacteria to invertebrates and fishes. We can recover eDNA by filtering water samples and then use it to characterise biodiversity.

Surveying biodiversity using the information in eDNA is an emerging area of focus in marine environmental management. The approach allows for surveys of almost any organism and can be used in areas that are difficult or expensive to sample. There are numerous examples where eDNA has been used to provide biodiversity baselines on a regional scale and where eDNA has been used to document temporal/spatial changes in species distribution. It is however, still a relatively new technology – therefore, it is a priority to carry out end-user focussed research to evaluate how well the approach can address specific questions relevant for environmental management and to optimise methods for specific applications.

One significant application of eDNA methods is for biodiversity surveys in Australia's Marine Park network. Commonwealth parks cover several million square kilometres and depths down to >6000 meters, monitoring these large diverse ecosystems requires a range of innovative approaches. Parks Australia has already started investing in eDNA methods to collect information on presence of important species and to collect data on composition and change in biological communities. This data will help with understanding the current state of marine parks, allow evaluation of management strategy effectiveness and identify opportunities for future adaptive improvements. The eDNA approach also has much broader applications for environmental management.

In this project we will analyse eDNA samples collected on RV Investigator as part of SEA-MES voyages (July 2023 and May 2024). Our work will be leveraging voyage funding that has been committed to survey biodiversity at ~ 100 sites using conventional trawl sampling, zooplankton sampling, water column sonar for mid-water marine organisms and deployment of a deep towed camera. The aim of the proposed NESP funded eDNA component of the voyage is to provide a detailed comparative evaluation of the ability for eDNA to provide non-extractive biodiversity information in offshore areas. This research will also deliver a detailed eDNA baseline knowledge in South-eastern temperate region and compare biodiversity inside and outside two Commonwealth marine parks. We also provide an eDNA baseline for the Gippsland priority area for offshore renewable energy infrastructure and evaluate the ability of eDNA to detect some priority shark species which are present in the region.

In total we expect to collect about 600 eDNA samples during the voyages. We collected 300 eDNA samples at ~ 50 research stations during the first 30-day voyage (depth range of sites from 50-500m) and plan to collect a similar number of samples in May 2024. Samples of eDNA are taken before

trawls sampling occurs at a site using Niskin bottles to sample at points through water column. Niskin bottle samples include two litre volumes filtered through fine 0.2 µm pore filters (standard method for plankton) and 10 litre volumes filtered through 0.45 µm pore filters (optimal for fishes). We also deploy a CSIRO developed auto-sampler on the deep tow camera system to collect eDNA when this device is collecting video data – allowing collection of eDNA samples along the video recorded transect. In Marine Parks (see location section below) we will deploy all eDNA collection methods.

The project goals are to:

Collect a unique set of eDNA samples and data from throughout the water column of Southeast Australia. From the samples outlined –above we will sequence eDNA markers to document: (i) bony fish and shark diversity with high taxonomic resolution (10 L, subset of 2L samples, deep tow samples), and (ii) broad eukaryotic plankton diversity (2L samples). The eDNA will be archived.

Compare eDNA results with biodiversity datasets collected by a range of conventional survey methods including extractive sampling. This will provide an objective evaluation of the eDNA approach and set a course for eDNA sampling programs in the future. We will focus on practical questions of interest to biodiversity managers to help refine long-term eDNA monitoring programs:

- Can eDNA based observations be used as a proxy for traditional observations of benthic/pelagic fish diversity/abundance?
- Can eDNA based observations be used to measure diversity and abundance of pelagic plankton to monitor the health of the pelagic ecosystem?
- What is the horizontal and vertical distribution of eDNA signal? Compared with conventional datasets how structured is the eDNA data (i.e., do eDNA observations from surface waters reflect what is seen in deep samples and the benthic community?
- Using a shark-specific marker how often is eDNA from relatively rare species of interest detected (white sharks, grey nurse shark, etc).

Evaluate DNA sampling methods to provide guidance on eDNA sampling on future oceanic voyages. Several important questions need to be addressed before eDNA is widely deployed for monitoring and/or biodiversity discovery.

- Direct comparison of eDNA results collected through different water filtering protocols. Specifically, do fish detected in 2 L volume filtration (standard for plankton analysis) match 10L water volumes.
- Evaluate the underwater towed video eDNA sampling approach compared to standard water sampling.

Overall, the eDNA component of the two SEA-MES voyages covered in this proposal will provide a new baseline and unique eDNA-based perspective on the biodiversity of southeast Australia. It will also address critical questions to enable integration of eDNA methods into marine monitoring programs. Because eDNA has potential to provide effective and scalable biomonitoring tools it is of interest to managers of Australia's marine parks as well as for monitoring applications in fisheries, oil and gas production, and emerging renewable energy industries.

Project 4.24 – Towards assessing the values of reefs in the southern Gulf of Carpentaria

Project type: Hub research project	
Cross-cutting initiative:	Yes Protected Places Management Initiative
Project start date: 01/02/2024	**Project end date**: 30/06/2025
Project leader details:	Name: Maya Srinivasan Organisation: James Cook University

Project description

Project summary

The Gulf of Carpentaria Marine Park was only recently declared in 2013. The zoning plan for this marine park, which permits trawling within a specific trawling zone is due for renewal by 2028. There is a strong need to collect, analyse, synthesise and make publicly available information on the values and conditions of key habitats within the Marine Park, such as recently identified patch reefs and coral reefs, to contribute to this upcoming review of the management plan for this marine park.

The limited scientific information that is available on the values of this marine park is hard to access and much of it has not been analysed or written up. In addition, the Traditional Owners hold much valuable information about the ecological and cultural values that should inform future park management decisions. This project aims to gather, synthesise and report on existing scientific data and information about coral and patch reefs in the marine park. This information will be presented to the Traditional Owners and other relevant stakeholders at community meetings or workshops. Documenting cultural values of the reefs in this marine park is beyond the scope of the current project and would require considerable further engagement with Traditional Owners. However, it is anticipated that presentation of existing scientific and biophysical data at community meetings will start this process. We will produce visual (e.g. photos and videos) outputs that illustrate the values of these reefs, in order to better inform stakeholders involved in decisions about future park management.

Project description

The environmental values and condition of habitats in the Gulf of Carpentaria are poorly known. Within this region is the Gulf of Carpentaria Marine Park, which is offshore from the Wellesley Islands and covers 23,771 square kilometres. The marine park has National Park and Special Purpose (Trawl) zones that support commercial prawn fisheries. The Gulf of Carpentaria Marine Park is culturally important for the Lardil, Yangkaal, Kaiadlit and Gangalidda people who have responsibilities for sea country here. The Wellesley Island Sea Claim and Thuwatha/Bujimulla Indigenous Protected Areas overlap with the marine park.

The Lardil, Yangkaal, Kaiadlit and Gangalidda people of the Wellesley Islands have a continuing spiritual connection with their sea country and responsibilities for managing that country. Both the Thuwathu- Bujimulla Indigenous Protected Area (IPA) and the Wellesely Island Sea Claim determination extend over part of the Gulf of Carpentaria Marine Park. The Lardil people, as the Traditional Owners of Mornington Island and surrounding sea country, are recognised as the people of the Wellesley Islands with the authority to speak for sea country within the Gulf of Carpentaria Marine Park. Many prominent marine features, such as reefs, have their own specific names and values.

The Gulf of Carpentaria Marine Park was proclaimed in 2013 and its Management Plan, including zoning, is due for renewal by 2028. The location of permissible trawling zones has been the subject of debate with the Traditional Owners and other stakeholders. There is a need to collect additional data to inform future decisions about the zoning plans and for park management in general. Ideally, this would include cultural values as well as biophysical data, but the former would require significantly more engagement with Traditional Owners than has been undertaken to date. Limited biophysical data has been collected in the region since the marine park was declared. Of particular interest are coral reefs, which were only first identified in the early 2000's, but which remain poorly studied. Since their discovery and initial mapping by Geoscience Australia, only a few reefs have been assessed ecologically, and even then, only briefly. The main source of existing, as yet unpublished data is the Reef Life Survey. Reef Life Survey (www.reeflifesurvey.com) is a citizen science program in which trained SCUBA divers undertake standardised visual surveys of rocky and coral reefs. It has been applied to numerous locations around the world. In Australia, Reef Life Survey methods have been

applied to several marine parks, including sites in and around the Gulf of Carpentaria Marine Park and Wellesley Islands (see https://atlas.parksaustralia.gov.au/amps/latest-maps/reef-life-survey-site-locations?rsid=27184&featureId=AMP_N_GOC)

It is not the intent of this project to collect new data, but to analyse and synthesise existing data and information. Specifically, this will cover synthesis of existing published information and analysis of the unpublished Reef Life Survey data. The Reef Life Survey raw data is publicly available and has already been obtained by the project team. The resultant information from the data analysis and information synthesis will be presented to Traditional Owners (and other stakeholders) at community meetings or workshops. These meetings will also serve to begin discussions for co-design of further work on cultural values of these reefs.

Description of research

• Compile and thoroughly analyse existing published data and information on the values of the Marine Park and surrounding waters.

• Host workshops/meetings with relevant scientific, management, industry and Indigenous authorities on their values and knowledge of the marine park and surrounding waters.

• Use photos and or video to document the values of special features in the Marine Park.

• Where permissible, document and analyse fishing effort in the marine park.

• Working collaboratively with relevant stakeholders, prioritise future research actions and locations, including identifying priority areas for surveys.

• Report back to Traditional Owners and research users through on country meetings and appropriate information sheets, maps, and reports.

Output(s) to be delivered

• Technical reports making available existing technical knowledge

• Culturally appropriate communication outputs to record and share knowledge of values of the marine park

• Defined future research program for the reefs of the southern Gulf region