National Environmental Science Program

Marine and Coastal Hub research plan 2022 – Attachment B project plans



Project 2.1 – Mapping temperate continental shelf seabed habitats

Project description

Project summary

This project aims to fill gaps in knowledge of the extent and distribution seabed habitats for continental shelf regions of temperate Australia, with a focus on new observation information in temperate marine parks. The project will also develop data workflows that will allow the national ecosystem map in temperate regions to be rapidly updated as new information becomes available. The work builds on seabed mapping programs led through previous NESP Hubs and regional projects led by research institutions and State agencies, with seabed data collated and managed through initiatives such as SeaMap Australia and AusSeaBed. While detailed habitat mapping has been substantially advanced in many nearshore regions, Commonwealth waters of the continental shelf typically lack detailed habitat maps and, at best, have coarse resolution bathymetric layers. The project will improve our understanding of the distribution and extent of habitats on the continental shelf in temperate Australia, with a particular focus on rocky reefs which represent important natural values in the Australian Marine Park networks.

Project description

Background and scope

Reef ecosystems are recognised as important natural values by marine planners and marine park managers, and represent habitats that provide considerable social and economic value. The Management Effective System for Australian Marine Parks (AMPs) identifies reef habitats as an important determinant in the location of key natural values (Hayes et al. 2021), however, understanding of the distribution and extent of the reef and other seabed habitats on Australia's continental shelf is quite limited. A recent collaboration between Parks Australia and the NESP Marine Biodiversity Hub determined that for many AMPs, the extent of seabed habitats (including reef) is a key unknown that needs to be addressed as a priority for advancing our capability to assess management effectiveness.

This project aims to address this problem by completing three activities: 1) collating and analysing existing data that can be used to validate the presence/absence of seabed habitats on the continental shelf in temperate Australia; 2) collecting and analysing new data to validate the presence/absence of habitats, 3) developing new mapping to advance our understanding of extent and distribution of seabed habitats on the continental shelf in temperate Australia and guidance to ensure this knowledge can be updated using the repeatable methodologies. There will be a particular focus on the South West Marine Park Network due to the current paucity of information on the distribution of natural values in AMPs in this region.

There are a number of national drivers and strategies that have complementary goals and expected outcomes that relate to this seabed mapping proposal, with a key component of this being outcome 2 of the Protected Places Initiative Strategy (Figure 1). There are also a number of related proposals in the MaC Hub's Research Plan 2022 that will inform or benefit from these projects (Figure 1).

Approach

Activity 1: Collection of existing data to validate presence/absence of seabed habitats on the continental shelf

This approach is building on successful approaches advanced through State government programs to produce accurately validated mapping products for seabed habitats for coastal waters. The project team have identified a suite of existing datasets that can be used to validate presence/absence of seabed habitats. Several existing datasets in South Australia have been identified with project team member Dr Gretchen Grammer providing a conduit for access to these, including (but not limited to); BRUV and towed camera observations currently being completed in Great Australian Bight, Murat and Western Eyre AMPs. Additional observation data from the Franklin AMP, Zeehan AMP, as well as recently completed work in the Huon and Freycinet AMPs, will also be incorporated. We will also work closely with the proposed MaC Hub *Project 2.8: Mapping critical Australia sea lion habitat* to include (where appropriate) animal-borne imagery data in our mapping efforts (Figure 2). Imagery collected for monitoring purposes associated with the Oil and Gas sector may also be explored (subject to access).



Figure 1. Contextualising the research user needs of this proposal.

Activity 2: Collection of new data to validate/presence of seabed habitats on the continental shelf

Collection of new data will be undertaken to fill priority gaps in understanding of habitats on the continental shelf in temperate Australia. New data will be collected with the deployment of drop cameras (Figure 2) that will be collected in accordance with a new national standard develop as part of *Project 2.2 - Advancing national standards and best practices to monitor key marine values and pressures*). The location of drops will follow the national standard for survey design developed in the previous NESP Marine Biodiversity Hub.





Confirmation of priority areas for collection of new observation data will be undertaken via a workshop with research-users (e.g. Parks Australia), this will build on the initial prioritisation based on observation data availability, the uncertainty of the existing reef ecosystems map, expert knowledge provided during NESP/Parks Australia Management Effectiveness System key natural values workshops in 2021 and additional priorities for AMP knowledge (e.g. state of current knowledge, protection category, accessibility, the urgency of data to underpin future survey planning, including priority AMPs suggested from NESP MaC Hub *Project 1.2* workshops with Parks Australia). The identification of areas of shared interests with Indigenous communities will also be completed and incorporated where appropriate (see Indigenous consultation and engagement section). The workshop will develop a detailed research and extension plan for this project and upload priority areas to the National Areas of Interest for Seabed Mapping, Characterisation and Biodiversity Assessment [Milestone 2].

Activity 3: Developing knowledge and a workflow to advance our understanding of seabed habitats on the continental shelf

Producing national marine ecosystem maps has been a largely manual workflow and convoluted mapping process, making updating maps (as new observation data becomes available) a costly process. This component will build on the mapping approach developed in *Project 1.3 – Support for Parks Australia's Monitoring, Evaluation, Reporting and Improvement System for Australian Marine Parks*. It will focus on developing a robust and reproducible framework for temperate reef ecosystem mapping [Milestone 5], thus reducing differences associated with implementing different methods in the creation of national marine ecosystem maps. The project will develop data workflows, building on the previous mapping, that will allow the temperate reef ecosystem map to be rapidly updated as new information becomes available. The project will deliver data and visualisations directly to the proposed *Project 2.3 - Improving knowledge transfer to support Australian Marine Park decision making and management effectiveness evaluation*, which is developing fit-for-purpose data flows to inform AMP management. The project team will coordinate outputs and the Protected Place Management Mission Leaders will be a key point of contact between the two projects.

Informing decision-making and on-ground action.

The project will significantly improve knowledge (targeted surveys) of the mapped extents and spatial distribution of continental shelf habitats (including but not limited to reef, sediments and seagrass

ecosystems) in temperate Australia. This project will inform Park managers about the presence/absence of natural values within temperate AMP networks.

More practically, this project will enable a more cost-effective means of targeting appropriate habitats in future biodiversity inventory and monitoring programs associated with future MaC Hub and Parks Australia's activities by reducing the potential for over-sampling lower priority ecosystems such as unvegetated sediments, which generally host lower conservation values.

The improved knowledge on the mapped extents of these reef habitats, and by extension the non-reef component comprising soft sediments (including seagrass beds), will be critical for quantifying ecosystem services through Ocean accounts, which are emerging globally as a core approach to managing marine ecosystems and resources. Improved maps of habitat extent are also critical for marine spatial planning and sustainable use of marine resources (e.g. Ecosystem-Based Fisheries Management and exploration and production of offshore energy), and new knowledge can inform the development of environmental assessments in these sectors. For example, Australian Fisheries Management Authority has already requested access to the reef data layers that the previous NESP MBH and MaC projects have developed.

Indigenous consultation and engagement

Indigenous engagement and identification of research priorities for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy.

This project is a Category 2 project for Indigenous partnerships. Category 2 projects involve collaboration and opportunities for knowledge sharing. The project team will engage with Indigenous scientists and Rangers to identify interests and prioritise field areas that have shared interest between our project and their own. As such we have included a budget to facilitate knowledge exchange workshops, Welcome to Country and cultural awareness training on country (\$12,500). Where agreed, we will work together to sample these regions.

This approach will be achieved by leveraging established and developing new relationships between the listed researchers and their collaborators:

- UWA has existing collaborations with Esperance Tjaltjraak Native Title Aboriginal Corporation (ETNTAC) and they have been involved in proposal planning. Through existing collaborations with the West Section - Marine and Island Parks Branch - Parks Australia, ETNTAC have already indicated some priority locations. Project member Tim Langlois is in close consultation with both ETNTAC and the West Section team in Parks Australia and Tim will be attending a Sea Country Planning workshop on Country during February to further prioritise areas of interest.
- UWA has also previously worked through the South West Aboriginal Land and Sea Corporation (SWALSC) in consultation with the South West Boojarah (now Karri Karrak) and the Undalup Association, to inform cultural mapping and biodiversity surveys within the previous NESP Marine Biodiversity Hub. Project member Tim Langlois will lead consultation with these groups as the Parks Australia priorities for the study locations are established through the project.
- We are in the process of beginning consultation with the Ngarrindjeri peoples in South Australia to identify priorities within the Murray AMP

Location of research

This project will predominantly focus on the AMPs within the temperate continental shelf waters of south-west and southern Australia, with a particular focus on regions in the southwest where observational datasets are most lacking (Figure 3). While the reef ecosystem map in the Temperate East and South East networks requires improvement, they are the AMPs with the most observational and bathymetric data. Most of these datasets have not been combined to create validated habitat maps. These datasets are likely to be incorporated into the reef ecosystem map through RP2023 and beyond using the framework developed in this project. This is due to the timing of several additional bathymetric surveys funded by the Australian Hydrographic Service, Marine National Facility and Parks Australia that are currently underway or soon to cover several of the AMPs in the Temperate east (e.g. Solitary Islands AMP) and southeast (e.g. Franklin, Flinders and Zeehan).



Figure 3. Locations of initial sampling priority areas within AMPs. Priorities defined by colour and criteria used are listed under each. Areas in Priority 1 Areas (Red) are those intended to be sampled within the RP2022 phase of the project. Areas with black polygons delineate regions where indigenous engagement and collaboration have begun. Numbers next to red polygons indicate the number of field operation days required to collect observation data.

Project 2.2 - Advancing national standards and best practices to monitor key marine values and pressures

Project description

Project summary

This project aims to advance the establishment and use of national standards and best practices to monitor the condition status of priority values and pressures of Australia's marine estate. We will achieve this by building on the national standards and best practice process developed in the previous NESP Marine Biodiversity Hub to produce three new national standards for monitoring (drop cameras, socioeconomic surveys of marine users, marine microplastics). We will also develop a practical implementation plan to embed the application of standards, with particular attention to inclusive and diverse approaches (e.g. engagement of community groups and Indigenous partnerships). The plan will set out a future path to develop, maintain and make available national standards; increase their uptake; and assess effectiveness and impact as related to the delivery of priority monitoring activities.

Project description

The NESP Marine Biodiversity Hub 2015-2021, delivered a project that developed and progressed adoption of nine national standards for marine survey design and sampling (<u>field-manuals-marine-sampling-monitor-australian-waters</u>, Przeslawski et al. 2019a), as well as related activities (Przeslawski et al 2019b,c; Przeslawski et al 2020; Langlois et al 2021a,b,c; Przeslawski et al 2021). Ultimately, these agreed standards ensure that information collected is comparable with other areas and sectors, thus strengthening its value for managing at regional and national scales.

The project was a success, with the standards being adopted at State, Commonwealth, and international levels by a range of users, including industry and in developing nations. One of the national standards (baited remote underwater stereo-video - BRUV, Langlois et al. 2020) was elevated to a global best practice in 2021 after being one of the first such methods formally endorsed by the Global Oceans Observing System (GOOS).

Whilst these nine standards have been recognised to be critical for advancing capacity for a comprehensive assessment of Australia's marine estate and to inform management of both AMPs and state marine parks (i.e. as stated in the National Marine Science Plan), they represent a relatively small fraction of the total number of national standards required to meet national needs. At the conclusion of the previous Marine Biodiversity Hub project, we also had numerous recommendations (Appendix A), some of which paralleled those made by other initiatives (e.g. Hayes et al. 2021, AODN review, Appendix A), but with no obvious funding source to achieve these. Without taking the next steps and establishing national and long-term governance and application guidance (e.g. Bax et al. 2019), the national standards and best practices run the risk of becoming outdated and no longer fit-for-purpose as related to national marine monitoring objectives for key values and pressures. In addition, there are several new projects proposed for funding in Research Plan 2022 (NESP Marine and Coastal Hub) that seek to develop or apply best practises or introduce new technologies for particular disciplines and applications (Project 2.1 Improving the process of seabed habitat predictions for southern Australia, Project 2.3 Condition status of values and development of monitoring program for AMP networks; Project 1.29 - Emerging Technologies).

The proposed project addresses the need for leadership to guide the promotion and updating of the existing nine national standards for marine survey design and sampling, develop new standards and manuals according to best practice guidance (figure below), and demonstrate their application to research-users for surveying and monitoring the condition status of priority values and pressures.

The project team is experienced at seeking input and forming consensus on national standards for field sampling and will use existing NESP Marine and Coastal Hub Scoping studies to identify and incorporate national priorities. A workshop and questionnaire (Milestone 2) will further drive a collaborative approach to gauge the current needs of the marine science, Indigenous, and management communities regarding national standards and best practices, including the need for revised or new national standards and how we can make them fit-for-purpose for a diverse range of users. The recommendations from Milestone 2 and consultation with research-users (e.g. Parks Australia and DAWE Environment Protection Reform Branch-Strategic Policy Design Section) will be used to design an implementation plan to be detailed in the Milestone 2 report.

The project will update the current web platform presenting the field manuals and national standards, to ensure they are fit-for-purpose and update the mature and internationally recognised BRUV national standard (Langlois et al 2020) with analytic case studies and reporting dashboard template for the condition status of priority values (Milestone 5). These milestones will also build off development work underway through co-investment by the Fish and Sharks Australian Data Partnership project the received investment (https://doi.org/10.47486/DP761) from the Australian Research Data Commons (ARDC). The ARDC is funded by the National Collaborative Research Infrastructure Strategy.

The current web platform (field manuals for marine sampling to monitor Australian waters) has been demonstrated to be robust, scalable and cost-effective. This will include the following:

- Change of branding and relevant links to the NESP Marine and Coastal website;
- Minor updates and corrections to current field manuals based on guidance from the working group leader(s);
- Updates of further resources to appropriately direct users to related reports and guidance;
- Based on research-user requests (i.e. Parks Australia and the WA-Department of Biodiversity Conservation and Attractions-DBCA) we will include in the BRUV national standard:
 - Exemplar workflows and analytic case studies, outlining principles and assumptions, that research-users could apply to external parties contracted to undertake research and monitoring.
 - Reporting dashboard template for the condition status of likely priority values supported by a co-investment from WA-DBCA and designed to complement future work on the development of monitoring program for AMP network within the Hub;

Research-users and ongoing NESP Marine and Coastal Hub scoping projects have already identified priorities for the development of additional national standards and best practices in three key areas identified as requiring consistent national approaches:

- A drop camera national standard (Milestone 6) will address the need for a consistent costeffective approach implementing spatially-balanced designs for large-scale validation of continental shelf habitats, supporting the aims of the new NESP Marine and Coastal Hub Project 2.1 'Mapping temperate continental shelf seabed habitats', as well as a key information requirement by the NESP Marine and Coastal Hub Project 1.3 'Support for Parks Australia's Monitoring, Evaluation, Reporting and Improvement System for Australian Marine Parks'.
- A framework for socio-economic surveys of marine users, with standards and schema for use and both management support and awareness (Milestone 7), has been identified as requiring consistent national approaches by Parks Australia and other research-users including WA-DBCA through the current Hub Scoping study 1.17 '*Research needs for a national approach to socio-economic values of the marine environment*'. These national standards would build on the

methods applied in the previous NESP Marine Biodiversity Hub project '*Socioeconomic benchmarks of the Australian Marine Parks*' (Navarro et al. 2021). The need for this standard has also been highlighted in previous reports on new national standards (Przeslawski et al 2019c).

 A marine microplastics national standard (Milestone 8) will address the need for cost effective, standard and consistent approaches that harmonize research, sampling, and analyses on coastal and marine plastics (UNEP 2021). A recurring conclusion from reviews of marine and coastal plastic assessments is that widespread use of different sampling approaches, sample preparation methods, measurement units, exacerbated by the lack of effective quality assurance and control procedures, result in datasets that are inconsistent, uncertain and seldom comparable. This gap and need has also been highlighted in the ongoing NESP Marine and Coastal Hub project 1.18 Synthesis of current data on microplastics in South Eastern Australia.

Importantly, these new national standards will be developed according to established international best practice (figure below) which adopts an inclusive, collaborative and iterative approach.

We will deliver a final report and implementation plan (Milestone 9) that synthesises results from the other milestones and includes a number of important outcomes (see below), many of which address the recommendations from the previous projects identified. The implementation plan will include an update on national standard uptake and impact (Przeslawski et al 2021) and include recommendations for governance, maintenance and future manuals. The implementation plan will contribute directly to delivering recommendations of National Marine Science Committee (NMSC) Baselines and Monitoring Working Group. The implementation plan will be presented to the NMSC and documented in a scientific publication (Milestones 3 and 4).

It is expected that this project will inform decision-making and on-ground action by:

- 1. Contributing to an improved information flow from survey through to management decision for the task of assessing condition status of key natural values and pressures;
- 2. Facilitating stronger and more general inferences about ecological processes to further scientific understanding. This will be achieved by providing consistent sampling methodology that will allow direct comparisons in space and time;
- 3. Aiding the cost-effective sampling of Australia's EEZ (including Australian Marine Parks) even when that sampling is performed by different institutions at different times.
- 4. Providing a reference point for regulatory and management agencies with a requirement to monitor the trend and status of communities and individual species.



Indigenous consultation and engagement

Indigenous engagement will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is a Category 2 project for Indigenous partnerships. Category 2 projects involve **collaboration** and opportunities for knowledge sharing.

We will make every attempt to ensure this project is Collaborative, soliciting and integrating input from Indigenous scientists and Rangers to ensure the national standards are applicable to a diverse range of practitioners. As such we have included a budget to facilitate two knowledge exchange workshops, Welcome to Country and cultural awareness training on country (\$25000). This approach will be achieved by leveraging off established relationships between the listed researchers and their collaborators, for example:

- AIMS has pioneered policies and procedures for establishing and growing meaningful 2-way Indigenous partnerships with Traditional Owners of sea country across northern Australia (<u>https://www.aims.gov.au/indigenous-partnerships</u>).
- UWA has existing collaborations with Esperance Tjaltjraak Native Title Aboriginal Corporation (ETNTAC) and the Nyinggulu Joint Management Body via research partnership through WA-DBCA. These groups have expressed an interest in learning from and contributing to national standards to ensure they are fit for purpose. In particular ETNTAC have been involved in this project proposal planning and Project member Tim Langlois is in close consultation with them and attending multiple Sea Country Planning workshop on Country during February and March.
- NSW DPI Fisheries has established relationships with Indigenous communities along the NSW coast, including strong marine research and training collaborations in Yuin country.
- All listed PIs have professional relationships with established Indigenous marine scientists who will be invited to provide input, review, or co-author project milestones.

In particular, for the proposed socio-economic and drop-camera standards, we propose to engage with the Esperance Tjaltjraak Native Title Aboriginal Corporation, Undalup Association via Karri Karrak, Nyinggulu Joint Management Body and the Murujuga Aboriginal Corporation. All of these groups have experience with one or two of the methods proposed to be adopted as national standards in this project. Project coordinator (Langlois) via UWA, already has research agreements in place with these groups and organisations that covers joint research and collaboration on these topics. In addition, we will be ready to engage with additional Indigenous and Traditional Owners groups on all standards if opportunities arise throughout the project.

Cultural awareness training, where possible and appropriate, will be co-designed with the different traditional owner groups to optimise the interaction of the project team with traditional owner groups to ensure the workshops are carried out in a culturally respectful manner whilst being focused on developing national standards for marine survey methods. Cultural awareness training is consistent with the Hub Indigenous Partnerships strategy, creating opportunities for researchers to positively engage and learn. In this project we are not seeking Indigenous Cultural Knowledge or Property, this project is seeking technical input and insights into the use of western science methodologies by Indigenous individual practitioners with technical experience in these western science methodologies.

The proposed discussions and questionnaires will be designed to collect information on the application and potential improvement of survey methods that are intended to be included in the new national survey standards. These discussions and questionnaires will not be designed to elicit ICIP.

However, project coordinator (Langlois) has experience with designing and delivering projects with ICIP for sea country cultural mapping projects to inform marine biodiversity surveys in the previous

NESP Marine Biodiversity Hub. As such Langlois will be responsible for discussing ICIP with traditional owner groups that we propose to engage with. The above-mentioned "discussions and questionnaires" will be designed to inform the standardisation of methods across research-users, however we will have a draft ICIP in place in case any of the traditional owner groups wish to include cultural information and knowledge into the proposed national standards. These ICIP arrangements will be based on a template agreed with the Traditional Owners groups before any workshops take place providing free, prior and informed consent (FPIC).

If the Traditional Owners groups engaged with do not want to share any cultural information through the national standards produced by this project, all cultural information provided in the "discussions and questionnaires" mentioned above will be removed. As an addition to Milestone 1, Langlois will provide templates to the NESP office and Parks Australia - Marine Parks Branch for discussion and comment before they are distributed to traditional owner groups that we plan to engage with in this project.

Human ethics approval for the standard survey targeting skilled and experienced individuals in these methods, which may include Indigenous practitioners, will be sought for the whole project. Langlois (Project Coordinator) via the UWA Human Ethics Committee already has approval in place for these surveys which has been jointly applied for with and names Esperance Tjaltjraak Native Title Aboriginal Corporation. This successful Human Ethics process will be used as a template for the larger project, including consultation with Traditional Owners. The project's final report (Milestone 9: implementation plan) will also include ways forward to ensure new and revised national standards are collaborative (Category 2) or co-designed where appropriate (Category 1).

Despite our best intention, the relatively short duration of the project (18 months) may impede comprehensive collaboration with Indigenous partners and their research needs. We are confident we can leverage off existing relationships (listed above) to expedite collaborations, but there is a possibility that the project will end up as communicative (Category 3) if these relationships between institutions, communities, or individuals change.

Location of research

Project is a desk-top study involving a geographically dispersed team with bases in Sydney, Perth, Townsville, Hobart and Canberra.

Project 2.3 – Improving knowledge transfer to support Australian Marine Park decision making and management effectiveness evaluation

Project description

Project summary

In the last decade Australia's researchers have made significant progress to provide managers with data and data products to inform the planning and establishment of Australian Marine Parks (AMPs). However, further work is required to adequately meet the data product requirements for assessing AMP management effectiveness. This project addresses this problem by: 1) Identifying priority data and data products to support characterisation of marine systems and reporting on AMP monitoring priorities; 2) Assessing availability and delivery mechanisms of high priority data and data products and whether they are fit for purpose; and 3) Estimating condition of park values (excluding cultural values) and assessing management effectiveness with available data/knowledge. This project advances the Hub's Protected Place Management Initiative and contributes to the national need for improving access to data and expanding the Australian Ocean Data Network.

Project description

The key aim of this project is to work closely with Parks Australia to design and implement a process that: (i) identifies the knowledge, data and data product needs of decision makers; (ii) articulates the pathways and tools required to deliver data and data products that meet their decision making needs; and (iii) demonstrates empirical methods for estimating condition of priority marine park values, and wherever possible, management effectiveness of AMPs. Where roadblocks are identified that currently prevent the delivery of suitable data, we will identify and recommend how to resolve these roadblocks in a way that supports a seamless end-to-end process from data collection to knowledge transfer and decision support.

The project will achieve this objective through three key activities, namely:

- Identify the priority data and data products required to support decision making related to
 protecting marine park values, evaluating the condition of marine park values and evaluating
 management effectiveness.
- Assess the timely availability of, and access to, the data identified and whether it is currently fit for purpose.
- The development and demonstration of empirical methods for estimating condition and if possible, management effectiveness of AMPs.

Identification of Priority Data

Working closely with Parks Australia, the project will consider data and data products that support characterisation of marine systems and reporting on AMP monitoring priorities. In particular (but not limited to) those identified in the South-east MERI Pilot project (Hayes et al., 2021; NESP 1 RPV6) and the project "Support for Parks Australia's Monitoring, Evaluation, Reporting and Improvement System for Australian Marine Parks" (NESP 2 RPV21).

Priority data identified will be arranged in a data product hierarchy from primary data through to derived data products and high level model-based indicators (see Supplementary information for a definition and example of a data product hierarchy).

Parks Australia and the project team will identify a shortlist of high priority data products that are fit-forpurpose, are aligned with the requirements for decision making and can be maintained and updated over meaningful timeframes (e.g., reporting cycles, management plan lifespan). The prioritisation of data products will take into consideration the resources and capacity available to specify, develop, manage, update and use the products.

Assessing availability, fitness and access to Priority Data

This assessment will be focused in two main areas: (i) the fitness of the data and data products to develop the outputs required to support knowledge transfer and decision support; and, (ii) the ability of the underlying software and hardware infrastructure used to store and manage the data to support processes required for knowledge transfer and decision support in a timely and efficient manner.

This project will identify the criteria required to meet these two requirements and test against available sources of data and data products. For data to be "fit for purpose", this may include (but not necessarily limited to) the following criteria:

- 1) how well does the data collection process and analysis align with best-practice (e.g., use of Standard Operating Procedures) or other standardised and well-accepted methodologies.
- 2) is the data available from a single source or widely disseminated (making access difficult and time consuming).
- 3) how well do the data and data products align with the decision making requirements of Parks Australia (either as standalone products or inputs to new empirical methods).
- 4) the availability of ongoing resourcing for collection, processing and analysis of the data.

An assessment of the hardware and software infrastructure supporting identified priority data and data products may include (but not be limited to):

- 1) alignment with the FAIR data principles and measures of stewardship consistent with ongoing management and access to the data in a timely and reliable manner.
- 2) consistent formats, vocabularies and units of measure.
- 3) machine-actionable interfaces for access to data.
- 4) use of standards specific to the marine research domain (e.g., OGC web services, ISO19115 metadata).

On completion of these assessments this project will provide a gap analysis and, where gaps are identified, recommendations for advancing delivery of priority data and data products to manage AMPs. This will be included with the outcomes and findings of the project compiled in a final report.

Estimating condition and management effectiveness

Fit for purpose, priority data and data products provide an opportunity for an empirical (data driven) assessment of the condition of marine park values. The extent and scope of this empirical assessment will be agreed with Parks Australia upon completion of the project outputs preceding this activity (Project Outputs 1 to 3 described below). The statistical methods employed will be determined by the available data and the identified values of interest. This data-driven approach will be complemented by expert elicitation where needed to address known data limitations including lack of monitoring data.

The project will collaborate with Parks Australia to develop a method for assigning the estimated condition (based on observed indicator metrics) to one of the Parks Australia's four management effectiveness categories for marine park values and pressures. We anticipate that this methodology

will draw upon (and be informed by) the approaches, experience and methods developed in State marine parks, such as the control charts approach implemented by Parks Victoria (lerodiaconou *et al.*, 2020), the status reports for the Great Barrier Reef Marine Park, WA Department of Biodiversity Conservation and Attractions - Marine Park reporting dashboard (under development), and experience using expert opinion to inform condition assessments for values and impact/status for pressures (and assignment to categories), both where there is quantitative data available to underpin assessments and where there is not (see for example Cook et al 2017).

Where traditional approaches for establishing condition categories linked to management effectiveness are not available (because historical estimates of condition prior to management are not available for comparison), the project will work with Parks Australia to identify other appropriate methodologies for measuring management effectiveness into the future. These methodologies may entail the use of expert elicitation.

Indigenous consultation and engagement

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

The project team will use existing mechanisms to communicate and share results with relevant Indigenous groups. We will work with Parks Australia to prepare appropriate communication materials to update members of their Australian Marine Park Advisory Groups, these regionally based groups include Indigenous members that are engaged in the management of Australian Marine Parks. Note,

Location of research

Project scope is national and desktop research would therefore be conducted throughout the locations of Parks Australia (Kingston, Tasmania) and the project partners, including Perth (Western Australia), Adelaide (South Australia), Warrnambool (Victoria), Mosman (New South Wales), Townsville (Queensland) and Hobart (Tasmania).

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Supplementary information

Data product hierarchy

A data product hierarchy in this context is a prioritised stack of related data products that can be used to answer one or more management questions (Figure 1). The product hierarchy may include products that are derived from primary data sets (for example modelled species distributions) or characterisations of primary data that are performed in a standardised fashion (for example image annotations). In general, higher levels represent additional information or additional processing and/or synthesis of data at the lower levels. Examples of data and data product hierarchies used elsewhere in the marine science data community can be found in Lear *et al*, (2020) and Picard *et al*, (2018).



Figure 1: An example of a product hierarchy that may be identified through this project focussed on characterisation of habitats in marine systems.

The project aims to identify a shortlist of high priority data products that are fit-for-purpose and can be maintained and updated over meaningful timeframes (e.g., reporting cycles, management plan lifespan). The prioritisation of data products will be taking into consideration the resources and capacity available to specify, develop, manage, update, and use the products.

Project 2.4– Ecological outcomes of wastewater discharges in contrasting receiving environments

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. Wastewater treatment plants currently report on a limited number of contaminants and lack consistent testing requirements. Scoping study 1.16 has determined there is a clear and consistent need for data on environmental concentrations of emerging contaminants and an assessment of their impact on ecological communities. This project aims to determine the concentration of emerging pollutants in different wastewater outfall settings, and assess where environmental impacts are greatest. It will also continue to collate, analyse and maintain the information from Water Treatment Authorities on outfall flows, pollutant concentrations and loads and presented annually within the National Outfalls Database.

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. In addition to wastewater treatment plants having limited coverage of contaminants they report on, there is currently a lack of consistent testing requirements, methods and coordination in sharing results amongst wastewater treatment managers, government agencies and regulators.

The Marine and Coastal Hub Scoping study 1.16 has determined there is a clear and consistent need for data on environmental concentrations of emerging contaminants and an assessment of their impact on ecological communities. In view of this, the problem being addressed in this project is to determine the concentration of emerging pollutants in different wastewater outfall settings, and assess where environmental impacts are greatest.

We will address this problem in a two-phase study at several key locations.

In **Phase 1 ('Selection of sampling locations using oceanographic analysis')**, we will collate data from Water Treatment Authorities and present this within the National Outfall Database, and use with other environmental information such as the Integrated Marine Observing System (IMOS) and the outputs of oceanographic simulations to identify a small set of locations for sampling that are representative of a range of receiving water contexts. In **Phase 2 ('Sampling and data analysis')**, we will collect samples from each identified location to quantify concentrations of a suite of Contaminants of Emerging Concern (CEC; encompassing several contaminant classes including pharmaceuticals, industrial chemicals, and microplastics) and assess a range of potential ecological impacts including the capacity for photosynthesis, changes in microbial population size, shifts in microbial community function, oxidative stress and ecosystem services (primary productivity).

The data collected from **Phase 2** will provide critical information on the concentrations of these contaminants at representative locations and their potential effects on marine ecosystems. Additionally, this information will establish a baseline that will allow assessment of the effectiveness of future interventions to alter the load of pharmaceuticals, industrial chemicals, and microplastics that are entering marine and estuarine environments from wastewater outfalls. The information, together

with data from other sources, may also be used in threat and risk management strategies that could be implemented to decrease the impact of contaminants entering marine and estuarine environments.

Phase 1: Collation of national outfalls data and selection of sampling locations using oceanographic analysis

In **Phase 1**, we will leverage the existing National Outfall Database (NESP July 2015 to June 2021) and the technical knowledge and resources of a physical oceanographer to examine the hydrology at proposed sampling locations. This work will be undertaken as a desktop study using existing observation and modelled datasets, and will determine three key locations for contaminant sampling, as well as representative control environments that are remote from significant terrestrial contaminant input, but comparable to each outfall site in terms of geography and physical characteristics.

Our criteria for choosing sampling locations will include sites with low levels of sewage treatment (primary treatment only) where the discharge enters receiving waters that have diverse physical/oceanographic characteristics, with consideration given to stratification, mixing, residence time scales, and exposure to the ocean. Locations chosen for sampling will be representative of other locations both in terms of low levels of treatment at wastewater plants and coastal environments across the nation. The sampling regime will be designed in close consultation with the relevant water authority or utility/regulator and relevant Traditional Owners.

The project will also continue to support collation and presentation of a number of water quality indicators in the National Outfalls Database (NOD) (<u>www.outfalls.info</u>; Rohmana et al. 2020; Gemmill et al. 2021), which allows communities to identify the quality of outfall effluents along the coastal areas of Australia. There is a primary focus on nitrogen, phosphorus, total suspended solids and flow volume, but a total of 38 indicators are included.

Phase 2: Sampling and data analysis

In **Phase 2**, a spatially-resolved sampling regime will be undertaken at each of the locations that were chosen in Phase 1. At each site, water and sediment samples will be collected at fixed distances away from the outfall, similar to the design of Birrer et al. (2021; doi: 10.3389/fmicb.2021.66117). Sample analysis will involve two principal goals:

Goal 1: quantification of contaminant levels, and associated physico-chemical variables

Goal 2: characterisation of ecosystem impacts.

For **Goal 1** we will quantify contaminant levels in both water and sediment samples using established techniques (see previous studies listed below). Briefly, concentrations of CEC such as pharmaceuticals and industrial chemicals (i.e. flame retardants), will be quantified using mass spectrometry techniques (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.

For Goal 2, we will focus our analysis on three ecosystem characteristics:

Firstly, marine ecological impacts will be examined by studying 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. Furthermore, several 'keystone microbes' perform fundamental ecosystem services and an assessment of their distribution at ocean outfall sites will deliver critical insight into the fundamental ecological impacts of CEC contamination. We will employ ecogenomic approaches, including shot-gun metagenomics to define the composition (including, for instance, presence of antimicrobial resistance genes) and functional capacity of microbial assemblages within ocean outfall samples. In addition to these genomic analyses, we will

quantify populations of microbes using well-established flow cytometry protocols, determine their photosynthetic capacity and assess their level of oxidative stress.

Linking analytical outcomes (Phase 2) to oceanographic analysis (Phase 1)

The results obtained from **Phase 2** of this study, including the concentrations and distribution of CEC and their ecosystem impacts, will be compared across the ocean outfall sites and related control environments to establish effects of outfalls on the receiving environment. We will use our residence time framework to test predictions that ecosystem impacts will be greatest at locations with low mixing and rates of dispersion.

Data derived from this component of the study will contribute essential baseline information on the concentration and distribution of novel CEC in Australian marine environments, which will fill this significant knowledge gap and inform risk-based analyses on the impact of CEC.

Out of Scope Analyses:

1) The NOD involves collection of data from 194 coastal outfalls, and while the characterisation of CEC at these sites has been highlighted as a knowledge gap and future priority, incorporating the analysis proposed here at more than a few representative sites is not currently feasible, given resources available. We will therefore choose 3 locations that receive wastewater with low treatment level, and that have contrasting (but representative) receiving environments.

2) There are hundreds of contaminants that are not fully removed in wastewater treatment plants, including human hormones such as estradiol that are known to have impacts on vertebrates. Here we will focus on the impacts on the lower trophic level of marine ecosystems and not direct impacts to human health.

• details of related prior research, if relevant

Relevant prior research includes the development of the National Outfall Database and the NESP Tropical Water Quality Hub Project 1.10: 'Identification, impacts, and prioritisation of emerging contaminants present in the GBR and Torres Strait marine environments' (Kroon et al. 2020). The latter report provided some regional-level insight into presence of contaminants and their potential impacts, but was undertaken prior to the rising concern about antimicrobial resistance outlined in Australia's National Antimicrobial Resistance Strategy.

In terms of the oceanographic context in Phase 1, the multi-decadal EAC ROMS model for the east coast of Australia (Li et al. 2021, Kerry and Roughan 2020), and the Australia wide OZ ROMS model (Wijeratne et al. 2018) are important prior works, as is data from the long term IMOS monitoring sites (<u>www.aodn.org.au</u>), and datasets provided by water agencies (such as the 30-year Ocean Reference Station dataset maintained by Sydney Water).

Supporting Phase 2 are published methods for the sampling of deep sediments (Sydney Water, 2020), sampling methodologies for specific classes of contaminants (for example, PFAS as in Szabo et al. 2021), as well as analytical procedures (French et al. 2015; Klosterhaus et al. 2013). Furthermore, there is significant prior research on the ecological impacts of human-derived chemicals (reviewed in Durán-Álvarez et al 2021; Gaw et al 2014), ranging from antibiotics (Grenni et al. 2018) to flame retardants (Dietrich et al. 2014). This literature is being comprehensively reviewed as part of Scoping Study 1.16.

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

This project links to the work of the NESP Sustainable Communities and Waste (SCaW) Hub, given the shared interests in managing waste generated by humans, need for increased knowledge on the environmental impacts of waste, and data to inform waste management practices to reduce environmental impacts.

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

This project will provide data on the concentrations of contaminants of emerging concern (CEC) adjacent to a representative selection of wastewater treatment outfalls in Australian coastal waters, as well as an understanding of the spatial attenuation of CEC to background concentrations. It will also maintain reporting of water quality variables from marine outfalls across Australia allowing an ongoing assessment of wastewater discharges and trends, which can inform evaluation of adherence to water quality guidelines, and assessment of options for treatment upgrades.

It will also provide ecological data, alongside physicochemical data, that will be used to assess impacts of CEC on lower trophic levels.

By sampling at outfalls with minimal to low wastewater treatment, we are targeting locations where contaminants may be expected to have highest concentrations and greatest ecological impact, depending on the receiving environment. Thus, the empirical results will inform future CEC risk assessments and risk management strategies.

The data obtained through this research may also be used as baseline concentration data to assess the effectiveness of risk management interventions aimed at reducing the concentrations of CEC entering Australia's coastal environment.

Indigenous consultation and engagement

Indigenous engagement and collaboration for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is a Category 2 project for Indigenous partnerships. Category 2 projects involve collaboration and opportunities for knowledge sharing.

The Indigenous community are important stakeholders in issues of water quality. Following Phase 1, when sampling locations have been selected, we will target our engagement, in collaboration with the Hub's Indigenous Facilitator, to relevant Indigenous organisations.

Through the Hub's and the project teams established networks, we will target Indigenous engagement to site-specific Indigenous organisations. We will seek to use state-based Indigenous networks engagement mechanisms and the Indigenous knowledge brokers appointed by relevant governments (e.g. Kylie Jacky, Aboriginal Initiatives Lead, NSW EPA). Possible site specific examples of Indigenous organisation in NSW include the Sydney Metro Local Aboriginal Land Council and the La Perouse Local Aboriginal Land Council (Chris Ingrey, CEO), relationships that are already being developed through the Sydney Institute of Marine Science.

The project team will work collaboratively with participating Indigenous organisations to communicate project progress and communicate the research results in a respectful and culturally appropriate way.

Location of research

Phase 1 of this study will involve a desktop study conducted at national scale.

Phase 2 of this study will occur at various marine sampling locations. The exact sampling locations are dependent on the outcomes of Phase 1. We anticipate taking a regional approach where we will sample several representative locations so that the data collected will inform water quality management issues on a national scale.

Analysis of the collected samples will take place at various analytical facilities including the University of Technology Sydney, NSW DPIE, the University of Adelaide (microplastics analysis), and other locations.

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Project 2.5 – Evaluation of recreational fishing behaviour, use, values and motivations that relate to compliance

Project description

Project summary

This project aims to inform the use of behavioural change interventions to support regulation compliance of recreational fishers and boaters. It will deliver proof of concept tailoring of behaviour change to inform the practical design of interventions in case studies for further refinement, implementation and evaluation in subsequent research plans. The project will focus on recreational fishers and boaters in 2-3 case study locations, including the Great Barrier Reef Marine Park, and within the newly designated Australian Marine Parks such as Two Rocks Marine Park and Jurien Marine Park.

Project description

Compliance of recreational boaters and fishers with regulations is essential for effective management, but challenging in an Australian context where the dispersed nature of these activities makes enforcement difficult. In such circumstances, achieving self-compliance through behavioural change interventions is essential to the management mix in achieving marine protection goals.

Whilst the application of behavioural change strategies has matured in recent years to a legitimate and topical area of interest for public policy (including in the areas of taxation, health and transport), its application to marine management has lagged. This project will also build on several previous NESP funded projects. The NESP Marine Biodiversity Hub D6 project produced a fundamental understanding of recreational fishers and boaters awareness and attitudes towards state and Commonwealth no-take marine reserves, relevant for identifying appropriate behaviour change interventions. Workshops held as part of the NESP MAC 1.17 project revealed that end users require guidance on which behavioural change strategies to use, how to implement them for success, and how to monitor outcomes. This project therefore builds on, and delivers the next stages of research, to address these identified research needs.

This project will provide guidance for end-users on the application of behavioural change interventions in the marine environment, with an initial emphasis on recreational fisher and boater compliance. This project will involve four major activities:

- 1. Synthesis of behavioural change interventions available to address recreational fisher and boater compliance, and recommendations on when each intervention is appropriate.
- 2. Development of a theory of change (TOC), based upon this synthesis, elaborating a generic causal chain of how behaviour change interventions are expected to result in the desired outcomes of fisher compliance and ultimate impact of improved marine systems and biodiversity values. Particular threatened species at risk from recreational fishing will be included in TOC to consider desired ultimate impacts of the desired outcome of recreational fisher compliance with regulations.
- 3. Tailoring the TOC to 3-4 case studies (indicative locations GBR, Two Rocks Marine Park, and Geographe Marine Park with other potential parks identified by Parks Australia to further scope such as Pimpernel Rock National Park Zone and Cod Grounds) through first characterizing the target population, using workshops (or other survey instruments time allowing) to further refine the TOC and segmentation of target population, investigate trends revealed through the NESP D6 socio-economic benchmarks in support across locations (within the AMPs), and identification of possible interventions. This approach will leverage any lessons learned on existing interventions (e.g. Eye on the Reef app, regular messaging campaigns, compliance efforts) to further refine available interventions. This is a proof of

concept test of the intervention design approach to both refine the TOC and ensure its application to multiple contexts but also to demonstrate the approach for a larger research application.

- 4. For the case of the GBR we will also use the TOC to design and implement messages and evaluate them in terms of short term impacts/observed immediate behaviour changes.
- 5. Co-design of larger behaviour intervention design implementation and evaluation research plans for the case studies (~ 3 year research programs required for full design, implementation, and short term evaluation of intervention).

Case studies will be chosen to stratify geographic location, type of likely intervention, and stage of marine estate implementation. Indicative case studies where marine park managers have indicated issues with noncompliance with zoning rules are the long standing Great Barrier Reef Marine Protected area (GBRMPA, zoned in 2005), and within the newly designated Australian Marine Park (AMP) network, the Two Rocks Marine Park, Jurien Bay Marine Park and Geographe Bay Marine Park. The final choice of AMPs will be scoped with Parks Australia as a key research user. The GBR case study is being co-designed with GBRMPA to deliver on their knowledge needs. The TOC will be tailored to the case studies based on the data gathered on the target population to identify novel interventions to refine and test in future research. The project will demonstrate the potential to use a theory of change to design novel behavioural change interventions tailored to case studies. We expect this process will refine development of research plans for use by stakeholders to enable them to refine design interventions, implement, and evaluate them (a longer 3 year program to allow for appropriate implementation and testing of interventions). Guidance on use of behavioural change interventions were identified as a key research need with research end users in the NESP MAC 1.17 project and this project will be strongly aligned with and necessarily build upon and use outputs from NESP MBH D6 and NESP2 Mac 2.2 in terms of identifying and characterizing values of stakeholders as a key step in segmenting the target audience for interventions.

Indigenous consultation and engagement

This is a category three project, and as such we will communicate and share results with relevant Indigenous organisations. This project is considered a category three project for Indigenous engagement as it is a primarily desktop study requiring deep engagement with DAWE research users that interact with recreational fishers and boaters (Great Barrier Reef Marine Park Authority, Parks Australia and Threatened Species Branch in particular). Indigenous consultation and engagement for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy.

The majority of work for this project will be desktop. However we do envision some data collection via workshops or surveys (time permitting). Where selected case study locations overlap with Indigenous native title or sea country interests we will engage with the appropriate cultural authorities to communicate the aims of the project and to understand their level of interest in the project. Indigenous groups will be tailored to specific circumstances, for example: : 1) there may be general interest in the project because of cultural or use connections to case study locations and there is a request to be informed about research results, 2) there may be a deeper interest in the project because they are actively engaged in managing the marine park and seek to be more engaged in the project (e.g. they have their own observations of recreational fishing and boating issues and suggested ways of addressing these concerns). If we find that we are engaging with Indigenous groups only under example 1 above then we will remain a category 3, and offer to include them in the survey consistent with our ethics approvals. If we find that example 2 above becomes relevant the project will more in line with a category 2 project (for Indigenous engagement) and appropriately engage with the relevant cultural authority. In this case we envision co-design of survey questions with Indigenous managers and payment for their contributions to the project.

Location of research

This is a desktop and field-based study at national scale. The research team members (CIs and RA) are based in Hobart, Perth, and Queensland (multiple cities) and thus the desktop study will take place in these locations with additional field work in Western Australia and Queensland. Research findings have been designed to provide cross comparison across case studies to draw inferences around what messages or behavioural nudges might be most relevant in particular contexts. The theory of change supports transferability of findings to diverse contexts. The research team will utilise their national networks and research collaborations to provide project outputs at the appropriate scales.

Project 2.6 – Mapping critical Australia sea lion habitat to assess ecological value and risks to population recovery

Project description

Project summary

Populations of the endangered Australian sea lion have declined by >60% over the last 40 years. There is a marked uneven distribution in abundance and trends across the species range, suggesting that localised risk profiles from threats vary at small spatial scales. Fine scale differences in habitat use are thought to underpin these differences, yet knowledge about the species dependency on key habitats and their vulnerability to human impacts is limited. This project will deploy underwater cameras onto sea lions to identify and map their critical habitats, assess their ecological value and identify risks to populations. Results will improve our understanding of threats to sea lion populations and support future conservation actions to recover the species.

Project description

Project problem and how to be addressed:

The endangered Australian sea lion (ASL) is Australia's only endemic pinniped. Monitoring of the species status has proved challenging due to its unique breeding biology of non-annual (18m breeding interval) and temporally asynchronous breeding. A recent assessment identified 80 extant breeding sites with an estimated species-wide breeding cycle pup production of just 2,739, (82% in SA, and 18% in WA), with half of the sites producing fewer than 15 pups each breeding season (Goldsworthy et al. 2021). Time-series data available for 30 breeding sites indicates an average decline of 2.0%/year (range -9.9% to 1.7%/yr), with an estimated 64% decline in abundance over three generations (42.3 years) (Goldsworthy et al. 2021).

The Recovery Plan for ASL released in 2013 (due for revision in 2023), identifies a range of potential threats to the species, including bycatch in fisheries, entanglement in marine debris, disease, pollution, and climate change (DSEWPC 2013). Although measures to mitigate bycatch impacts in demersal gillnet and lobster fisheries were introduced a decade ago (AFMA 2015, Goldsworthy et al. 2022), some populations have undergone recent declines that cannot be explained by fishery interactions. Furthermore, the spatial distribution in abundance and trends is markedly uneven across the species range, suggesting that localised risk profiles from threats also vary markedly among breeding sites and over small spatial scales. Within and between colony difference in foraging behaviour and habitat use, are thought to mediate regional impacts facilitating fine-scale (inter-colony) differences in risk-profiles and population dynamics (Lowther et al. 2011, 2012, Goldsworthy et al. 2021). Sea lion foraging is restricted to shelf waters, and adult females remain faithful to their foraging areas throughout their lives (Lowther et al. 2012). As such the integrity, health and management of key foraging habitats and threats to them are essential to the long-term viability of populations. However, the benthic habitats critical to sea lions and the role of existing management measures (e.g., marine reserves) in protecting them are poorly understood.

Although satellite tracking and time-depth recorders have provided a wealth of data that clearly show the species are obligate demersal foragers restricted to continental shelf waters (Goldsworthy et al. 2022), the only insight into habitat use and preference comes from 10 National Geographic crittercam deployments conducted between 2008 and 2012 (Fragnito 2013). Although these limited data

provided some important insights into the diversity in habitat usage and feeding strategies among individual sea lion, the instruments were too large (and subject to high failure rates) to be widely applied as a tool to map and understand the habitat use of populations. However, technical advances have led to improved instrumentation (smaller units, solid state, more battery capacity and longer recording times). We are currently working with an instrument developer and initial trials are producing very promising results. This proposal seeks to further develop the application of instrumentation to collect data on sea lion habitat. This proof-of-concept approach will be undertaken at three key sea lion colonies adjacent to State and Commonwealth marine reserves and has the potential to be expanded at other sites and marine reserves across the South-west Marine Park Network.

The project will deploy underwater cameras and GPS tags on Australian sea lions to:

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

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

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

How research will be undertaken:

The research will be undertaken initially at three sea lion colonies adjacent to Commonwealth and State marine reserves off South Australia including Olive and Pearson Islands (Western Eyre Marine Park) and Seal Bay (Southern Kangaroo Island Marine Park). Seals will be sedated (darted intramuscularly) and then anaesthetised (under gas anaesthesia) following which an archival GPS tags with integrated time-depth recorders (Wildlife Computers Mk10+), triaxial accelerometer and magnetometer and miniature underwater camera (Zoolog Solutions) will be glued to the dorsal midline of the seal using fast setting two-part epoxy glue. Instrumented seals will be recaptured following a single foraging trip, usually 2-5 days from initial capture, and the instruments removed.

Time-matched GPS, video, dive and accelerometer/magnetometer data will be used to identify and map fine-scale habitat/prey use and core ecological habitats both within and outside state/federal marine reserves. Habitat and prey will be scored and analysed using video-analysis software, with accelerometer data (measuring head movement) aiding identification of feeding events. Magnetometer data will be used to dead-reckon sub-surface movement between inter-dive GPS locations (~5-8 minutes apart) to better assess fine-scale habitat use. Habitat analysis will use the same grading system as those from other marine park monitoring projects utilising ROV and towed surveys, to ensure standardisation of habitat mapping with other survey methods.

Related prior research:

National Geographic crittercam deployments were conducted between 2008 and 2012. These data identified a broad range of habitats and diverse feeding strategies (Fragnito 2013). Sea lions provide a very stable platform for underwater cameras and provide amazingly clear footage that was used to assess habitat utilisation, key prey species and foraging strategies (Fragnito 2013). The footage was used by SA DEW marine scientists to map benthic habitats and integrated with other towed camera data to assist in the spatial planning of SAs marine parks. Crittercams have been used to characterise habitat usage elsewhere (e.g. Arnould et al. 2015).

How project addresses Government and MaC Hub priorities and links to other research:

Australian sea lions are a priority species. They have recently been uplisted to Endangered (EPBC Act), are the only marine mammal species to have been identified in the Threatened Species Strategy '100 Priority Species' and are identified as one of the Theme 4 (Threatened and migratory species and ecological communities) priority species (RP 2022 priority need 18 and potential project area 2.8). The project will directly address the species Conservation Advice (2020) key priority to improve our

understanding of threats to ASL and will provide important information to inform the revision of the ASL Recovery Plan (due in 2023). The project will provide new information on the distribution and movement of ASLs that will improve the evaluation of risks to populations from fisheries interactions (bycatch and prey depletion) and other threats (RP 2022 priority research needs 20 & 21).

ASL utilise the entire continental shelf and are exceptional reef finders. The approach provides a costeffective way to explore large areas of unmapped shelf and locate valuable sea lion habitat both within and outside of protected places (Commonwealth and State marine reserves), providing a novel complimentary approach to other existing surveys methods. The instrumentation used in this study will enable the discovery of new rocky reefs, kelp forests and seagrass meadows. Estimating the time individual sea lion allocate to different habitats within regions provides a unique means to assess their ecological value. The project also directly addresses Theme 1 (Protected Places) and 2 (Ecosystem restoration and protection) Marine and Coastal Hub priorities, including improved data on the extent, distribution, cover/biomass and ecological value of continental shelf habitats (RP 2022 priority need 1, 5, 6 & 7; high priority research need 2.1). The project intends to work closely with MaC Hub project 2.1 (Generating a national marine ecosystems map for Australia: improving the process) to ensure consistency in analytical methods, and provide all the sea lion derived data for inclusion in the mapping of continental shelf seabed habitats.

Australian sea lions are a flagship species for the South-west Marine Park Network. They are Australia's only endemic pinniped, an endangered species and their entire distribution is restricted to the South-west Marine Region, including all breeding sites and foraging areas. They are identified as both a core natural value, and as being directly impacted by pressures (climate change, extraction of living resources, human presence and marine pollution) in the South-west Marine Park Network Management Plan. As such, the management of human impacts both within and outside the Marine Park Network is critical to ensure the species survival and recovery.

Application of research to inform decision-making/on-ground actions:

Australian sea lions fitted with GPS tags and underwater cameras provide a unique and cost-effective means to map and survey hundreds of kilometres of seabed, remotely. Traditionally, benthic habitat mapping is undertaken from ship-based surveys using either underwater towed cameras or ROVs, often requiring many days or weeks of ship time and personnel, and costing tens of thousands of dollars for individual surveys. Sea lions have the potential to locate and survey large sections of the South-west Marine Parks Network in an extremely cost-effective way, simply by deploying and recovering instruments onshore at accessible breeding sites. Furthermore, the sea lions provide a means to target ecologically significant habitats that are biologically important to them, but they also transit over areas where they don't feed. Feeding rates along an animal's foraging path (transect) provide a means to assess the importance and value of different habitats to the species, providing an important conservation and management context that is often difficult to obtain from traditional survey approaches that rely on species richness or habitat heterogeneity as proxies for habitat value.

Through the further refinement of instrumentation and analyse approaches developed through this study, there will be opportunity to expand deployments at other ASL breeding sites adjacent to other marine reserves within the South-west Marine Parks Network, both in SA as off the south and west coasts of WA. Such information not only provides insights into the critical habitats of sea lions, but it also enables comprehensive spatial risk evaluation of the threats to individual sea lion populations.



Left: Rocky reef and kelp forest in the Nuyts Archipelago (SA) filmed with an underwater camera fitted to an Australian sea lion female.

Indigenous consultation and engagement

Marine scientists embarking on building Indigenous partnerships often lack an understanding of culturally exclusive research practices based on western perspectives and understandings of Sea Country. Embracing knowledge system diversity, cultural perspectives and priorities are central to building trust and meaningful, long-term relationships with Indigenous communities. This project will harness the unique and culturally inclusive approach of connecting people to Sea Country through a culturally significant species, Bul:gada, the Australian sea lion.

Through the development of this project, we have consulted with the Far-West-Coast Aboriginal Corporation (FWCAC) and discussed opportunities to connect people to Sea Country through this project. FWCAC is the Native Title prescribed body corporate for six distinct Aboriginal cultural groups, including Wirangu and Mirning. Australian sea lions (Bul:gada) are an important spiritual totem species for the Wirangu peoples.

There is also a strong cultural connection between Far West Coast groups and the ancient coastline, with song lines and stories tracing the journey of people hunting and gathering across the now flooded plains of the continental shelf. Both people and sea lions had to adapt to the changes to their environment as sea level rose, and flooded the continental shelf. Sea lions instrumented as part of this project can potentially retrace and film these journeys, bringing the former landscape to life, and drawing in the connection between the land and the sea. In discussion with the FWCAC, this concept of sea lions retracting ancient song lines is seen as an evocative and potentially powerful way to connect people back to Sea Country.

Wirangu encompass a region where field work will be undertaken to deploy and recover tracking and camera instruments on sea lions, providing opportunities for collaborative fieldwork in partnership with local Aboriginal Rangers. FWCAC have agreed to support the project with Aboriginal Rangers being involved in fieldwork, providing excellent opportunities to learn new skills and gain experience. FWCAC are also keen for us to deliver information through engagement sessions to local Aboriginal schools such as Yalata and Koonibba.

FWCAC are excited about the opportunity for Aboriginal Rangers to be directly involved in field work for the project, to inspire communities about the uniqueness of Australian sea lions and their intricate connection to, and dependence on Sea Country. In the very early stages of the project (early June 2022), the project leader will participate in a FWCAC on-country workshop focused on sea country. The project will be discussed during this workshop with the goal to secure free, prior and informed consent from FWCAC to participate in the project and how NESP funding will be used to support this. We will also use the opportunity to better understand whether or not the FWCAC intend to share any Indigenous cultural and intellectual property (ICIP) with the project team (e.g. song lines), and if so, what provisions and agreements need to be made to record, share and protect this property. There is also strong interest from FWCAC that the project providing an opportunity for an Elder to visit Olive Island during the first field trip and conduct a smoking ceremony, and to obtain some media footage that will assist with community engagement and school presentations.

All are in agreement that the project presents unique opportunities to develop and foster greater awareness, grow sea lion custodianship and stronger connections to Sea Country.

This initiative provides a unique platform for communication tools to be developed that can connect Indigenous communities to Sea Country that are otherwise difficult to physically access. In accordance with Aboriginal lore, land and sea are not viewed as separate entities but as one customary 'country'. Using Bul:gada (sea lions) as the flagship species and communicator of Country aligns with Aboriginal understandings of connectivity and provides a culturally inclusive mechanism for raising awareness of the role of Commonwealth Marine Parks in protecting Bul:gada.

Indigenous engagement and consultation for this project will be undertaken in a manner that is consistent with the NESP Indigenous Partnerships Principles and will be aligned with the Marine and Coastal Hubs Indigenous Partnerships Strategy. This project is a Category 2 project for Indigenous partnerships. Category 2 projects involve collaboration and opportunities for knowledge sharing.

Location of research

This project will be undertaken at several Australian sea lion breeding sites off South Australia (Olive Island, Pearson Island and Seal Bay, Kangaroo Island) (see Figure below). The current project is developed at a regional level, however, there is potential to expand the project to a national level, encompassing the entire range of the Australian sea lion and the South-West Marine Park Network.



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Project 2.7 – Aerial survey of the Southern Right Whale 'western' sub-population off southern Australia

Project description

Project summary

Aerial surveys of Southern Right Whales (*Eubalaena australis*) have been conducted across the southern Australian coast from Perth (W.A.) to Ceduna (S.A.) since 1993, as part of a long-term program to assess the recovery of this Endangered species from commercial whaling. This program has provided population size, trend and status and life history information that has been critical to inform the species Conservation Management Plan (2011-2021).

Project description

Related prior research and statement of problem

Surveys establishing relative abundance estimates, population trends and reproductive parameters of Southern Right Whales from the 'western' sub-population have been conducted since 1993. These surveys have provided the majority of information on the overall population recovery of the species post commercial whaling, due to the 'eastern' sub-population showing little recovery. Data provided by these surveys have informed previous recovery plans and the current Conservation Management Plan (2011-2021) for the species. The NESP Marine Biodiversity Hub (MBH) has funded these surveys (under Project A7 and 1.26) over the last seven years (2015-2021), with the data generated from the surveys providing important contributions into the NESP MBH project (A13) on population connectivity between the 'eastern' and 'western' populations for a national assessment of the species. Recent estimates of the population growth rate (2010-2018) suggests increased variability in sightings per unit of effort (and hence population estimates) and potential slowing down in annual population growth rate based on aerial sightings data (Evans et al 2021).

Recent years have shown anomalous years of unusual low sightings per unit effort in 2007, 2010, 2015 and 2020 (Bannister et al. 2016, Smith et al. 2021), potentially reflecting disruption to the approximate 3-year female breeding cycle. For example, the 2020 aerial survey recorded the lowest number of non-calving whales since 1993. Unpredictable fluctuations in relative overall numbers and associated fluctuations in cohort structure have been reported in other Southern Right Whale populations in the Southern Hemisphere, such as South Africa (e.g. van den Berg et al. 2021). These have been suggested to reflect fluctuations in food availability on feeding grounds in the Southern Ocean and near the Antarctic continent that influence migratory behaviours. Calving rates of southern right whales have consequently been suggested as a potentially viable indicator of climate change impacts in the Southern Ocean (Newson et al. 2009).

Undertaking a survey in 2022 will ensure an uninterrupted time series in the long-term population trend data for this Endangered species. This is particularly important given the non-annual breeding cycle (typically every 3 years), such that annual surveys are essential to maintain an acceptable level of precision in estimating population trends and key life history parameters (e.g. calving intervals) to track the recovery of the species (Bannister et al. 2011). Continued monitoring of the population is needed to evaluate whether there is a longer term and continuous change (in population size and calving intervals) in the population as indicated by recent sightings and population trend data.

Methods

An aerial survey utilising established protocols developed and used in previous surveys (since 1993) of the south-west Australian region will be undertaken during August 2022 when seasonal whale numbers are estimated to be highest across the region. The surveys will be conducted using a high wing, single engine aircraft (Cessna 172) crewed by a pilot/observer, photographer/observer and data scribe. The survey will be flown along the southern coast of Australia (to 1nm offshore) between Cape Leeuwin (Western Australia) and Ceduna (South Australia) at a survey altitude of 1000 feet. Dependent on weather, it is expected that the return survey time will be ~5-6 days to fly the survey region and back (based on previous surveys). Photo-identification images of encountered whales are taken and life history data is obtained by matching whales to the Australian Right Whale Photo Identification Catalogue (ARWPIC) dataset managed by the Australian Antarctic Division Data Centre of the Department of Agriculture, Water and the Environment.

Outputs

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

The specific outputs from the project include:

- A report that details overall numbers of southern right whales observed within the survey region, their gender (and life stage where possible) and spatial distribution of individuals;
- An estimate of relative abundance and population trend when compared to the long term aerial survey sightings dataset;
- A summary of the photographs taken, the extent to which they have been submitted to the Australasian Right Whale Photo Identification Catalogue (ARWPIC), and any subsequent matching of individuals;
- Recommendations for next steps that can inform further work on southern right whales within the context of the Conservation Management Plan.

Application of research to inform decision making and other Hubs

Survey results will directly inform the Australian Department of Agriculture, Water and the Environment Conservation Management Plan for the Southern Right Whale (2011-2021) and contribute critical information to the CMP review process and development of a new Recovery Plan for the species. As part of the long-term dataset, it will contribute to an assessment of the conservation status of Australia's southern right. Specifically, it address the 'very high priority' Action Area B1 in the current CMP, to 'continue to obtain and refine population abundance and trends for the south-west population' by 'maintaining a long-term aerial survey and photo-identification monitoring of the south-west coastal region (Cape Leeuwin to Ceduna) on an annual basis'. It also addresses, in part, the 'high priority' Action Area B2 to 'investigate a two-population model'. The photo- identification data from the surveys has provided important information to NESP MBH Project A13 on the connectivity and demographic independence between the 'western' and 'eastern' populations to investigate temporary or permanent movement between these groups. Research outputs from this project will be used in co-ordination with the Resilient Landscapes Hub to support the conservation of habitat important for priority threatened and migratory species and update the recovery plan for southern right whales.

Indigenous consultation and engagement

The nature of this project is such that there is limited capacity to include additional staff in the aircraft (2-3 people max), requires highly specialised skills of the personnel conducting the survey (e.g. pilot and photographer) and depends on long-term consistency in the protocols for data collection. Consequently, this project identifies as a Category 3 project (in the Three-category approach) and has no direct input from Indigenous people or organisations, although works to communicate project outcome and results with relevant indigenous organisations. The Project Team identifies engagement with relevant Indigenous groups across the surveyed region could be effective through communication of outputs from the project and greater involvement in whale related activities.

The Project Team identifies the short-term nature of this project and the long-tern approach required to establish substantive indigenous engagement. With the assistance of the NESP MaC Indigenous engagement officer, we suggest a staged approach that initially identifies the relevant indigenous groups throughout the survey area and best approach to indigenous engagement for this project. The next stage is to establish conversations that support relevant indigenous groups having a better understanding of the project and its outputs to determine the level of engagement relevant indigenous groups might want and how the outputs might be useful to them. The next stage would then be working with those groups to deliver the desired outputs that had been identified as useful, which would form the basis for further engagement in a multi-year Southern Right Whale Program established through the NESP Initiative Scoping process for NESP RP2022/23 and beyond.

Information and results from the long-term right whale aerial survey monitoring program in combination with the long term land-based right whale project at the Head of Bight (in South Australia; conducted by GABRWS) have in the past been presented to the Yalata Aboriginal Community coinciding with their Whale of a Day in August. Unfortunately, this was not able to be undertaken in 2021 due to COVID19 restrictions, although we would seek to maintain engagement with this group. We will seek other relevant groups in which to initiate engagement with the assistance of the NESP MaC Indigenous engagement officer, likely involving the Head of the Bight Visitors Centre and its connection with the Aboriginal Lands Trust as well as Natural Resources Alinytjara Wilurara and Yalata Land Management and the South Australian Whale Centre (in Victor Harbour) in collaboration with the Miwi-Inyeri Pelepi-Ambi Aboriginal Corporation (MIPAAC). Initial engagement and conversations will be undertaken through online communication.

Location of research

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

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