NOPSEMA | OIR

Research Strategy 2024-2027

Promoting a collaborative approach to prioritising, funding and designing research to deliver improved outcomes in the environmental management of offshore energy projects.

Summary

As Australia's independent regulator for offshore energy operations in Commonwealth waters, NOPSEMA uses balanced and quality research outputs to effectively fulfill our legislated functions, including making evidence based and robust decisions.

NOPSEMA is Australia's independent expert regulator for health and safety, structural (well) integrity and environmental management for all offshore oil and gas operations and greenhouse gas storage activities in Commonwealth waters and in coastal waters where regulatory powers and functions have been conferred. The Offshore Infrastructure Regulator (OIR) is an entity established under the *Offshore Electricity Infrastructure Act 2021* to oversee the offshore renewables industry. The functions of the OIR are administered by NOPSEMA and include regulation of work health and safety, infrastructure integrity and environmental management for offshore infrastructure activities. NOPSEMA and the OIR rely on balanced and quality research outputs to support evidence-based decision making under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act), streamlined regulatory arrangements under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Offshore Electricity Infrastructure Act 2021* (OEI Act).

We do not carry out nor commission research, but with a pan-industry viewpoint, we are in a unique position to identify key science needs and research priorities relevant to offshore energy industries. Addressing these needs and priorities collaboratively, especially where regional scale research effort is needed, will deliver benefits for risk and impact management to regulators and industry that would otherwise be challenging to achieve when tackled by proponents individually.

Proponents routinely commission monitoring and research programs to suit the needs of an individual project, with environmental data collected and housed within their respective companies.

While there are recent examples where a collaborative approach has been taken to fill gaps in scientific knowledge, there is an opportunity for industry to further collaborate to ensure that the benefits of this approach are realised sooner. For example, adopting standardised methodologies and establishing data transparency and sharing arrangements would be advantageous for addressing common or regional research priorities across a broader range of industry activities and scientific disciplines. This approach is needed to utilise industry and research sector resources more effectively, meet the needs of a broader suite of end-users and tailor research outputs to support offshore activity regulatory approvals processes and management. While it is not within NOPSEMA's remit as offshore energy regulator to develop or oversee frameworks for data sharing and collaborative research, NOPSEMA is committed to promoting and providing appropriate support to organised collaborative research (such as research hubs and alliances between academia and industry), and data sharing platforms as part of NOPSEMA's advise and promote functions.

In response we have been promoting industry-wide collaborative approaches and encouraging the collection of fit-for-purpose data to address key research priorities, which have been identified through regulatory activities and the provision of advice to proponents and other environmental regulators of the offshore energy sector. Our regulatory advice on priority research needs is set out in this Research Strategy.

This Research Strategy aims to provide industry with a clear vision for enhanced research outcomes and includes our goals and role in supporting that vision. The Research Strategy will be accompanied by a regularly updated list of research priorities, based on current and emerging issues and industry activities, to help guide industry and the research community funding and scientific design decisions.

Vision

Collaborative, co-designed approaches to prioritising, funding and designing research that will deliver outputs that enhance confidence in the environmental management of offshore energy projects.

Goals

- Industry and the research community address identified research priorities in a timely, cross disciplinary, collaborative and integrated way. Varied, balanced and transparent research outputs with clear pathways to adoption in risk and impact assessment, regulatory decision-making, and offshore activity planning, monitoring and adaptive management.
- Improved understanding of species, processes, places and industry activities to support improved impact and risk assessments and offshore energy activity planning and management.
- A deepened understanding of Sea Country values and traditional practices of First Nations people and communities to inform measures needed to protect indigenous culture while achieving ecologically sustainable development outcomes.
- Enhance uptake of relevant research products and support tools including data curation, quality assurance and transparency platforms to improve access to quality data for the purposes of environmental impact assessment, reporting, policy development and environmental management planning.
- Greater use of science and research across a range of relevant disciplines to improve links between industry environmental performance, environmental outcomes and reporting at regional and national levels.

Key Strategies

Engage directly with industry, the research community and government agencies to identify needs and options for collaborative research framework(s) in Australia and support proposals for collaborative research hubs and science communication where they are aligned to this strategy by providing end-user perspectives and advice.

Promote best practice options for collaborative research frameworks and funding models that support Australia's regulatory setting.

Monitor industry and regulatory uptake of research outputs and environmental outcomes to inform future regulatory priorities and national reporting.

Implement institutional structures to retain and develop technically competent staff with relevant expertise in research and impact assessment, in a regulatory setting.

Collaborate with government agencies to identify and agree on research needed to support implementation of relevant policies and encourage and facilitate the uptake of contemporary research and industry datasets into centralised databases.

Utilise regulatory processes and broader communication channels to address inaccurate interpretations or misuse of relevant science.

Use communication tools to clarify that the regulator does not have a role in conducting or funding research but is a key end-user of research.

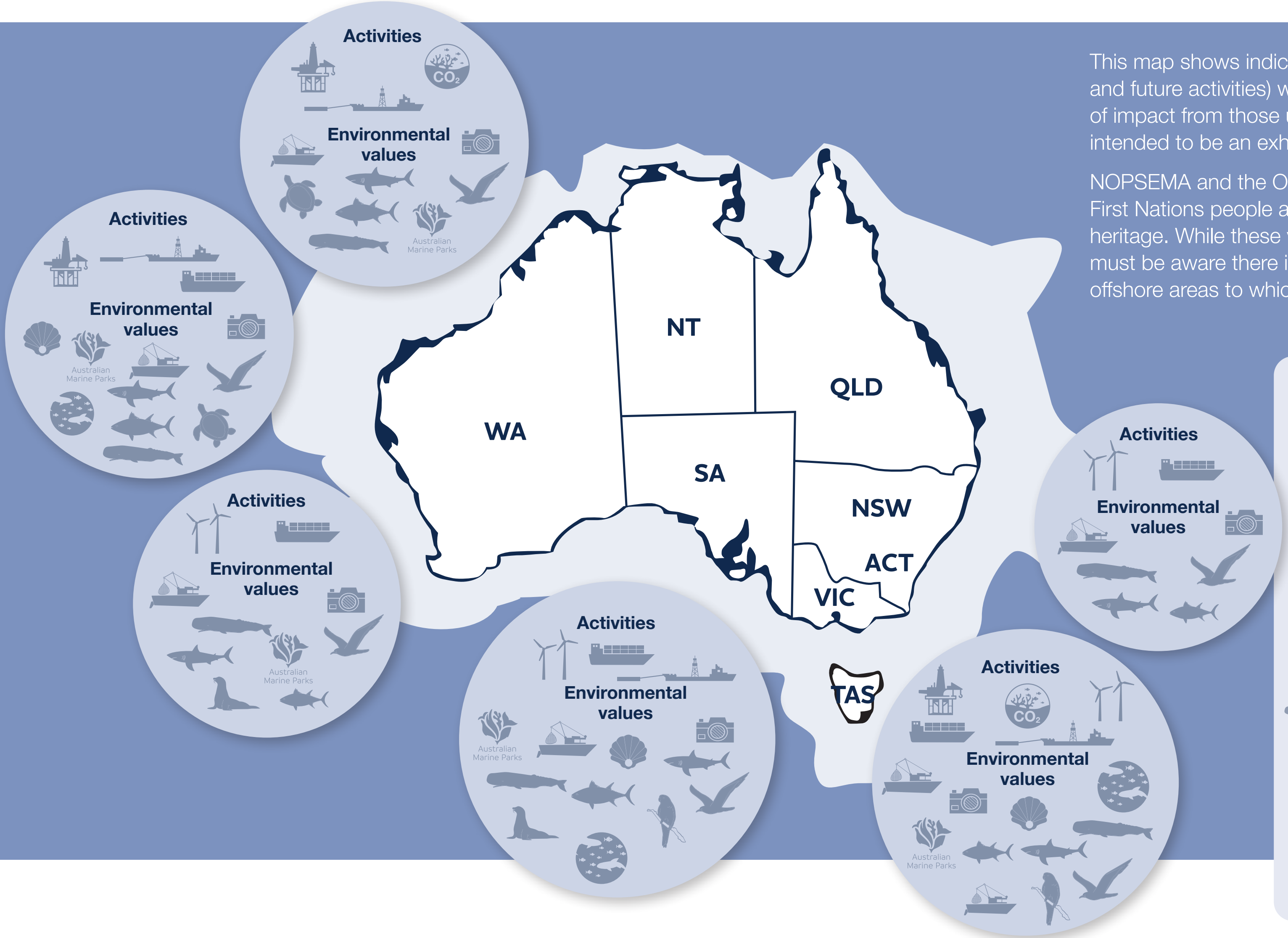
Engage directly with industry, government, First Nations peoples and communities, community stakeholders and research organisations to promote research priorities and principles for planning and design of research to meet end-user needs.

Utilise intelligence from regulatory activities, research outputs and relevant external forums to maintain and publish a list of industry related strategic research needs and priorities.

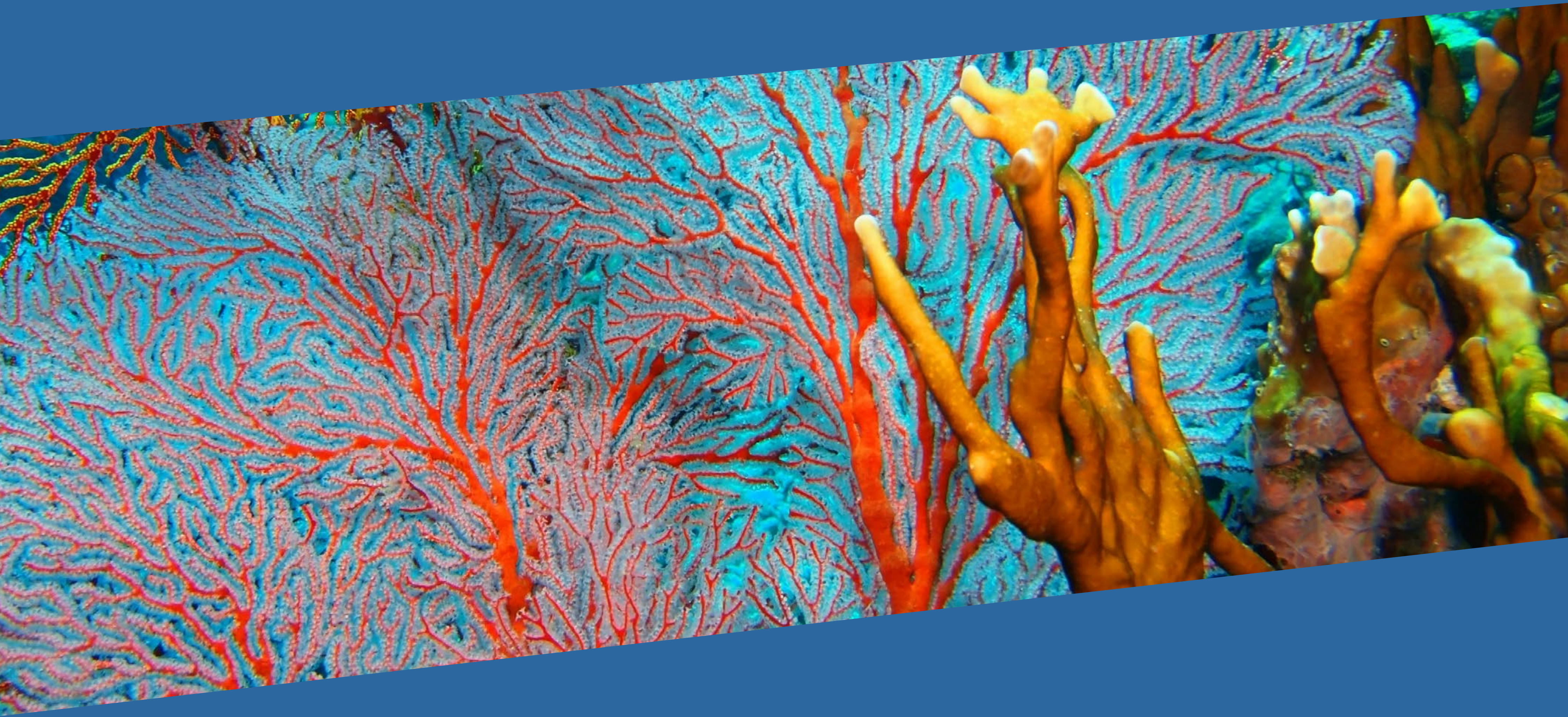
Current and emerging industry activities and environmental values that may be affected

This map shows indicative locations of multi-use overlap (current and future activities) with environmental values at highest risk of impact from those uses in Commonwealth waters. It is not intended to be an exhaustive list.

NOPSEMA and the OIR respectfully recognise the knowledge of First Nations people and their custodianship of Sea Country and heritage. While these values are not depicted on the map, industry must be aware there is potential for Sea Country values in all offshore areas to which this strategy relates.



NOPSEMA and OIR end user research priorities



Understanding the ecological and cultural environment

Environmental assessment and management challenges	Research topic	O&G	ORE	CCS
Threatened and migratory mammals Baseline^ information is needed to understand threatened and migratory mammals including whale migratory pathways, foraging habitats and breeding and calving areas at scales suitable to inform environmental impact assessments, levels of acceptable impact, monitoring and ongoing management of offshore energy developments.	**Blue whale and southern right whales:** Abundance, distribution and habitat utilisation patterns of blue whales (foraging and migration) and southern right whales (migration and calving) at regional and local scales across multiple years including inter-seasonal and intra-seasonal variability. **Regions:** Offshore petroleum and greenhouse gas acreage areas, *Offshore Electricity Infrastructure Act* (OEI Act) declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓
	Southern right whale: Understanding migratory pathways of southern right whales from offshore foraging areas to coastal breeding areas. **Priority region:** Gippsland / Bass Strait	✓	✓	✓
	Abundance, distribution and habitat utilisation patterns for other threatened and/or migratory mammals (e.g. fin, sei and Bryde's whales, odontocetes, pinnipeds and delphinids) considering regional and local scales across multiple years including inter-seasonal and intra-seasonal variability. **Regions:** Offshore petroleum and greenhouse gas acreage areas, OEI Act declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓
	Understanding relationships between physical and biological oceanographic conditions, including food source density and abundance of foraging blue whales and whether reliable models can be developed to predict whale presence.	✓	✓	✓
Avifauna Baseline^ information to define migration patterns and behaviours of priority threatened and migratory bird species most at risk from offshore windfarm developments is needed to inform project location, design parameters, monitoring programs and mitigation measures.	Threatened seabird/migratory bird* abundance and distribution patterns at regional and local scales across multiple years including inter-seasonal, intra-seasonal and diel variability. This should include defining foraging habitats and migration pathways and the identification of areas where seabirds/migratory birds* are more susceptible to the impacts offshore renewable energy developments. **Priority regions:** OEI Act declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	
	Conservation status, population size, demographic parameters (adult survival and reproduction, population abundance trends at breeding sites) for species most at risk from attraction/displacement/collision with offshore installations as the basis for assessing population viability and the cumulative impacts of offshore developments and other stressors on priority populations (e.g. Orange bellied parrot and swift parrot, threatened albatross and petrels). **Priority regions:** Offshore renewable energy declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓

Environmental assessment and management challenges	Research topic	O&G	ORE	CCS
Sharks Baseline^ condition for threatened shark species is needed to improve understanding of distribution, abundance and habitat utilisation patterns to inform environmental impact assessments, levels of acceptable impact, monitoring of effects and ongoing activity management.	Baseline understanding of shark (e.g. listed threatened and commercially important species) distribution, abundance and habitat utilisation using standardised survey protocols and monitoring techniques. **Priority regions:** Offshore renewable energy declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓
Marine turtles There are multiple offshore development activities that overlap with biologically important areas for marine turtles. Better definition of important foraging areas will assist in spatially and / or temporally avoiding biologically important periods and habitats. Consistent with the National Recovery Plan for Marine Turtles in Australia, offshore activities will need to demonstrate that anthropogenic activities in biologically important areas will be managed such that biologically important behaviours can continue.	Understand the relative importance of offshore areas for marine turtle internesting and foraging to inform light and noise impact assessment for offshore projects and activities. This should include the identification of important foraging and internesting habitat for green, flatback, hawksbill, leatherback and olive ridley turtles at scales necessary to understand habitat utilisation patterns and the relative importance of habitats within 'biologically important areas'. **Regions:** North and Northwest Marine regions	✓		✓
First Nations cultural and heritage values Culturally appropriate co-designed methods for identifying, evaluating and managing culturally sensitive information held by First Nations people so that potential impacts to cultural features of the environment from offshore energy developments can be understood, evaluated and appropriately managed.	The development of co-designed First Nations Heritage assessment framework(s) to create culturally safe and secure platform in which First Nations knowledge of and connection to Sea Country can be understood, evaluated and protected. An enhanced understanding of culturally important submerged places/locations, species and their cultural significance to inform the design and management of offshore energy projects and their potential impacts to First Nations communities, their traditional values and their culture. **Regions:** Offshore petroleum and greenhouse gas acreage release areas, OEI Act declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓

Glossary: O&G = Oil and gas | ORE = Offshore renewable energy | CCS = Carbon capture and storage

^Acknowledging that migration paths and biologically important areas may have already changed due to anthropogenic influences Baseline data refers to a contemporary dataset to describe the distributions of species and their biologically important behaviors at a defined point in time, prior to implementation of a particular offshore energy project in Commonwealth waters

*Focus avifauna species are listed in Table A on page 22

Environmental assessment and management challenges	Research topic	O&G	ORE	CCS
Benthic habitats A national approach to establishing marine baselines and monitoring is needed to provide an evidence-based understanding of the status and trends in the health of marine ecosystems at local to regional scales to effectively evaluate, monitor and manage environmental impacts from offshore energy developments.	Establish methods[1] and standards for the collection and classification of benthic habitat data at appropriate scales to inform assessment and management of new proposals and decommissioning of offshore energy developments. This should consider classification schemes that capture sufficient detail (e.g. at the biotope level) to ensure that benthic habitats are able to be mapped at scales suitable for project impact assessment, and the impacts from offshore developments can be predicted, evaluated, measured and verified over a range of spatial and temporal scales. **Regions:** Offshore petroleum and greenhouse gas acreage release areas, offshore renewable energy declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓
	Using nationally and/or internationally accepted methods and standards, undertake benthic habitat surveys and long-term monitoring programs at scales suitable to inform assessment and management of new proposals and decommissioning of offshore energy developments. **Regions:** Offshore petroleum and greenhouse gas acreage release areas, offshore renewable energy declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓
	Understand the importance of seabed habitat types and quality to the life history of commercially and culturally important marine species, such as potential nursery areas for juvenile demersal fish (e.g., gravel/pebble mixed sediment habitats). **Regions:** Offshore petroleum and greenhouse gas acreage release areas, offshore renewable energy declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓
	Understand the effects of offshore infrastructure on local and regional scale physical oceanographic processes (e.g. ocean currents, sediment transport, coastal processes) and potential flow on effects to benthic habitats. **Regions:** Offshore petroleum and greenhouse gas acreage release areas, offshore renewable energy declared areas and priority areas identified for future offshore renewable energy project assessment.	✓	✓	✓
Climate change Improved understanding of the potential effects of climate change on protected species and their habitats to account for a dynamic ecosystem and how the effects of pressures associated with offshore energy projects on those species and habitats may change over time.	Develop a greater understanding of the effects of climate change on the distribution of protected species, enhance capacity to forecast potential changes in habitat distribution and utilisation, including in the context of combined pressures associated with climate change and marine based human activities, including offshore energy.	✓	✓	✓
	Understand the cumulative impacts resulting from not only multiple industrial uses, but also from these uses and additive effects of climate change on the marine environment.	✓	✓	✓

[1]This to applies where there is a recognised absence of existing standardised benthic habitat survey and data classification approaches at a national level.

Underwater noise emissions – mortality, injury and behavioural effects (all offshore industries)

Environmental assessment and management challenges	Research topic	O&G	ORE	GHG activities
Effects				
Precautionary controls need to be applied to reduce interactions between underwater noise emissions and biologically important areas and seasons for listed threatened whales. This is due to uncertainty on the levels of noise that result in significant behavioural responses and the implications of this disturbance for species recovery. Better understanding of the effects of underwater noise emissions on listed threatened whales will inform the management necessary to ensure offshore developments do not impede population viability and recovery for these species.	**Blue whales and southern right whales:** Better understanding, and where possible quantifying, behavioural responses to underwater noise and implications for foraging, feeding, fitness and breeding success in the context of EPBC Act species recovery requirements (e.g. Actions relevant to underwater noise management set out in in-force EPBC Act species conservation management documentation).	✓	✓	✓
	Blue whales and southern right whales: The development of standardised protocols for cumulative impact assessment of underwater noise from multiple noise generating activities in the same region and evaluation of implications for species recovery.	✓	✓	✓
	The effect of anthropogenic noise on whale physiology and behaviour to inform the management needed to avoid whale injury and displacement from biologically important areas.	✓	✓	✓
	Understanding of levels of underwater noise exposure that incur impacts on biologically important behaviours of southern right whales and blue whales as a result of cumulative disturbance from anthropogenic noise associated with multiple offshore renewable energy developments within OEI Act declared areas.		✓	
	Understanding the effects of underwater noise on prey species, including the possible effects on food source density for protected species.	✓	✓	✓
Scientific uncertainty about the behavioural, physical and physiological impacts of noise on fish and invertebrates and implications for the fisheries that target them results in concerns from fishing stakeholders that at times requires precautionary control measures to be implemented.	Improved understanding of the impacts from underwater noise on commercially and ecologically important fish, sharks and invertebrates (including reproduction, fitness and catchability) and implications for the fisheries that target them.	✓	✓	✓

Environmental assessment and management challenges	Research topic	O&G	ORE	GHG activities
Effects				
Scientific uncertainty about the behavioural and physiological impacts of noise on marine turtles can require precautionary control measures to be implemented where offshore energy developments interact with biologically important areas and times.	Improved understanding of the behavioural and physiological responses of marine turtles to underwater noise and implications for feeding, fitness and breeding success in the context of species recovery requirements set out in in-force EPBC Act species conservation management documentation.	✓	✓[2]	✓
Improving monitoring and mitigation techniques				
Wind farms will need to be designed and installed such that they can be managed in a manner not inconsistent with statutory conservation management instruments (e.g. recovery plans) for listed threatened species.	Best practice offshore windfarm design and installation techniques to reduce underwater noise emissions and mitigate impacts to noise sensitive species.		✓	
Improvements in turbine foundation design and installation methods, including noise reduction and mitigation techniques for foundation installation to reduce potential impacts to noise sensitive listed threatened species.	Research, development and testing of innovative technology to effectively mitigate noise emissions from turbine foundation installation, including pile driving, particularly for noise in low frequency bands that are coincident with the hearing and sensitivity ranges of listed threatened baleen whales.		✓	
Currently available detection technologies for marine fauna are often not able to detect fauna out to the full extent of noise effect distances to inform mitigation actions and are not capable of detecting fauna at night.	Research, development and testing of marine fauna detection technologies that can reliably detect the location of fauna in offshore conditions and provide real-time data to inform mitigation decisions.	✓	✓	✓

[2] Considered relevant to ORE developments for potential future development in tropical regions.

Light pollution impacts on marine wildlife

Environmental assessment and management challenges	Research topic	O&G	ORE	CCS
Effects studies				
The potential for population level consequences associated with attraction of marine birds to offshore facilities is not well understood including from the perspective of cumulative impacts from multiple sources.	Impact of light and other attractants from offshore structures on migratory behaviour, breeding and feeding ecology of birds. Particular focus should be placed on attractants that result in a high mortality rate, such as offshore flaring activities.	✓	✓	✓
At present, there are no nationally or internationally accepted impact criteria in place for the effects of light on marine turtles during critical life stages. This leads to the need for precautionary control measures, monitoring and adaptive management to address scientific uncertainty.	Light impact thresholds (relevant to offshore environments) for assessing the level of artificial light that may be tolerated from multiple sources without disrupting biologically important behaviour of nesting adult marine turtles (including neophytes) and dispersing hatchlings including seafinding hatchlings and the in-water phase of dispersal.	✓	✓	✓
There is a need for best practice methods and instrumentation for measuring the received levels of light in biologically relevant intensities and wavelengths in remote offshore areas.	Best practice methods and instrumentation for measuring light to assess its effect on birds and marine turtles that can be deployed in remote offshore areas.	✓	✓	✓
Improving monitoring and mitigation techniques				
There are limited mitigation measures to further reduce operational lighting if unforeseen unacceptable impacts from artificial light are detected.	Best practice and novel options for reducing effects of artificial light if impacts to marine turtles during nesting or hatchling seafinding are detected, including options for shielding and other methods to reduce intensity in biologically relevant bandwidths.	✓	✓	✓
There are limited effective mitigation options for the effects of attraction to offshore facilities	Best practice methods for deterring seabirds from roosting and nesting on offshore structures (including consideration of light reduction technologies and non-harmful deterrent techniques).	✓	✓	✓

Drilling and oil and gas operations

Environmental assessment and management challenges	Research topic
Operational and drilling discharges	
Offshore oil and gas projects will need to be able to demonstrate compliance with the Minamata Convention.	Characterisation of the sources, transformation and fate of mercury related to offshore oil and gas including development of conceptual models and standardised approaches to monitoring of mercury contamination in sediment, water and biota to underpin such conceptual models.
	Application of best available techniques and best environmental practices for the offshore oil and gas industry to control releases of mercury and manage mercury waste in an environmentally sound manner.
GHG and climate change mitigation	
New and existing facilities are required to demonstrate that all best practice and feasible methods have been investigated and adopted for fugitive emissions management.	Application and deployment of emerging technologies for methane emissions detection and quantification/monitoring.
	Equipment design and retrofitting to reduce methane emissions in production, transport and storage of hydrocarbons.
New and existing facilities are required to demonstrate that all best practice and feasible methods have been investigated and adopted for energy efficiency and use.	Application and deployment of technology and operational changes for energy supply and use in existing operations (e.g. demand management solutions).
Oil spill response	
There is a need for ongoing improvements to timely oil spill response and innovative monitoring techniques that can be deployed in sensitive and remote areas.	Building on best practice methods for timely detection, monitoring, response and remediation of subsea loss of well control incidents that may impact wide geographic areas.
	Best practice and innovative techniques for detecting, monitoring and remediating oil spill contamination in remote coastal environments.

Decommissioning

Examples of key environmental assessment and management challenges	Research topic
Effects	
There is a need to characterise and understand the sources, fates and consequences of all types of contaminants and pollutants (such as, but not limited to: metals, mercury, hydrocarbons, naturally occurring radioactive materials (NORMs), plastics, coatings, concrete, grout, asbestos, per- and polyfluoroalkyl substances (PFAS)) relevant to the lifecycle of petroleum activities to inform impact assessment and decision making relating to petroleum activity decommissioning and title relinquishment. The current uncertainty may result in the need for long-term contaminant monitoring and adaptive management measures.	Best practice techniques and threshold/guidance levels for monitoring of infrastructure and seabed contamination and associated consequences for ecological integrity, biodiversity, and/or human uses relevant to all life cycle stages of offshore petroleum activities.
	Monitoring of, and reliable and validated predictive tools, to predict the spatial extent, severity (relative to thresholds) and fate of contamination and in situ impacts over decadal time scales (including toxicants in degradation products, plastics and polymers and asbestos).
	Species or types of organisms that should be sampled to meet (national/global) best practice requirements for impact assessment, including potential for bioaccumulation effects.
	Timeframes for breakdown/corrosion of infrastructure and potential release of contaminants and pollutants if decommissioned at sea.
	The potential risks and impacts of contaminants in infrastructure and in seabed sediments (including from the operations phase) and understanding of potential implications for ecological integrity, biodiversity and socio-economic (including heritage) receptors.
	Application of contaminants, living organisms and environmental factors that can be reliably used in predicting and monitoring contamination-related impacts to support assessment of a wide range of decommissioning activities.

<table>
<tr><th>Examples of key environmental assessment and management challenges</th><th>Research topic</th></tr>
<tr><td colspan="2">Effects</td></tr>
<tr><td rowspan="6">There is a need to understand the benefits, risks and impacts to habitats and biota over a range of spatial and temporal scales from leaving infrastructure in situ, to inform impact assessment, decision making and the design of ongoing monitoring programs.</td><td>Methodologies to define and measure ‘meaningful’ productivity, connectivity and biodiversity so that there is a clear and consistent process for determining whether a proposal to leave property in situ could have an ‘environmental benefit’. Methodologies should account for:
• relevant parameters of all components of the environment as defined under the Environment Regulations including ecosystems and their constituent parts, natural and physical resources and the heritage value of places including social, economic and cultural features; and
• differences in the structural design of property left in situ that may influence productivity.</td></tr>
<tr><td>Understanding the level of regional productivity and the relative ecological benefits that can be reasonably attributable to infrastructure proposed to be left in situ, including consideration for different water depths. There is also a need to:
• differentiate between localised (specific to property left in situ) increases in abundance of fish assemblages of species that are attracted to the structure and actual enhancement of productivity; and
• consider the contribution of benthic ‘halo effect zones’ to biodiversity and productivity of the property left in situ (as part of the “novel ecosystem” concept) e.g. potential diurnal migration to/from structure to feed, fish and benthic assemblages associated with the ‘halo zone’ as well as seasonal variability.</td></tr>
<tr><td>Understanding the spatial and temporal variability in biological assemblages, infrastructure and sediment contaminants at multiple geographic locations (e.g. between different subsea infrastructure or title area(s); within or between basin(s) or region(s); along environmental gradients such as latitudinal effects).</td></tr>
<tr><td>Cause-effect pathways – environmental/biological/structural factors that affect biological assemblages (including species of socio-economic interest), and the mechanisms of effect (e.g. bioaccumulation of contaminants).</td></tr>
<tr><td>How the presence of infrastructure has modified adjacent benthic habitats and fauna assemblages over the lifetime of the structure (e.g. shellfish mounds, benthic productivity, fish association).</td></tr>
<tr><td>The differences in ecological importance (e.g. connectivity, productivity, biodiversity) between operations phase (pre-decommissioned) infrastructure and property proposed to be left in situ (post decommissioning), including:
• the connectivity between offshore structures and natural habitats and potential ecological implications of removal; and
• identification of species that are likely to be useful indicators of connectivity including species of fisheries interest/ecological health indicator species (e.g. based on life history traits or a combination of factors).</td></tr>
</table>

Examples of key environmental assessment and management challenges	Research topic
Effects	
	Where there are multiple facilities to be decommissioned in a region, understanding whether all are likely to be required to support ecological connectivity (where ecological connectivity has potentially been indicated), or if not, identification of facilities that would be required to support, i) the optimum and ii) minimum level of connectivity.
	The impacts of subsea infrastructure and modified adjacent seabed habitat including consideration of diel cycles in the potential use of offshore structures and adjacent benthic habitats by fish and motile invertebrate assemblages.
	Understanding of impacts and risks that infrastructure that is left in-situ may have on future human activities/industries (e.g. trawl fishing) and/or human health risks.
Understanding the potential invasive marine species (IMS) risk from connectivity of property proposed to be left in situ is an important factor in assessment and decision making for proposals for at sea decommissioning.	Relevance of offshore infrastructure for ecological connectivity, and implications of removal, transport and disposal (including potential spread of invasive marine species)
	If there is the potential spread of IMS, identification of the facilities that would need to be removed to prevent the spread of IMS (mitigation options).
Improving monitoring and mitigation techniques	
Best practice monitoring techniques are needed to inform management intervention/remedial action for seabed and sediments impacted by offshore energy developments.	Best practice techniques for monitoring of seabed contamination and associated consequences for ecological integrity, biodiversity, and/ or human uses with consideration of the challenges of sampling in close proximity to infrastructure whilst maintaining quality requirements.
	Impacts and benefits of removal of infrastructure as well as impacts and benefits of disposal at sea (on or off title) in the context of current legal requirements, ongoing governance and management, future liabilities and government policy positions
Understanding potential mitigation and/or rehabilitation options for seabed habitats impacted by operations and/or decommissioning activities is needed for demonstrating that impacts to seabed and sediments can be or have been 'made good'.	Best practice and innovative methods and engineering solutions for environmentally safe remediation of seabed contamination during and following decommissioning (when and how to remediate).
	Understanding potential risks and impacts (including benefits) of remediation/mitigation methods for contaminated sediments in offshore hard and soft seabed environments, e.g. to nutrient cycling, habitat stability, demersal fish habitat/foraging area, and with consideration of potential to build in ecological benefits.

GHG exploration, injection and storage

Key environmental assessment and management challenges	Research topic
Effects	
There is uncertainty in the effectiveness and reliability of using depleted offshore reservoirs for use in carbon capture and storage activities to reduce GHG emissions that would have otherwise been released to the atmosphere.	Demonstration studies focused on depleted offshore petroleum reservoirs to enhance community confidence that CCS is an effective means of supporting GHG reduction targets.
Reliable predictions of the likelihood and environmental consequences of the inadvertent release of injected GHG and other chemical constituents will be a fundamental consideration in impact assessment stages for GHG injection and storage activities.	Impact assessment techniques to predict the potential impacts and consequences of potential release of injected CO_2 and associated chemical contaminants from geological storage formations to the marine environment and atmosphere.
	Studies to demonstrate the feasibility of converting oil and gas infrastructure (including wells) for the use of carbon capture and storage such that the risks to the environment associated with well and reservoir integrity will be acceptable.
Improving monitoring and mitigation	
There will be a need to demonstrate that selected reservoirs for geological carbon storage offshore can trap carbon dioxide in perpetuity.	Validating modelling tools to appraise potential CO2 storage sites and accurately predicting long term fluid trapping processes.
	Validated tools that provide reliable demonstration that the CO2 can be safely stored and monitored in depleted hydrocarbon reservoirs offshore.
GHG injection and storage activities will need to be able to demonstrate that any reservoir integrity issues can be detected and managed.	Monitoring techniques to verify and assure CO2 migration and trapping.
	Proven adaptive management measures to mitigate environmental impacts, including the release of contaminants, associated with loss of reservoir integrity.
Traditional methods for monitoring CO_2 trapping and migration (e.g. 4D marine seismic surveys) result in the high intensity underwater noise emissions that have potential to have unacceptable impacts on the environment. There is a need to consider whether there are other reliable and less impactful methods for monitoring that can be used to monitor the trapping and migration of CO_2 following injection into offshore reservoirs.	Research, development and testing of innovative technology to: • effectively monitor reservoir integrity following the injection of CO_2; and • attenuate noise emissions from seismic surveys, particularly for noise in low frequency bands that have greatest potential to result in unacceptable impacts on listed threatened baleen whales.

Offshore renewable energy

Note: Please refer to the underwater noise emissions section for research priorities relating to underwater noise aspects of offshore windfarm developments.

Key environmental assessment and management challenges	Research topic
Effect studies	
Enhanced capacity to predict risk to physical and ecological components of the environment associated with different infrastructure scales, designs and layouts to inform environmental impact assessment, decision making, ongoing monitoring and management.	Reliable / validated prediction tools to evaluate effects of the physical presence of offshore renewable energy infrastructure on environmental conditions (e.g. metocean conditions) and physical processes (e.g. water currents, sediment transport, nutrient cycling, erosion/ deposition) and understand potential knock-on risks to ecological integrity and functioning over the development lifecycle at local and regional levels including: • ecological shifts, connectivity, biodiversity, productivity, habitat modification; and • potential indirect effects associated with marine growth, benthic halo effects and invasive marine species risk.
	Effects of artificial hard structures on fish assemblages including any population consequences that may be associated with changes to recruitment patterns, habitat modification and ecological shifts.
	Understanding how different scales, designs and layouts of offshore renewable energy infrastructure influence the level of risk to ecological receptors.
	Investigate the potential to minimise the risk of bird collision and barrier effects on susceptible marine species through engineering and design mitigation.
Relevant, reliable and sufficient information and tools are needed to predict potential population consequences for listed threatened and migratory bird species that may interact with offshore windfarm developments (e.g. barrier effects, collision risk). The information and prediction tools will be required for impact assessments and to demonstrate predicted impacts, when appropriately managed, will not impede recovery of listed threatened species.*	Understanding the spatial and temporal variability in relative densities of seabird/ migratory bird* populations, in particular threatened species with foraging habitats and migration pathways within declared areas and identified priority areas for offshore renewable energy.
	Orange bellied parrot, swift parrot: Increased understanding of migration timing, migration paths, flight height, susceptibility to displacement (and energetic costs) and encounter potential (light attraction to vessels/infrastructure and collision risk with turbines) for threatened species*.
	Development and adoption of standardised monitoring approaches for birds so that data from regional and small-scale studies can be aggregated to examine cumulative impacts.
	Understanding potential consequences on priority avifauna species* population, health and viability and biodiversity value of Ramsar wetlands and obligations under international agreements.
	Research, development and testing of methods to predict and quantify attraction/displacement/collision risk on seabird and migratory bird species to estimate mortality from offshore infrastructure on long-term population viability, particularly for species vulnerable due to life history characteristics.
	Improved understanding and data quality and local relevance for flight height of threatened bird species to aid in improved risk assessments and predictions of collision risk.

*Priority avifauna species are listed in Table A on page 22

Key environmental assessment and management challenges	Research topic
Effect studies	
Reducing the scientific uncertainty relating to the potential effects of electromagnetic field impacts on sharks, rays, fish and invertebrates will be important to guide the need for control measures. In absence of this information precautionary control measures may be required.	Understanding cause-effect pathways for electromagnetic radiation (or conceptual models for these) and the spatial extent of effect fields for sharks, rays, fish, invertebrates (including larval stages) to: • enhance understanding of the potential for electromagnetic fields to affect habitat utilisation (e.g. for foraging, migration, aggregation, breeding) in relevant species and functional groups of species; and in turn • generate outputs with applications in impact prediction, monitoring and management (e.g. effects thresholds, standardised impact prediction methodologies, criteria to interpret monitoring data and trigger management).
Improving monitoring and mitigation techniques	
There is a need for new and innovative techniques to enable impacts from operational stages of offshore windfarms to be monitored and verified over time so as to inform further mitigation and adaptive management (where needed)	Real-time monitoring techniques that can reliably detect birds in the vicinity of wind turbines, including the detection of collisions with offshore wind turbines, to inform mitigation decisions. Examples include automated detection technologies that can be deployed and effective in offshore locations to verify predictions of impact.
There is an opportunity to reduce the risk of bird collision and barrier effects on species most susceptible to offshore windfarm developments through engineering, design and technical mitigations.	Research, development and validation of the effectiveness of existing and emerging mitigation technologies to reduce the risk of bird interactions with wind turbines such as: • location, size, number, orientation, and spacing of turbines; • speed of rotor and blade tips; • blade visibility and visual / acoustic stimuli; • the efficacy of turbine shutdown or curtailment during important seasonal windows; and • best practice methods for lighting wind farm turbines to reduce night-time collision risk for birds without compromising navigation and vessel safety.
There is uncertainty as to whether mitigation measures such as burial of electricity cables are effectivein mitigating potential impacts of electrometric fields (EMF) on environmental receptors.	Effective and validated mitigation measures for managing uncertainty and or avoiding / reducing impacts of EMF on sharks, rays, fish and invertebrates (including larval stages).

Key environmental assessment and management challenges	Research topic
Effect studies	
Best practice models for cooperative co-existence and habitat enhancement to ensure that impacts of offshore renewable activities on commercial fisheries and aquaculture operations can be managed to an acceptable level	Best practice models to facilitate cooperative coexistence of offshore renewables activities and commercial fishing and aquaculture operations.
	Understanding of the application of exclusion zones around offshore infrastructure and how fit for purpose zones may be applied to meet infrastructure management requirements while achieving the best possible ecological and co-existence outcomes.
	Investigations into the potential ecological and socio-economic benefits of nature based infrastructure design and disturbed site remediation associated with offshore renewable energy projects.

Table A - Priority avifauna species relevant to offshore renewable energy research focus areas

Specific advice on priority species in a specific location should be obtained from the Department of Climate Change, Energy, Environment and Water and relevant State agencies.

For the purpose of this Research Strategy, NOPSEMA has considered the advice and feedback from a range of avifauna specialists to develop a focus list for research aligned with this strategy. The focus list considers seabird species and critically endangered migratory parrot species that may be at particular risk due to offshore energy development. The focus list comprises two tiers based on an ecological risk assessment approach applied in the assessment for the impacts of offshore wind farms on birds in Australia[3]:

- Focus species include species considered by Reid et al (2023) with an overall risk score of 4 or higher and an EPBC Act status of Vulnerable or higher plus the critically endangered Orange bellied parrot and Swift parrot.
- Focus species list (Table A) represents a subset of species selected from the focus species which are considered at higher risk and are therefore afforded a higher weighting for research priorities. The Focus species list presented in Table A excludes several species from Reid et al 2023 that are considered to be rarely occurring vagrants in waters where offshore renewable energy declaration areas are currently located or proposed around Australia.

This focus species list is not static and may change with time as knowledge of particular species and threats increases or changes, (e.g. new priority areas for offshore wind are identified). It may also be appropriate that reasonable surrogate species may be considered as candidates for research and that any research of avifauna species is coordinated and undertaken in a collaborative manner so that the considerable effort typically required of seabird research is aligned and efficient to ensure that investment is balanced, and oversampling is avoided.

Additional consideration should also be given to regional context. It may be that a species has a higher level of significance at a regional scale, and therefore becomes a priority species in a region if a significant proportion of its population occurs in that region and their distribution intersects with pressures associated with offshore wind developments.

[3]Reid, K., Baker, G.B. & Woehler, E.J. (2023) An ecological risk assessment for the impacts of offshore wind farms on birds in Australia. Austral Ecology, 48, 418–439. Available from: https://doi.org/10.1111/aec.13278

Table A: Focus list of avifauna species

Common Name	Scientific Name
Northern Royal Albatross	*Diomedea sanfordi*
Eastern Antipodean Albatross	*Diomedea antipodensis antipodensis*
Gibson's Albatross	*Diomedea antipodensis gibsoni*
Wandering Albatross	*Diomedea exulans*
Campbell Albatross	*Thalassarche impavida*
Indian Yellow-nosed Albatross	*Thalassarche carteri*
Shy Albatross	*Thalassarche cauta*
White-capped Albatross	*Thalassarche steadi*
Southern Royal Albatross	*Diomedea epomophora*
Australian Gould's Petrel	*Pterodroma leucoptera leucoptera*
Southern Buller's Albatross	*Thalassarche bulleri bulleri*
Black-browed Albatross	*Thalassarche melanophris*
Sooty Albatross	*Phoebetria fusca*
Southern Giant-Petrel	*Macronectes giganteus*
Northern Giant-Petrel	*Macronectes halli*
Orange bellied parrot	*Neophema chrysogaster*
Swift Parrot	*Lathamus discolor*

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