# State of Exmouth Gulf

## Reporting analysis and framework 2025

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INSTITUTION

Striped catfish. Nick Thake

## State of Exmouth Gulf: Reporting Analysis and Framework 2025

The Exmouth Gulf Taskforce, through the Department of Water and Environmental Regulation engaged the Western Australian Marine Science Institution to advise on a reporting framework suitable for the Exmouth Gulf and its surrounding region, encompassing the marine area, the adjacent terrestrial environments, and associated social and cultural components. This report provides recommendations for a proposed 'State of Exmouth Gulf' reporting framework and implementation process based on best practice methods and the analysis of relevant case studies from around Australia. The Exmouth Gulf Taskforce will consider this option as part of its advice to the Minister for Environment, with a view to deliver long-term integrated management and protection of Exmouth Gulf's land and sea environment.




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### Author Contributions and Acknowledgements

Dr Luke Twomey scoped and developed this project for the Exmouth Gulf Taskforce and Dr Jenny Shaw had project oversight. Dr Asha McNeill uncovered the relevant case studies and skilfully constructed and wrote the content. Dr Alicia Sutton provided strategic input and creative ideas. All contributed to the structuring, writing, editing and finalising of the report.



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### Western Australian Marine Science Institution

The Western Australian Marine Science Institution is a collaboration of state and federal government and academic science organisations working together to provide independent marine research for the benefit of the environment, the community and the blue economy.
www.wamsi.org.au


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The State does not necessarily endorse any information, product, process or outcome.


Front cover: Aerial view North East Exmouth Gulf. Michael Tropiano

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# Acronyms

| | |
|---|---|
| **DBCA** | Department of Biodiversity, Conservation and Attractions |
| **DPSIR** | Drivers, Pressures, State, Impact, Response model |
| **DWER** | Department of Water and Environmental Regulation |
| **EPA** | Environmental Protection Authority |
| **EPBC Act** | *Environment Protection and Biodiversity Conservation Act 1999* (Cth) |
| **GHG** | Greenhouse gases |
| **IEA** | Integrated Ecosystem Assessment |
| **IPBES** | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Global Assessment (2019) |
| **IUCN** | International Union for the Conservation of Nature |
| **NOAA** | (United States) National Oceanic and Atmospheric Administration |
| **NTGAC** | Nganhurra Thanardi Garrbu Aboriginal Corporation |
| **OUV** | Outstanding Universal Value |
| **PFAS** | Per- and polyfluoroalkyl substances |
| **SEAF** | Shared Environmental Analytics Facility |
| **SEP** | State Environmental (Cockburn Sound) Policy 2015 |
| **SoE** | State of the Environment |
| **SRE** | Short-Range Endemics |
| **UNEP** | United Nations Environment Program |
| **UNESCO** | United Nations Educational, Scientific, and Cultural Organisation |
| **WA** | Western Australia |
| **WAMSI** | Western Australian Marine Science Institution |

# Glossary

| | |
|---|---|
| **Conceptual framework** | A structured approach to organising thoughts, processes, or systems to provide clarity and focus (also known as a conceptual model). |
| **DPSIR model** | A conceptual model for describing the interactions between society and the environment consisting of Drivers, Pressures, State, Impact and Response. |
| **Environmental Assessment** | The social process of undertaking a critical, objective evaluation and analysis of data and information to support decision-making. |
| **Integrated Environmental Assessment (IEA)** | A type of environmental assessment formalised by Levin et al. (2009, 2014) and UNEP (2017) which evaluates all components of an ecosystem, including natural and human processes and their interactions, and explores future trends and outlook. |
| **Reporting** | The process of communicating information to a specific audience. |
| **Traditional Knowledge and Science** | The terminology used in this report to describe the cultural evidence system for Indigenous Knowledge production (Archer et al., 2023). We recognise each culture develops their own template for how Indigenous Peoples produce their holistic body of knowledge, learnings and discoveries, and this language may not reflect all interpretations. The language in each case study analysis reflects that used in the original documentation. |

*Adopting a structured reporting process will provide Exmouth Gulf decision-makers with high-quality, transparent, and policy-relevant information to guide conservation, protection and management efforts.*

Spider crab. Nick Thake

# Executive summary

**Exmouth Gulf and the surrounding area is an ecologically, culturally, and socio-economically significant marine region in Western Australia, supporting diverse habitats, marine species, and industries such as fisheries, tourism, and recreation.**

However, increasing pressures from industrial development, shipping, and climate change pose significant challenges to the region's sustainability. In response, the Department of Water and Environmental Regulation in conjunction with the Exmouth Gulf Taskforce has identified the opportunity for an integrated reporting framework to support long-term management and protection. This report provides an analysis of existing environmental reporting frameworks and recommends a tailored reporting framework for Exmouth Gulf.

The report examines key case studies, including the Great Barrier Reef Outlook Report, Australia's National State of the Environment Report, Cockburn Sound environmental reporting, and World Heritage Area reporting. A 'State of Exmouth Gulf' Reporting Framework is proposed, based on international best practices and key lessons identified from the case study analyses, alongside a high-level roadmap to guide the implementation of the framework.

Drawing on the established Integrated Ecosystem Analysis approach provides an internationally recognised and robust process for conducting assessments, working to ensure that the outputs are regarded as credible, relevant, and legitimate. The fundamentally participatory principle of this approach entails deep and continual engagement with stakeholders throughout the process, offering a pathway to enhance stakeholder relationships and facilitate knowledge exchange. In the Exmouth Gulf and its surrounds, an assessment should be conducted in partnership with the Traditional Owners, including the Nganhurra Thanardi Garrbu Aboriginal Corporation to recognise Traditional Owners' unique rights, responsibilities, and cultural knowledge.

The Drivers, Pressures, State, Impact, Response (DPSIR) model is recommended as the preferred conceptual framework to systematically assess ecosystem health, social and economic values, and management responses. The DPSIR model provides a structure within which to identify and present the required indicators. Applying this model ensures consistency with international best practices and aligns with existing national environmental reporting. The flexibility of the DPSIR allows for integrating western scientific evidence alongside Traditional Knowledge and Science as well as local knowledge to inform the assessment.

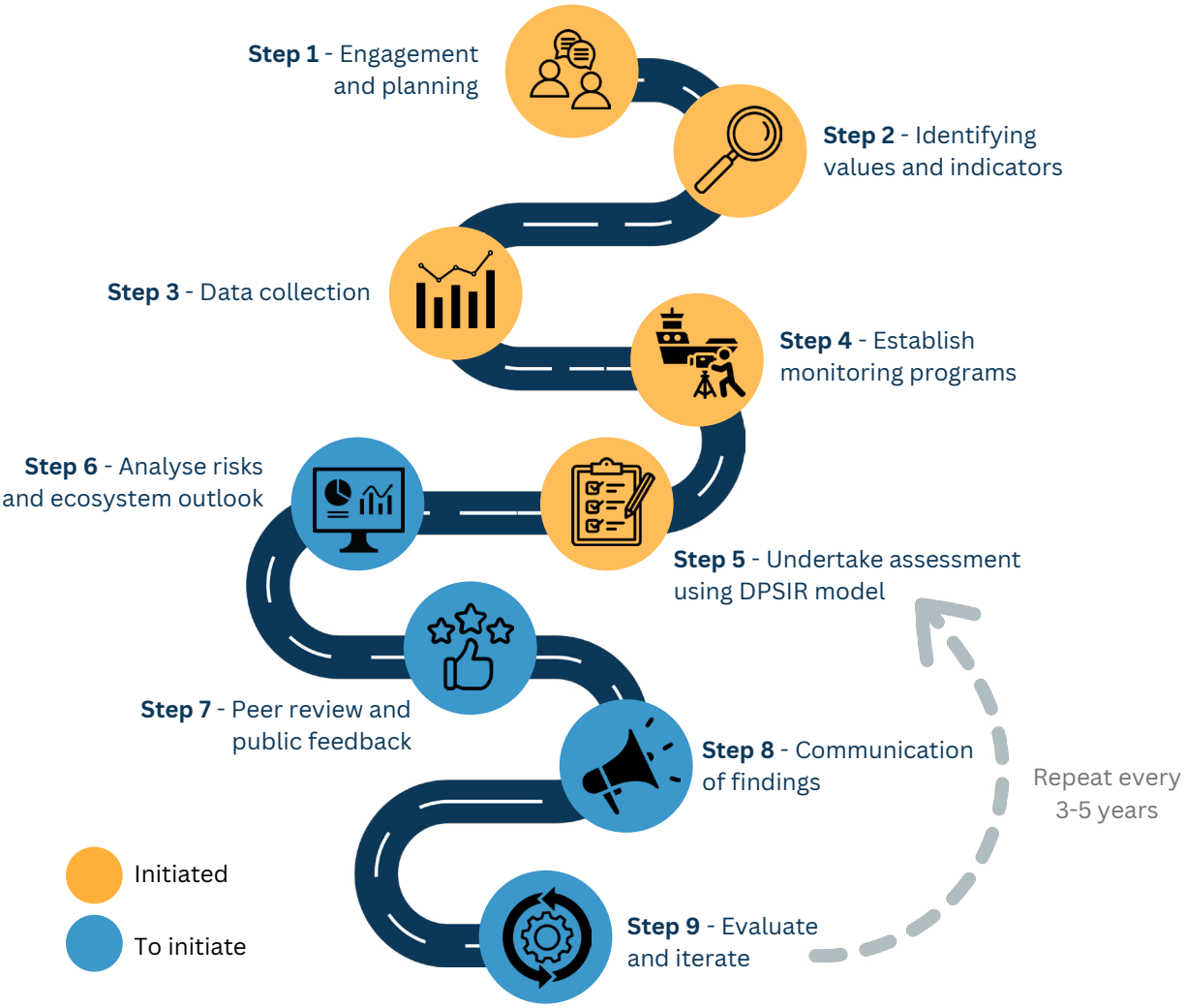
Implementing long-term, integrated socio-ecological monitoring programs is essential for effective ecosystem assessment, enabling structured, ongoing data collection to track trends over time. The proposed reporting process can both benefit from and contribute to existing shared data initiatives, including the Shared Environmental Analytics Facility, a secure data-sharing and analytics platform that is in the pilot stage of development in the region.

The implementation plan outlines nine key steps to establish a State of Exmouth Gulf assessment and reporting process. Steps one through five have been initiated through the Western Australian Marine Science Institution's (WAMSI) previous work in the region and the connections between these resources and the implementation plan have been identified. The importance of establishing transparent communications is highlighted in the recommendations and implementation plan, to ensure the findings are accessible to policymakers, Traditional Owners, resource managers, and the public.

Adopting a structured reporting process will provide Exmouth Gulf decision-makers with high-quality, transparent, and policy-relevant information to guide conservation, protection and management efforts. Importantly, the proposed framework does not replace the need for sector-based regulation and monitoring in the region. Instead, it offers a strategic approach to enhance the capacity of knowledge – gathered systematically from diverse sources – to inform future decision-making.

The framework supports the long-term resilience of the Gulf's environment, economy, social and cultural values while fostering collaboration among the community, stakeholders and Traditional Owners. Periodic reassessments every three to five years will enable tracking of trends, adaptive responses to emerging pressures, and informed decision-making that balances protection and sustainable development.

## PROPOSED ROADMAP FOR THE 'STATE OF EXMOUTH GULF' REPORTING FRAMEWORK




High-level implementation plan for undertaking a State of Exmouth Gulf assessment and reporting process. Steps that have been initiated (orange) include elements that have been delivered through WAMSI's existing research, however, further work remains to be completed. See Section 4.2 of this report, *Implementation plan*.

# 1. Background

## 1.1. Exmouth Gulf

**Western Australia's (WA) Exmouth Gulf (the Gulf) and its surrounds is a region of exceptional ecological significance, supporting a range of habitats and biodiversity critical to its environmental, cultural, social, and economic values. Its marine ecosystems include productive prawn fisheries, extensive mangrove forests, salt flats, algal mats, and coral reefs, collectively providing vital ecosystem services such as carbon sequestration and coastal protection.**

Surrounding the Gulf, unique karst systems and diverse vegetation complexes harbour high levels of endemism and subterranean fauna, contributing to the region's global conservation importance.

Socially and culturally, the Gulf is deeply connected to the Traditional Knowledge and practices of the Baiyungu, Yinnigurrura and Thalanyji people, who have sustainably managed the region for millennia. Their stewardship and a growing local population reinforce the Gulf's value as a hub of natural and cultural heritage. Economically, the area supports a thriving tourism industry driven by its wilderness appeal, pristine ecosystems, and opportunities for recreational fishing, whale watching, and eco-tourism.

However, the Gulf faces increasing pressures from industrial development, shipping, tourism, climate change, and resource extraction, presenting significant challenges to sustainable management. Recognising these risks, the State Government, through the Department of Water and Environmental Regulation (DWER), has highlighted the opportunity for an integrated reporting framework that balances protection with socio-economic development, ensuring the long-term resilience of Exmouth Gulf's ecosystem and communities.

The Exmouth Gulf Taskforce (the Taskforce), of which DWER is the Secretariat, is a Ministerial advisory body established under WA's *Environmental Protection Act 1986*. Under the Taskforce's *Terms of Reference*, the Government and non-government representative members work collaboratively to advise the Minister for Environment (Minister) on options to deliver long-term integrated management and protection of the land and sea environment. DWER engaged WAMSI to summarise reporting frameworks used in other jurisdictions and provide a recommended approach for Exmouth Gulf. The Taskforce will consider this approach as part of its advice to the Minister.

## 1.2. Scope and objectives

DWER commissioned this paper to advise on a reporting framework suitable for Exmouth Gulf and its surrounding region, encompassing the marine area, the adjacent terrestrial environments, and associated social and cultural components. We provide recommendations for a proposed State of Exmouth Gulf reporting framework and implementation process based on best practice methods and the analysis of relevant case studies from Australia.

The objectives of this paper are to:

- Analyse relevant case studies of ecosystem reporting and synthesise key characteristics of their frameworks, methods and processes
- Propose a recommended State of Exmouth Gulf reporting framework
- Outline a high-level implementation roadmap that could be delivered through a future Exmouth Gulf coordinating body.

The proposed framework and implementation roadmap are informed by the analysis detailed above, the current trends and advice on reporting in Australia and WAMSI's extensive experience understanding the research undertaken in Exmouth Gulf, including the recent *Knowledge Review of Exmouth Gulf and Prioritisation of Future Research* (WAMSI *in prep*, 2025) and *Cumulative Pressures on the Distinctive Values of Exmouth Gulf* (Sutton and Shaw, 2021).

## 1.3. Background

### Ecosystem assessment and reporting

Globally, ecosystems face challenges from emerging uses and growing demands from current activities. As a result, their management is evolving from a siloed, sector-based management system towards a more integrated, ecosystem-based approach that considers ecosystems holistically. This encompasses their biological, physical, social

(including cultural), and economic components, considers how they interact and aims to balance human use with environmental protection.

High-quality information is essential to inform ecosystem-based management. An environmental assessment is a planning and management tool to facilitate sound decision-making and support sustainable development goals. The United Nations Environment Program (UNEP) defines environmental assessments as "the social process of undertaking a critical, objective evaluation and analysis of data and information to support decision-making".

Environmental assessment methods vary in purpose, content, coverage, design, process and cadence. Categories of assessment may include, for example (UNEP, 2015; see Appendix 1 for an expanded summary of different assessment types):

- **Ecosystem Assessment** evaluates ecosystems' state, trends and the services they provide, and the consequences of ecosystem change for human well-being
- **Environmental Impact Assessment** focuses on the impacts of specific development proposals (e.g., mining, industry, infrastructure) and statutory planning schemes to identify and evaluate the potential consequences, impacts and effects
- **Risk Assessment** identifies and evaluates risks from specific agents or scenarios (e.g., chemicals, disasters)
- **Vulnerability Assessment** examines exposure and sensitivity to risks, such as climate change and disasters.

In contrast to an Environmental Impact Assessment's localised or specific project focus, an Ecosystem Assessment has a broad view of the entire ecosystem and the interactions between its components. While there is no formal definition of the approach, an Ecosystem Assessment can be described as "the systematic evaluation of the state, trends, and value of ecosystems and the services they provide to humans and the environment" (Millenium Ecosystem Assessment, 2005).

An Ecosystem Assessment evaluates the consequences of ecosystem change on human well-being, providing the evidence basis for action.

Prominent international examples of Ecosystem Assessment have included the Millennium Ecosystem Assessment (2005) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Global Assessment (2019), which have set benchmarks for global biodiversity and ecosystem management.

Similarly, *Integrated Ecosystem Assessments* (IEA) (Levin et al., 2009, UNEP, 2017) are a type of holistic ecosystem assessment that includes environmental, social and economic aspects in an integrated way to analyse the environmental state, trends and policy. An IEA evaluates the potential outcomes of alternative management actions on ecosystem components (natural and human, across marine and terrestrial boundaries) and identifies trade-offs within management objectives. Integrated assessments are envisioned as an ongoing, iterative process that does not necessarily conclude upon delivering reporting outputs.

The steps for conducting an IEA have been detailed in various resources, most notably by UNEP and the United States National Oceanic and Atmospheric Administration (NOAA) (Levin et al., 2009, 2014). While these resources use differing terminology, the core concepts and principles underpinning the methods are analogous. A summary of the key steps from UNEP's *Guidelines for conducting Integrated Ecosystem Assessments* (2017) is presented in Table 1 to illustrate the process undertaken to complete an IEA assessment. These guidelines are not strictly prescriptive but rather a versatile approach that can be adapted to any application.

A key feature of these assessments is the importance of the process as a critical factor of their success. This process of compiling an assessment is an important means through which ecosystem knowledge is shared and priorities are discussed. The IEA process emphasises the importance of engaging with diverse stakeholders early and often throughout the process and integrating diverse knowledge, including natural and social sciences, and local and Traditional Knowledge. It provides opportunities to bring together stakeholders to develop consensus, designed to inform ecosystem-based management and decision-making (Levin et al., 2009).

Table 1: A summary of the key steps in each stage of conducting an Integrated Ecosystem Assessment. Adapted from Guidelines for conducting Integrated Environmental Assessments (UNEP, 2017).

| Stage | Summary of key steps in each stage of assessment |
|---|---|
| Planning | Establish the mandate for the assessment and set clear goals, objectives and the intended audience, in alignment with stakeholder priorities and management objectives. Define the geographic, thematic, and temporal boundaries of the assessment, stakeholder engagement strategies and necessary roles and responsibilities. Establish a theory of change to guide the assessment and its desired outcomes, an impact strategy, and a communications and outreach strategy. |
| Selection of Framework and Methods | Define the components that make up an ecosystem, including relationships, connections and feedback. Select an appropriate conceptual framework to inform and/or structure the assessment and ensure a systematic approach to integrating data from diverse sources, including scientific research, Traditional Knowledge, and socio-economic datasets (discussed in greater detail below). Develop indicators, methods, and data sources to monitor ecosystem functions, services, and pressures. Indicators should align with management objectives and be measurable over time. |
| Integrated Analysis of Environmental Trends and Policy Responses | Combine ecological, social, and policy perspectives to assess ecosystem trends and dynamics. Analyse the drivers, pressures, ecosystem states, impacts on services, and responses to evaluate past and present conditions. Use diverse datasets and knowledge systems to ensure a comprehensive understanding of ecosystem functioning, pressures, and trade-offs. |
| Assessment of Policy Effectiveness | Examine existing policies to determine their effectiveness in addressing ecosystem challenges. Evaluate governance structures and identify trade-offs between objectives. Use cost-benefit analysis and scenario modelling to assess gaps and opportunities in current policies and responses. |
| Compiling and Environmental Outlook | Develop scenarios and use trend analysis to project future changes under different management strategies. This step identifies opportunities, risks, and explores alternative policy pathways to informs adaptive strategies for improved ecosystem health and resilience. |
| Communicate the Assessment Process and Findings | Design an inclusive communication strategy to disseminate findings to diverse audiences in accessible and relevant formats. Ensure data and insights are actionable for stakeholders, incorporating visualisations and providing clear, evidence-based recommendations for decision-makers and resource managers. |
| Evaluating the Assessment | Conduct an independent evaluation of the assessment's processes and outcomes. Adapt future assessments based on lessons learned, new data, and evolving environmental priorities. Regular monitoring and iterative learning ensure the process remains dynamic and responsive to changing conditions, supporting adaptive management and continuous improvement. |

For scientific knowledge to effectively inform policy and practice, both the information and the process through which it was produced require three key attributes:

- ***Credibility*** (the trustworthiness of the source)
- ***Relevance*** (the pertinence of the information to the issue at hand)
- ***Legitimacy*** (the perceived fairness and acceptability of the process by which the information was generated) (Cash et al., 2003).

The design of the process influences the perceived credibility, relevance and legitimacy of the exercise, and determines if it reaches its intended audience.

IEAs are emerging as a key international tool for informing decision-making in marine and coastal systems, having been adopted as the preferred approach by UNEP, NOAA, and the International Council for the Exploration of the Seas. In Australia, the National Marine Science Committee have endorsed the approach, with a working group producing an overview of the principles, an analysis

of case studies in Australia and scoped appropriate pilot projects (Smith et al, 2021). The working group found that while full IEAs have never been undertaken in Australia, there are examples of similar but partial approaches in progress, including across all New South Wales waters under the Marine Estate Management Strategy (considered the most mature), and Westport/Cockburn Sound in WA (considered in progress) (Smith et al., 2022).

## Conceptual frameworks

A conceptual framework (also conceptual model) is a structured approach to organising thoughts, processes, or systems to provide clarity and focus. Conceptual frameworks are essential tools that bring together researchers, resource managers, and decision-makers from diverse disciplines and cultural backgrounds. By offering a shared perspective, a conceptual framework establishes a common understanding of how assessments should be approached and what outcomes are required.

Conceptual frameworks serve multiple purposes within Ecosystem Assessments. They help structure research and analysis, integrate diverse forms of knowledge, and identify key areas of focus, such as drivers of change, ecosystem services, and societal responses. Furthermore, they facilitate communication between stakeholders by offering a visual or textual representation of the system being studied.

Conceptual frameworks are derived from existing understanding of the system of focus and represent a simplified version of reality. Conceptual frameworks for an Ecosystem Assessment build on existing models of how the world works. The collaborative process of defining and populating a conceptual framework forms an integral part of the assessment process; therefore, there is flexibility on how frameworks are applied, adapted and used (Potschin & Haines-Young, 2016).

Internationally, the **D**rivers, **P**ressures, **S**tate, **I**mpact, **R**esponse (DPSIR) model is often recommended as the preferred conceptual framework for informing Ecosystem Assessments (UNEP, 2017).

DPSIR is a causal model (or framework) used to describe the interactions between society and the environment. The model was originally developed by the National Institute of Public Health and Environment in the Netherlands and has since been widely adopted, including by the European Environmental Agency. Global examples of Ecosystem Assessments which apply the DPSIR model include the United Nations World Ocean Assessment and the United Nations Global Environment Outlook.

Applying the DPSIR framework to a complex system provides a systematic way of breaking it down into components and the links among them. The components include drivers (D), or root causes of environmental change, stemming from human needs that create pressures (P) through activities impacting the environment. These activities alter environmental conditions (S), impacting its ability to provide goods and services (I). In response (R), political or other actions may be taken to mitigate impacts and restore environmental and societal well-being (Figure 1).

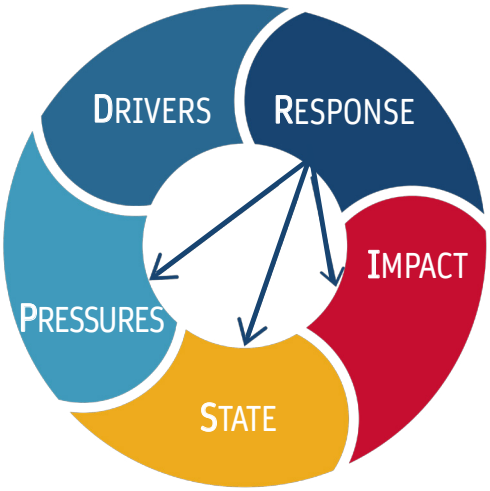
Within an Ecosystem Assessment process, the DPSIR model organises assessment elements and indicators related to the environmental issues in question, aligns them with objectives and emphasises causal relationships between human activities and environmental changes. The flexibility offered by the model makes it an effective tool with numerous applications, not limited to Ecosystem Assessment and allows it to be applied at various scales.

When the DPSIR framework is subsequently re-applied to a region or area, an assessment of the (new) current state of the environment can be made to compare how the drivers and pressures may have acted between assessment periods and whether the state had responded negatively, positively or neutral. If adequate monitoring programs exist and the data are available, an assessment of the impact on key values may be made over the period. Trend analysis enables assessment of the effectiveness of management programs for those values.

Figure 1: **The Drivers-Pressures-State-Impacts-Responses (DPSIR) model. This model is used to assess and manage environmental problems (redrawn from UNEP, 2017). Responses are often depicted as flowing into other components, representing actions that can adjust the Drivers, reduce the Pressures on the system, bring the system back to its initial State, and mitigate the Impacts.**

The underlying social, economic, and environmental factors that drive environmental change (e.g., population growth, economic development).

The direct effects of drivers on the environment (e.g., pollution, land use changes).




The actions taken by society to address environmental issues (e.g., policies, regulations).

The effects of environmental changes on ecosystems and human well-being (e.g., loss of species, health issues).

The current condition of the environment (e.g., air and water quality, biodiversity).

Emu in the Cape Range National Park near Exmouth.
Tourism Western Australia

# 2. Case studies

**A selection of relevant examples is detailed here to provide an overview of their methods and processes, the frameworks informing their analyses and reporting structure. Although these examples draw primarily from marine-based examples, the key learnings apply across marine and terrestrial ecosystems.**

## 2.1. Great Barrier Reef Outlook

### Background and Purpose

The Great Barrier Reef Outlook is a comprehensive environmental reporting framework designed to assess the health, pressures, and future outlook of the Great Barrier Reef (the Reef). The Great Barrier Reef Marine Park Authority (the Authority) prepares an Outlook Report for the Great Barrier Reef Region every five years. The content and timing of reporting are specified under the *Great Barrier Reef Marine Park Act 1975* (Cth) (the Act).

The Outlook Report underpins decision-making for the long-term protection of the Reef. Its purpose is to provide an accountable and transparent assessment of the overall performance of measures to protect and manage the Reef using the best available evidence. The report provides a summary of the long-term outlook for the Reef based on assessments of condition, use, influencing factors, management effectiveness, resilience and risks.

The Outlook Report does not include recommendations about protection or management initiatives. Rather, it provides an evidence-based assessment that can be used to inform future initiatives. The Outlook Report is a key input to Reef management by the Authority and reviews of the Reef 2050 Long-Term Sustainability Plan and zoning. It also plays a significant role in informing Australia's reports to the World Heritage Committee addressing the state of conservation of the Great Barrier Reef World Heritage Area.

### Method

The 2024 report is the fourth in the series of reports, building upon reports released in 2009, 2014, and 2019. According to the Act, each Outlook report must contain the following matters:

a) An assessment of the current health of the ecosystem within the Great Barrier Reef Region and of the ecosystem outside that region to the extent it affects that region

b) An assessment of the current biodiversity within that region

c) An assessment of the commercial and non-commercial use of that region

d) An assessment of the risks to the ecosystem within that region

e) An assessment of the current resilience of the ecosystem within that region

f) An assessment of the existing measures to protect and manage the ecosystem within that region

g) An assessment of the factors influencing the current and projected future environmental, economic and social values of that region

h) An assessment of the long-term outlook for the ecosystem within that region

i) Any other matter prescribed by the regulations for the purposes of this paragraph.

The Outlook Report is prepared by the Authority, with contributions of evidence from Australian and Queensland government agencies, researchers from a range of institutions, industry data holders and Traditional Owners. The report compiles and synthesises data from various monitoring programs, scientific studies, and management records. No new research is conducted; instead, the focus is on analysing readily available information to provide a holistic view of the Reef's status.

The perspectives and knowledge of First Nations peoples are incorporated through co-produced place-based stories, participation in workshops and, where available, published literature and reports.

Expert elicitation workshops, attended by more than 45 scientists in preparation for the 2024 report, contributed to the assessments of biodiversity, ecosystem health and heritage value and informed the forward-looking risk and resilience assessments.

Five independent assessors in protected area management, monitoring and evaluation, public policy and governance review the effectiveness of existing protection and management arrangements for the region's ecosystem, its heritage value and, where relevant, the Catchment. Peer review is also a statutory requirement of the Act and must occur before the report is given to the Australian Minister for the Environment and Water. Five experts appointed by the Minister independently review the draft before the final report is tabled in Parliament.

## Reporting

Each of the assessments required under the Act and relevant regulations forms a chapter of the report, organised into three themes:

- **Values**: What are the current conditions and trends of the Reef's ecosystem, heritage, economic and social values?
- **Threats, responses and risks**: What influences the Great Barrier Reef, is it resilient, how well is it protected and managed, and what risks remain?
- **Long-Term Outlook**: What does this report mean for the Great Barrier Reef's future?

Each chapter contains assessments of a specific set of criteria and a various number of components (Figure 2). Each assessment element is evaluated against a four-point grading scale, which has been used since 2009 and is continued for consistency (Figure 3).
The grade allocated is a 'grade of best fit', based on a qualitative assessment of the available evidence from existing research and information, with a focus on sources from the past five years.
An assessment of confidence and trend are reported against each assessment element.
The Outlook uses an integrated cross-cutting approach, with factors affecting the region's values (i.e. climate change, coastal development, etc) broken down by the different categories of values (i.e. ecological, economic, heritage, social).

A reflection of the inaugural Outlook Report 2009 by Dobbs, et al. (2011) concluded the design and presentation of the report played a crucial role in securing its acceptance by government, stakeholders, and the community. The report was intentionally developed as a high-quality, visually engaging, and accessible publication, striking a balance between scientific credibility and readability. Cross-sectoral engagement was also highlighted as important for its success, with the Outlook process providing a new avenue for fostering connection between stakeholders.

Shorebirds in flight. Grant Griffin

## Chapter 2: Biodiversity

**Habitats to support species**
- Islands
- Mainland beaches and coastlines
- Mangrove forests
- Seagrass meadows
- Coral Reefs
- Lagoon floor
- Other banks and shoals
- *Halimeda* bioherms and meadows
- Continental slope
- Water column

**Populations of species and groups of species**
- Mangroves
- Seagrasses
- Benthic algae
- Corals
- Other Invertebrates
- Plankton and microbes
- Bony fishes
- Sharks and rays
- Sea snakes
- Marine turtles
- Estuarine crocodiles
- Seabirds
- Shorebirds
- Whales
- Dolphins
- Dugongs

## Chapter 3: Ecosystem health

**Physical processes**
- Currents
- Cyclones and wind
- Freshwater inflow
- Sediment exposure
- Sea level
- Sea temperature
- Light

**Chemical processes**
- Nutrient cycling
- Ocean pH
- Ocean salinity

**Ecological processes**
- Microbial processes
- Particle feeding
- Primary production
- Herbivory
- Predation
- Symbiosis
- Recruitment
- Reef building
- Competition
- Connectivity

**Coastal ecosystems that support the Great Barrier Reef**
- Saltmarshes
- Freshwater wetlands
- Forested floodplains
- Heath and shrublands
- Grass and sedgelands
- Woodlands and forests
- Rainforests

**Outbreaks of disease, introduced species and pest species**
- Outbreaks of disease
- Outbreaks of crown-of-thorns starfish
- Introduced species
- Other outbreaks

## Chapter 4: Heritage values

**Natural heritage values – world heritage and national heritage values**
- Natural beauty and natural phenomena
- Major stages of the Earth's evolutionary history
- Ecological and biological processes
- Habitats for conservation of biodiversity
- Integrity
- Natural heritage values

**Indigenous heritage values**
- Cultural practices, observances, customs and lore
- Sacred sites, sites of particular significance and places important for cultural tradition
- Stories, songlines, totems and languages
- Indigenous structures, technology, tools and archaeology

**Historic heritage values – Commonwealth heritage values**
- Commonwealth heritage values

**Historic heritage values**
- Commonwealth lightstations
- Other historic lightstations and lighthouses
- Historic voyages and shipwrecks
- World War II features and sites
- Other places of historic significance

**Heritage – other**
- Social heritage value
- Aesthetic heritage value
- Scientific heritage value

## Chapter 5: Commercial and non-commercial use

**Economic and social benefits**
- Commercial marine tourism
- Defence activities
- Fishing
- Recreation (not including fishing)
- Research and educational activities
- Ports
- Shipping
- Traditional use of marine resources

**Impacts of use on the Region's values**
- Commercial marine tourism
- Defence activities
- Fishing
- Recreation (not including fishing)
- Research and educational activities
- Ports
- Shipping
- Traditional use of marine resources

## Chapter 6: Factors influencing the Region's values

**Impacts on ecological values**
- Climate change
- Coastal development in the Catchment
- Land-based run-off
- Direct use

**Impacts on heritage values**
- Climate change
- Coastal development in the Catchment
- Land-based run-off
- Direct use

**Impacts on economic values**
- Climate change
- Coastal development in the Catchment
- Land-based run-off
- Direct use

**Impacts on social values**
- Climate change
- Coastal development in the Catchment
- Land-based run-off
- Direct use

## Chapter 7: Existing protection and management

**Elements of the management cycle**
- Understanding of context
- Planning
- Financial, staffing and information inputs
- Management systems, processes and governance
- Delivery of outputs
- Achievement of outcomes

**Individual management topics**
- Commercial marine tourism
- Defence activities
- Fishing
- Ports
- Recreation (not including fishing)
- Research and educational activities
- Shipping
- Traditional use of marine resources
- Climate change
- Coastal development in the Catchment
- Land-based run-off
- Biodiversity values
- Heritage values
- Community benefits of the environment

## Chapter 8: Resilience

**Ecosystem resilience**
- Coral reef habitats
- Seagrass meadow habitats
- Black teatfish (sea cucumber)
- Coral trout
- Loggerhead turtles
- Urban coast dugongs
- Humpback whales

**Heritage resilience**
- Social heritage value
- Indigenous heritage value
- Historic heritage value

## Chapter 9: Risks to the Region's values

**Overall risk to the ecosystem** (natural heritage values)
**Overall risk to the heritage values** (Indigenous, historic and other)

## Chapter 10: Long-term outlook

**Outlook for the Region's ecosystem**
**Outlook for the Region's heritage values**

Figure 2: The Great Barrier Reef Outlook Report 2024 assessment criteria and their components. Each chapter of the report contains assessments of a specific set of criteria (bold text) and components (bullet points). From Great Barrier Reef Marine Park Authority (2024).

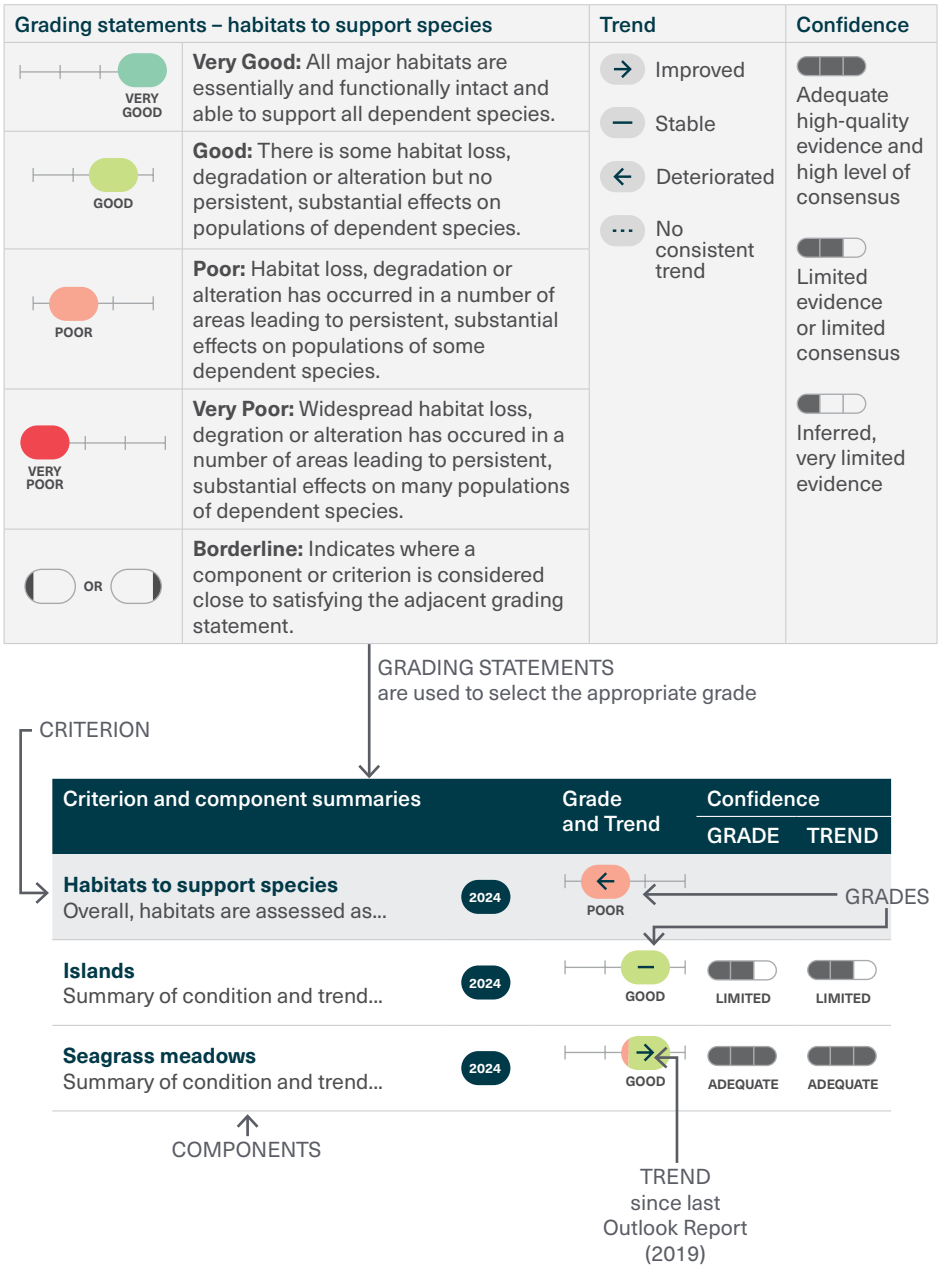



Figure 3: An example from an assessment table for one of the biodiversity assessment criteria in the Great Barrier Reef Outlook Report 2024. The grades for individual components (in this example, islands, seagrass meadows and mangrove forests) are key in informing the grade for the criterion (in this example, habitats to support species). Ultimately, both the criterion and component level assessments are guided by the relevant set of grading statements. From Great Barrier Reef Marine Park Authority (2024).

Several strategic supporting resources were developed to enhance interpretation and accessibility. This included a 20-page summary booklet, brief information sheets on key topics, and Outlook Online, an information system that provided direct access to evidence sources (no longer available online in 2025). Additionally, the report was made available on government web pages alongside ministerial responses and media releases to encourage broad dissemination and policy engagement.

## 2.2. Australia's National 'State of the Environment' Reporting

### Background and Purpose

Australia's State of the Environment (SoE) reporting is mandated under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act, Cth) to provide a broad scale, national assessment of the environment's condition every five years. Notably, the EPBC Act defines the 'environment' as:

- Ecosystems and their constituent parts, including people and communities
- Natural and physical resources
- The qualities and characteristics of locations, places and areas
- Heritage values of places
- The social, economic and cultural aspects of the above.

The overarching goals of the report are to provide the Australian government, decision-makers and managers and the Australian public with authoritative information on the key national issues influencing and affecting the environment (as defined above), the current state and recent trends in the environment and how effectively the environment is being managed in response to those issues. Additionally, the reports play a vital role in aligning national efforts with international obligations, such as the United Nations Sustainable Development Goals and the Kunming-Montreal Global Biodiversity Framework.

The SoE Report serves as an independent, evidence-based assessment of the nation's environmental health, aiming to inform policy and action. It is funded by the Commonwealth Government through the Department of Climate Change, Energy, the Environment and Water. However, the report itself is produced by a committee of independent scientists and experts who draw data from various government and partner sources. While the report provides a comprehensive analysis of environmental conditions and trends, it does not prescribe specific policy or management recommendations, similar to the Great Barrier Reef Outlook. Instead, its purpose is to supply policymakers, managers, and the public with credible and accessible information to support decision-making and facilitate the development of effective environmental policies and management strategies.

Under proposed Commonwealth legislative reforms, SoE reporting may transition from the current five-year reporting cycle to every two years as part of a broader suite of nature-positive law reforms. These reforms aim to modernise environmental reporting and data management, ensuring timely and transparent access to critical information.

### Method

The most recent assessment, SoE 2021, covers the current state, pressures, impacts, management, and outlook for 12 environmental themes. Each theme is reported in a different chapter, namely *Air quality, Antarctica, Biodiversity, Coasts, Heritage, Inland water, Land, Marine* and *Urban* themes, which were carried over from the 2016 assessment. Chapters on Climate, Extreme events and Indigenous were new additions in 2021.

The 2021 SoE report introduced an Indigenous co-authorship model, a significant shift towards recognising Indigenous knowledge systems in environmental assessments. This change aimed to incorporate Traditional Owners' perspectives on environmental management, land and sea Country, and biodiversity conservation. An Indigenous co-chief author was appointed alongside two senior scientists, and Indigenous co-authors were engaged to contribute to all themes.

Since 2011, the SoE report has used an adaptation of the DPSIR model (Figure 4) to structure its assessments. Each chapter contains:

- A comprehensive review of the **state** of the environment, based on available data and information
- information on the **pressures** on the environment and the **drivers** of these pressures
- information on the effectiveness **of management** to address environmental concerns
- information on the **human wellbeing impacts** of the above
- An overall **outlook** for the Australian **environment**.

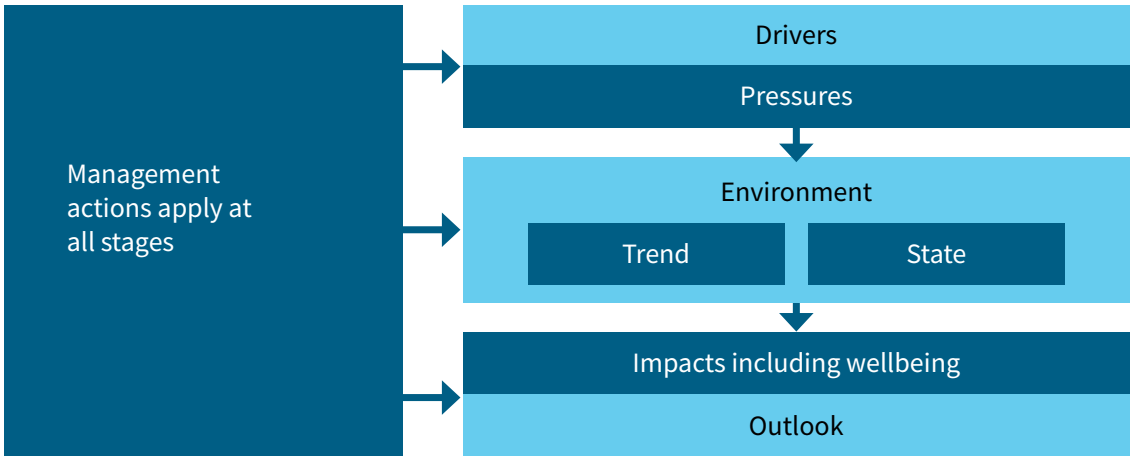



Figure 4: **Australia's National State of the Environment Report approach to assessment. Continuing the 2011 and 2016 approach, the 2021 report assesses drivers, pressures, state and trend of the environment, impacts and management effectiveness. From Cresswell et al. (2021).**

The assessment process incorporates multiple information sources, including both quantitative and qualitative data. This includes empirical data from long-term environmental monitoring programs; and expert elicitation, where direct observational data is lacking. The methods by which the grades are determined vary between SoE report editions and chapters.

For the Marine and Coasts chapters in 2021, 'western science' assessment results are presented alongside Indigenous assessments. Two activities were developed to incorporate Aboriginal and Torres Strait Islander views and inputs into the Marine and Coasts chapters: online yarning circles about outcomes and sea Country management, and an online survey to seek views about assessment indicators. Input from Traditional Owners was used exclusively to evaluate components like 'Policy and management to support Indigenous leadership of adaptive management of Country'.

For the first time, the 2021 SoE Report underwent an independent evaluation to aid future development. The evaluation focused on the impact, utility, relevance, and effectiveness of the report's promotion, conducted by independent, certified, majority Indigenous-owned consultants, IPS Management Consultants.

## Reporting

Within each of the 12 thematic chapters, 4-point graded state and trend assessments are provided for each category and subcategory of assessment elements (Table 2). These are accompanied by an estimate of confidence and a short descriptive evidence synthesis (Figure 5). Graphical Indigenous assessments are provided for each category (in bold in example Table 2) Historical data for 2011 and 2016 SoE reports are provided where available. Further explanatory text for each element provides a short literature review of the evidence. A national synthesis overview chapter offers an overarching perspective, integrating findings to highlight interconnected trends and challenges. The links between key components of human wellbeing and the state of the environment are presented in a summary table.

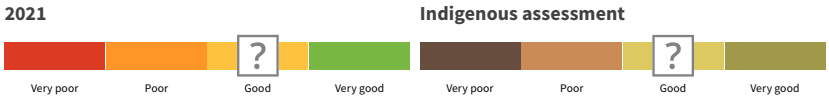
The SoE Marine chapter reporting provides an example breakdown of topics on the environment, pressures and management (Table 2). The SoE reports are designed to be broadly accessible to a wide audience, including policymakers, researchers, industries, and the general public; therefore, detailed information is traded off against the breadth of the topics covered. They are published online and supplemented with interactive tools, summaries, and visual aids to enhance understanding and engagement.

Table 2: An example breakdown of topics on the environment, pressures and management in Australia's National State of the Environment Report, 2021. A summary of the topics (bold) and categories (bullet points) in the Marine Chapter, some categories are further broken down but not listed here for brevity (Trebilco et al., 2021).

| Environment | Pressures | Management |
|---|---|---|
| **Marine habitats and communities**<br>• Water column<br>• Coral reefs<br>• Rocky reefs and kelp beds<br>• Canyons and seamounts<br>• Other seabed habitats<br>**Marine Species**<br>• Marine mammals<br>• Sharks, rays, and chimaeras<br>• Tuna and billfish<br>• Reef fishes<br>• Other fishes<br>• Sea turtles and sea snakes<br>• Seabirds<br>• Invertebrates<br>**Marine Ecosystem Processes**<br>• Water clarity (turbidity, transparency, and colour)<br>• Microbial processes<br>• Primary production (phytoplankton)<br>• Secondary production (zooplankton)<br>• Food webs and connectivity | **Climate and climate change**<br>• Climate and system variability<br>• Changes to water temperature and salinity<br>• Ocean acidification<br>• Changes to ocean circulation<br>• Extreme weather events<br>• Introduced species, diseases, pests, and algal blooms<br>**Population**<br>• Recreational fishing<br>• Marine plastics and debris<br>• Other marine pollution<br>• Tourism<br>**Industry**<br>• Commercial fishing<br>• Indigenous commercial fishing<br>• Marine vessel activity<br>• Marine petrochemical and mineral industries<br>• Offshore renewable energy generation<br>• Anthropogenic marine noise | **National and international policy and frameworks**<br>• National policy<br>• Marine biodiversity protection<br>• Indigenous inclusivity<br>• International policy<br>**Management approaches**<br>• Integrated management<br>• Management and data agreements with Traditional Custodians<br>• Marine ecosystem restoration and engineering<br>**Management of specific pressures**<br>• Climate and climate change<br>• Commercial fishing<br>• Indigenous commercial fishing<br>• Recreational fishing<br>• Marine petrochemical and mineral industries<br>• Plastics and marine debris<br>• Other marine pollution<br>• Marine vessel activity<br>• Offshore renewable energy generation<br>• Anthropogenic marine noise |

Salt flats of Exmouth Gulf. Sharyn Hickey

**Assessment** Status of marine species




Somewhat adequate confidence

Most marine species are in good condition, but it is not clear whether this condition is stable or declining. Notable exceptions are reef fishes, sea snakes, turtles and pinnipeds (fur seals and sea lions), which are in poor condition and are deteriorating (trend unclear for turtles). Traditional Owners assessed sea snakes and sea turtles as in good condition.

Related to United Nations Sustainable Development Goal targets 14.2, 14.4, 14.5, 14.6

**Assessment** Dolphins and porpoises


Limited confidence

Population state and trends for most species are unknown but assumed stable; Australian humpback and snubfin dolphins are demonstrating decreasing trends (Evans 2021).

The Indigenous assessment regionally was good, with an unclear trend.

**Assessment** Whales


Limited confidence

Population state and trends for most species are unknown but assumed stable; humpback and southern right whales (Australian western population only) are demonstrating clear increasing trends (Evans & Harcourt 2021).

**Assessment** Pinnipeds (fur seals and sea lions)


Somewhat adequate confidence

Populations of long-nosed fur seals are in good and improving condition, but populations of Australian sea lions and Australian fur seals are in very poor and poor condition, respectively, and both are deteriorating (McIntosh 2021).

Figure 5: An example of reporting an assessment category and subcategories from Australia's National State of the Environment Report, 2021. In this example from the 'Marine' Chapter, the category 'Status of marine species' represents an overall assessment of all the relevant subcategories, including (for example) 'Dolphins and porpoises', Whales' and 'Pinnipeds', among others (Trebilco et al., 2021).

## 2.3. Cockburn Sound

### Background and purpose

Cockburn Sound (the Sound) is one of the most intensively used areas in WA, with significant industrial development alongside extensive recreational activity and commercial fishing. The Cockburn Sound Management Council (the Council) is an advisory body to the Minister for Environment (the Minister), set up to provide advice on the management of the Sound and oversee environmental monitoring and research. Comprising members from local authorities, recreational users, conservation interests, industry and the community, the Council coordinates reporting to the Minister and the community on the state of the environment of the Sound. Reporting comprises of three different levels of outputs:

1. Annual reporting of the results of environmental monitoring in the Sound
2. Three-yearly reporting on the state of the Sound
3. Intermittent comprehensive critical assessment of the Sound's ecosystem.

Annual and three-yearly reporting are components of the *State Environmental (SEP) (Cockburn Sound) Policy 2015*, a non-statutory policy developed to guide protection and provide a management framework for the Sound. The Policy sets five environmental values (one ecological and four social), supported by eight measurable environmental quality objectives signalling the environmental quality needed to protect the values. Each year, the Council reports to the WA Minister for Environment and the community on the results of environmental monitoring of the Sound and the extent to which they meet the environmental quality objectives and criteria set in the Policy. Every three years (in 2018 and 2022), the Council reports to the Minister on the overall state of the Cockburn Sound marine area, including trends in water quality and associated environmental values.

Comprehensive critical assessments of the Sound's ecosystem were carried out in 2001, 2017, and 2023, commissioned by the Government and the Council and undertaken by independent consultants and WAMSI (DAL, 2001; BMT, 2018; WAMSI, 2023 unpublished). These reports build upon each other and offer a comprehensive time series, facilitating a comparison with the prior assessment.

They assessed the current and emerging driving forces and pressures on the Cockburn Sound marine area, current condition and trends of the environment, as well as the impacts and management responses.

### Method

The purpose and methods underpinning annual and three-yearly reporting are set out in the SEP and the associated implementation documentation, including environmental quality criteria reference and a manual of standard operating procedures. This reporting is limited to the components in the management framework and applying methods adapted from the National Water Quality Management Strategy.

Following on from this strategy and its application, reporting under the mandate of the SEP only includes environmental values insofar as they can be affected by pollution, waste discharges or deposits. As a result, the environmental values identified are a subset of the broader list of ecological and social values that could be attributed to Cockburn Sound, for example: biodiversity, fish resources, access, soundscape or beach condition. Other important indicators of environmental values are not reported. For example, 'Fishing and Aquaculture' reporting is narrowly limited to the objectives of 'maintenance of seafood food safe for human consumption', measured by biological and chemical contaminant indicators.

While lacking a consistent reporting rhythm, occasional reporting offers a broader evaluation beyond the individual ecosystem elements governed by the SEP management framework. The Pressure-State-Response conceptual model was first applied in 2001 (DAL, 2001), before the publication of the first SEP in 2005. This was expanded into a full DPSIR model in 2017 by incorporating linkages between human activities and the environment to enable feedback for decision-makers and the community (BMT, 2018). A qualitative update to the DPSIR was undertaken in 2023 to understand the contemporary state of the environment and to capture improvements or impacts to the system from natural or anthropogenic changes between DPSIR assessments (WAMSI, 2023). The qualitative approach used the existing framework, stakeholder consultation and subject matter expert meetings and workshops to inform assessments.

## Reporting

Annual reporting to the Minister, producing a technical report that offers limited value to the general public audience. The report comprises detailed summaries of the monitoring program and the results organised under each environmental value managed under the SEP. Each individual indicator is assessed and reported to have 'met' or 'not met' the relevant environmental quality criteria (threshold numerical values or narrative statements). No gradings or rating system is applied, although a narrative overview is provided as an Executive Summary.

The 'State of Cockburn Sound Marine Area' synthesis report is published every three years, based on the findings of annual monitoring reports and aimed at a broader audience. Colour-coded state and trend assessments are included for each of the elements listed in Table 3, organised by environmental value.

A mix of quantitative and qualitative assessments are used. The environmental value of 'Ecosystem integrity' comprises one quantitative composite indicator, the 'Water Quality Index', reported separately for each area by protection level (Figure 6). This Index is based on a subset of five water quality indicators and represents the average percentage of time each ecological protection area met environmental quality criteria concentration, converted to an A through F grade. The other four environmental values are evaluated at the environmental objective level and are categorised as meeting 'all', 'some', or 'none/a few' of the environmental quality criteria.

Two environmental quality objectives, the 'Maintenance of aesthetic values' and 'Maintenance of Indigenous and cultural and spiritual values', are included despite a lack of specific environmental quality criteria and monitoring programs; therefore, are declared unknown.

Table 3: **A list of assessment elements in the State of Cockburn Sound Marine Area Report, 2022. State and trend are reported for each listed element (Cockburn Sound Management Council, 2022).**

| Ecosystem health | Fishing and aquaculture |
|---|---|
| **Maintenance of ecosystem integrity**<br>• Water Quality Index (composite indicator)<br>  • Total nitrogen concentration<br>  • Total phosphorus concentration<br>  • Chlorophyll *a* concentrations<br>  • Light attenuation coefficients<br>  • Dissolved oxygen concentrations | • Maintenance of seafood safe for human consumption<br>• Maintenance of aquaculture |
| | **Recreation and aesthetics** |
| | • Maintenance of primary contact recreation<br>• Maintenance of secondary contact recreation<br>• Maintenance of aesthetic values |
| | **Cultural and spiritual** |
| | • Maintenance of Indigenous cultural and spiritual values |
| | **Industrial water supply** |
| | • Maintenance of water quality for industrial use |

## Calculation of the Cockburn Sound Water Quality Index

| Indicators | | Chlorophyll *a* | Light attenuation coefficient | Dissolved oxygen | Total nitrogen | Total phosphorus | Score | Grade |
|---|---|---|---|---|---|---|---|---|
| Monitored | | Approximately monthly over the non river-flow period (December to March) at 18 sites in Cockburn Sound | | | | | | |
| Assessed against guideline values calculated from the Warnbro Sound reference site to determine the percentage of times each ecological protection area met the guideline | | **High protection areas** | | | | | | |
| | | ≤ 1.1 µg/L | ≤ 0.096 $\log_{10} m^{-1}$ | > 90% saturation | ≤ 130 µg/L | ≤ 14 µg/L | | |
| | | **Moderate protection areas** | | | | | | |
| | | ≤ 1.8 µg/L | ≤ 0.014 $\log_{10} m^{-1}$ | > 80% saturation | ≤ 140 µg/L | ≤ 15 µg/L | | |
| 2021–22 results | High Protection Area North (6 sites) | 92% | 96% | 92% | 100% | 58% | 88% | A |
| | High Protection Area South (4 sites) | 88% | 81% | 63% | 75% | 13% | 64% | B- |
| | Moderate Protection Area Eastern Sound (6 sites) | 96% | 88% | 96% | 96% | 17% | 79% | B |
| | Moderate Protection Area Careening Bay (1 site) | 100% | 100% | 100% | 100% | 50% | 90% | A |
| | Moderate Protection Area Northern Harbour (1 site) | 25% | 0% | 75% | 0% | 0% | 20% | D- |

## Social environmental values: state and trends

| Environmental value | Environmental quality objective | State in 2022 | Trend |
|---|---|---|---|
| **Fishing and aquaculture** | Maintenance of seafood safe for human consumption | ✓ | → |
| | Maintenance of aquaculture | ✓ | → |
| **Recreation and aesthetics** | Maintenance of primary contact recreation[12] | ✓ – | → |
| | Maintenance of secondary contact recreation[14] | ✓ | → |
| | Maintenance of aesthetic values | ? | ? |
| **Cultural and spiritual** | Maintenance of Indigenous cultural and spiritual values | ? | ? |
| **Industrial water supply** | Maintenance of water quality for industrial use | ✓ | → |

Figure 6: An extract from the State of Cockburn Sound Marine Area Report illustrating the assessment and reporting of water quality and social environmental values. From Cockburn Sound Management Council (2022).

The publicly available report Cockburn Sound – Drivers, Pressures, State, Impacts, Responses Assessment (BMT, 2018) provides an example of ecosystem assessment and reporting using the DPSIR model in WA. Applying the DPSIR enables an assessment of changes in the driving forces and pressures which have led to environmental change in the Sound between assessment periods, alongside assessment of the current state of the Sound.

The report details the background and historical context of the Sound and provides a narrative overview of the driving forces underpinning environmental change. Assessments are based on a mix of expert elicitation and quantitative data and are reported using a graded/traffic light approach with a mix of colours and symbols (Figure 7). Assessments are included for each of the key pressures and ecosystem elements listed in Table 4. Finally, a narrative assessment of management responses and their effectiveness is provided, based on examining recent trends in pressures and the state of ecosystem elements in earlier sections. All sections inform an evaluation of the future outlook of Cockburn Sound.

The 2023 reassessment used the same structure and reporting elements, with the exception of the addition of the emerging pressure, 'Underwater noise' (from construction, operations and maintenance, and vessel noise). Accompanying this pressure was an additional ecosystem element, 'Underwater soundscape'.

| Fundamental pressure | Component | Summary | Recent trend | Impact grade | Confidence | Comparability of data to 2001 | Risk to marine environmental values |
|---|---|---|---|---|---|---|---|
| Industrial point source discharges | Nitrogen loading | Point source nutrient and contaminant loads to the Sound are now estimated to be immaterial. The contribution of residual nitrogen bound in sediments to the Sound's nutrient budget remains uncertain. | ↗ | ■ | ◕ | ◆ | ▲ |
| | Other contaminants | The improvements to the management of industrial discharges has resulted in large reductions in other contaminants loads (metals and hydrocarbons) entering the Sound from point sources. | – | ■ | ◒ | ◇ | ▲ |
| | Cooling water discharges | Seawater used for cooling is expected to result in a minimal change to the environment after discharge and mixing. | – | ■ | ◒ | ◇ | ▲ |
| | Desalination discharges | Continuous real-time monitoring conducted since commencement of the Perth Seawater Desalination Plant operation has demonstrated that brine discharge and stratification does not generate low dissolved oxygen (DO) in the deep basin of Cockburn Sound or exacerbate naturally occurring, low-DO events. | – | ■ | ◕ | ◇ | ▲ |
| Contaminated land and groundwater inputs | Contaminated land inputs | The primary pathways for contaminants from terrestrial sources entering Cockburn Sound are in surface run-off via drains and contamination of groundwater from land-use practices in the catchment. There is no systematic monitoring of surface quality or flows discharging to the Sound, which makes determining contaminant loads difficult. | ? | ■ | ◒ | ◇ | ▲ |
| | Groundwater inputs | Large groundwater flows to Cockburn Sound have the potential to serve as a conduit for contamination. However, there is no systematic monitoring of groundwater flow or quality near the coast to assist assessment of contaminant loads in groundwater discharging to the Sound. | ? | ■ | ◒ | ◆ | ▲ |
| Coastal and sea floor modification | Coastal structures | The large number of coastal structures within Cockburn Sound has resulted in a highly modified coastline. Due to the prevailing low-energy conditions, the coastal response to structural intervention within Cockburn Sound will be slow, with coastal response times in the order of many years to decades. | ↙ | ■ | ● | ◆ | ▲ |
| | Dredging and nourishment | Ongoing future dredging works are expected from the maintenance of shipping channels, servicing of boat ramps, jetties and marinas and potential large-scale infrastructure projects. Impacts associated with dredging are typically well contained, however, have potential for broadscale impacts if not well managed. | – | ■ | ● | ◆ | ▲ |
| Marine vessel activities | Recreational boating | Recreational boating in Cockburn Sound is extremely popular and is set is to increase in line with population increases. Key pressures on the marine environment associated with recreational boating include multiple-user conflicts, vessel strikes on marine fauna and craft mooring. | ↙ | ■ | ◕ | ◇ | ▲ |
| | Introduced marine species and pests | While four pest species are known to occur in Cockburn Sound, their populations are considered stable and are not disturbing native populations of flora and fauna. | – | ■ | ◕ | ◆ | ▲ |
| | Biofouling controls | While there is evidence of some localised sediment contamination by tributyltin (TBT; the active constituent in legacy antifoulant paints) in the vicinity of jetties and wharves, sediment quality is generally considered acceptable. | – | ■ | ◒ | ◆ | ▲ |
| | Shipping activities | The level of commercial shipping activity in Cockburn Sound is fairly stable, although the size of vessels is increasing. The environmental effects associated with vessel activities are presently well managed. | – | ■ | ● | ◆ | ▲ |

Figure 7: An example assessment of key pressures on Cockburn Sound. From Cockburn Sound Drivers-Pressures-State-Impacts-Responses Assessment 2017 (BMT, 2018).

Table 4: A list of assessment elements from the 2017 Cockburn Sound DPSIR assessment. Recent trend, impact grade, confidence, comparability of data to 2001 and risk to marine environmental values are reported for each pressure. Recent trend, impact grade, confidence and comparability of data to 2001 are reported for each ecosystem element (BMT, 2018).

| Pressures | Ecosystem Elements |
|---|---|
| **Industrial Point Source Discharges**<br>• Nitrogen loading<br>• Other contaminants<br>• Cooling water discharges<br>• Desalination discharges<br>**Contaminated Land and Groundwater Inputs**<br>• Contaminated land inputs<br>• Groundwater inputs<br>**Coastal and Sea Floor Modification**<br>• Coastal structures<br>• Dredging and nourishment<br>**Marine Vessel Activities**<br>• Recreational boating<br>• Introduced marine species and pests<br>• Biofouling controls<br>• Shipping activities<br>**Fishing Pressures**<br>• Commercial fishing and aquaculture<br>• Recreational fishing<br>**Climate Change Pressures**<br>• Water temperature<br>• Sea level rise<br>• Long-term reduction in rainfall<br>• Extreme and altered weather patterns | **Hydrodynamics**<br>• Marine water movements<br>**Coastal Processes**<br>• Coastal processes<br>**Ecosystem Health**<br>• Phytoplankton primary production, composition, and toxicity<br>• Benthic primary producers<br>• Water quality<br>• Sediment quality<br>• Ecosystem integrity<br>**Marine Fauna**<br>• Benthic macrofauna<br>• Fish and fish communities<br>• Little penguins<br>• Dolphins<br>• Protected marine fauna<br>**Recreation and Aesthetics**<br>• Recreational use of the coastal environment<br>• Recreational use of the marine environment<br>• Aesthetic values of Cockburn Sound<br>**Cultural and Spiritual Values**<br>• Indigenous culture and heritage<br>• Non-indigenous culture and maritime heritage<br>**Industrial Water Supply**<br>• Industrial water supply |

Humpback mother and calf. Holly Raudino

## 2.4. World Heritage Area Reporting

### Background

World Heritage Sites are designated by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) World Heritage Convention (1972) through a rigorous evaluation process assessing their Outstanding Universal Value (OUV). Sites are nominated by national governments, reviewed by expert advisory bodies, and approved by the World Heritage Committee. Once listed, World Heritage Sites are subject to two reporting processes to ensure their conservation as mandated by the convention text. These include Periodic Reports, a self-report submitted by all State Parties in a region, and Reactive Monitoring in response to specific concerns or criteria at a particular heritage site.

Periodic reporting is for the purpose of:

- Evaluating how effectively States Parties are applying the World Heritage Convention at both national and site-specific levels
- Providing updated information on the current conditions of World Heritage properties, identifying potential changes or threats to their OUV
- Informing the development of regional and global strategies for heritage preservation and assisting in identifying areas where capacity-building efforts are needed.

In comparison, reactive monitoring is for the purpose of:

- Responding to imminent or ongoing threats and crises such as armed conflicts, natural disasters, or unregulated development that jeopardise OUV
- Informing the World Heritage Committee's decisions, including inscription on the List of World Heritage in Danger or deletion from the World Heritage List
- Facilitating missions by Advisory Bodies to assess damage and recommend corrective measures.

### Methods

Approximately every six to eight years, signatory countries to the convention (States Parties) are invited to submit comprehensive reports to the World Heritage Committee detailing their implementation of the Convention within their territories (Periodic Reporting). The Periodic Reporting process is undertaken at the regional level and facilitated by the World Heritage Centre.

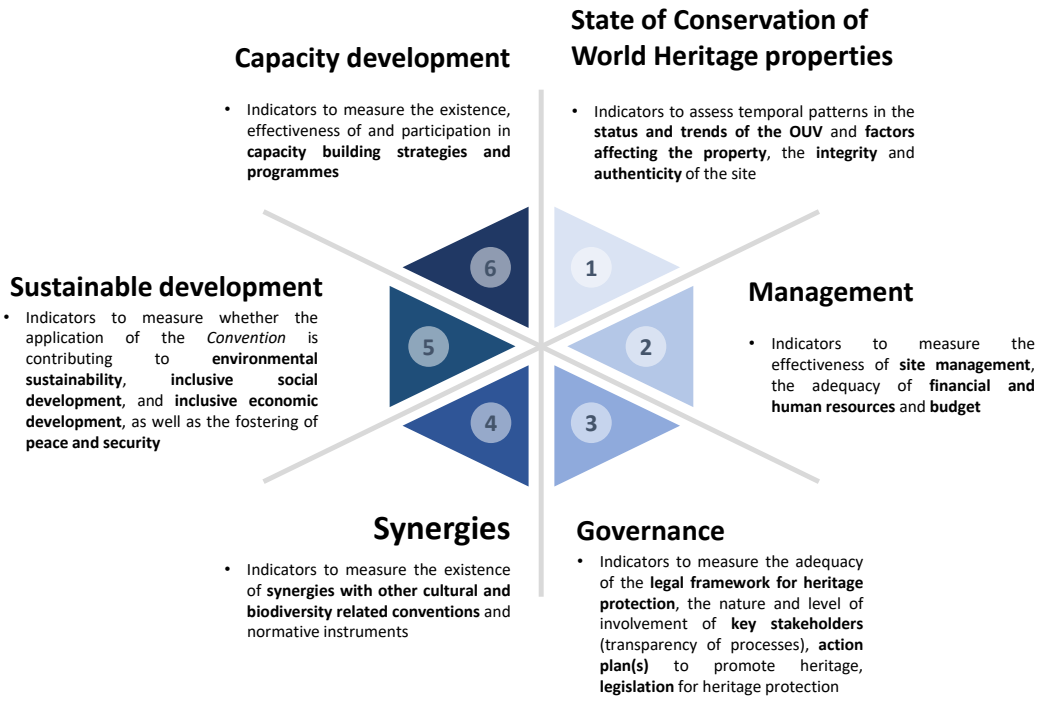



Figure 8: The analytical framework used to periodically assess World Heritage sites and their management during the Third Cycle (2018-2014). From UNESCO (n.d.).

The periodic monitoring analytical framework includes six themes drawn from the key elements of the implementation of the World Heritage Convention (Figure 8). Monitoring indicators drawn from this framework measure the different aspects of management across the implementation cycle, including *inputs, processes, outputs, outcomes* and *impacts* of management.

Reactive Monitoring is the process of assessing and responding to acute threats that may impact the OUV of World Heritage sites. It involves evaluating reported risks, conducting expert assessments, and producing State of Conservation reports with site management and protection recommendations. If significant threats persist, the World Heritage Committee may request corrective actions, place the site on the List of World Heritage in Danger, or, in extreme cases, remove it from the World Heritage List.

Although the State of Conservation reports are submitted using a standard compulsory format, a variety of scientifically robust assessments and tools are used to inform the reporting information. In the Great Barrier Reef World Heritage Area, the Outlook Report (discussed in detail above) is a critical input for State of Conservation reporting by providing a comprehensive, scientifically credible assessment of the Reef's condition and key threats. As a result, the ongoing Outlook reporting process is considered a key initiative that enabled Australia to respond to the Committee when UNESCO experts recommended inscription on the List of World Heritage in Danger due to climate change impacts in 2021.

As another example, the Climate Vulnerability Index is a rapid assessment tool developed to systematically assess vulnerability in World Heritage Sites across State Parties. This method builds upon the Intergovernmental Panel on Climate Change assessment framework and was piloted in Shark Bay in collaboration with WAMSI (Heron et al., 2020). An assessment of current conditions, trends and vulnerability was derived using a risk assessment approach to evaluate potential climate impacts on the OUV and other attributes.

In addition to the monitoring work carried out under the World Heritage Convention, the International Union for the Conservation of Nature (IUCN) also regularly assesses World Heritage sites through the World Heritage Outlook. The World Heritage Outlook assesses all natural World Heritage sites to track their state of conservation over time. The methodology was developed by an IUCN-led technical advisory group, drawing from existing protected area assessment frameworks, including World Heritage Periodic Reporting, IUCN's World Commission on Protected Areas' methodologies and the Great Barrier Reef Outlook. The first comprehensive Conservation Outlook Assessments were completed in 2014, with updates every three years (however, has not been published since 2020). The methodology is reviewed and refined after each cycle to incorporate feedback and advancements in methods.

The desk-based assessment process involves eight structured steps:

1. **Data Collection**: Gathering existing information from various sources
2. **Assessment Preparation**: Compiling data into a draft assessment
3. **Expert Consultation**: Engaging with experts familiar with the site
4. **Drafting Assessments**: Developing initial assessments based on collected data and expert input
5. **Internal Review**: Conducting reviews within IUCN to ensure accuracy
6. **External Review**: Soliciting feedback from external stakeholders, including site managers and the scientific community
7. **Finalisation**: Incorporating feedback and finalising the assessment
8. **Publication**: Sharing the completed assessments publicly.

## Reporting

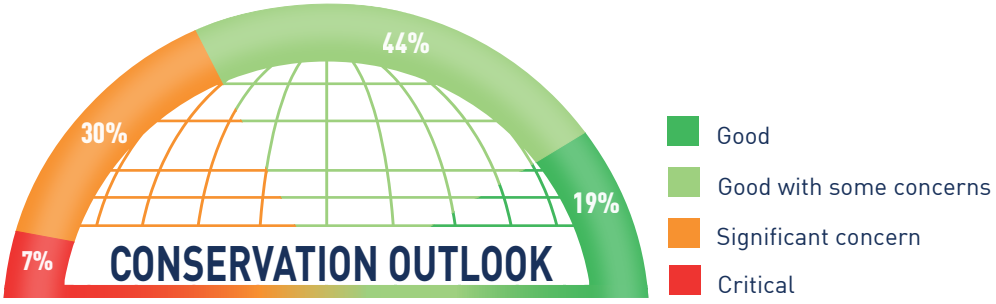
The results of each Periodic Reporting cycle are presented as regional or sub-regional averages, ensuring alignment with the report's primary objective – to guide regional strategies and targeted conservation efforts based on specific needs. Limited public facing materials are published, with most data presented in tables or basic column graphs.

While this broad-scale assessment provides valuable insights for regional planning, its direct application to the management of individual sites is limited.

For site-specific management, Reactive Monitoring and in-depth State of Conservation reports offer a more comprehensive and tailored approach to addressing conservation challenges.

Similarly, the World Heritage Outlook reporting Assessment presents results at the global and regional scale, with results presented as a proportion of the total number of sites globally (Figure 9). Each site is classified as 'Good', 'Good with some concerns', 'Significant concern' and 'Critical'. All sites with an improved or deteriorated conservation outlook since 2017 are reported individually to emphasise trends. However, finer resolution of indicator results at the site level are not available publicly. The Outlook also reports site, regional and global summaries of:

- The current state and trend of OUVs
- The threats affecting those values
- The effectiveness of protection and management.

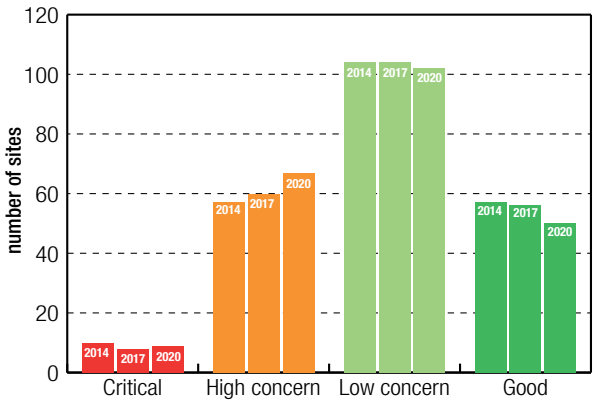



Sites with a deteriorated conservation outlook since 2017*

| Site | Country | Conservation Outlook 2017 | Conservation Outlook 2020 | Values | Threats | Protection and management |
|---|---|---|---|---|---|---|
| Great Barrier Reef | Australia | Significant concern | Critical | ↘ | → | → |
| Islands and Protected Areas of the Gulf of California | Mexico | Significant concern | Critical | ↘ | → | → |

** The columns Values, Threats and Protection and Management show the change in these aspects (arrows) and the 2020 rating (colours)*

Overall state of values of all natural World Heritage sites in 2014, 2017 and 2020




Comparison between 2014, 2017 and 2020 of overall protection and management in 228 sites inscribed up to 2014

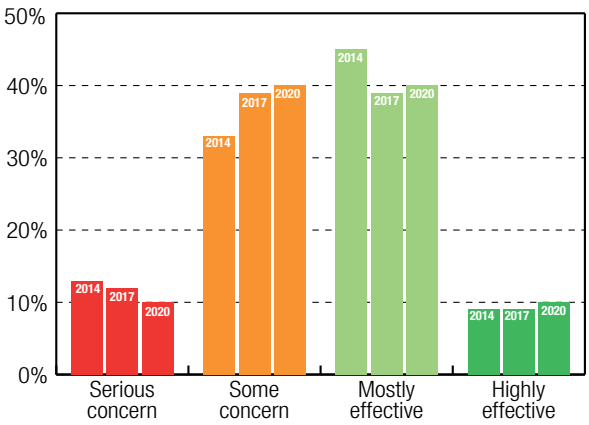



Figure 9: **An extract from the IUCN Conservation Outlook 2020.**

| CASE STUDY | Background | Methods | Reporting | Comments |
|---|---|---|---|---|
| **Great Barrier Reef Outlook (the Outlook)** | The Outlook assessment by the Great Barrier Reef Marine Park Authority (the Authority) is mandated by the Great Barrier Reef Marine Park Act 1975 to be published **every five years**. The Outlook provides a comprehensive evaluation of the Reef's ecological, cultural, and socio-economic values, identifying pressures, management effectiveness, and future risks to inform policy and conservation efforts. It does not include recommendations about future protection or management initiatives. | The Outlook compiles and analyses existing data from government agencies, researchers, industry, and Traditional Owners, integrating findings from monitoring programs, scientific studies, and management records. First Nations perspectives are incorporated through co-produced stories, workshops, and literature, while expert elicitation workshops inform biodiversity, ecosystem health, and risk assessments. Management effectiveness is assessed independently from the Authority, followed by statutory peer review. | The report is structured around nine assessment themes required by law with each assessment element graded using a four-point scale based on qualitative analysis of evidence. An integrated cross-cutting approach assesses factors affecting the Reef's values, such as climate change and coastal development, across ecological, economic, heritage, and social dimensions. The report prioritises accessibility and readability, with supporting resources including an online information system. | The 2024 Outlook is the fourth in the series with similar assessment method to maintain comparability between reports and provide information on trends. Independent evaluation and review of elements of the assessment are credited for improving its credibility and acceptance across stakeholders. The Outlook process is well integrated into management of the Reef, providing a structured foundation for cyclical planning by the Authority, ensuring regular assessment and analysis of management effectiveness to inform decision-making. |
| **Australia's National State of the Environment Report (SoE)** | The national SoE report is established under the Commonwealth EPBC Act. Published **every five years** since 1996, the report evaluates environmental conditions across 12 thematic chapters (inc. marine, coastal biodiversity, land, climate, heritage and others), evaluates management effectiveness, and tracks trends over time and emerging issues. No policy or management recommendations are included, and there is no statutory requirement for Government to respond. | The report synthesises information from government agencies, research institutions, community groups, and Indigenous knowledge holders, ensuring a comprehensive and evidence-based analysis. The 2021 report incorporated a new Indigenous co-authorship model and incorporated Traditional Owner insights through yarning circles and surveys. It applies an adapted DPSIR framework, structuring each chapter around state, pressures, drivers, impacts, management effectiveness, and future outlook, using a mix of quantitative data, expert elicitation, and long-term monitoring programs. | Each chapter includes 4-point graded state and trend assessments, separate Indigenous assessments, confidence estimates, descriptive evidence syntheses, and historical data from previous reports where available. A national synthesis overview chapter integrates findings across themes, highlighting interconnected trends, challenges, and links between human wellbeing and environmental conditions. The reports have a broad target audience, aiming to serve policymakers, researchers, industries, and the public. | This case study provides an example of the use of the DPSIR framework to analyse and organise the State of Environment in Australia. An independent evaluation of the published report found the response to the report was largely positive due to its incorporation of First Nations knowledge throughout. It also found improvements can be made by providing accompanying recommendations and a mechanism for tracking progress against them in future reports. It also recommended aligning State and Territory reporting with the national SoE. |

*Summary of case studies continues*

*Summary of case studies continued from previous page*

| CASE STUDY | Background | Methods | Reporting | Comments |
|---|---|---|---|---|
| **Cockburn Sound** | Cockburn Sound environmental reporting occurs at three levels with varying intervals: **annual** monitoring reports, **three-yearly** state of the Sound reports, and **intermittent** comprehensive assessments. Annual and three-yearly reporting is under the existing management framework (the SEP), which only includes environmental values insofar as they can be affected by pollution, waste discharges or deposits. Comprehensive, integrated ecosystem assessments in 2001, 2017, and 2023 were undertaken by independent consultants and WAMSI, providing a time-series analysis of environmental pressures, conditions, and responses. | Annual reporting is a technical document for the Minister, providing a summary of monitoring results for each environmental value under the SEP. It evaluates whether indicators have 'met' or 'not met' environmental quality criteria. The three-yearly report consolidates annual findings, summarising the proportion of criteria met over time. Intermittent reporting originally followed the Pressure-State-Response model in 2001 but transitioned to a full DPSIR approach in 2017, strengthening the links between human activities and environmental change to improve decision-making. In 2023, a qualitative DPSIR update was conducted using expert consultation and stakeholder input to re-evaluate the system. | Annual and three-yearly reporting assesses progress against SEP objectives, identifying emerging pressures such as climate change and industrial impacts, but does not prescribe specific management actions. Annual reporting is a technical document for the Minister, whereas reporting is aimed at a broader audience, using colour-coded state and trend assessments to summarise findings from annual monitoring reports. Intermittent DPSIR assessments are based on a mix of expert elicitation and quantitative data and are reported using a graded/traffic light approach with a mix of colours and symbols. | The State of Cockburn Sound report is designed to monitor and evaluate the SEP management framework, resulting in a strong focus on water quality. However, it does not explicitly assess processes leading to environmental change or provide a future outlook. Some environmental quality objectives, such as aesthetic and Indigenous cultural values, remain unassessed due to the absence of defined criteria and monitoring programs. While the report serves as an example of a DPSIR assessment in WA, the lack of regular assessments has created significant reporting gaps. Additionally, the absence of a mandate for public release has contributed to delays in reporting. |
| **World Heritage Area Reporting** | The World Heritage Convention agreement includes requirements for two reporting formats: periodic (regular, State Party/country-level reporting **every 6-8 years**) and reactive 'State of Conservation' reporting (site-based reporting on demand in response to acute issues, **no set frequency**). IUCN provides an additional assessment of natural World Heritage sites, the World Heritage Conservation Outlook, published **every three years** in 2014, 2017 and 2020. | Periodic reporting employs a bespoke analytical framework based on the convention text and stages of management implementation. Responsive reporting applies a variety of methods to respond to specific concerns and queries at the site level. The Conservation Outlook is a public-facing synthesis of periodic reporting data with no additional analysis, summarised at the global and regional scales. | Periodic reporting is the core conservation monitoring mechanism for World Heritage sites, aimed at informing regional strategies and the World Heritage Commission rather than a general audience. The Conservation Outlook reports on the state and trends of the overall outlook for sites globally, OUVs, threats and management effectiveness at the regional and global levels. Site-specific data are only provided for the overall assessment of outlook and trend. | This case study provides an example of a bespoke framework to inform periodic reporting to ensure assessments are fit for purpose. High-level reporting in the Conservation Outlook is useful for understanding regional/global trends but has limited relevance to site-based management. As demonstrated in the Great Barrier Reef, regular ongoing ecosystem assessment (the Outlook Report) is a critical tool to respond to State of Conservation requests in the event of acute issues such as sudden climate change impacts. |

Cyanobacterial mat with tessellated plate structure. Jenny Shaw

# 3. Key learnings

A review of the literature and examination of case studies highlights key learnings for a proposed State of Exmouth Gulf Reporting Framework.

### 1. Regular ecosystem assessment and reporting transfers knowledge to decision-makers, managers and the public.

Ecosystem assessment and reporting provide the means through which evidence informs decision-making, accommodating western science alongside Traditional Knowledge and Science and local knowledge. The process brings together these diverse ways of knowing in a form that is useful for decision-makers and strengthens the relationship between science and policy. The structured assessment and reporting mechanisms demonstrate how various types of knowledge can be accommodated through a mix of qualitative and quantitative assessments within the same framework, for example within the 2021 Australian National SoE Report.

The mandates, scope and process differ in the case studies, reflecting how assessments are tailored to meet the individual needs and purpose of the exercise. Both the Australian National SoE and the Reef Outlook Reports are commissioned by the relevant management authorities; however, they specifically omit recommendations for future management initiatives. Rather, these assessments focus on providing a strong evidence base for future management decisions. Setting the assessment mandate will direct the approach and outputs, making sure they align with the specific needs of users.

The case studies also indicate the value of repeated assessments over time to inform trend analysis, with all case studies retaining existing methods to provide historical comparisons. Regular reporting intervals are usually long (from 2–5 years in the case studies), requiring ongoing dedicated investment over the long term to ensure continuity, consistency, and impact.

### 2. Integrated assessments of environmental, social, and economic factors are the leading approach to evaluate cumulative impacts on ecosystems.

Ecosystem assessment is increasingly integrating broader ecological, social, and economic dimensions to address complex, interrelated issues such as climate change, biodiversity loss, and sustainable development. IEAs are a particular method of environmental assessment formalised by Levin et al. (2009, 2014) and UNEP (2017) which evaluates all components of an ecosystem, including natural and human processes and their interactions, and explores future trends and outlook. IEAs increase the capacity to identify and evaluate the cumulative environmental impacts resulting from multiple sectors.

A review of the current literature on ecosystem assessments demonstrates that IEA is the preferred approach both nationally (Smith et al., 2021) and internationally (UNEP, 2017), as it provides a holistic, systems-based approach that integrates multiple environmental, social, and economic factors. Although none of the case studies examined applied the IEA method formally, many of the fundamental principles of the approach were applied when compiling the Great Barrier Reef Outlook Report and were specifically highlighted as contributing to its success (Dobbs et al., 2011).

Within an ecosystem assessment process such as an IEA, a conceptual framework provides a structure within which to identify and present the required indicators. Two of the reviewed case studies applied the DPSIR model as the conceptual framework to inform the analysis and organise assessment components (SoE Reporting and Cockburn Sound). UNEP's guidelines specifically identify DPSIR as the most appropriate model to understand fundamental human-nature relationships and inform IEAs (UNEP, 2017). The flexibility of the DPSIR model allows it to be tailored to different environmental and governance contexts, from a small local assessment of Cockburn Sound to the broad-scale National SoE report.

### 3. The assessment process is equally as important as the findings it generates.

Experiences have shown that a well-structured assessment process not only generates valuable insights but also strengthens stakeholder relationships and facilitates knowledge exchange. According to UNEP, the success of an ecosystem assessment depends on "who is managing and who participates in the process, in which specific role, how the process is structured, and how it allows for flexibility to adapt to... local conditions" (UNEP 2017, page 12).

Across all case studies, the collaborative nature of assessments is consistently highlighted, with the active involvement of key stakeholders interested in and responsible for ecosystem management. The only noted exception applies to certain site-based assessments focused on evaluating management effectiveness, where independent experts were engaged to provide an objective, arms-length review to regulatory bodies, as demonstrated in the Great Barrier Reef Outlook assessment. Independent evaluations after the fact also contribute to continued improvement over time, e.g. as commissioned to review the 2021 National SoE.

A well-defined IEA process ensures stakeholders – including policymakers, scientists, Indigenous communities, and industry representatives – are engaged from the outset. This fosters trust, transparency, and inclusivity, leading to greater acceptance and legitimacy of the assessment findings and resulting policies. Without a structured approach such as the stages proposed by IEA, assessments risk producing outputs that are not scientifically robust, are contested, or are ineffective in reaching their intended goals.

Assessments also provide a forum for a broad diversity of stakeholders, including scientists, Indigenous peoples, communities, policy-makers, and decision-makers across sectoral interests, to interact and discuss environmental issues and potential solutions. This is a core principle of IEA and was highlighted as a driver of success in formulating the Great Barrier Reef Outlook Report.

# 4. Recommendations for a State of Exmouth Gulf Reporting Framework

## 4.1. Approach

**High-quality information on the state of Exmouth Gulf and its surrounds is essential for ensuring the region's long-term sustainability and resilience.**

We recommend establishing a long-term, comprehensive reporting process to conduct regular, systematic 'State of Exmouth Gulf' ecosystem assessments. This will ensure that information is accessible and actionable to support sustainable management and development in the future.

Drawing on the established IEA approach provides an internationally recognised and robust process for conducting State of Exmouth Gulf assessments. The fundamental participatory principles of this approach work to ensure that the outputs are regarded as credible, relevant, and legitimate. This approach provides a systematic process for integrating and communicating knowledge from diverse sources (including western scientific evidence, Traditional Knowledge and Science, and local knowledge) to inform and enhance decision-making.

We strongly recommend adopting the DPSIR model as the preferred conceptual framework to conduct the ecosystem assessment. The DPSIR model provides the organisational structure within which to identify, analyse and present the indicators needed to inform the assessment. DPSIR provides a comprehensive and adaptable model for understanding the complex interactions between human activities and environmental changes to guide policy development, management interventions, and long-term monitoring.

Data and knowledge are integral for informing robust ecosystem assessments and adequately evaluating cumulative impacts (now a legislated requirement for project proponents). Stakeholders are becoming more aware of the need for shared data, and the proposed State of Exmouth Gulf reporting process can both benefit from and contribute to existing shared data initiatives.

One existing initiative is the Shared Environmental Analytics Facility (SEAF) pilot program that is underway for the Pilbara region, a collaboration of WAMSI and the Western Australian Biodiversity Science Institute. SEAF is a secure, cloud-based data-sharing mechanism that draws on data already held in multiple portals and repositories to provide trusted, single-point access to disparate information sources. It draws on data for use in predictive models and custom-built analytics, turning it into practical, useable information and forecasting tools. SEAF has the technological infrastructure necessary to provide access to shared, policy-relevant data and analytics for informing ecosystem assessments.

Periodic reassessment of the ecosystem at predefined intervals enables an understanding of the effectiveness of policy decisions on the region, such as environmental management plans or major infrastructure development. The interval for repeating State of Exmouth Gulf assessments should be sufficient to enable the evaluation of changing pressures on the important values of the region (e.g., 3–5 years).

The proposed framework does not replace the necessity for sector-based regulation and monitoring in the region. Instead, it provides a strategic approach to planning and ensures that monitoring efforts are more targeted and effective. By integrating knowledge from diverse sources, this framework enhances the capacity to gather and apply information in a way that effectively informs future decision-making in the Exmouth Gulf.

# KEY RECOMMENDATIONS:

| | | |
|---|---|---|
| 1 | **Apply the DPSIR model to systematically assess the Gulf and surrounding ecosystem** | Use the DPSIR model to systematically assess key environmental drivers, pressures, ecosystem state, socio-ecological impacts, and necessary management responses. The DPSIR model provides a structure within which to identify and present the required indicators. Applying this model ensures consistency with international best practices for ecosystem assessment and aligns with existing national environmental reporting. The flexibility of the DPSIR allows for integrating western scientific evidence alongside Traditional Knowledge and Science, and local knowledge, to inform the assessment (as demonstrated in Australia's National SoE reporting). |
| 2 | **Implement long-term, integrated socio-ecological monitoring programs** | Core to successful ecosystem assessment is a structured, ongoing socio-ecological monitoring strategy, ensuring regular data collection and the ability to assess trends over time. This will facilitate adaptive management and evidence-based decision-making to support the long-term protection of the Gulf and surrounds. A SEAF is the recommended support platform as it can provide the architecture to access and analyse shared data to inform a DPSIR reporting model, as demonstrated by the SEAF pilot in Cockburn Sound. |
| 3 | **Ensure transdisciplinary engagement in the process** | Recognise Traditional Owners' unique rights, responsibilities and cultural standing and ensure a governing partnership with Traditional Owners including the Nganhurra Thanardi Garrbu Aboriginal Corporation (NTGAC). Embed a participatory approach into the governance structures and implementation by engaging experts from natural and social sciences, as well as representatives of industry, regulatory bodies, conservation and other community groups. This will strengthen data accuracy, policy relevance, and long-term stakeholder buy-in. |
| 4 | **Support transparent communication and accessibility** | Establish clear reporting mechanisms that make the findings accessible to policymakers, resource managers, and the public. This will enhance public trust, accountability, and the integration of robust scientific knowledge into decision-making. Quality information alone doesn't drive action; thus, integrating strategic communication from the outset is essential. |

## 4.2. Implementation plan

WAMSI's existing research can inform the design and execution of the proposed State of Exmouth Gulf assessment. Notable advancements have been achieved to initiate steps one through five of the implementation roadmap outlined below, indicated by the icons (Figure 10).

Additionally, a significant body of literature exists to provide guidance for completing ecosystem assessments using best practice methods. NOAA and the UNEP provide resources for completing assessments, both of which have informed the following tailored advice for the Gulf.

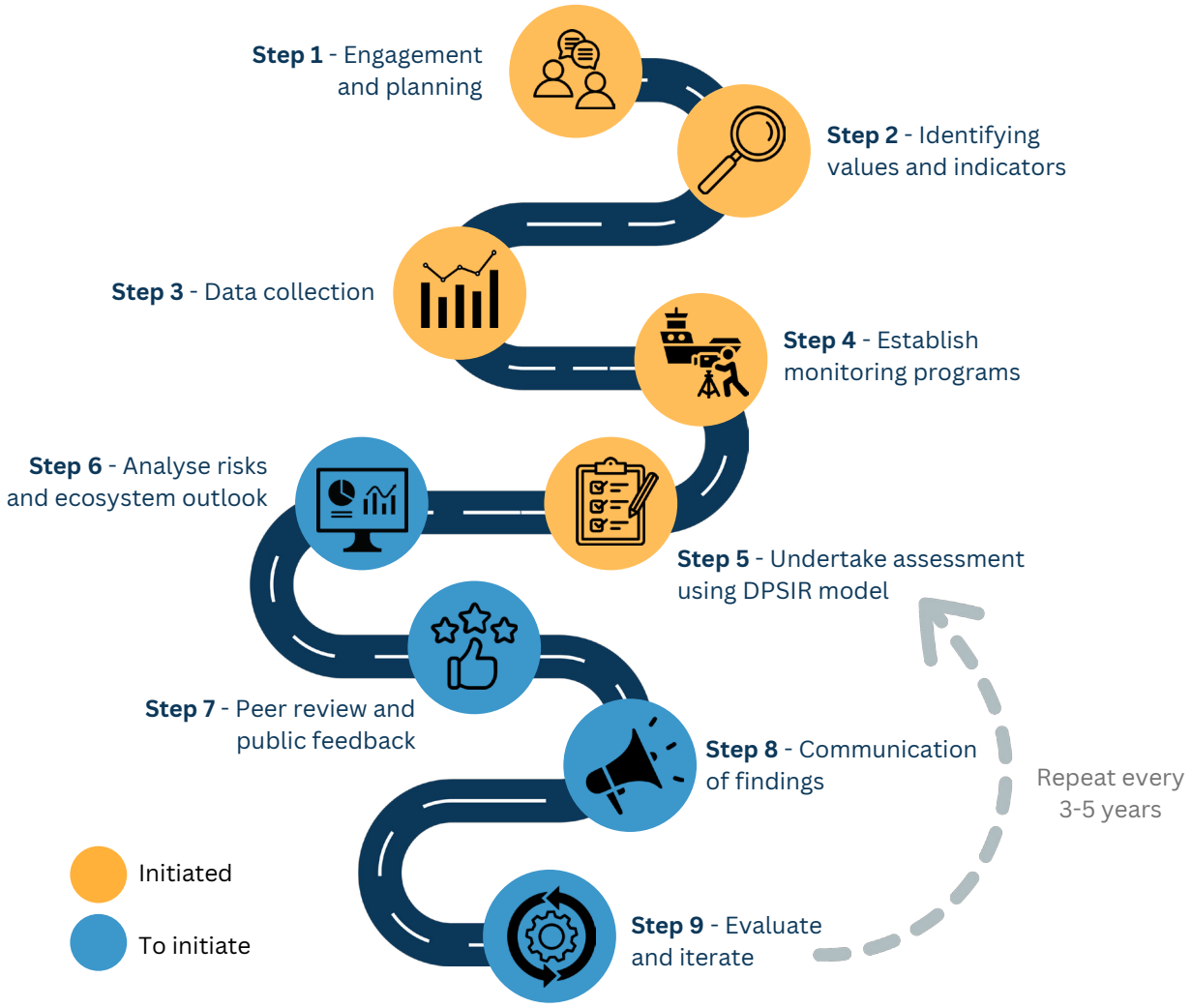



Figure 10: **High-level implementation plan for undertaking a State of Exmouth Gulf assessment and reporting process. Steps that have been initiated (orange) include elements that have been delivered through WAMSI's existing research, however, further work remains to be completed.**

## **STEP-1** ENGAGEMENT AND PLANNING

### a) Initiate early and continuous stakeholder engagement

> Identify and involve key stakeholders, including local communities, government agencies, NGO's and environmental organisations.

> Recognise the legal and cultural standing of the Baiyungu, Yinnigurrura, and Thalanyji Traditional Owners and ensure ongoing meaningful engagement, decision-making authority, and respect for their role in managing Land and Sea Country.

> **Initiated**: Significant stakeholder engagement has occurred to date in communities surrounding the Gulf, albeit for different primary purposes; therefore, the risk of consultation fatigue must be considered when planning additional engagement.

### b) Establish roles, functions and Traditional Owner partnership

> Establish a governance partnership with Traditional Owners including NTGAC to ensure appropriate decision-making authority and respect for their role in managing Land and Sea Country.

> Form appropriate governance arrangements to deliver the required functions to complete the assessment, including:

- Central decision-making authority with responsibility for management and communication (e.g. Co-ordinating Body, Steering Committee or Secretariat).
- Scientific advice, including a diversity of natural and social sciences, Traditional Knowledge and Science, and local knowledge to ensure credibility and overall quality of the assessment (e.g. Scientific Advisory Panel).
- Stakeholder forum for consultation and communication to stakeholder communities (e.g. Multi-stakeholder Co-ordinating body).
- Sufficient expertise and capacity for conducting assessment and drafting technical outputs (e.g. team of practitioners with required range of scientific, technical and socio-economic expertise and balance).
- Expert review process for ensuring scientific rigour (e.g. Independent Review Panel).

### c) Define vision and objectives

> Clearly outline the goals of the State of Exmouth Gulf assessment, including the stakeholders' shared vision for the region to guide decision-making.

> Identify assessment purpose, objectives and target audience (users) for planned outputs to target information requirements and inform the design.

# STEP-2 IDENTIFYING VALUES AND INDICATORS

## a) Identify ecosystem values to assess

> Identify values, attributes and assets that stakeholders (people and organisations) care about and require management.

> **Initiated**: Significant stakeholder engagement to understand the key values and priorities in Exmouth Gulf has already occurred:

- Sutton and Shaw (2021) present the distinctive values of the Gulf identified from Environmental Protection Authority (EPA) public submissions and engagement with subject matter experts (Table 5).
- WAMSI (2025, in prep) identifies priority knowledge gaps in the Gulf (related to values identified in Sutton and Shaw (2021)), as determined by stakeholders, whereby important values can be derived (Table 6).

> Values and concerns of the Traditional Owners require greater attention in the above projects.

> Social or economic values were partially identified but not explicitly included in the above projects.

Table 5: List of distinctive values of the Exmouth Gulf. Values were identified through public submissions, consolidated, and organised by EPA themes and factors (Sutton and Shaw, 2021). A full list of values is provided in Appendix 2.

| Sea | Land |
|---|---|
| **Benthic Habitats and Communities**<br>• Macroalgae and turf algae<br>• Seagrass<br>• Coral<br>• Sponges and filter feeders<br>• Sand and mud<br>• Mangroves<br>• Samphire<br>• Blue-green algal mats<br>• Reef flats and oyster beds<br>• Salt flats<br>**Marine Fauna**<br>• Crustaceans<br>• Teleosts (fish species)<br>• Elasmobranchs (sharks and rays)<br>• Marine reptiles<br>• Marine mammals<br>• Seabirds and shorebirds<br>**Marine Environmental Quality**<br>• Water quality<br>• Sediment quality<br>**Coastal processes**<br>• Geophysical processes<br>• Hydrodynamic processes<br>• Nutrient flow | **Flora and Vegetation**<br>• Coastal plains<br>• Limestone cliffs and gullies<br>• Coastal dunes<br>• Threatened/priority flora<br>**Terrestrial Fauna**<br>• Reptiles<br>• Mammals<br>• Birds<br>• Short-range endemic invertebrates<br>• Amphibians<br>**Landforms**<br>• Karst systems<br>• Islands<br>**Subterranean Fauna**<br>• Troglobionts (Troglofauna)<br>• Stygofauna<br>**Terrestrial Environmental Quality**<br>• Topsoil |
| **Water** | **People** |
| **Groundwater systems**<br>**Surface water systems** | **Social Surroundings**<br>• Aboriginal heritage and culture<br>• National heritage<br>• Amenity<br>• Economic<br>**Human Health**<br>• Potable water |
| **Air** | |
| **Air quality** | |

Table 6: Examples of key values that can be derived from knowledge gaps prioritised by stakeholders in the Exmouth Gulf. From WAMSI (2025, in prep).

| Priority knowledge gaps | Derived values |
|---|---|
| How could development footprints on the eastern coastline of Exmouth Gulf affect nutrient flows and, in turn, marine life reliant on these nutrient flows? | Nutrients |
| How will groundwater systems be affected by expansion of mining activities (e.g., limestone, potash, salt)? | Groundwater |
| How is Exmouth Gulf influenced by processes and pathways across the land-sea interface (e.g. nutrient sources and flows, groundwater movement)? | Nutrients, Groundwater |
| Where do nursery locations occur for threatened fauna in Exmouth Gulf e.g., sea snakes, sawfishes, shovelnose rays? | Threatened and protected species |
| What is the carrying capacity of people for Exmouth and what are the implications of increasing numbers of people on the Gulf? | Sustainable population |
| How are megafauna and seabirds/shorebirds using specific benthic habitats and to what extent could these associations be affected by habitat damage and degradation? | Seabirds/shorebirds<br>Benthic habitats<br>Threatened and protected species |
| What are the effects of bitterns discharge on marine fauna and flora, as well as on water and sediment quality? | All marine fauna groups<br>Benthic habitats<br>Water and sediment quality |
| How resilient are benthic habitats and marine fauna to recurring marine heatwaves? | All marine fauna groups<br>Benthic habitats |
| What introduced marine pests currently exist in Exmouth Gulf and what risks do current and future pests (from shipping or ocean warming) pose to marine life and habitats? | All marine fauna groups<br>Benthic habitats |
| What is the extent of per- and polyfluoroalkyl substances (PFAS) contamination and what effect does this have on the marine food web? | Food webs |
| Are elasmobranch species utilising Exmouth Gulf and its intertidal habitats seasonally and how reliant are they on these environments? | Threatened and protected species |
| What is the seasonal exchange between the oceanic and Exmouth Gulf waters and how does this influence species recruitment and dispersal? | Connectivity |
| What are the characteristics of food webs in Exmouth Gulf and how do they vary seasonally? | Food webs |
| What are the effects of copper-based contaminants, such as antifouling agents, on marine life and benthic communities? | All marine fauna groups<br>Benthic habitats |
| What are the specific climate change projections for Exmouth Gulf, and what are the likely effects on key marine and terrestrial ecosystems and taxa? | All marine fauna groups<br>Benthic habitats |

### b) Develop indicators and targets

> Determine the 'desired state' for a value, attribute or asset to track progress against.

> Identify appropriate and measurable indicators, as well as reference points or thresholds.

**EXAMPLE 1**

> **Value:** Nutrients

> **Desired State:** Nutrient sources and nutrient transport pathways are maintained and are sufficient to support food webs and sustainable catches of commercially important species, such as prawns.

> **Indicators:** Concentration of nutrients (nitrogen, phosphorus, silicon and iron), concentration of radon (for detecting submarine groundwater discharge), prawn catch per unit effort, species richness, species abundance.

**EXAMPLE 2**

> **Value:** Sustainable human population

> **Desired State:** Population size is supported by local resources, capacity and land use is well managed to prevent habitat degradation.

> **Indicators:** Population demographics (size, growth rate, life expectancy, net migration rate, birth rate), access to potable water, land use change, resource consumption.

## STEP-3 DATA COLLECTION

### a) Knowledge collation

> Collate existing datasets, knowledge sources and identify gaps.

> **Initiated**: Reviews of primarily western science have been completed up to 2025, under an environmental lens:

- Sutton and Shaw (2021) – over 600 pieces of literature.
- WAMSI (2025, in prep) – over 400 pieces of literature.

> A social and economic knowledge review is required.

> NTGAC is undertaking Sea Country planning.

### b) Data collation

> Available raw and processed quantitative and qualitative data should be consolidated into a shared space for informing assessments.

> **Initiated**: The SEAF Pilbara pilot program is already underway with the infrastructure to support and facilitate data sharing amongst industry, research, and government.

# STEP-4 ESTABLISH MONITORING PROGRAMS

## a) Identify existing monitoring programs

> Collaborating on existing monitoring programs will allow more timely access to data and reduce resource needs, particularly for field campaigns.

## b) Develop new monitoring programs related to the identified indicators

> Any gaps in the baseline assessment and data collation steps can help inform the scope of the monitoring (e.g. location, seasons, frequency).

> **Initiated**: WAMSI (2025, in prep) recommended a range of monitoring programs (Table 7) that link to the top 15 marine and coastal knowledge gaps identified by stakeholders. These would need to be refined with the identified indicators in mind.

> Monitoring programs have not been determined for cultural, social and economic values.

## c) Develop standardised protocols for monitoring

> Different standards for monitoring currently exist and can be adapted to suit the Gulf.

Table 7: Recommended monitoring programs that could benefit priority research projects and adaptive management from WAMSI (2025, in prep).

| Program | Frequency | Scale/location |
|---|---|---|
| Water and sediment quality monitoring | Seasonally | Whole of Exmouth Gulf, including intertidal areas |
| Real time oceanographic monitoring | Hourly/Daily – real time | Multiple locations within the Gulf |
| Marine and coastal fauna surveys | Seasonally | Whole of Exmouth Gulf, including intertidal areas |
| Groundwater monitoring | Seasonally | Coastal margins and deep basin of Exmouth Gulf, as well as along Cape Range |
| Nutrient sensor arrays | Hourly/Daily – real time | Multiple locations within the Gulf |
| Acoustic tracking arrays for tagged fauna | Hourly/Daily – real time | Multiple locations within the Gulf |
| Shoreline monitoring for sea level rise and erosion | Annually | Coastal margins of Exmouth Gulf |
| Marine pest surveys | Annually | Western Gulf, e.g. Exmouth Marina, boat ramps, Navy Pier |

# **STEP-5** UNDERTAKE ASSESSMENT USING DPSIR MODEL

## a) Establish preferred method for undertaking assessment

> Ecosystem status and trends can be assessed using indicator-based methods, literature/evidence reviews, and expert consultation, often in combination.

> Findings are graded systematically using qualitative and quantitative data, as seen in the National SoE Report and Great Barrier Reef Outlook.

> Engaging reputable experts, including cultural knowledge holders, ensures assessment quality, while uncertainties should be explicitly estimated and communicated. Even with limited data, qualitative uncertainty ratings (low, medium, high) can be provided to enhance transparency.

> **Initiated**: A combination of literature review assessments and expert assessments were used in Sutton and Shaw (2021) and WAMSI (2025, in prep).

## b) Identify and assess **Drivers**

> **Initiated**: Drivers were identified from public submissions, EPA development proposals and subject matter experts (Table 8).

Table 8: Drivers and pressures identified from public submissions, EPA development proposals and subject matter experts. Adapted from Sutton and Shaw (2021).

| Drivers | Pressures |
|---|---|
| Natural events: large changes driven by geological events and ocean currents | • Tsunamis and earthquakes<br>• Cyclones, tropical storms<br>• Strong winds and currents |
| Climate change and severe weather: long-term climatic changes that may be linked to global warming and other severe climatic or weather events outside the natural range of variation that could wipe out a vulnerable species or habitat | • Habitat shifting and alteration<br>• Drought<br>• Storms and flooding<br>• Temperature extremes |
| Natural system modifications: pressures from actions that convert or degrade habitat in service of “managing” natural or seminatural systems, often to improve human welfare | • Fire<br>• Water use management<br>• Clearing<br>• Other ecosystem modification |
| Biological resource use: consumptive use of “wild” biological resources including deliberate and unintentional harvesting effects; also management or control of specific species | • Hunting and collecting terrestrial animals<br>• Gathering terrestrial plants<br>• Fishing and harvesting aquatic resources<br>• Logging and wood harvesting |
| Agriculture and aquaculture: pressures from farming and pastoral activities as a result of agricultural expansion and intensification, including silviculture, mariculture, and aquaculture | • Annual and perennial crops<br>• Livestock farming<br>• Marine aquaculture (fishing and farming) |

*Table 8 continues*

*Table 8 continued from previous page*

| Drivers | Pressures |
|---|---|
| Invasive and other problematic species and genes: pressures from non-native and native plants, animals, pathogens/microbes, or genetic materials that have or are predicted to have harmful effects on biodiversity | • Invasive species (terrestrial)<br>• Invasive species (marine)<br>• Pathogens<br>• Problematic native species<br>• Introduced genetic material |
| Human intrusions and disturbance: pressures from human activities that alter, destroy and disturb habitats and species associated with non-consumptive uses of biological resources | • Marine recreational activities<br>• Land recreational activities<br>• Military and other activities |
| Residential and commercial development: human settlements or other non-agricultural land uses with a substantial footprint | • Housing and urban areas<br>• Commercial and industrial areas<br>• Tourism and recreation areas |
| Transportation and service corridors: long narrow transport corridors and the vehicles/ vessels that use them | • Roads and rails<br>• Infrastructure corridors: utilities and service lines<br>• Flight paths<br>• Shipping lanes<br>• Dredging<br>• Coastal infrastructure: ports, marinas, jetties |
| Energy production and mining: production of non-biological resources | • Oil and gas drilling<br>• Mining and quarrying<br>• Renewable energy |
| Pollution: pressures from introduction of exotic and/or excess materials or energy from point and nonpoint sources | • Garbage/solid waste<br>• Household sewage and wastewater<br>• Marine pollution<br>• Industrial and military effluent/waste<br>• Agricultural and forestry effluent/ waste<br>• Noise (atmospheric/terrestrial)<br>• Noise (marine)<br>• GHG emissions and air quality<br>• Light spill<br>• Other |

### c) Identify and assess **Pressures**

> **Initiated**: comprehensive list of pressures was identified from public submissions, EPA development proposals and subject matter experts (Table 8).

- Sutton and Shaw (2021) consolidated these pressures for use in the risk assessment process (Table 9).
- WAMSI (2025, in prep) also identified pressures of high priority for stakeholders.
- Pressures were assigned a risk score to determine the level of impact they would have on each value.

Table 9: Pressures identified in Exmouth Gulf and surrounds. All activities and pressures are included from Sutton and Shaw (2021), and key pressures derived from prioritised knowledge gaps are included from WAMSI (2025, in prep).

**Sutton and Shaw (2021) – all identified pressures**

**Climate change**
- Marine heatwaves
- Tropical storms and cyclones
- Sea level rise
- Fire
- Atmospheric temperatures

**Shipping**
- Port infrastructure footprint (incl. channel)
- Vessel strike
- Noise pollution – vessel, pile driving and dredging
- Pollution (oil, fuel, antifoul)
- Pests
- Light pollution
- Suspended sediments (dredging)

**Fishing**
- Commercial – physical trawling, catch
- Recreational – catch

**Development**
- Residential – footprint, groundwater drawdown, solid waste, light, noise, emissions
- Industrial – footprint, groundwater drawdown, solid waste, light, noise, emissions
- Tourism – footprint, groundwater drawdown, solid waste, light, noise
- Sedimentation

**Mining**
- Industrial salt facility – footprints, bitterns discharge, seawater intake, emissions, groundwater drawdown,
- Oil and gas – seismic surveys
- Limestone – footprint, operation, emissions, groundwater drawdown
- Potash – footprint, abstraction of brine, emissions

**Tourism/visitation**
- Disturbance – marine noise, marine damage (anchoring/diving)
- Marine pollution – oil/fuel, rubbish
- Potable water use
- Terrestrial rubbish
- Human waste
- Camping
- Off-road driving

**Pastoralism**
- Overgrazing
- Pests/ferals

**Defence**
- Contamination

**WAMSI (2025, in prep) – key pressures derived from prioritised knowledge gaps**

- Climate change – marine heatwaves, tropical storms and cyclones, sea level rise, air temperatures, rainfall, fire
- Coastal development
- Mining expansion
- Marine pests
- Pollution and contamination – bitterns, PFAS, copper

## d) Identify and assess **State**

> **Initiated**: A baseline qualitative assessment of 'State' was undertaken in Sutton and Shaw (2021) (Table 10). Values that were assessed as having low to medium confidence were included as a knowledge gap in WAMSI (2025, in prep).

> Some social and economic values were assessed in Sutton and Shaw (2021) but not comprehensively.

> Indigenous Cultural Values have not been assessed and would be considered in NTGAC Sea Country planning.

> A quantitative assessment based on indicators has not been completed.

Table 10: State of distinctive values in Exmouth Gulf adapted from Sutton and Shaw (2021). Justification for 'grade' is provided in Appendix 3. Conf. = level of confidence in 'grade' informed by the literature (High – H, Medium – M, Low – L).

| Very good | Good | Poor | Very poor | Unknown |
|---|---|---|---|---|

| | State | Conf. | State | Conf. |
|---|---|---|---|---|
| SEA | **Marine Fauna** | | **Marine Environmental Quality** | |
| | Crustaceans - prawns | H | Water quality | L-M |
| | Crustaceans - mud crabs | L | Sediment quality | L-M |
| | Teleost - whiting | M | **Coastal Processes** | |
| | Teleost - mangrove jack | | Geophysical processes | M |
| | Teleost - trevally | | Hydrodynamic processes | M |
| | Teleost - coral trout | | Nutrient flow | L-M |
| | Teleost - red emperor | | **Benthic Communities & Habitats** | |
| | Teleost - tuskfish | | Macroalgae and turf algae | M |
| | Elasmobranchs - rays (shovelnose) | | Seagrass | M |
| | Elasmobranchs - rays (manta) | M-H | Coral | M |
| | Elasmobranchs - sawfish | | Sponges and filter feeders | L |
| | Elasmobranchs - sharks | M | Sand and mud | L |
| | Marine reptiles – sea snakes | L-M | Mangroves | M |
| | Marine reptiles - turtles | M-H | Samphire | L |
| | Marine mammals - whales (humpback) | H | Blue-green algal mats | M |
| | Marine mammals - dolphins (coastal) | | Reef flats and oyster beds | L-M |
| | Marine mammals - dugongs | M-H | Salt flats | L |
| | Seabirds and shorebirds | L-M | | |
| LAND | **Flora and Vegetation** | | **Terrestrial fauna** | |
| | Coastal plains | L-M | Reptiles | |
| | Limestone cliffs & gullies | L-M | Mammals | |
| | Coastal dunes | M | Birds | |

*Table 10 continues*

*Table 10 continued from previous page*

| | State | Conf. | State | Conf. |
|---|---|---|---|---|
| | Threatened/priority flora | | Short-range endemic invertebrates | |
| | **Landforms** | | Amphibians | |
| | Karst systems | | **Subterranean Fauna** | |
| | Islands | M | Troglofauna | |
| | **Terrestrial Environmental Quality** | | Stygofauna | |
| | Topsoil | | | |
| PEOPLE | **Social surroundings** | | **Human health** | |
| | Aboriginal heritage & culture * | | Potable water | H |
| | National heritage | M | | |
| | Amenity - land-based recreation | H | | |
| | Amenity - marine based recreation | H | | |
| | Amenity - intrinsic/wilderness aesthetic | H | | |
| | Amenity - noise, dust, odour, light | H | | |
| | Economic - tourism | H | | |
| | Economic - commercial fishing | H | | |
| | Economic - pastoralism | | | |
| | Economic - science and research | H | | |
| WATER | **Inland waters** | | | |
| | Groundwater systems | H | | |
| | Surface water systems | M | | |
| AIR | Air quality | H | | |

* cannot assess without Traditional Owner input

## d) Identify and assess **Impacts**

> **Initiated**: The impacts of pressures on values have been qualitatively assessed in Sutton and Shaw (2021). A risk score was assigned for each value against each pressure, using a consequence x likelihood approach (e.g. Figure 11, Appendix 4). Consequence ratings related to different levels of impacts.

> An assessment of impacts has not been adequately completed for all social and economic values.

> NTGAC Sea Country planning (due for upcoming release) is likely to identify impacts on cultural values.

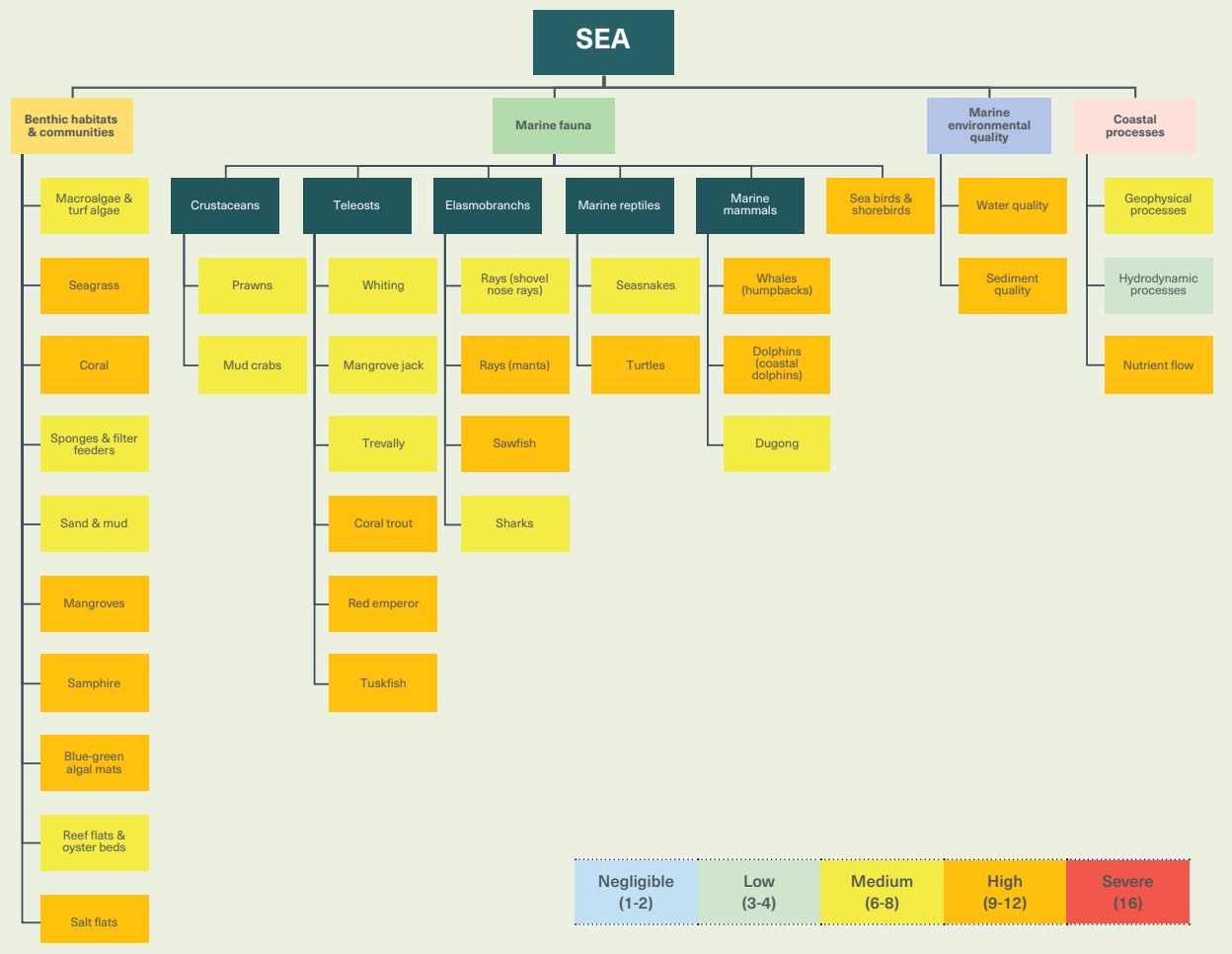



Figure 11: A summary of the risks to Distinctive Values under the Environmental Protection Authority 'Sea' theme. The highest risk scored across all activities and pressures assessed is shown, rather than an average. Adapted from Sutton and Shaw (2021), risks for all EPA themes are provided in Appendix 4.

## f) Identify and assess **Responses**

> Identify and evaluate the responses (e.g., actions and policies) to reduce the impact of the drivers and pressures on the ecosystem.

> This analysis is similar to management effectiveness evaluation but also includes informal strategies (e.g. behaviour changes) and private sector responses.

> Where management effectiveness is evaluated, the Co-ordinating Body/Secretariat is advised to engage an external, independent assessor to assist in acceptance of the results.

## **STEP-6** ANALYSE RISKS AND ECOSYSTEM OUTLOOK

### a) Employ future-orientated analyses to inform policy decision-making

> Appropriate analyses are chosen based on the specified purpose and objectives of the assessment and data availability; these may include:

- Risk analyses: qualitative (e.g. expert judgment and stakeholder input) or quantitative (e.g. statistical modelling) assessment and categorisation of risk considering likelihood and severity of impact.
- Trend Analysis: Analyse trends over time to identify significant changes and emerging issues.
- Scenario Development: Co-design future scenarios (e.g., 'business-as-usual, 'climate-resilient fisheries') with stakeholders based on different management strategies to predict the impacts of management alternatives.

## **STEP-7** PEER REVIEW AND PUBLIC FEEDBACK

### a) Conduct independent peer review

> Before finalising the assessment, an external, independent review is essential to ensure the integrity of the process and the accuracy and credibility of outputs.

> This review should be planned early in the assessment to ensure all stakeholders understand how it will be evaluated.

### b) Consult with stakeholders and the public on final outputs

> Stakeholder input helps validate whether the recommendations are feasible and aligned with real-world challenges, making the assessment more useful for decision-makers.

> Engaging the broader public alongside existing stakeholders ensures that the assessment reflects diverse knowledge systems and lived experiences, increasing public confidence in the findings.

> Public feedback can highlight missing information, local perspectives, or unintended consequences, refining the final recommendations.

## **STEP-8** COMMUNICATION OF FINDINGS

### a) Compile findings into a range of communication tools

> Findings are optimally presented as grades, colours and symbols to allow readers to easily interpret complex information. An indicative assessment sample to illustrate what a future State of Exmouth Gulf assessment may look like is provided in Figure 12.

> Use clear, relevant, and non-technical language, leveraging visual tools like infographics, story maps, and interactive content to improve engagement and comprehension.

> Establish an online information system to provide stakeholders and users access to all the evidence used to inform assessments (e.g. SEAF, Outlook Online as described in Dobbs et al., 2011).

### b) Develop a communication strategy

> Embed strategic communication specialists into the assessment from the outset to develop a collaborative communication plan.

> Clearly define how assessment findings will inform policy and decision-making, identifying key audiences and tailoring messages across varied communication channels such as policy briefs, media, workshops, and digital platforms.

> Ensure a two-way exchange of information with stakeholders and Traditional Owners, building trust, ownership, and legitimacy to enhance policy influence.

## **STEP-9** EVALUATE AND ITERATE

### a) Evaluate and adapt for continuous improvement

> Ongoing evaluation of the assessment process and its outputs encourages continuous improvement, allowing future iterations to refine methodologies and incorporate new data while responding to emerging challenges and shifting management objectives.

> Undertaking a formal independent evaluation of the process and/or assessment has a range of benefits, such as increasing credibility and improving the effectiveness, impact, utility and relevance of assessments. For example, the Australian Department of Climate Change, Energy, Environment and Water commissioned an evaluation of the 2021 National SoE report by IPS Management Consultants, an independent certified majority Indigenous-owned consultancy.

### b) Reassess the ecosystem at regular intervals

> Ongoing, secure funding is essential for regular assessment and reporting to reflect new data and changing conditions.

> The interval for repeating State of Exmouth Gulf assessments should be sufficient to enable the evaluation of changing pressures on the important values of the region, e.g., 3–5 years, agreed in advance with stakeholders.

### c) Revise stakeholder involvement

> As gaps are identified and the political and environmental landscapes change, it is necessary to review stakeholder involvement for relevance and currency.

[ S A M P L E  O N L Y ]

| Distinctive Values | Current State (colour) and change from last assessment (icon) | Confidence | Justification | Risk assessment |
|---|---|---|---|---|
| **Benthic communities and habitats** | — | **Medium** | | |
| Macroalgae and turf algae | ↗ | Medium | Algae has recovered well from past disturbances (e.g., Cyclone Vance) (Loneragan et al. 2013). Exmouth Gulf-wide mapping has not occurred for benthic habitats, so confidence is not high. Uncertainty around impacts of marine heatwaves on macroalgae. | |
| Seagrass | ↗ | Medium | Natural variability in abundance and cover across seasons for different species is evident (Vanderklift et al. 2016). Seagrass showed recovery after Cyclone Vance (Loneragan et al. 2013). *Halophila ovalis* populations are considered genetically resilient. Exmouth Gulf-wide mapping has not occurred for benthic habitats, so confidence is not high. | |
| Coral | ↘ | Medium | Bleaching of corals has occurred after past marine heat stress events (Moore et al. 2012; Depczynski et al. 2013; Clarke et al. 2019). There is anecdotal evidence of bleaching for corals along the eastern margin following warming in 2021. Coral rubble is widespread, indicating continued impact over time (Loneragan et al. 2003, Day et al. 2013). No Gulf-wide mapping, so confidence is not high. | |
| Sponges and filter feeders | — | Low | Diverse communities are present, particularly between North West Cape and Muiron Islands (RPS Bowman Bishaw Gorham 2004; Hooper et al. 2002; Hooper and Ekins 2004; Kangas et al. 2007). Cyclone Vance caused damage to sponges (Loneragan et al. 2003). No Gulf-wide mapping has been conducted, so confidence is not high. No recent monitoring of sponge communities in the Gulf since the 2000s. | |

KEY

State/condition: Very good | Good | Poor | Very poor | Unknown

Trend: ↗ Improved | — Stable | ↘ Deteriorated | No data

Risk assessment: Low | Medium | High | Critical

Figure 12: An indicative assessment sample to illustrate what a future State of Exmouth Gulf assessment may look like. Distinctive values, current state, confidence and justification taken from Sutton and Shaw (2021). Trend icons and risk assessments include simulated data.

Turbinaria coral found in the southern Exmouth Gulf. Shannon Dee

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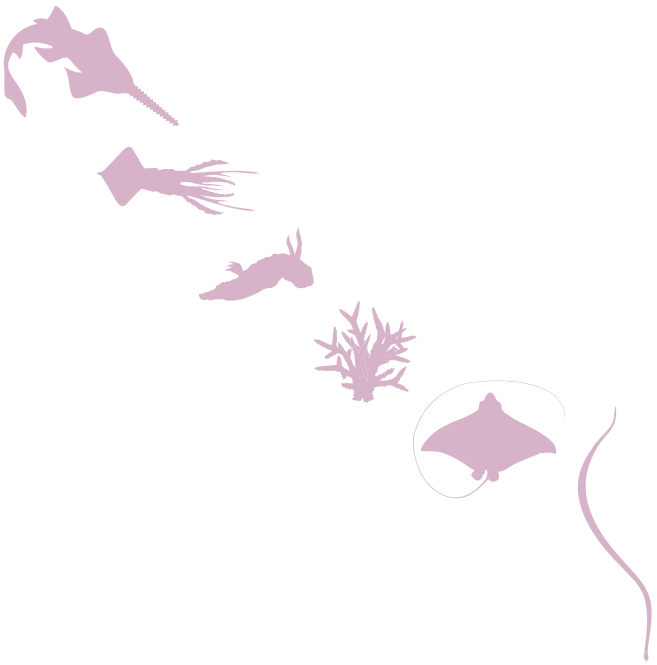

# 6. Appendices

Appendix 1: Summary of the different types of environmental assessment methods and key attributes from UNEP, 2015.

| Assessment type | Focus | Purpose | Key questions | Examples |
|---|---|---|---|---|
| Integrated Environmental Assessment | Identifies, analyses and evaluates all natural and human processes and their interactions and explores how current social, economic, and environmental trends might evolve, along with their potential impacts on the environment and human well-being development. | Links science and policy; analyses drivers, pressures, state, impacts, and responses for informed decision-making. | What is happening to the environment and why? What are the consequences? What actions are needed? | Global Environment Outlook; Africa Environment Outlook. |
| Ecosystem Assessment | Evaluates the state, trends, and value of ecosystems and the services they provide to humans and the environment. | Provides a scientific basis for conservation and sustainable use, highlighting trade-offs and future impacts. | What is the condition of ecosystems? What services are provided, and what are the trends? Who relies on them? | Millennium Ecosystem Assessment; UK National Ecosystem Assessment. |
| Environmental Impact Assessment | Focuses on the impacts of specific development proposals (e.g., mining, industry, infrastructure) | Provides information to minimise or mitigate adverse environmental impacts of projects. | What impact will the project have? What measures can reduce, avoid, or compensate for these impacts? | Mekong River Transboundary Environmental Impact Assessment; Offshore Drilling in the Falkland Islands. |
| Risk Assessment | Identifies and evaluates risks from specific agents or scenarios (e.g., chemicals, disasters). | Helps policymakers understand risks to systems or populations and devise mitigation or adaptation strategies. | What are the risk sources? What needs protection? How can acceptable risk levels be achieved? | Disaster Risk Assessment; Environmental Risk Assessment of chemicals and pollutants. |
| Strategic Environmental Assessment | Evaluates the environmental impacts of plans, programmes, and policies (e.g. statutory planning schemes). | Supports sustainable development by providing foresight and identifying the best environmental options. | What are the cumulative effects of the proposed strategies? What are the reasonable alternatives? | Strategic Environmental Assessment for water use in South Africa; Ghana's National Growth Strategy. |
| Vulnerability Assessment | Examines exposure and sensitivity to risks, such as climate change and disasters. | Identifies risks, evaluates adaptive capacity, and develops strategies to reduce vulnerabilities. | What are the key exposures and sensitivities? What adaptation strategies are effective? | Climate Change Vulnerability Assessment; Nile Basin Vulnerability Report. |
| Post-Crisis Environmental Assessment | Evaluates environmental damage and risks during or after conflicts and disasters. | Provides input for recovery, ensuring environmental considerations in response and reconstruction. | What are the immediate environmental impacts? How can secondary risks be mitigated during recovery? | UNEP Post-Conflict Environmental Assessments (e.g., Sudan, Democratic Republic of the Congo). |
| Environmental Valuation | Links environmental and economic data for decision-making. | Highlights the economic contributions of ecosystems to encourage integration into planning and policies. | What is the value of ecosystem services? How does nature contribute to the economy? | The Economics of Ecosystems and Biodiversity; WAVES partnership. |

Appendix 2: Full list of distinctive values of Exmouth Gulf, as presented in Sutton and Shaw (2021). Values were identified through public submissions, consolidated, and organised by EPA themes and factors.

## Sea

**Benthic Habitats and Communities**
- Macroalgae and turf algae
- Seagrass
- Coral
- Sponges and filter feeders
- Sand and mud
- Mangroves
- Samphire
- Blue-green algal mats
- Reef flats and oyster beds
- Salt flats

**Marine Fauna**
- Crustaceans
  - Prawns
  - Mud crabs
- Teleosts (fish species)
  - Whiting
  - Mangrove Jack
  - Trevally
  - Coral Trout
  - Red Emperor
  - Tuskfish
- Elasmobranchs (sharks and rays)
  - Rays (shovel nose rays)
  - Rays (manta)
  - Sawfish
  - Sharks
- Marine reptiles
  - Seasnakes
  - Turtles
- Marine mammals
  - Whales (humpbacks)
  - Dolphins (coastal)
  - Dugong
- Seabirds and shorebirds

**Marine Environmental Quality**
- Water quality
- Sediment quality

**Coastal Processes**
- Geophysical processes
- Hydrodynamic processes
- Nutrient flow

## Land

**Flora and Vegetation**
- Coastal plains
- Limestone cliffs and gullies
- Coastal dunes
- Threatened/priority flora

**Terrestrial Fauna**
- Reptiles
- Mammals
- Birds
- Short-range endemic invertebrates
- Amphibians

**Subterranean Fauna**
- Troglobionts (Troglofauna)
- Stygofauna

**Terrestrial Environmental Quality**
- Topsoil

## People

**Social Surroundings**
- Aboriginal heritage and culture
- National heritage
- Amenity
  - Land-based recreation
  - Marine-based recreation
  - Intrinsic/wilderness aesthetic
  - Noise, dust, odour, light

**Economic**
- Tourism
- Commercial fishing
- Pastoralism
- Science and research

**Human Health**
- Potable water

## Water

**Groundwater systems**

**Surface water systems**

## Air

**Air quality**

Appendix 3: State of Distinctive Values in Exmouth Gulf including justifications (Sutton and Shaw, 2021).

| | | |
|---|---|---|
| | Very good | Value has been relatively unimpacted in Exmouth Gulf and long-term viability of the Value is positive. |
| | Good | A small portion of the Value has been impacted in Exmouth Gulf, which may threaten long-term viability. |
| | Poor | A significant proportion of the Value has been negatively impacted across most or all of Exmouth Gulf, which may threaten long-term viability. |
| | Very Poor | A large proportion of the Value has been negatively impacted in Exmouth Gulf with limited prospects of long-term viability. |
| | Unknown | Limited understanding of the value to assess its current state. |

| Distinctive Values | Current state | Conf. | Justification |
|---|---|---|---|
| SEA | | | |
| **Benthic Communities and Habitats** | | | |
| Macroalgae and turf algae | | M | Algae has recovered well from past disturbances e.g., Cyclone Vance (Loneragan et al. 2013). Exmouth Gulf wide mapping has not occurred for benthic habitats so confidence is not high. Uncertainty around impacts of marine heatwaves on macroalgae. |
| Seagrass | | M | Natural variability in abundance and cover across seasons for different species is evident (Vanderklift et al. 2016). Seagrass showed recovery after Cyclone Vance (Loneragan et al. 2013). *Halophila ovalis* populations considered to be genetically resilient. Exmouth Gulf wide mapping has not occurred for benthic habitats so confidence is not high. |
| Coral | | M | Bleaching of corals has occurred after past marine heat stress events (Moore et al. 2012; Depczynski et al. 2013; Clarke et al. 2019). Currently anecdotal evidence of bleaching for corals along eastern margin following warming earlier in 2021. Coral rubble is a widespread habitat indicating that corals have been continually impacted over time (Loneragan et al. 2003, Day et al. 2013). Gulf wide mapping has not occurred for benthic habitats thus confidence is not high.<br>Department of Biodiversity, Conservation, and Attractions (DBCA) considers the decreasing trend in coral cover, coral recruitment and changing community composition to be having a negative effect on coral communities of the Ningaloo Marine Park (with med-high confidence) (DBCA 2017d). |

*Summary of case studies continues*

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|---|---|---|
| Sponges and filter feeders | L | Diverse communities are present, particularly between North West Cape and Muiron Islands (RPS Bowman Bishaw Gorham 2004; Hooper et al. 2002; Hooper and Ekins 2004; Kangas et al. 2007). Cyclone Vance did cause some damage to sponges (Loneragan et al. 2003). Exmouth Gulf wide mapping has not occurred for benthic habitats thus confidence is not high. No recent information on communities within the Gulf and if this has changed since 2000s. |
| Sand and mud | L | Sandy habitats are continually trawled for prawns, so would expect that infaunal and epifaunal communities have been impacted somewhat. A comparison of trawled versus untrawled areas for prawns in Exmouth Gulf found some evidence that high trawl effort sites had lower faunal abundance (Kangas *et al.* 2006). Sand and mud habitat is extensive across Exmouth Gulf, however knowledge of infaunal communities is not well known. |
| Mangroves | M | Tropical Cyclone Vance caused the loss of 44% of cover along eastern margin (Paling et al. 2008). Uncertain if this has fully recovered. Mangroves been impacted to some extent by fluctuating sea levels (e.g., La Niña vs El Niño years) (Reef and Lovelock 2019) and rare locust swarms (Reef et al. 2012). |
| Samphire | L | Occur extensively along the eastern margin of Exmouth Gulf and also southern and western margin and around tidal creeks (Keighery and Gibson 1993; Oceanica 2006). Large Defence communication towers sit on samphire saltmarshes. No known significant impacts to extensive samphire along eastern margin. Limited literature on samphire in Exmouth Gulf. No widespread losses have been recorded. |
| Blue-green algal mats | M | Occur extensively along the eastern margin of Exmouth Gulf (Humphreys et al. 2005; Straits Salt Pty Ltd 2006; EPA 2008; Straits Salt Pty Ltd 2009). No known obvious damage is evident to mats. Considered one of the last intact extensive salt flat ecosystems in W.A. Mats need room to migrate landward and seaward with fluctuating sea levels. |
| Reef flats and oyster beds | L-M | Productive rocky intertidal and subtidal areas occur at all the creek mouths along the western shoreline (pers. comm. DWER). These creek mouths are numerous and prone to high levels of visitation and occasional severe disturbance from flood runoff. Extent of any damage is uncertain. Extensive coastal/intertidal mapping has not been carried out. Low relief subtidal reef is extensive around Bundegi and North West Cape across to Muiron Islands, and likely occur around many of the islands (Bancroft and Sheridan 2000; Beckley and Lombard 2012; van Keulen and Langdon 2011; Dee et al. 2020). |

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| Salt flats | | L | Considered one of the last intact extensive salt flat ecosystems in W.A (EPA 2008). No known obvious damage is evident to flats. Limited literature on salt flats in Exmouth Gulf. |
| **Marine Fauna** | | | |
| Crustaceans - prawns | | H | Commercially fished so have been impacted for a long time, though considered sustainable by DPIRD. Cyclone Vance resulted in an immediate significant loss in critical prawn nursery habitat, seagrass and macroalgae, which resulted in a decrease in prawn landings two years after the cyclone (Loneragan et al. 2013). Landings increased as macroalgae and seagrass recovered. |
| Crustaceans - mud crabs | | L | Fishing pressure would be having an impact. Limited available information on mud crab populations in Exmouth Gulf. |
| Teleost - whiting | | M | Fishing pressure would be having an impact. A widespread species. Limited available information on populations in Exmouth Gulf, though stocks are generally considered sustainable-adequate for the Gascoyne region (Gaughan et al. 2019). |
| Teleost - mangrove jack | | | Fishing pressure would be having an impact. Limited knowledge available on mangrove jack population in Exmouth Gulf. |
| Teleost - trevally | | | Fishing pressure would be having an impact. Limited knowledge available on trevally population in Exmouth Gulf. Widespread species. |
| Teleost - coral trout | | | Fishing pressure would be having an impact. Limited knowledge available on coral trout population in Exmouth Gulf. |
| Teleost - red emperor | | | Fishing pressure would be having an impact. Limited knowledge available on red emperor population in Exmouth Gulf. |
| Teleost - tuskfish | | | Fishing pressure would be having an impact. Limited knowledge available on red emperor population in Exmouth Gulf |
| Elasmobranchs - rays (shovelnose) | | | Uncertainty around current state. Current research underway. Fin Focus has been collecting citizen science data and has a catalogue of photos. |
| Elasmobranchs - rays (manta) | | M-H | Tourism may be having an impact for a portion of the population. Mantas have had focused research effort. McGregor et al. 2019 provides '*indirect evidence for potential increased vessel strikes on manta rays within the Ningaloo Coast World Heritage Area*'.<br>Armstrong et al. 2020b – *'With an exceptionally low maximum population growth rate (Dulvy et al., 2014), M. alfredi is particularly susceptible to human impacts and is classified as* |

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| | | | *"Vulnerable" on the International Union for the Conservation of Nature Red List of Threatened Species….For example, recent studies conducted in the Ningaloo Coast WHA have reported short-term behavioural changes in M. alfredi in up to a third of tourism interactions (Venables et al., 2016)'.* |
| Elasmobranchs - sawfish | | | Uncertainty around current state. Current research underway. |
| Elasmobranchs - sharks | | M | No evidence of long-term impacts of tourism on the whale sharks at Ningaloo has been found (e.g. Sanzogni et al. 2015; Lester et al. 2019).<br>Less is known about other shark species (e.g., reef, grey nurse, white pointer), though some work has focused on depredation by sharks in the region (Mitchell et al. 2018, 2019, 2020), which has caused concern. |
| Marine reptiles – sea snakes | | L-M | In a declining state elsewhere across the NW of Australia. Caught as by-catch in the Exmouth Prawn Trawl Fishery. It is believed improved reporting practices are responsible for the increased number of sea snakes recorded as bycatch (Gaughan and Santoro 2019), and that those sea snakes found alive are typically returned alive (Kangas et al 2015). Some species have small home ranges, so would be more susceptible to impacts.<br>AIMS website: *'Global sea snake populations have declined in recent years, including those in the Great Barrier Reef, Western Australia and New Caledonia. Declines in native sea snake populations at the remote offshore Ashmore reef, NW Australia, have made this species a focus for conservation and long-term monitoring. While the reasons for decline are not well understood, one key concern in Australian waters is that they are frequently caught as by-catch in trawl fisheries.'* |
| Marine reptiles - turtles | | M-H | Area well used by turtle for foraging, and nesting occurs on islands just north of Exmouth Gulf (Thums et al. 2018; Rob et al. 2019; Fossette et al. 2021). All marine turtles are EBPC Act listed threatened species and there is a recovery plan for marine turtles in Australia. Turtles face threats outside of Australian waters given they are migratory. Since the implementation of exclusion devices in prawn trawl fisheries in Exmouth Gulf, an estimated drop of 95% of large animals, including turtles, sharks and rays, was observed (Kangas and Thomson 2004). Exmouth Gulf was an exploited fishing ground for turtles up until the industry closed in 1973 (Halkyard 2009). Historical records show upwards of 55,000 green turtles, and 15,000-32,000 hawksbill turtles were harvested in WA. Observable declines in marine turtles resulted from commercial harvesting. Prince at al. (2012) reported unusual numbers of sick and dying turtles on a number |

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| | | | of occasions between 1990-98 in the Exmouth area, though no obvious cause was identified. |
| Marine mammals - whales (humpback) | | H | Exmouth Gulf has long been a recognised resting and nursery area for humpback whales (Chittleborough 1953; Jenner et al. 2001). Humpback whale population numbers have continued to increase at a rate of ~11% per year (last assessment done in 2016). Some evidence that whales are being harassed by silver gulls in Exmouth Gulf (Harkness and Sprogis 2020). Humpback whales are migratory and impacts to food availability in Antarctica will impact humpback whales. |
| Marine mammals - dolphins (coastal) | | | Uncertainty around current state as species level data is not available for most of Exmouth Gulf. Current boat-based research about to begin. Aerial surveys have been conducted previously, however, surveys are focused on whales and dugongs, so different dolphin species were not always separated (e.g., Jenner and Jenner 2005; Irvine and Salgado Kent 2019). Aerial surveys in 2018 sighted 556 dolphins from 179 pods, including 10 calves; dolphins had a broad distribution across Exmouth. |
| Marine mammals - dugongs | | M-H | Penrose (2005) details a range of impacts and potential impacts to dugongs, in relation to the Straits Salt proposal, but concludes 'the current knowledge of dugongs in Exmouth Gulf is inadequate to assess the potential threats of the Straits Salt proposal and thus to effectively plan for their management'. Some knowledge has been gathered since then, with several aerial flights surveying dugongs (e.g., Irvine and Salgado Kent 2019). A decline in dugongs occurred following Cyclone Vance in 1999 and the removal of seagrass Gales et al. (2004). More recent assessment of dugong population trends is needed. A study by Hodgson et al. (2008) found no real change across years. Is a listed threatened species on the WA Threatened and Priority Fauna list. |
| Seabirds and shorebirds | | L-M | Exmouth Gulf Mangroves is designated as an Important Bird Area, and also qualifies as a Key Biodiversity Area based on this (Biodiversity Areas Partnership 2020). It has national and international significance and many that are critically endangered, endangered, vulnerable etc. 4WD activity has likely caused some damage to burrows/nests. Trampling on islands (seabird nests and burrows and physical disturbance) and pets (i.e. dogs) are also greatest disturbance risks (pers. comm. DBCA). Storm surges can inundate islands and destroy nesting sites. Difficult to assess such a diverse group of species, but based many being listed species, a 'poor' score is given. |
| **Marine Environmental Quality** | | | |

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| Water quality | | L-M | Exmouth is a naturally turbid environment. Widespread water quality issues are not evident in Exmouth Gulf, though widespread continual monitoring is not carried out. Microplastic pollution is evident in Exmouth Gulf. Water temperature is typically considered under water quality. DBCA considers the increasing trend in seawater temperature as having a negative effect with high confidence for water quality of the Ningaloo Marine Park (DBCA 2017d). |
| Sediment quality | | L-M | Exmouth sites had highest concentrations of Cobalt, Lead and Vanadium and were thought to be related to the region's geology (DEC 2006). Widespread sediment quality issues are not evident in Exmouth Gulf, though widespread continual monitoring is not carried out. |
| **Coastal Processes** | | | |
| Geophysical processes | | M | Geophysical processes are influenced by tropical cyclones e.g., large washover fans occur at Point Lefroy (Brill et al. 2016) and sandy ridges at Giralia Bay (May et al. 2018). Cyclones have also caused erosion (Nott and Hubbert 2005). |
| Hydrodynamic processes | | M | No evidence of significant impact. The hydrological environment remains relatively stable given freshwater sources from rainfall and run off are very low (Penn & Caputi 1986). Tides can contribute to the turbidity of Exmouth Gulf (Dufois et al. 2017). |
| Nutrient flow | | L-M | No evidence of significant impacts apart from natural disturbances. The Gulf is considered relatively productive. All sources of nutrients into Exmouth Gulf are yet to be 100% determined, though largely thought to be influenced by salt flats and blue-green algal mats (McKinnon and Ayukai 1996; Ayukai and Miller 1998; Lovelock et al. 2009; Penrose 2011). |
| **LAND** | | | |
| **Flora and Vegetation** | | | |
| Coastal plains | | L-M | Development has removed vegetation. There is no fine scale vegetation mapping that covers the whole of the project area. As of 2019, a total of 21 plant species are identified as endemic to the Cape Range peninsula (Keighery and Lilburn 2019). 22 species from the Peninsula are priority taxa - species of conservation significance (DBCA 2019b). In some pastoral areas, native grasses have been replaced by annual pastures. Buffel grass has spread extensively throughout the region, including the national park (Meissner 2010). Selective overgrazing by sheep, goats and cattle has also exposed areas to wind and erosion (WA Planning Commission 1996). Trampling of |

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| | | | vegetation and compaction of the earth are also issues particularly around watering points. |
| Limestone cliffs & gullies | | L-M | Possibly less disturbed than coastal plains and dunes due to access? Selective overgrazing and trampling by introduced herbivores may remove some species (WA Planning Commission 1996). Weed invasion can displace native species and change fire regimes (especially buffel grass). Basic raw material extraction or groundwater drawdown may have also resulted in vegetation decline, however, the extent of loss of vegetation is not well known. |
| Coastal dunes | | M | Twelve taxa are found exclusively within the northern red sand dunes within the UCL on the Cape Range peninsula (Meissner 2011; Metcalf and Bamford 2005). Camping and 4WD has caused extensive damage across dune vegetation (pers. comms.; Kobryn et al. 2017). |
| Threatened/priority flora | | | Uncertainty around current state. Surveys needed. |
| **Terrestrial Fauna** | | | |
| Reptiles | | | The Exmouth Gulf area is the northern extent of distribution of at least six species' ranges. Six endemic reptile species are known from the North West Cape. Five species of conservation significance are listed in the WA Threatened and Priority Fauna list (DBCA 2019). Off-roading likely to have caused some damage to habitats but uncertain of extent. Overgrazing by livestock, weed invasion and predation from pests/feral animals has likely had the biggest impact to reptiles (pers. comm. DBCA). Baseline information missing for reptiles around Exmouth so uncertain as to current status. |
| Mammals | | | At least half of the original mammals in the Cape Range area have become extinct since European colonisation (Baynes and Jones, 1993; McKenzie et al. 2002). Increasing use of the islands (e.g., by tourists, fishermen and shell collectors) has been a long standing concern.<br>Bandicoots have been translocated onto Doole Island – all nesting sites are below storm surge level as based off Olwen surge level, so they are at risk from storm surge (pers. comm.). Current status unknown due to lack of detailed surveys and baseline data. |
| Birds | | | The terrestrial birdlife of the North West Cape is typical of the Pilbara and Carnarvon Basin regions and has a diverse assemblage with over 240 terrestrial bird species recorded within the cape and surrounds (within a 50 km search area, ALA 2021; WA Museum 2021b). Off-roading likely to have caused |

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| | | | damage to habitats, nests and burrows. Bird surveys are undertaken by volunteers (e.g. Birdlife Australia). However, uncertainty around the current status of birds in the area. |
| Short-range endemic invertebrates | | | The short-range endemic (SRE) invertebrate fauna of Cape Range are data deficient. |
| Amphibians | | | Limited studies on amphibians, but endemic species are found e.g. Douglas' toad (*Pseudophryne douglasi*). Off-roading likely to have caused some damage to habitats but uncertain of extent. Uncertainty around the current status of birds in the area. |
| **Landforms** | | | |
| Karst systems | | | Dumping of rubbish and rocks occurs (pers. comm.). Sedimentation during heavy rains and floods can occur. There is currently uncontrolled access to some caves e.g., Camerons Cave and Bundera Sinkhole. Disturbances, such as diving and swimming can cause alteration of chemico-physical attributes of the waterbody in Bundera Sinkhole. Unknown how past variations in water chemistry has impacted fauna living in systems. Uncertain around the connectivity between karst systems. |
| Islands | | M | Inundation of some island has occurred in the past with storm surge e.g., Tropical Cyclone Olwyn. Currently receiving research focus. An analysis of the platform and geomorphic attributes of several northwest Australian islands was used to assess their potential vulnerability to future erosion (Bonesso et al. 2020). In Exmouth Gulf, Y Island recorded an increase in island volume and average elevation whilst Eva Island (also known as Victor Island) recorded a decrease in land area, volume and elevation, potentially suggesting erosion. |
| **Subterranean Fauna** | | | |
| Troglofauna | | | Communities are vulnerable as they may only be known from single sites. Uncertainty around the connectivity between karst systems and thus faunal communities. Current impacts to karst systems would likely be impacting communities. Many species listed as endangered, vulnerable and critical on the Threatened or Priority Species list. Groundwater drawdown will impact humidity. Past declines of troglobitic fauna in a single-chambered cave on the Cape Range peninsula (C-118) has been noted (Humphreys 1991). |
| Stygofauna | | | Communities are vulnerable as they may only be known from single sites. Uncertainty around the connectivity between karst systems and thus faunal communities. Current impacts to karst |

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| | | | systems would likely be impacting communities. Many species listed as endangered, vulnerable and critical on the Threatened or Priority Species list. Groundwater drawdown will impact water chemistry. |
| **Terrestrial Environmental Quality** | | | |
| Topsoil | | | Overgrazing is likely to have had some impact on erosion of topsoil, and runoff for some areas of Exmouth. Van Vreeswyk et al. (2004) found ~77% of 12,445 visual traverse assessments of Pilbara pastoral land, indicated 'good' or 'very good' vegetation condition, 11% indicated fair condition and 12% indicated poor or very poor condition. Uncertainty around current quality and state of topsoil. |
| **WATER** | | | |
| **Inland waters** | | | |
| Groundwater systems | | H | Groundwater resources on the Exmouth peninsula are limited due to the relatively small size of the peninsula and low rainfall. Exmouth's only source of freshwater is an unconfined karstic limestone aquifer of the Cape Range Peninsula (Boulton et al. 2003; Lee 2008). Thinning of the freshwater lens and increasing groundwater salinity in the past has been attributed to periods of low rainfall, tidal influences and groundwater abstraction (Lee 2008). At risk groundwater ecosystems include ephemeral creeks and permanent soaks. Abstraction of groundwater and localised groundwater drawdowns have been recognised as risks since Exmouth was established in the 1960s. |
| Surface water systems | | M | Impacts have already occurred to surface water systems - many no longer in a 'natural' or 'pristine' state. PFAS have been detected in the backwater lagoon, east of the Harold E. Holt Naval Communication Base (DoD 2019). Some main river channels in the region have also been reported to be blocked with sand (McKenzie et al. 2002). |
| **AIR** | | | |
| Air quality | | H | No issues with air quality given the relatively small population and infrastructure. |
| **PEOPLE** | | | |
| **Social surroundings** | | | |
| Aboriginal heritage & culture | | | Not scored – needs Indigenous input. |
| National heritage | | M | Ningaloo Coast World Heritage Area has had some impacts to its Outstanding Value e.g., coral bleaching. |

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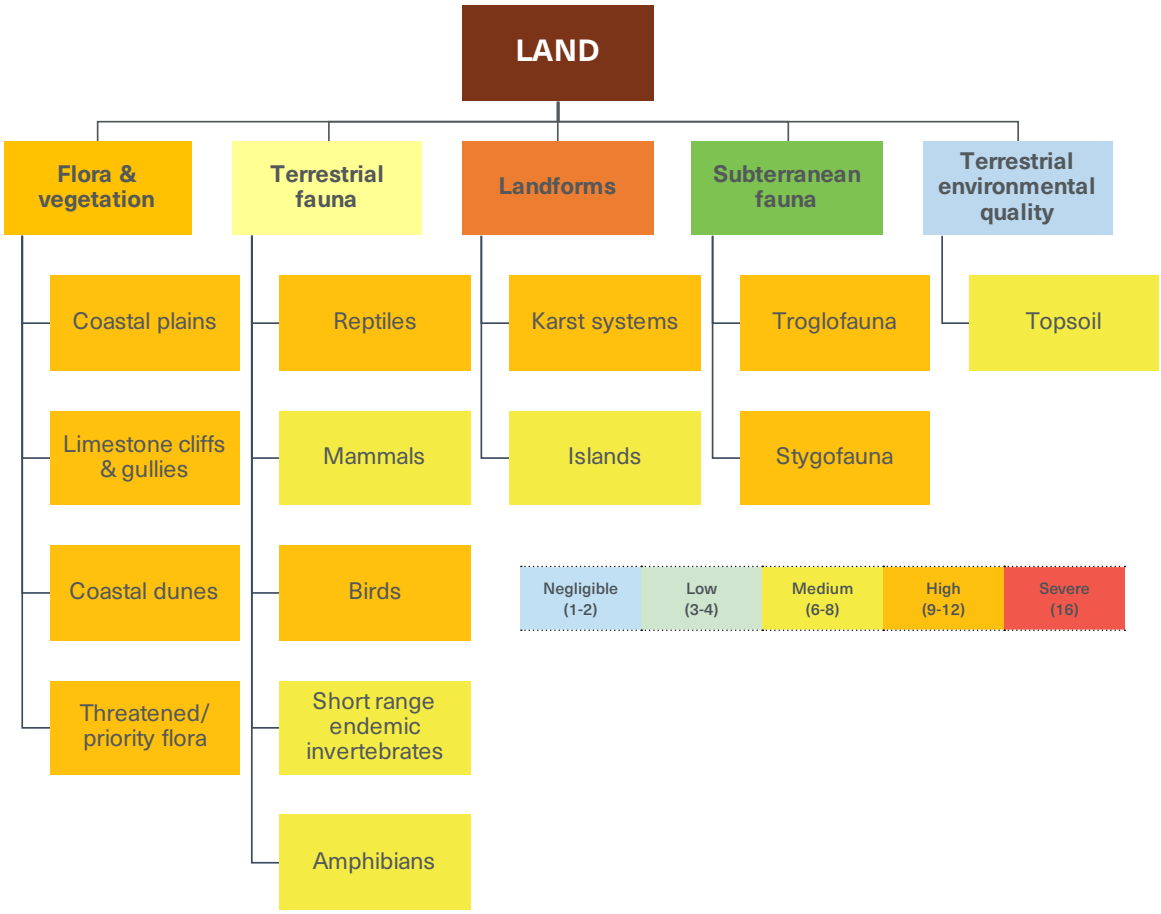
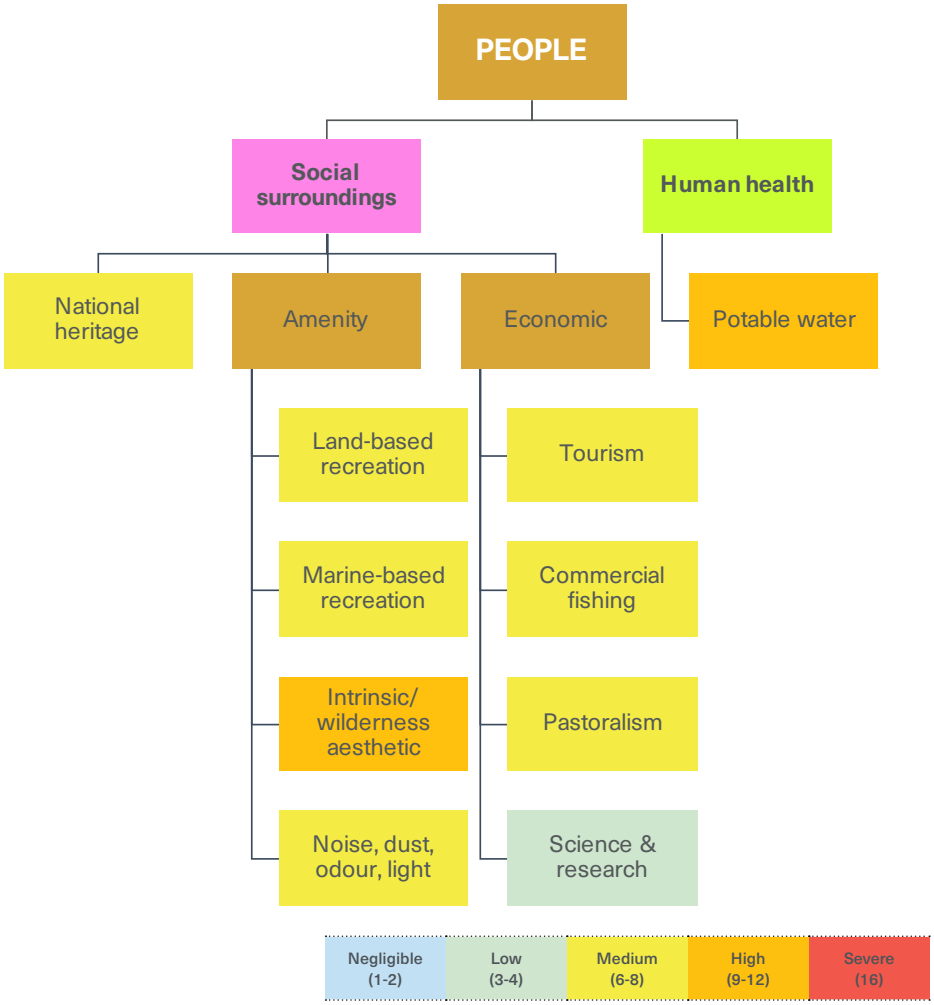
| Amenity - land-based recreation | | H | Many land-based recreational activities are currently occurring. |
| Amenity - marine based recreation | | H | Many marine-based recreational activities are currently occurring. |
| Amenity - intrinsic/wilderness aesthetic | | H | Exmouth is a major attraction for those people wanting the intrinsic/wilderness aesthetic. Some concerns over increased uses of Exmouth Gulf. Oil platforms seen from lighthouse and current industrial activities impact the sense of wilderness. COVID-19 saw increased numbers of tourists to Exmouth which impacted upon aesthetic (pers. comm.) |
| Amenity - noise, dust, odour, light | | H | All at relatively good levels. |
| Economic - tourism | | H | Tourism is significant source of economic stimulus (Shire of Exmouth 2018). |
| Economic - commercial fishing | | H | Prawn trawling has been impacted by past extreme events but has recovered (Loneragan et al. 2013). Managed by DPIRD and considered sustainable. |
| Economic - pastoralism | | | Uncertainty around current state. Pastoral stations are now offering accommodation and experiences to tourists. |
| Economic - science and research | | H | Has and is still being used as a key location for research. Currently, accommodation issues are inhibiting full research capacity. Minderoo Foundation Exmouth Research Laboratory is up and running to accommodate research. |
| **Human health** | | | |
| Potable water | | H | Shire is confident that enough potable water will be available for human use. The Shire commented that supplies were able to handle the influx of people during COVID-19 tourist influx. There are strong concerns over potable water availability and groundwater drawdown (pers. comm.). |

Appendix 4: A summary of the risks to Distinctive Values under the EPA themes (Sutton and Shaw, 2021). The highest risk scored across all six activities assessed was applied, rather than an average.






**Water**: Both ground water systems and surface water systems received a high risk from at least one pressure. For groundwater systems, the high risks came from potable water use in relation to Tourism/ visitation and potential contamination (by PFAS). Similarly, contamination also rated as a high risk for surface water systems. Most of the remaining pressures were scored as low risk to the two Distinctive Values, though some medium risks to these values were associated with Mining and Development.

**Air**: Air quality was the only Distinctive Value assessed under the Air theme, and negligible to low risks were assigned to emissions from Mining (industrial salt, potash and limestone operations) and Development pressures (residential and industrial), as well as the potential increase and intensity of fires associated with climate change.

Qualing Pool reeds. Wendy Thompson

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