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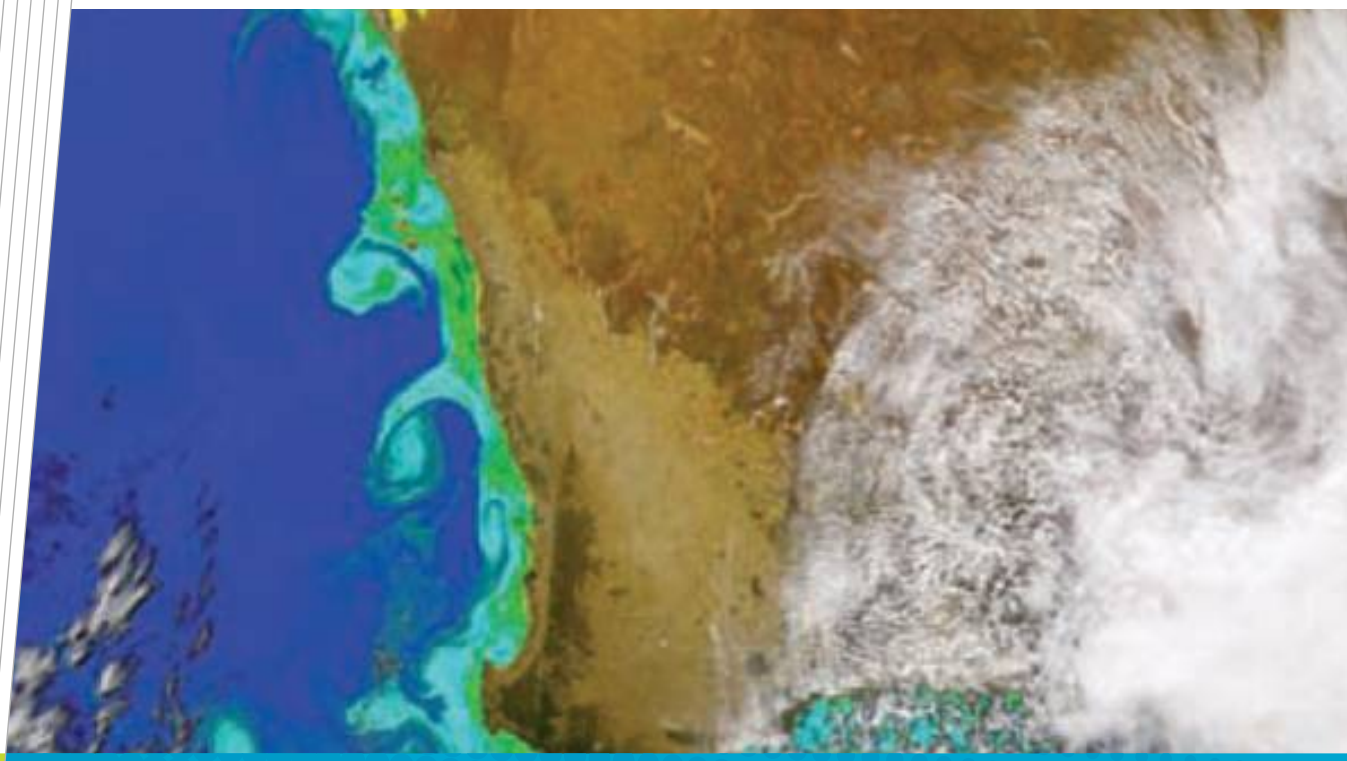

Project Summary: National Marine Ecological Indicators

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1 Introduction

1.1 Background and Approach to Project

In 2006 the Department of Water Heritage and Arts - now the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) - prepared an information paper for the Australian State of the Environment Committee, noting the lack of any systematic long-term national programs for monitoring and reporting on key features of Australia's oceans and coasts (http://www.environment.gov.au/soe/2006/publications/integrative/data/index.html). The information paper was supplemented by a national audit of indicators of marine health conducted by the Department, which concluded that while there was substantial literature available on theoretical frameworks and categories of indicators that could be monitored, there were no specific recommendations on which indicators should be used to best assess the health of marine ecosystems, and very little information on what quantitative data are available to support indicators. Fortunately, the amount and availability of data on marine ecosystems is rapidly increasing. Increased access to environmental data raises a number of important challenges, however, not least of which is the interpretation and subsequent use of the data to assess the health of marine ecosystems.

In August 2008 the CSIRO completed a twelve month pilot project designed to develop, test and recommend a method to identify ecological indicators in Australia's Exclusive Economic Zone (EEZ). The project examined a number of methods to identify indicators within the Driver-Pressure-State-Impact-Response (DPSIR) framework. The project concluded that the best method was process-based ecosystem modelling and subsequently adopted a qualitative modelling approach. Ecological indicators are identified as the biological, physical or chemical variables in these models that are predicted to respond to sets of possible pressures in a consistent and unambiguous manner.

The project also recommended a national approach for identifying, selecting and evaluating ecological indicators for Australia's Commonwealth marine environment (Figure 1.1). This framework emphasises:

- the use of transparent descriptions of our current understanding of the cause and effect relationships between multiple pressures acting on the ecosystem and the ecosystem's response;
- making, and subsequently testing, predictions about how the ecosystem will respond to pressures, thereby creating feedback between monitoring and research (e.g., where model predictions are inconsistent with monitoring data, the models can be revisited, and research questions focused on critical gaps in knowledge); and,
- representing our uncertainty about the important ecological interactions within an ecosystem, and capturing the effects of this uncertainty on model predictions.

Qualitative modelling is advantageous in this context because it quickly and transparently captures the understanding of a diverse set of stakeholders, provides testable hypothesis about how specific components and processes of the ecosystem respond to pressures, and enables management agencies to interpret trends in ecological indicators and ultimately improve their understanding of a system's behaviour by comparing observations with predictions.

Note that while cast within marine ecosystems, the national approach would be equally applicable to terrestrial ecosystems.

Figure 1.1: Flow chart summarising the recommended national approach for identifying, selecting and evaluating ecological indicators for Australia's Commonwealth marine environment. Inputs and processes in blue represent steps completed by DSEWPaC that were used by this project. Inputs and processes in orange represent steps completed in this project, while processes and outputs in green represent steps that were beyond the scope of the project and have yet to be completed.

1.2 Scope of Project

The scope of this project was to identify a national set of indicators of marine ecosystem health for the Commonwealth marine environment. The project applied the recommended national approach to: a) identify highly valued ecological features, together with the pressures that threaten them, within the south-west, north-west, north, east and south-east marine regions; b) map spatial patterns and intensity of pressures within Australia's EEZ; c) draw on expert knowledge and existing published information to document conceptual models of the ecological features, and how pressures interact with them; and, d) use qualitative modelling to identify ecological indicators. Reports submitted to SEWPaC document the development of ecological indicators for each marine region, and pressure mapping results. The project scope did not include design of monitoring programs, nor the measurement, assessment or reporting of indicators.

1.3 Input from Marine Bioregional Planning-Key Ecological Features

DSEWPaC through its marine bioregional planning process has identified conservation values in each marine regions. These values include species and heritage places that are protected under the Environment Protection and Biodiversity Conservation Act 1999, and Key Ecological Features (KEFs) in the Commonwealth marine environment. KEFs were used as foci for developing ecological indicators because they help to focus conservation, research and monitoring activities on the most valued ecological aspects of the marine environment. KEFs were identified by DSEWPaC based on advice from scientists about the ecological processes and characteristics within a region, and are valued for their exceptional productivity or biological diversity or both. They meet one or more of the following criteria:

- a species, group of species or a community with a regionally important ecological role (e.g., a predator or prey that affects a large biomass or number of other marine species);
- a species, group of species or a community that is nationally or regionally important for biodiversity
- an area or habitat that is nationally or regionally important because of high productivity, aggregations of marine life (such as feeding, resting, breeding or nursery areas) or high biodiversity and endemism; or,
- a unique sea floor feature with known or presumed ecological properties of regional significance.

The project systematically considered all KEFs proposed by DSEWPaC, and subsequently developed qualitative models for 31 KEFs (Table 1.1) that were then analysed to identify potential indicators (Figure 1.2).

The decision to develop and analyse qualitative models for a KEF was based on whether or not there was sufficient and documentable knowledge of the KEF's values, its physical and biological features, anthropogenic threats, and its ecological processes. This decision was made following an initial assessment by project staff from DSEWPaC and CSIRO, and then a more in-depth assessment by a panel of regional experts assembled by DSEWPaC. A total of 63 regional experts in oceanography and marine ecology were consulted in the course of this study. A concerted effort was also made to validate expert knowledge with published literature. The decision to not model a KEF does not bring into question the justification for the KEF itself, which can be substantiated on other grounds. Note also that the KEFs and their models are based on current knowledge, and this will be refined as new information becomes available.

Table 1.1: Key ecological features (KEFs) of Australia's Commonwealth marine environment. Numbers refer to KEFs in Figure 1.2 for which qualitative models were developed and analysed to identify ecological indicators; KEFs without numbers were not modeled.

Marine Region		Key Ecological Feature
North	1)	Gulf of Carpentaria Basin
	2)	Submerged Coral Reefs of the Gulf of Carpentaria
		Carbonate Bank and Terrace System of the Van Diemen Rise
		Gulf of Carpentaria Coastal Zone
		Pinnacles of the Bonaparte Basin
		Plateau and Saddle North-West of the Wellesley islands
		Shelf Break and Slope of the Arafura Shelf
		Tributary Canyons of the Arafura Depression
North West	3)	Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters
	4)	Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals
	5)	Seringapatam Reef and Commonwealth Waters in the the Scott Reef Complex
	6)	Commonwealth Waters Adjacent to Ningaloo Reef
		Ancient Coastline at 125 m Depth Contour
		Canyons Linking the Argo Abyssal Plain and Scott Plateau
		Canyons Linking the Cuvier Abyssal Plain and the Cape Range Peninsula
		Carbonate Bank and Terrace System of the Sahul Shelf
		Continental Slope Demersal Fish Communities
		Exmouth Plateau
		Glomar Shoals
		Pinnacles of the Bonaparte Basin
		Wallaby Saddle
South West	7)	Meso-Scale Eddies
	8)	Commonwealth Marine Environment Surrounding the Houtman Abrolhos Islands
	9)	Benthic Invertebrate Communities of the Eastern Great Australian Bight
	10)	Kangaroo Island Pool, Canyons and Adjacent Shelf Break, and Eyre Peninsula Upwellings
	11)	Small Pelagic Fish
	12)	Commonwealth Marine Environment Within and Adjacent to the West-Coast Inshore Lagoons
	13)	The Commonwealth Marine Environment Surrounding the Recherche Archipelago
	14)	Perth Canyon and Adjacent Shelf Break, and Other West Coast Canyons
	15)	Commonwealth Marine Environment Within and Adjacent to Geographe Bay
		Albany Canyon Group and Adjacent Shelf Break
		Ancient Coastline Between 90 and 120 m Depth
		Cape Mentelle Upwelling
		Demersal Slope and Associated Fish Communities of the Central Western Province
		Diamantina Fracture Zone
		Naturaliste Plateau
		Western Rock Lobster
South East	16)	East Tasmanian Subtropical Convergence Zone
	17)	Bass Cascade
	18)	Upwelling East of Eden
	19)	West Tasmania Canyons
	20)	Big Horseshoe Canyon
	21)	Seamounts South and East of Tasmania
	22)	Bonney Coast Upwelling
	23)	Shelf Rocky Reefs and Hard Substrate
East	24)	Tasman Front and Eddy Field
	25)	Norfolk Ridge
	26)	Lord Howe Seamount Chain
	27)	Elizabeth and Middleton Reefs
	28)	Reefs, Cays and Herbivorous Fishes of the Queensland Plateau
	29)	Reefs, Cays and Herbivorous Fishes of the Marion Plateau
	30)	Upwelling off Fraser Island
	31)	Shelf Rocky Reefs
		Canyons on the Eastern Continental Slope
		Tasmantid Seamount Chain

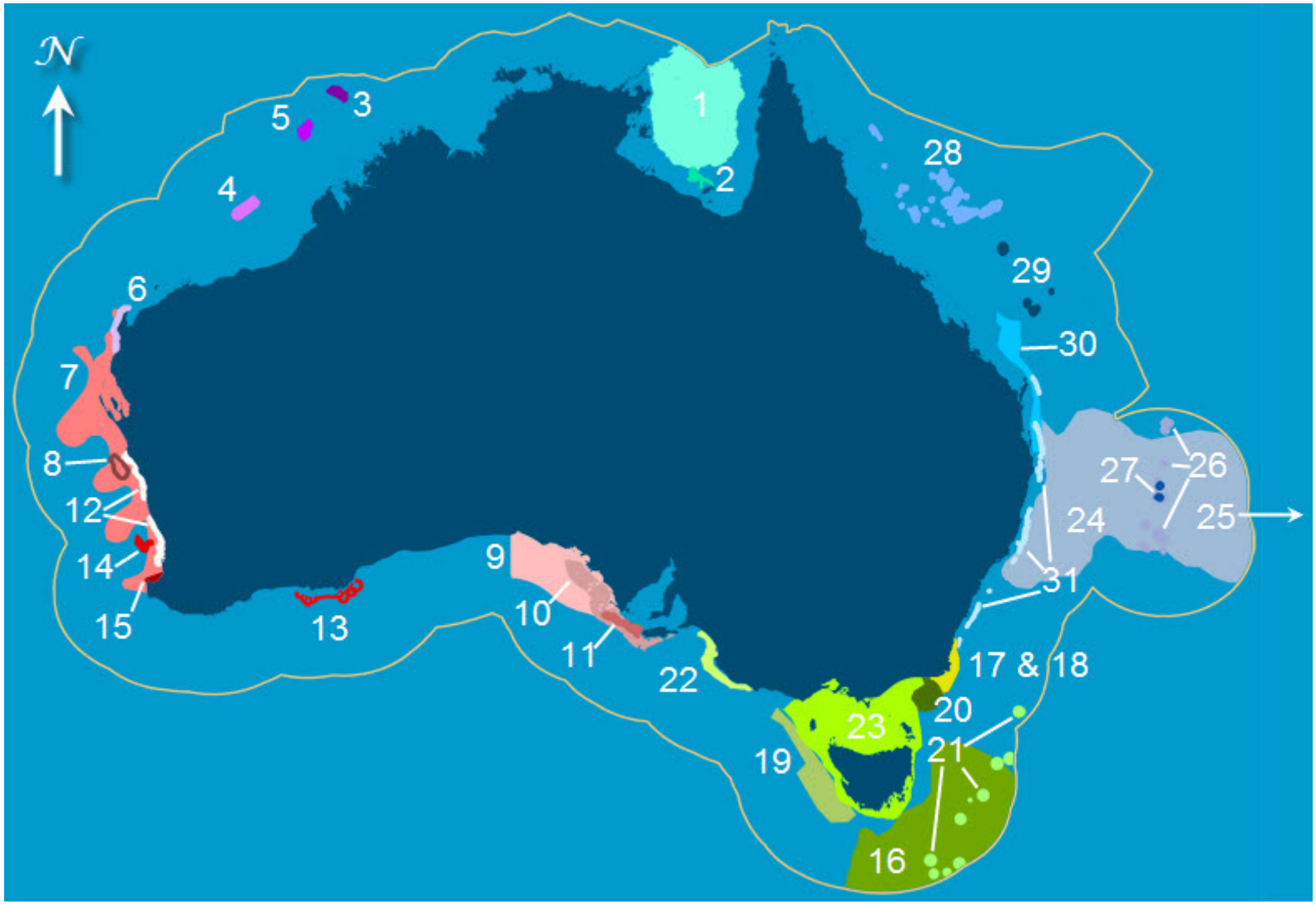


Figure 1.2: Key ecological features (KEFs) identified by DSEWPaC for which qualitative models were developed and analysed to identify ecological indicators for Australia's marine regions. KEFs are depicted in approximate spatial extent and form only. KEFs in each region are in a different monochromatic colour scheme, and numbers refer to KEF names listed in Table 1.1; KEF number 25 (Norfolk Ridge) is located in Commonwealth waters off-map to the east.

2 Key Findings

2.1 Indicators

Nationally, 15 pressures and 23 ecosystem indicators were identified (Table 2.1) from the 31 KEFs modelled and analysed in this project (Appendix 4). All of the ecological indicators can be measured via one or more of ten general methods or sampling platforms (Figure 2.1). The two most common methods are water column sampling (e.g. ship-based sampling of water chemistry or biota), and census via direct visual (i.e. diving) or video-based. Current or planned sampling by Australia's Integrated Marine Observing System (IMOS) will occur in 21 KEFs, 11 of which are valued for biodiversity and 19 for productivity (Figures 2.2a and 2.3a). Most of the indicators were common to multiple KEFs. Note that while multiple indicators were commonly identified for a KEF (i.e., on average seven per KEF), not all would be required in an effective and efficient monitoring program.

The most frequent category of ecological indicators for biodiversity valued KEFs was coral, followed by predatory fishes and invertebrates (Figures 2.2c). For productivity valued KEFs, predatory fishes were the most frequent indicator, followed by nutrients and plankton (Figure 2.3c). Across both types of KEFs, predatory fishes, coral and invertebrates were within the top five most-frequent indicators. Between them, these three indicators were associated with 22, or 71%, of the KEFs analysed. While predatory fishes were commonly identified as potential indicators, other large bodied animals such as whales, dugongs and turtles, were infrequently identified.

The ecological indicators identified by this method were designed to be informative across a range of potential environmental and anthropogenic pressures. Monitoring these indicators will support DSEWPaC to provide evidence-based statements at a national level on trends in biodiversity, productivity and threats to biodiversity and productivity, for State of the Environment reporting.

2.2 Key Ecological Features

A total of 58 KEFs were submitted by DSEWPaC for consideration by this project; of these 27 were not developed or analysed with qualitative models. The most common reason to not model a KEF was insufficient knowledge, which was especially the case for KEFs that were based on unique sea floor features, but where knowledge of ecosystem structure and function was lacking. Two KEFs (Commonwealth waters adjacent to Quondong Point, and Commonwealth waters adjacent to the Head of the Bight) were not modelled because they were refuted during expert elicitation workshops, which was reported to DSEWPaC. One new KEF (upwelling off Fraser Island) was proposed during the workshops and subsequent to DSEWPaC's consideration, was analysed by qualitative modelling.

Of the 31 KEFs modelled and analysed in this project, 5 were valued exclusively for their biodiversity, 12 for their productivity, and 14 for both their biodiversity and productivity (Figure 2.4). KEFs valued for their biodiversity were typically ecosystems in benthic habitats, with none in pelagic habitats (Figure 2.2a), while pelagic or bentho-pelagic habitats were associated with nearly half of the KEFs that were valued for productivity (Figure 2.3a). There were twice as many KEFs in temperate waters as in tropical waters for both biodiversity and productivity valued KEFs (Figures 2.2a and 2.3a).

Table 2.1: National set of pressures and ecological indicators for Australian commonwealth waters; the 23 general categories of indicators were combined from a more detailed list of 60 distinct indicators.

Pressures	Ecosystem indicator
1. Acidification	1. Algae
2. Aquaculture	2. Bacteria
3. Change in currents	3. Bioturbators
4. Change in upwelling	4. Blue whales
5. Change in winds	5. Coral
6. Disease	6. Demersal fishes
7. Fishing	7. Dugongs
8. ilegal fishing	8. Filter feeders
9. Marine debris	9. Habitat feature
10. Ocean temperature	10. Herbivorous fishes
11. Oil spills	11. Invertebrates
12. Sea level	12. Invertivorous fishes
13. Seals	13. Mid-sized predators
14. Storm intensity	14. Nutrients
15. Terrestrial runoff	15. Oceanographic feature
	16. Planktivorous fishes
	17. Plankton
	18. Predatory fishes
	19. Seabirds
	20. Seagrass
	21. Small pelagic fishes
	22. Turtles
	23. Whale carcasses

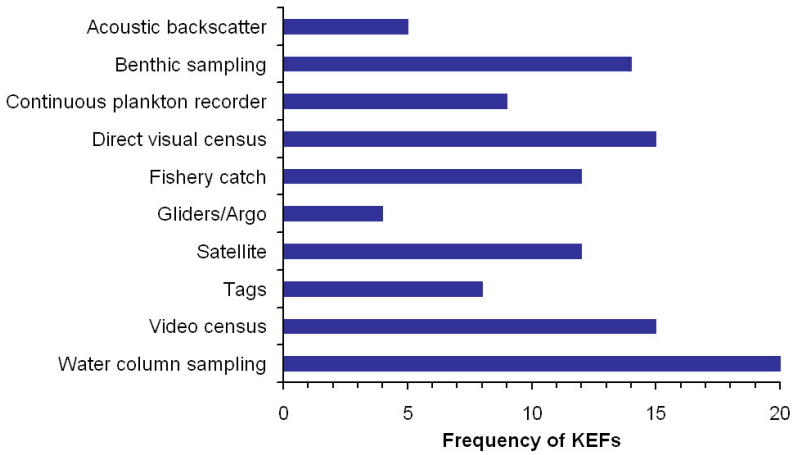
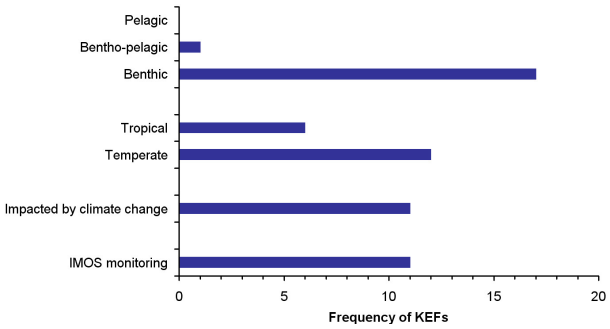
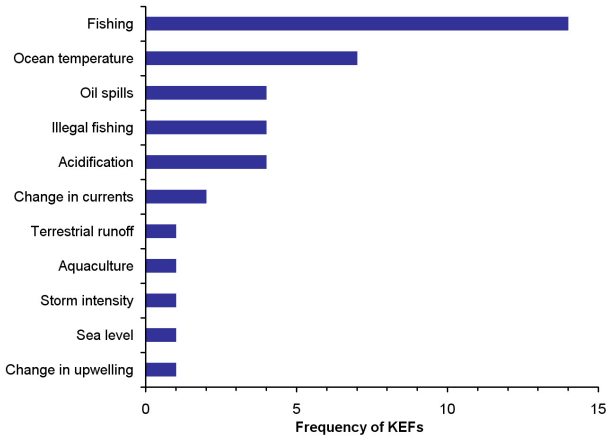


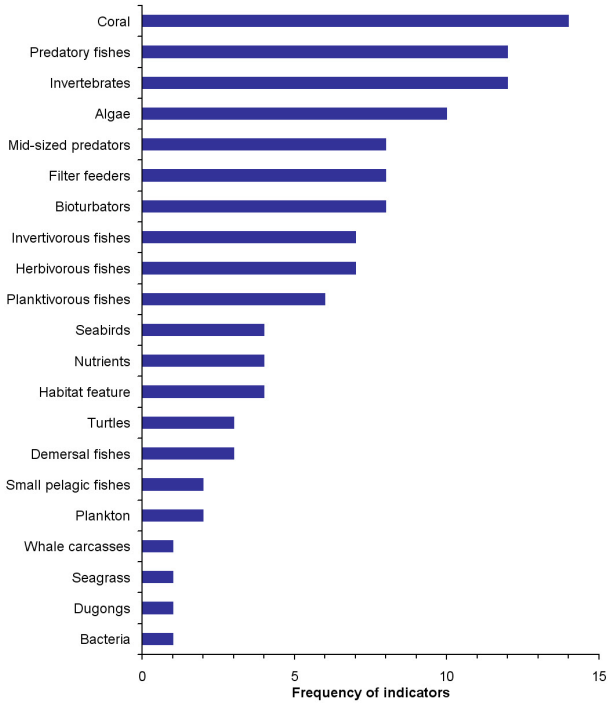
Figure 2.1: General methods that can be applied to the monitoring of KEFs.



(a) Characteristics of KEFs valued for biodiversity

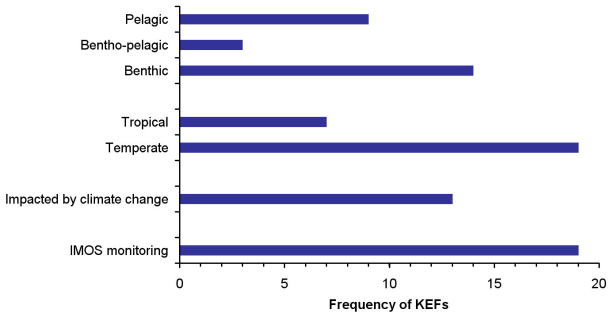


(b) Pressures on KEFs valued for biodiversity

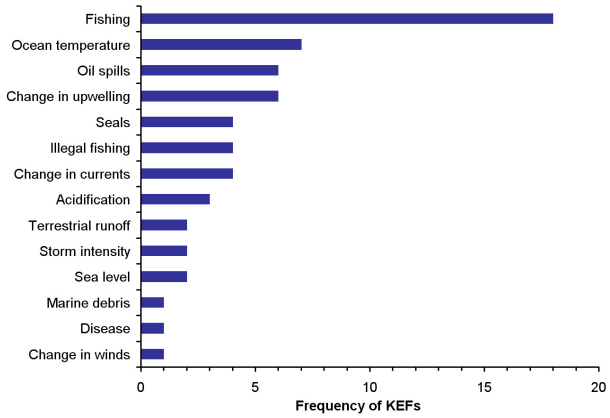


(c) General categories of indicators for KEFs valued for biodiversity

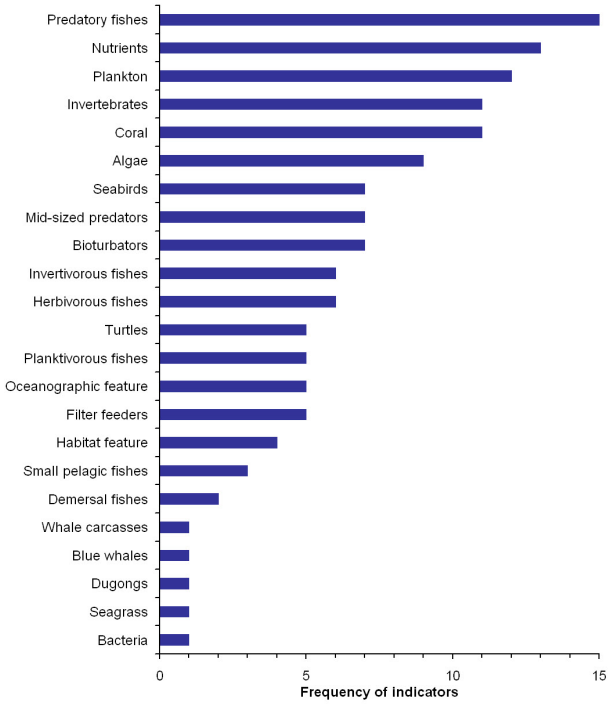
Figure 2.2: Summary of key ecological features (KEFs) valued for biodiversity.



(a) Characteristics of KEFs valued for productivity

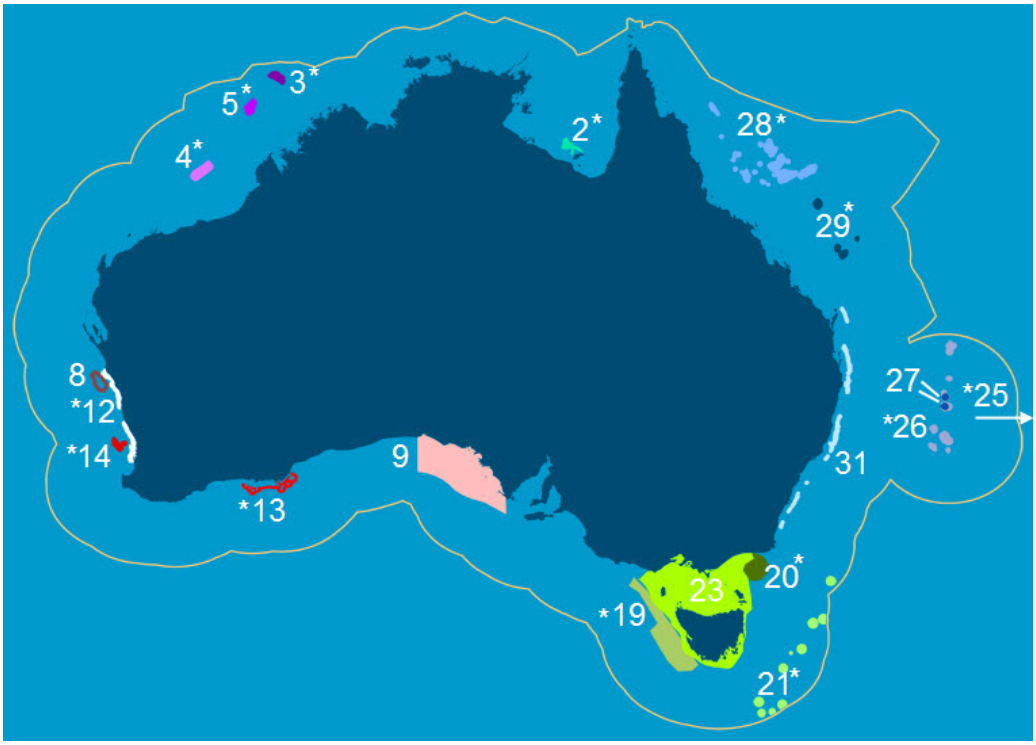


(b) Pressures on KEFs valued for productivity

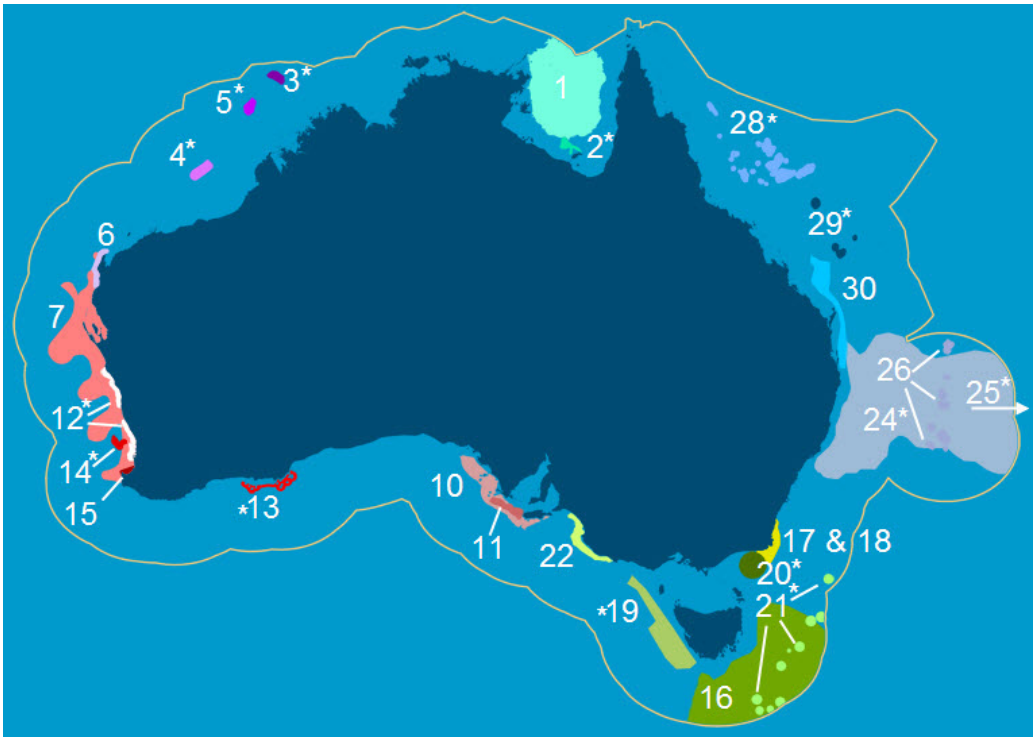


(c) General categories of indicators for KEFs valued for productivity

Figure 2.3: Summary of key ecological features (KEFs) valued for productivity.



(a) KEFs valued for biodiversity



(b) KEFs valued for productivity

Figure 2.4: Key ecological features (KEFs) identified by DSEWPaC that are valued for (a) biodiversity and (b) productivity. Numbers refer to KEF names listed in Table 1.1, and those with an asterisk are valued for both productivity and biodiversity; KEF number 25 (Norfolk Ridge) is located in commonwealth waters off-map to the east.

2.3 Pressures and pressure maps

Pressure maps were used to constrain the set of plausible or suspected pressures acting upon KEFs to a sub-set of documented pressures, and to show the relative intensity of human activity at a national scale. They served as an important prerequisite to identification of ecological indicators within the DPSIR framework, because this framework presumes knowledge of the human drivers and subsequent pressures, together with the cumulative impact that these pressures have upon the environment. During the course of this project 30 federal and state agencies were contacted, and over 3600 individual files were eventually collated, analysed, grouped and mapped. Each of ten human-induced pressures was mapped separately. A cumulative-pressure map (Figure 2.5) was also produced to show a combined intensity of human-induced pressures in Australian commonwealth waters. Key results of the pressure mapping exercise include identification of the highest intensity of fishing operations to be along the east coast shelf and the southern portion of the west coast shelf.

Of the 15 pressures identified during the modelling workshops, seven were associated with climate change (i.e. acidification, increasing ocean temperature, change in upwelling, change in currents, increasing storm intensity, sea level rise, and change in winds). Over 60% of KEFs were acted on by one or more of the climate change pressures (Figures 2.2a and 2.3a). The most common pressure on KEFs was fishing (recreational and commercial combined), followed by ocean temperature and oil spills. This is true for biodiversity and productivity valued KEFs (Figures 2.2b and 2.3b).

2.4 KEFs, indicators and ecosystem health

KEFs represent those components and processes of ecosystem that are most highly valued. In this project they serve as a bridge that links science to relevant laws, policies and generally held social-based values about the abundance and diversity of life, and thereby ensure that the ecosystem health indicators are relevant to society. KEFs act as a fundamental unit of inquiry that can focus diverse scientific disciplines at a commensurate and practical level of physical and biological scale. Once identified, KEFs were defined in a dialectical process at the relevant scale in which they exist, function, and could be observed and measured. They therefore provide a clear context and bound around what otherwise can be ambiguously defined and highly complex ecological systems.

KEFs do not represent a systematic evaluation of all the components and processes of Australia's EEZ, although in many cases they are manifestations of what are considered to be the most important components and processes. By adopting a KEF-centric approach to indicators, the project cannot guarantee that all the process and components that contribute to a "healthy ecosystem" (however this is defined) have been considered. KEFs are, however, adaptable and additional ones can be developed if there is evidence to suggest a serious omission, as occurred during this project with the upwelling off Fraser Island.

Taken together, KEFs can be used to effectively guide and prioritise the distribution of monitoring resources across the vastness of Australia's EEZ. Moreover, KEFs provided a practical means to approach marine ecosystems across the entire EEZ of Australia, and they have proved to be an efficient organising principle by which to construct ecological models and identify indicators within a relatively short time-frame.

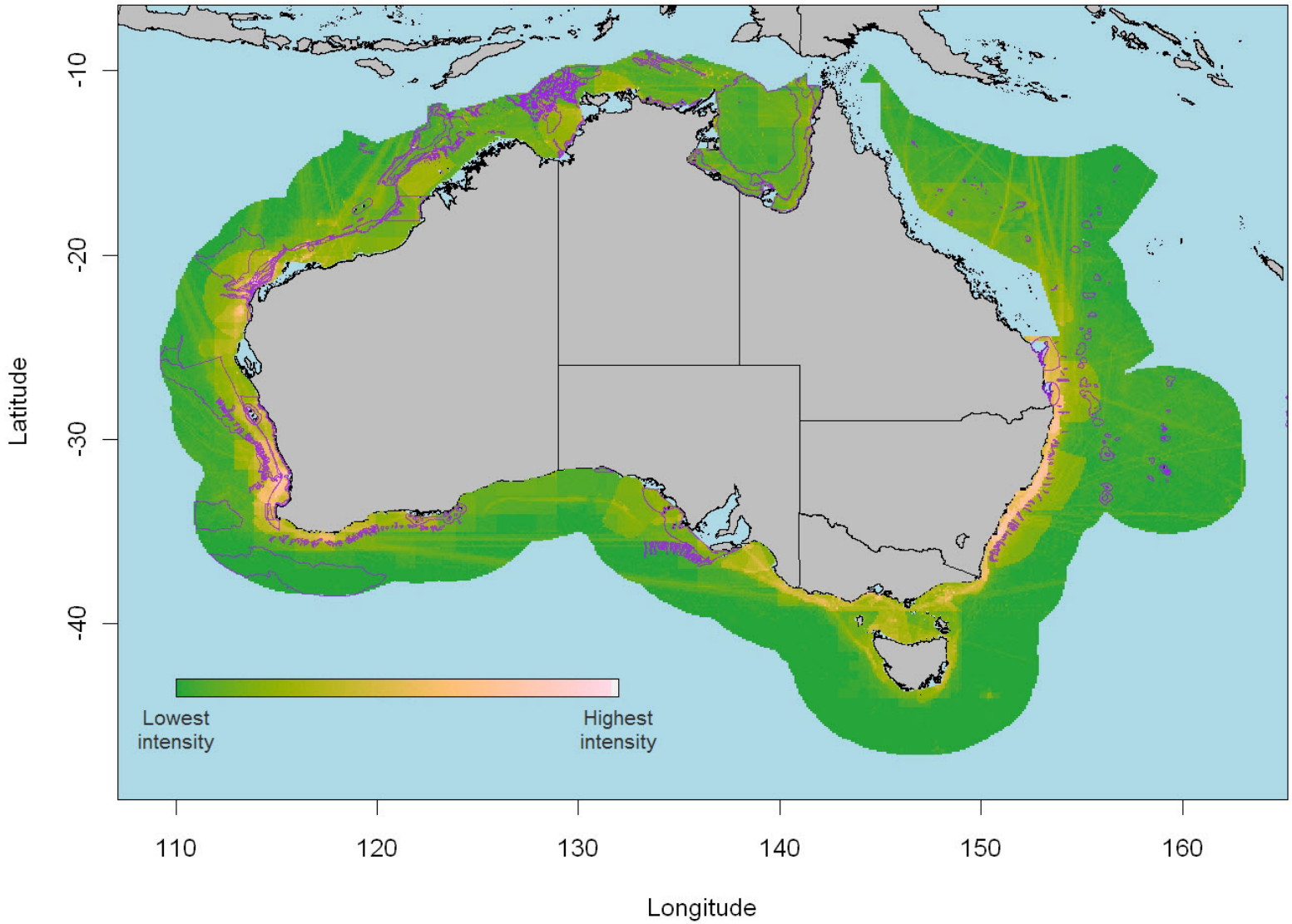


Figure 2.5: Cumulative pressure map for Australian commonwealth waters; includes combined human-induced pressures from commercial and recreational fishing, underwater pipelines and wells, shipping traffic, sea dumping sites, military exercise areas, seismic surveys, licensed aquaculture sites, documented illegal fishing, and ship-related oil or chemical spills.

3 Opportunities for the Future

3.1 Knowledge Gaps and Recommendations

This project has synthesized the knowledge of Australia's marine environment, as perceived through the lens of KEFs. For many KEFs (27), however, there was insufficient knowledge of their physical and biological features and ecological processes. This was especially the case in the North and North-west marine regions, and also for bathyl habitats, most notably submarine canyons.

During the pressure mapping exercise it became clear that climate change metrics are sensitive to the starting date chosen for comparison, and that the distribution of marine debris and invasive species in commonwealth waters is not currently known. Such data would aid monitoring activities associated with KEFs. There was also an identified need for a more timely collation of fisheries data, and for state and Commonwealth fisheries to report on similar spatial scales.

This project recommends:

- focused surveys and research is needed on basic biological components and ecological processes of poorly understood KEFs in the North and North-west marine regions;
- additional research to understand ecological relationships within sessile invertebrate communities and their relative susceptibility to disturbance;
- management agencies liaise with climate scientists over an appropriate start-date for climate change metrics;
- management agencies develop a better understanding of the distribution of marine debris and invasive species in commonwealth waters; and,
- the spatial scale of State and Commonwealth fisheries data are harmonised.

3.2 Opportunities for the Next Steps of the National Approach

This project followed the national approach (Figure 1.1) to identify ecological indicators for Australia's marine ecosystems, and in so doing, has laid the groundwork for more effective State of the Environment reporting. Next steps in the national approach include developing and implementing effective and efficient monitoring programs, and collation and analysis of existing and ensuing data.

Three current Australian Government initiatives offer real opportunities to progress the next steps in the national approach and address some of the recommendations made by this project. The National Environment Research Program (NERP) Marine Biodiversity Hub is investing approximately $29.6M in marine research over the next four years. The Australian IMOS is investing approximately $52M in marine biological and physical observation infrastructure over the next 3 years. The National Plan for Environmental Information (NPEI), a multi-million dollar initiative with on-going funding, is investing $18M over the next 3 years to bring together all our efforts in national environmental information (including marine), to build and maintain this critical information infrastructure for the future. To this end, the national approach set forth in this project has made the following opportunities more readily available:

- develop a national-level monitoring program, collate and analyse data through the NERP Marine Biodiversity Hub. The structure of such monitoring of indicators for KEFs, and the pressures that threaten them, is currently being developed through NERP;

- increase understanding of KEFs through the NERP Marine Biodiversity Hub. A survey to Northern Australia with part of its focus on poorly known KEFs is being planned through the NERP;
- coordinate increased monitoring of biological indicators through IMOS. IMOS is currently expanding its deployment of biological observation infrastructure and actively seeking advice on location of monitoring sites; and,
- inform the marine component of NPEI. The national priorities for the NPEI are in the process of being identified and the Bureau of Meteorology is conducting a marine-focussed pilot to demonstrate how the NPEI might function.

4 Acknowledgements

We thank our DSEWPaC collaborators Chris Marshall, Paul Hedge, Michaela Guest, Bianca Priest, Danielle Thomson, and Andrew Zacharek for their thoughtful guidance and advice throughout the lifetime of this project. This work is based on the wealth of knowledge that was generously offered during workshops and consultations. Without it this endevour could scarcely have been possible; for this we are grateful and thank the following for their many contributions: Francis Althaus (CSIRO Marine and Atmospheric Research), Russ Babcock (CSIRO Marine and Atmospheric Research), Neville Barret (University of Tasmania), Nic Bax (CSIRO Marine and Atmospheric Research), Lars Bedjar (Murdoch University), Steve Blaber (CSIRO Marine and Atmospheric Research), Barry Bruce (CSIRO Marine and Atmospheric Research), Chris Burton (Western Whale Research), Rodrigo Bustamante (CSIRO Marine and Atmospheric Research), Alan Butler (CSIRO Marine and Atmospheric Research), Dani Ceccarelli (Marine Ecology Consultant), Howard Choat (James Cook University), Scott Condie (CSIRO Marine and Atmospheric Research), David Curry (South Australian Research and Development Institute), Malcolm Dunning (Queensland Primary Industries and Fisheries), Piers Dunstan (CSIRO Marine and Atmospheric Research), Mike Emslie (James Cook University), Phillip England (CSIRO Marine and Atmospheric Research), Meng Feng (CSIRO Marine and Atmospheric Research), Kim Friedman (WA Department of Environment and Conservation), Dan Gaughan (WA Department of Fisheries), Simon Goldsworthy (South Australian Research and Development Institute), Nicholas Graham (James Cook University), David Griffin (CSIRO Marine and Atmospheric Research), Mick Guinea (Charles Darwin University), Norman Hall (Murdoch University), Peter Harrison (Southern Cross University), Andrew Heyward (Australian Institute of Marine Science), Alistair Hobday (CSIRO Marine and Atmospheric Research), Greg Ivey (University of Western Australia), Alan Jordan (NSW Department of Environment, Climate Change and Water), Cath Kemper (South Australia Museaum), Gary Kendrick (University of Western Australia), Rudy Kloser (CSIRO Marine and Atmospheric Research), Matt Koopman (Queensland Department of Environment and Resource Management), James Larcombe (Australian Bureau of Rural Sciences), Colin Limpus (Queensland Environmental Protection Agency), Vince Lyne (CSIRO Marine and Atmospheric Research), Hamish Malcolm (NSW Marine Parks Authority), Rory McAuley (WA Department of Fisheries), Jessica Meeuwig (University of Western Australia), Stephen Newman (WA Department of Fisheries), Tim O'Hara (Museum Victoria), Peter Oke (CSIRO Marine and Atmospheric Research), Nicola Patrick (Rottnest Island Authority), Chari Pattiaratchi (University of Western Australia), Adele Pile (University of Sydney), Bob Prince (WA Department of Environment and Conservation), Jeremy Prince (Biospherics), Ken Ridgway (CSIRO Marine and Atmospheric Research), Anthony Roelofs (Queensland Department of Fisheries), Peter Rothlesberg (CSIRO Marine and Atmospheric Research), Chris Simpson (WA Department of Environment and Conservation), Hugh Sweatman (Australian Institute of Marine Science), Peter Thompson (CSIRO Marine and Atmospheric Research), Ron Thresher (CSIRO Marine and Atmospheric Research), Jim Underwood (University of Western Australia), Anya Waite (University of Western Australia), Tim Ward (South Australian Research and Development Institute), Trevor Ward (Greenward Consulting), Fred Wells (WA Department of Fisheries), Alan Williams (CSIRO Marine and Atmospheric Research), and Jock Young (CSIRO Marine and Atmospheric Research).

Appendices

Table .1: Ecological indicators for key ecological featues of Australian commonwealth waters.

Marine Region		Key Ecological Feature/Ecological Indicator
North	1)	Gulf of Carpentaria Basin
		Invertebrates
	2)	Submerged Coral Reefs of the Gulf of Carpentaria
		Algae
		Coral
		Herbivorous fishes
		Predatory fishes
		Small pelagic fishes
North West	3)	Ashmore Reef and Cartier Island and Surrounding Commonwealth Waters
		Algae
		Bacteria
		Bioturbators
		Coral
		Dugongs & turtles
		Herbivorous fishes
		Invertebrates
		Mid-sized predators
		Nutrients
		Planktivorous fishes
		Predatory fishes
		Seabirds
		Seagrass
	4)	Mermaid Reef and Commonwealth Waters Surrounding Rowley Shoals
		Algae
		Bioturbators
		Coral
		Herbivorous fishes
		Invertebrates
		Invertivorous fishes
		Mid-sized predators
		Nutrients
		Planktivorous fishes
		Predatory fishes
	5)	Seringapatam Reef and Commonwealth Waters in the the Scott Reef Complex
		Algae
		Bioturbators
		Coral
		Herbivorous fishes
		Invertebrates
		Invertivorous fishes
		Mid-sized predators

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Marine Region	Key Ecological Feature/Ecological Indicator
	Nutrients
	Planktivorous fishes
	Predatory fishes
	6) Commonwealth Waters Adjacent to Ningaloo Reef
	Plankton
South West	7) Meso-Scale Eddies
	Nutrients
	Oceanographic feature
	Plankton
	8) Commonwealth Marine Environment Surrounding the Houtman Abrolhos Islands
	Coral
	Invertebrates
	Seabirds
	Small pelagic fishes
	9) Benthic Invertebrate Communities of the Eastern Great Australian Bight
	Filter feeders
	10) Kangaroo Island Pool, Canyons and Adjacent Shelf Break, and Eyre Peninsula Upwellings
	Nutrients
	Plankton
	Seabirds
	Small pelagic fishes
	11) Small Pelagic Fish
	Nutrients
	Plankton
	Seabirds
	Small pelagic fishes
	12) Commonwealth Marine Environment Within and Adjacent to the West-Coast Inshore Lagoons
	Algae
	Filter feeders
	Invertebrates
	Invertivorous fishes
	Predatory fishes
	13) The Commonwealth Marine Environment Surrounding the Recherche Archipelago
	Algae
	Filter feeders
	Invertebrates
	Invertivorous fishes
	Predatory fishes
	14) Perth Canyon and Adjacent Shelf Break, and Other West Coast Canyons
	Filter feeders
	Mid-sized predators
	Predatory fishes
	Whale carcasses
	15) Commonwealth Marine Environment Within and Adjacent to Geographe Bay
	Invertebrates

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Marine Region	Key Ecological Feature/Ecological Indicator
	Predatory fishes
South East	16) East Tasmanian Subtropical Convergence Zone
	Nutrients
	Oceanographic feature
	Plankton
	Predatory fishes
	17) Bass Cascade
	Nutrients
	Oceanographic feature
	Plankton
	Predatory fishes
	18) Upwelling East of Eden
	Nutrients
	Oceanographic feature
	Plankton
	Predatory fishes
	19) West Tasmania Canyons
	Bioturbators
	Coral
	Filter feeders
	Habitat feature
	20) Big Horseshoe Canyon
	Bioturbators
	Coral
	Filter feeders
	Habitat feature
	21) Seamounts South and East of Tasmania
	Coral
	Mid-sized predators
	Plankton
	22) Bonney Coast Upwelling
	Blue whales
	Nutrients
	Oceanographic feature
	Plankton
	23) Shelf Rocky Reefs and Hard Substrate
	Coral
	Demersal fishes
	Filter feeders
	Invertebrates
East	24) Tasman Front and Eddy Field
	Nutrients
	Plankton
	Seabirds
	Turtles

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Marine Region	Key Ecological Feature/Ecological Indicator
	25) Norfolk Ridge
	Algae
	Coral
	Demersal fishes
	Invertebrates
	Plankton
	Predatory fishes
	26) Lord Howe Seamount Chain
	Coral
	Demersal fishes
	Invertebrates
	Predatory fishes
	27) Elizabeth and Middleton Reefs
	Algae
	Bioturbators
	Coral
	Herbivorous fishes
	Invertebrates
	Invertivorous fishes
	Mid-sized predators
	Planktivorous fishes
	Predatory fishes
	28) Reefs, Cays and Herbivorous Fishes of the Queensland Plateau
	Algae
	Bioturbators
	Coral
	Habitat feature
	Herbivorous fishes
	Invertebrates
	Invertivorous fishes
	Mid-sized predators
	Planktivorous fishes
	Predatory fishes
	Seabirds
	Turtles
	29) Reefs, Cays and Herbivorous Fishes of the Marion Plateau
	Algae
	Bioturbators
	Coral
	Habitat feature
	Herbivorous fishes
	Invertebrates
	Invertivorous fishes
	Mid-sized predators
	Nutrients

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Marine Region	Key Ecological Feature/Ecological Indicator
	Planktivorous fishes
	Predatory fishes
	Seabirds
	Turtles
	30) Upwelling Off Fraser Island
	Nutrients
	Plankton
	Seabirds
	Turtles
	31) Shelf Rocky Reefs
	Filter feeders

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