

Marine Vertebrate Conservation (including Threatened and Protected Species)

Submission for National Marine Science Plan, White paper submissions for Biodiversity Conservation and Ecosystem Health

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Abstract

A diverse range of important and endemic marine vertebrate species occurs in Australia's vast marine area. Australian scientists produce significant proportions of global research on marine vertebrates, and are internationally recognised leaders in some fields including conservation and management. Many end-users require this knowledge, but relatively few species have been studied sufficiently to determine their conservation status hence data deficiency is a major problem for management. Key science needs include improved taxonomic, distribution, demographic and trend data from long-term funded programs, improved threat mitigation to ensure sustainability, and development of national marine vertebrate science hub(s) to co-ordinate and integrate future research.

Background

An extraordinary diversity of marine vertebrate species occurs in Australia's vast >10 million km² marine territorial sea and EEZ and Australian Antarctic Territory waters, which encompass shallow coastal to deep ocean ecosystems from tropical to polar latitudes. Major marine vertebrate groups include chondrichthyans (sharks, rays, chimaeras), bony fishes, marine reptiles, seabirds (petrels, albatrosses, sulids, gulls, terns and shags) and marine mammals. The numbers of species within each group occurring in Australia's marine waters and numbers of nationally listed threatened species (and subspecies) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are summarised in Table 1. The total numbers of species are uncertain for some marine vertebrate groups, particularly marine Actinopterygii where a comprehensive list of species is not available for all Australian marine waters. Estimates in 2009 included 4807 marine Actinopterygii species listed in the four main databases (AFD+CAAB+OZCAM+OBIS – see Realisation section, eliminating the majority of duplicate records), to 4949 'anticipated known' species and species described but not yet included in those databases (Butler et al. 2010). Furthermore, many other fish species require full descriptions e.g. 21% of the almost 1500 deepwater demersal fish species analysed by Last et al. (2005) in their validation of national demersal fish datasets did not have full scientific names and many were considered likely to be new to science. Some of Australia's marine vertebrates are also listed as marine species and/or as migratory species under the EPBC Act. Listed threatened species (Vulnerable, Endangered and Critically Endangered, but not Conservation Dependent species) and listed migratory species are protected as matters of National Environmental Significance (NES) under the EPBC Act that provides a higher level of protection and require assessment of activities to avoid significant impacts.

Australia is a biodiversity hotspot for many marine groups including vertebrates (Table 1), with high levels of endemism evident in some groups. For example, Australia is a recognised global centre of chondrichthyan biodiversity with about 323 described species, 51% of which are endemic. Six of the world's seven marine turtle species occur in Australian waters, and there are 11 endemic species among the 35 sea snake species recorded from Australian waters, which represents more than half of the world's >60 described species. A large number and variety of seabird species breed on the Australian mainland or its islands including a number of endemic species. Australia also supports the world's largest colonies of little penguin and short-tailed shearwater (estimated 11.5 million pairs of short-tailed shearwater in Tasmania alone). In addition, a number of endangered seabirds that breed elsewhere, forage in Australian waters. For marine mammals, Australia is the recognised stronghold for the sirenian dugong, pinnipeds include the endemic Australian sea lion and nine other pinniped species (plus vagrant New Zealand sea lion records) among the world's 33 extant pinniped species,

and 47 (52%) of the world's 89 extant cetacean species are recorded from Australian waters, including two near-endemic inshore dolphin species.

Table 1. Marine vertebrate groups in Australia's marine area, species count or estimate for each group, and EPBC Act listed threatened marine species and subspecies

| Marine Group | Species | Source | Vulnerable | Endangered | Critically Endangered | Conservation Dependent |
|-------------------------------|---------------|-------------------------|------------|------------|-----------------------|------------------------|
| Agnathans | 4 | Butler et al. (2010) | | | | |
| Chondrichthyans | 323 | White and Kyne (2010) | 5 | | 2 | 3 |
| Bony fishes Actinopterygii | 4807- 4949 | Butler et al. (2010) | 2 | | 2 | 3 |
| Reptiles | | Butler et al. (2010) | | | | |
| Turtles | 6 | | 3 | 3 | | |
| Sea snakes | 35 | | | | 2 | |
| Crocodile | 1 | | | | | |
| Seabirds | 155 | Butler et al. (2010) | 23 | 9 | 2 | |
| Mammals | | Woinarski et al. (2014) | | | | |
| Dugong | 1 | | | | | |
| Pinnipeds | 10 | | 3 | | | |
| Cetaceans | 47 | | 3 | 2 | | |
| Total species | ~5,532 | | 39 | 14 | 8 | 6 |

Marine vertebrates include ecologically important predators that help maintain ecosystem health and resilience and are sentinels for the condition of large and complex marine ecosystems. For example, dugongs and seagrass communities, baleen whales and the Southern Ocean ecosystem, while some larger bony fish and sharks, seabirds, pinnipeds and dolphins and toothed whales are important higher trophic level or apex predators including some central placed foragers and other species that range widely throughout Australian and international waters. Marine vertebrates are also important for diverse cultural, economic and other reasons to a wide range of community groups including Aboriginal or Torres Strait Islanders, the ecotourism industry, and commercial and recreational fishers, while whaling and sealing were historically important commercial drivers during the early stages of European settlement. Some fish, marine turtles, seabirds, the dugong, pinnipeds and cetaceans are iconic marine megafauna, and are important flagships for marine conservation and management efforts within Australia and internationally.

Institutions: A wide range of Australian institutions (Universities, Research Agencies, Museums, Government Departments etc.) undertake research on marine vertebrates and conservation, with long-term research programs continuing at some of these institutions over many decades. Using Web of Science (WoS) searches for publications on different marine vertebrate groups over the past ten years (2004-2013) as a proxy (albeit imperfect) for more recent research on these vertebrate groups, the following trends were evident:

- 61 Australian institutions contributed to publications on shark conservation (Topic=shark AND conservation AND Address=Australia).
- 83 Australian institutions contributed to publications on marine fish conservation (Topic=marine AND fish* AND conservation AND Address=Australia).
- 34 Australian institutions contributed to publications on marine turtle conservation (Topic=marine AND turtle AND conservation AND Address=Australia).
- 36 Australian institutions contributed to publications on seabird conservation (Topic=seabird AND conservation AND Address=Australia).

- 43 Australian institutions contributed to publications on marine mammal conservation (Topic=marine AND mammal AND conservation AND Address=Australia).
- 30 Australian institutions (23 universities, 5 research agencies and 2 museums) each contributed to more than 1% of publications in the field of marine vertebrate conservation from 2004 to 2013.

Australian institutions included on at least 5% of publications for one or more of these marine vertebrate groups were James Cook University (all 5 vertebrate groups), CSIRO (5), University of Tasmania (5), University of Queensland (3), Australian Antarctic Division (2), AIMS (2), Australian National University (2), Charles Darwin University (2), Deakin University (2), Macquarie University (2), University of Adelaide (2), University of Western Australia (2), Flinders University (1), Monash University (1), Murdoch University (1), Queensland Government Department of Environment and Heritage Protection (1), SARDI (1), and University of Canberra (1 vertebrate group).

There is no nationally coordinated list of researchers who work on marine vertebrates so the total number of research scientists currently involved in research on marine vertebrates in Australia is uncertain, but hundreds of researchers are active in these various marine vertebrate fields.

Australian contributions and research impact: Using WoS global searches as a proxy for research productivity for the different marine vertebrate groups, Australian institutions contributed to 12.2% of all marine mammal conservation publications (Topic=marine AND mammal AND conservation AND Address=Australia), 10.9% of seabird conservation publications (Topic=seabird AND conservation AND Address=Australia), 15.7% of marine turtle conservation publications (Topic=marine AND turtle AND conservation AND Address=Australia), 28.4% of sea snake publications (Topic= sea AND snake AND Address=Australia), 27.3% of shark conservation publications (Topic=shark AND conservation AND Address=Australia), and 17.8% of marine fish conservation publications (Topic= marine AND fish* AND conservation AND Address=Australia) published between 2004 and 2013.

Australian scientists have contributed substantially to research on all of the major marine vertebrate groups and have developed international reputations for leadership in research on some aspects including survey techniques and design, population modelling, eco-physiology, reproductive biology, molecular ecology, behaviour, acoustics, climate and ocean change impacts, fisheries bycatch and mitigation of fisheries impacts, conservation and management. Some research publications also integrate traditional knowledge from Aboriginal or Torres Strait Islanders, with additional research outputs collating Indigenous knowledge through video recordings, stories or GIS mapping.

Australian researchers are strongly represented on many international research organisations and professional societies including on IUCN Specialist Groups (e.g. sharks, marine turtles, sirenians, pinnipeds, cetaceans, sea snakes, including as Co-Chair in some), CMS Advisory Committees, Agreement on the Conservation of Albatrosses and Petrels (ACAP), International Fisheries RFMOs, Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), International Whaling Commission Scientific Committee, and recent and current Presidents of the Society for Marine Mammalogy. Australian scientists have had major roles in leading national and international global conservation efforts for marine vertebrates, including providing advice to State, Australian and many overseas Governments, and have been recognised with various national and international awards for this work.

Current and recent funding

Sources of funding for this research include/d: ARC, AAD, AAS, AFMA, AIMS, Australian Marine Mammal Centre (until recently), CSIRO, CRC Reef and CRC Torres Strait, Department of the Environment (NERP/NESP and MTSRF etc.), Endangered Species Fund, GBRMPA, FRDC, Oil and Gas industry, Port Corporations, Sea World Research and Rescue Foundation, Universities and other grant organisations within Australia and overseas.

Relevance

A wide range of end-users use and benefit directly and indirectly from research on Australian marine vertebrates. These include:

- Australian Government Department of the Environment (DoE), including AAD and AMMC
- Australian Government Department of Agriculture (formerly DAFF), including ABARES
- Australian Fisheries Management Authority (AFMA)
- Australian Government Department of Defence (DoD)
- Australian Government Department of Industry (DoI)
- Geoscience Australia (GA), particularly the Australian Marine Spatial Information System
- Great Barrier Reef Marine Park Authority
- State and Territory Governments (various Environment and/or Fisheries Departments etc.)
- Indigenous Land Councils
- Torres Strait Regional Authority
- Regional NRM bodies (Catchment Authorities)
- National and international scientific community
- Higher education and research institutions
- Indigenous community organisations
- Non-Government conservation and management organisations (NGOs)
- Aquaculture Industry and related stakeholders
- Commercial fishing industry and related stakeholders
- Recreational fishing groups and related stakeholders
- Offshore oil and gas exploration industry, e.g. Australian Petroleum Production and Exploration Association (APPEA)
- Ports Australia and related stakeholders
- Tourism Industry and related stakeholders – e.g. whale and dolphin watching operators, who benefit from the conservation of Australia's marine living resources and Australia's international reputation as a tourist destination on account of these
- Environmental consultants and related practitioners

Marine vertebrate conservation and threatened species are also very important to a range of other groups and individuals within the broader public community. Consequently, the Australian public and media organisations are more strongly engaged in environmental issues concerning high profile marine vertebrates and particularly some iconic megafauna than in most other countries, with a clear public expectation that human activities will not cause further significant harm to iconic and protected taxa.

Australia has important leadership roles in a number of international fora and is signatory to multi-lateral treaties/conventions directly relevant to marine vertebrate conservation, including CITES, CMS, CBD, IUCN, SPREP, CCAMLR, ACAP, Antarctic Treaty, JAMBA, ICRW and IWC and others (see [Perspective](#) section below). Therefore, international end users will include other Parties/signatories to these treaties and conventions and nations involved with other international fora.

Science needs Science gaps, needs and challenges

Australian research has provided substantial information on some marine vertebrate species including sufficient information to enable their conservation status to be assessed under the EPBC Act, various State/Territory Acts and IUCN Red List categories and criteria. However, there is insufficient information on distribution and abundance, population trends, population structure, habitat use and key threats for most marine vertebrate species in Australian waters to enable accurate assessments of their conservation status and identification of management actions that can be taken to avoid, reduce or effectively mitigate the most important threats.

This data deficiency is an almost ubiquitous and serious problem for most marine groups (and many terrestrial groups) in Australia. For example, among the chondrichthyan species in Australian waters,

23% were assessed as Data Deficient (White and Kyne 2010), while the most recent assessment of all Australian mammal species including marine species showed that 74% of the 47 cetacean species were Data Deficient (Woinarski et al. 2014), a situation that has not improved for most cetacean species over the past two decades (cf. Bannister et al. 1996, Ross 2006). Similar problems of data insufficiency occur even for some comparatively well studied species such as the dugong (Marsh et al. 2011) and all six threatened marine turtle species (Hamann et al. 2010), for which significant knowledge gaps remain across Northern Territory and Western Australian waters, and for migration routes, breeding grounds and carrying capacity of seagrass meadows for dugongs, and migration zones and foraging areas for four of the six marine turtle species. Similarly, movement patterns and migration routes, and critical foraging habitats and breeding grounds are largely unknown or insufficiently known for most other marine vertebrate species.

Insufficient or lack of information on population size and trends, survivorship and other key life history parameters preclude the development of population viability models for most marine vertebrate sub/populations and species. Therefore estimating sustainable potential biological removals and the cumulative impacts of mortality in various fisheries and from other anthropogenic activities is not possible for most species, which in turn impedes or prevents the determination of appropriate triggers for management action and the ability to effectively focus management and conservation efforts where they are most needed. Furthermore, there is clear need for inter-disciplinary research to include social, economic and human behavioral issues in relation to threat mitigation and improved management outcomes in future.

There are many challenges to resolving these issues for marine vertebrates including problems with detecting and identification of many marine vertebrate species at sea, and the lack of comprehensive baseline data or funding for long-term nationally coordinated research and monitoring programs for most species using agreed best practice survey designs and techniques. This is particularly challenging for those marine vertebrate species distributed in remote Australia, further offshore and in open ocean habitats where research and surveys are expensive and logistically difficult.

Another significant problem is the lack of a nationally co-ordinated comprehensive database that integrates all available information on marine vertebrate species or groups, including most listed threatened species. For listed threatened marine vertebrate species, which are all known to be at increased risk of further decline or extinction, Recovery Plans should provide regular 5-yearly reassessments of current knowledge and gaps, conservation status, trends and key threats to enable adaptive management and further improvements in the conservation status. However, Recovery Plans may not be effectively implemented due to inadequate funding and resource allocation, monitoring programs are often insufficiently completed, and the planned 5-yearly cycle of reassessment and adaptive management is often not met. Further investment and effective resourcing of Recovery Plan actions and associated applied research would enable the Commonwealth and State Governments to minimise the impacts of anthropogenic activities and associated environmental changes on these important matters of National Environmental Significance, and enable 5 and 10 year and longer term management goals to be achieved. These investments are needed to halt the decline, maintain and support the recovery of threatened species with the ultimate aim to remove these species from the list of threatened species under the EPBC Act and relevant State/Territory legislation.

However, most marine vertebrate species are not listed as threatened under the EPBC Act (Table 1). Therefore, there is currently no legislated means or requirement to regularly reassess the conservation status and trends, key threats and effectiveness of management for most marine vertebrate species in Australian waters. In the US, the Marine Mammal Protection Act requires an annual stock status report for all marine mammal species including an annual update of the latest population assessments and trends in abundance, and detailed assessment of all forms of anthropogenic mortality including relevant fisheries bycatch information from annual NOAA Fisheries reports.

An alternative approach is to assess marine vertebrate species as part of larger taxonomic groups using regional assessments such as for chondrichthyans in the Indo-Australasian region (White and Kyne 2010), or nationally coordinated Action Plans. For example the Action Plan for Australian Birds 2010 (Garnett et al. 2011) and the Action Plan for Australian Mammals 2012 (Woinarski et al. 2014) provide comprehensive assessments of current knowledge and the conservation status of Australian birds including seabirds and Australian mammals including marine mammals, respectively. These recent Action Plans have demonstrated that the conservation status of many birds and mammals (including some marine species) in Australia continues to decline, and that the current list of threatened species under the EPBC Act needs to be updated urgently as some clearly threatened species are not currently listed while others are incorrectly listed (Garnett et al. 2011, Woinarski et al. 2014). Nationally coordinated Action Plans also enable assessments of groups of taxa or regions that need priority conservation action and therefore provide important information for priority setting. For example, the Action Plan for Australian Birds highlighted the fact that all albatross and several petrel taxa continue to be threatened by mortality from fisheries bycatch (noting that substantial progress has been made in developing and implementing mitigation techniques in some fisheries), and most of the threatened seabird species in Australia frequent the Southern Ocean, particularly in the region around Tasmania (Garnett et al. 2011).

Given the critical science gaps and challenges noted above, the key science needs include:

- Adequate (at a minimum), robust baseline information and long-term monitoring programs at appropriate temporal and spatial scales to determine marine vertebrate species' population size and trends, critical habitat preferences and use, conservation status and trends, and existing and potential impacts of known and emerging natural and anthropogenic threats, as the basis for effective adaptive management and conservation decisions.
- Comprehensive research programs to investigate important issues including: direct fisheries interactions including total allowable catches of target species and entanglement and bycatch injury and mortality of non-target species; habitat degradation or loss of coastal and other marine environments arising from coastal development, offshore oil and gas exploration and production, aquaculture and port expansion; rates of injury and mortality resulting from vessel strike; effects of pollution including marine debris on health status; effects of climate and oceanographic variability and change including altered sea temperature and oceanographic currents and altered carbonate saturation and pH ('ocean acidification'); sustainable and culturally appropriate levels of Indigenous hunting of marine vertebrates; effects of anthropogenic noise disturbance including seismic surveys and naval active sonar, shipping, industrial and coastal development; national coordination of live and post-mortem stranding assessments; rates of recovery or decline and need for active management of threatened species; competition for prey resources and indirect effects of fishing and prey depletion; and impacts of extralimital activities on Australian populations of wide ranging marine vertebrates including directed takes and bycatch mortality, and potential resumption of commercial or IWC 'Special Permit' whaling or hunting of other marine vertebrates.
- Enhancement or development of powerful non-lethal technologies and methodologies for determining population structure, abundance and trend estimation including: development, standardisation, training and implementation of more sophisticated statistically powerful best practice survey designs and associated population modelling analyses; improved molecular techniques for taxonomic identification, connectivity, population size estimates, substructure and delineation of effective management units and trends (e.g. expanded use of close-kin genetics); development of bioassays e.g., hormones, stable isotopes, bio-markers, persistent pollutant contaminants and effects on health status; improvements in acoustic techniques and underwater detection of marine vertebrate species; development of improved remote sensing capabilities, including satellites and remote operated vehicles and potential use of ex-military and industrial technologies to track marine vertebrates and explore understudied regions of Australia's marine territories; improved telemetry and biologging capacity using animal-borne sensors for understanding movement and behaviour and environmental conditions across their range.

- Development and optimisation of improved techniques to reduce or mitigate injury or mortality from fisheries bycatch and other anthropogenic activities, and development of ecologically sustainable usage models for managing interactions e.g. for non-target marine vertebrates and fisheries.

Outputs from these applied research areas will directly inform the development and implementation of improved management strategies and policy through an enhanced ability to forecast, assess, manage and, where possible, mitigate threats to ensure the sustainability of marine vertebrate populations. This would in turn improve capacity to conserve and protect the marine vertebrate and critical habitat components of Australia's environmental assets, while facilitating a more predictable and science-based process for the management of economically valuable marine-user activities.

Establishment of an Australian Marine Vertebrate Science hub or network of hubs (or integration of these key science needs for marine vertebrates into an expanded national network of Marine Biodiversity hubs) would facilitate the integration of research and knowledge, collaborative linkages between researchers and all levels of Government, industry and other stakeholders, and funding mechanisms within the Australian marine vertebrate research community leading to improved science, conservation and management outcomes. The hub(s) would enable more seamless cross-jurisdictional exchange between research and policy and more effectively communicate research outcomes to the broader public and other end-users. Such hub(s) would also create high profile, internationally competitive research centre(s) similar to those established in some other countries and would help coordinate Australia's international activities. The Australian Marine Mammal Centre provides an excellent model of an applied research hub for the marine mammal component of Australia's marine vertebrates.

Perspective

As noted in Marine Nation 2025, Australia is a recognised world-leader in some aspects of marine biodiversity conservation, and Australia's representative network of marine reserves encompasses over a third of Commonwealth waters and includes internationally significant marine protected areas such as the Great Barrier Reef and Ningaloo Reef. The primary national environmental legislation is the EPBC Act that establishes a strong legal framework for environmental protection and together with frameworks such as Australia's Biodiversity Conservation Strategy 2010-2030, Marine Nation 2025, and Commonwealth marine bioregional plans, these provide guidance to support the future conservation and management of marine vertebrates and the broader marine environment over the next 5, 10 and 20 year timeframes.

Australia has important roles in a number of international fora that are directly relevant to marine vertebrate conservation including various RFMOs and is signatory to many multi-lateral treaties/conventions including:

- The **Convention on Biological Diversity (CBD)**: <http://www.cbd.int/>
- The **Convention on the Conservation of Migratory Species (CMS)**: <http://www.cms.int/en>
- **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**: <http://www.cites.org/eng>
- The **Antarctic Treaty**: http://www.ats.aq/index_e.htm
- Signatory to and host of the Secretariat of the **Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)**: <https://www.ccamlr.org/>
- The **Convention for the Conservation of Antarctic Seals (CCAS)**: http://www.ats.aq/documents/recatt/Att076_e.pdf
- Signatory to and host of the Secretariat of the Agreement on the Conservation of **Albatrosses and Petrels (ACAP)**: <http://acap.aq/>
- Signatory to the **Secretariat of the Pacific Regional Environment Programme (SPREP)**: <http://www.sprep.org/>

- **International Whaling Commission (IWC):** <http://iwc.int/home>. Australia has been active in maintaining the global moratorium on whaling and instrumental in the landmark ruling of the International Court of Justice in Australia's favour in the case, *Whaling in the Antarctic, Australia v. Japan: New Zealand Intervening*, which was strongly supported on the basis of Australia's expertise and development of non-lethal research tools for cetaceans.
- **Japan-Australia Migratory Bird Agreement (JAMBA):** <http://www.austlii.edu.au/au/other/dfat/treaties/1981/6.html>
- **China-Australia Migratory Bird Agreement (CAMBA):** <http://www.austlii.edu.au/au/other/dfat/treaties/1988/22.html>
- **Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA):** <http://www.austlii.edu.au/au/other/dfat/treaties/2007/24.html>

Australian marine vertebrate researchers are involved in a range of highly influential multi-national consortia that generate high calibre science and state-of-the-art technology and method development, build capacity nationally and internationally, and provide conservation, management and policy advice to a range of Governments. These include:

- The **Scientific Committee on Antarctic Research (SCAR)**, specifically the **Expert Group on Birds and Marine Mammals (EG-BAMM)**: <http://www.scar.org/ssg/life-sciences/bamm>
- The **Southern Ocean Research Partnership (IWC-SORP)**: <http://www.marinemammals.gov.au/sorp> (Secretariat hosted by Australia)
- The **South Pacific Whale Research Consortium (SPWRC)**: <http://www.whaleresearch.org/projects/spwrc.php>

Despite Australia's active and influential role in these international fora/activities, critical gaps still exist in our knowledge of Australian marine vertebrates and overall biodiversity patterns, their ecosystem function and roles, the processes governing their health and status of their populations, carrying capacity, natural changes versus anthropogenic impacts, cumulative impacts from various stressors including climate and oceanographic changes and extreme weather events, and vulnerability to existing and emerging threats to their survival. Furthermore, there is an urgent need to develop a decision support framework within the next 5-10 years to prioritise research and management investments among different marine vertebrate taxa and groups, at local, regional and national scales. The investments and infrastructure requirements highlighted in the Realisation section below underpin the key science priorities for the next 5, 10 and 20 years.

Realisation

Key infrastructure and capability requirements and associated funding and coordination requirements for realisation of the research and management needs of Australia's marine vertebrates include the following:

Hub(s) and Funding: Establishment of an Australian Marine Vertebrate Science centre of excellence hub or a coordinated network of hubs (or integration into an expanded national network of Marine Biodiversity hubs) requires infrastructure support and allocation of funding. Adequate (at a minimum), dedicated funding that is specific to marine vertebrates operating over at least 5-10 year timeframes is essential, with effective hub(s) governance arrangements to manage competitive grant schemes and reporting, and administered by expert bodies. An example of a successful grants scheme using this model was the Australian Marine Mammal Centre Grants Program (2008-2014), currently suspended due to lack of funds.

Research and Monitoring: National co-ordination of long-term research and monitoring programs at appropriate temporal and spatial scales using best practice survey designs and analyses is required to ensure comprehensive and adequate data on marine vertebrate species distribution and abundance and sub/population trends for assessing their conservation status. Where necessary long-term

research and monitoring programs that are already established and have demonstrated effective data acquisition, analyses and publication/dissemination processes should be enhanced, and for other groups where such programs are lacking or insufficient, comprehensive research and monitoring programs need to be established at representative sites. In addition, there is an obvious need for further development of non-lethal research techniques and technologies including remote sensing, acoustic arrays, aerial drones and other remotely operated submersible vehicles to more effectively survey Australia's vast marine areas in future.

Data Coordination: There is a clear need to enhance and better integrate nationally coordinated repository/ies of datasets and metadata on marine vertebrates that are accessible to researchers, Commonwealth Government and State/Territory Government agencies, policy makers, industry stakeholders and other users. For example, various databases with relevant Australian marine vertebrate records include:

- Species Profile and Threats Database (SPRAT) for species and ecological communities listed under the EPBC Act as part of the Environmental Resources Information Network (ERIN) within the Department of the Environment which also hosts the Australian Faunal Directory (AFD)
- Online Zoological Collections of Australian Museums (OZCAM)
- Atlas of Living Australia (ALA) and associated Global Biodiversity Information Facility (GBIF)
- Codes for Australian Aquatic Biota (CAAB) database hosted by CSIRO
- Ocean Biogeographic Information System (OBIS) and associated Census of Marine Life Program
- BirdLife Australia's 'The Atlas of Australian Birds' and Birddata
- BirdLife International's Global Procellariiform Tracking Database
- National Marine Mammal Data Portal hosted by AMMC, and

Sufficient and ongoing funding would enable one or more of these programs to serve as an integrated data portal to cover all marine vertebrate species within the next 5-10 years, and at least within the next 5 year timeframe enable these separate databases to be more effectively linked and regularly updated with data integrity cross-checked and integrated across all systems. Related to this dataset coordination issue is the need to more effectively access, compile and analyse existing long term data archives including long-term research datasets held by individuals, research groups or agencies, historic catch records, and other potential sources of useful data including declassified military records and desensitised industrial archives.

Capacity Building: In addition to support for research hub(s) and associated research and monitoring programs, there is a clear need for increased marine vertebrate research capacity. Therefore, competitive postgraduate research scholarships and student research mentoring programs are required to build future capacity in this area. Australia also lacks available capacity for integrating research in the biological and ecological, social, economic and human dimensions of marine vertebrate management issues and a coordinated training program to enhance indigenous engagement is needed.

Integration and Partnerships: The proposed Marine Vertebrate Science hub(s) would provide a mechanism for maintaining or establishing new cross-jurisdictional integration arrangements between researchers from different institutions, Government, industry, and other stakeholders. Partnerships with industry and co-investment in independently commissioned and peer-reviewed research and monitoring programs would broaden the exposure of the research and enable rapid integration of results into relevant Government management and policy areas. The hub(s) would also provide a means of coordinating Australian and international research and management activities for marine vertebrates, and for disseminating new information to stakeholders and the broader community.

National Facilities: National Facilities for dedicated marine vertebrate research are required. These include research vessels equipped with marine vertebrate observation platforms, trawl decks for scientific stock assessment, and remote operated vehicles for surveys.

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