Global Ecology and Conservation 3 (2015) 401–411

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: www.elsevier.com/locate/gecco

Original research article

Australia's protected area network fails to adequately protect the world's most threatened marine fishes

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ARTICLE INFO

Article history:
Received 21 January 2015
Accepted 21 January 2015
Available online 23 January 2015

Keywords:
Sawfish
Pristidae
Protected areas
Marine reserves
National parks

ABSTRACT

In order to maintain ecosystems and biodiversity, Australia has long invested in the development of marine and terrestrial protected area networks. Within this land- and seascape, northern Australia represents a global population stronghold for four species of the world's most threatened marine fish family, the sawfishes (family Pristidae). The distribution of sawfishes across northern Australia has previously only been coarsely estimated, and the adequacy of their representation in protected areas has not been evaluated. The calculated range of each species was intersected with Australia's marine and terrestrial protected area datasets, and targets of 10% marine and 17% inland range protection were used to determine adequacy of sawfish range protection. Marine targets have been achieved for all species, but the inland range protection targets have not been met for any species. Results indicate that further protection of inland habitats is required in order to improve sawfish protection and habitat connectivity.

1. Introduction

The development of terrestrial and marine protected areas (MPAs) is essential in balancing the pressure of human development, the protection of biodiversity, and in aiding recovery of threatened species (Gaston et al., 2008). Globally, there has been a steady increase in protected areas with many countries investing in the development of protected area networks to reduce the loss of species and meet targets set forth in the Convention on Biological Diversity (CBD); however many ecoregions remain inadequately protected (Spalding et al., 2008; Jenkins and Joppa, 2009). While protected area planning must consider the conservation needs of various habitats and species, global and regional assessments of progress towards both the CBD Aichi Target 11 and 12 (protect 17% of the world's land surface by 2020, and prevent the further loss of known threatened species, respectively) show that many threatened species are not adequately protected and there are still significant shortfalls in meeting the targets (Shaw et al., 2014; Venter et al., 2014). Given that protected areas are an essential conservation tool for protecting threatened species and their critical habitat (Miller et al., 1990), due consideration is required to adequately incorporate threatened species into their design.

In Australia, both marine and terrestrial protected area networks have been developed through the use of the Comprehensive, Adequate, and Representative (CAR) system (NRMMC, 2005). This protected area planning system aims to protect adequate levels of ecosystems for each Australian bioregion to ensure viability and ecological integrity (ANZECC, 1999; Commonwealth of Australia, 2013). While the protected area system in Australia is extensive, there remain many ecoregions that are not adequately protected (Spalding et al., 2008; Jenkins and Joppa, 2009; Barr and Possingham, 2013).

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http://dx.doi.org/10.1016/j.gecco.2015.01.007

Though the ecoregional target shortfalls for the Australian protected area system and priority areas for further protection to meet targets have been explored (e.g. Watson et al., 2010 and Barr and Possingham, 2013), few studies have focused on investigating whether Australia's protected area systems are adequately protecting threatened species. Those that have been conducted focus on terrestrial birds, mammals and amphibians (Lemckert et al., 2009; Watson et al., 2010; Venter et al., 2014). No studies have been conducted to determine if aquatic, euryhaline, estuarine, or marine threatened species are effectively protected. A major barrier to conducting assessments on the adequacy of protection for these species is the lack of information required to accurately estimate species' ranges. Identifying a species' range is dependent upon spatial distribution information (Gaston and Fuller, 2009) and these data can be sparse for aquatic, euryhaline, estuarine, and marine species (for a more detailed review on the difficulties of assessing species distributions see Williams et al., 2002 and Cooke, 2008). Furthermore, given many of these species occupy or move between multiple realms, estimation of ranges should span relevant realms. Constructing these ranges is the first barrier to estimating the current adequacy of protection for these species.

The cartilaginous fishes (class Chondrichthyes) face a global conservation crisis, with an estimated one quarter of species threatened with extinction (Dulvy et al., 2014). The sawfishes (family Pristidae) are the most threatened chondrichthyan family, having undergone unprecedented declines in both range and abundance in the last few decades; indeed they are arguably the most threatened group of marine fishes (Faria et al., 2013; Dulvy et al., 2014). The world's five sawfish species face similar threats across their tropical ranges due to their shallow inshore coastal (and for some species, riverine) distributions in areas facing high exploitation and development pressures, and their toothed rostrums, which are highly vulnerable to entanglement in fishing gear and are often sought as curios (Harrison and Dulvy, 2014). Sawfishes generally conform to the limited life history characteristics displayed by long-lived and late-maturing elasmobranchs, which further increases their vulnerability (Peverell, 2005). Sawfishes also represent cross-realm management challenges as some species occupy different habitats (freshwater, estuarine, marine) at different stages of their life cycle.

Northern Australia holds some of the few remaining viable sawfish populations, providing globally important habitat for four of the five sawfish species: *Pristis pristis* Linnaeus, 1758 (Largetooth Sawfish), *P. clavata* Garman, 1906 (Dwarf Sawfish), *P. zijsron* Bleeker, 1851 (Green Sawfish) and *Anoxypristis cuspidata* (Latham, 1794) (Narrow Sawfish). Ranges for each species in Australian waters have been very coarsely mapped using limited records (for example, see the Atlas of Living Australia; www.ala.com.au). However, no studies have been conducted to define accurate range estimates. Defining a species' range can be accomplished by identifying the extent of occurrence (EOO) and area of occupancy (AOO), parameters which are also important when assessing the extinction risk of a species (IUCN, 2012). A species' EOO is defined as the minimum area that encompasses all known, projected, or inferred records of a species, excluding cases of vagrancy. The AOO refers to the area within the EOO that the species actually occurs in (IUCN, 2012). Both parameters have not been determined for sawfish species in northern Australia.

Given the current imperilled status of sawfishes globally, Australia's stated goals to reduce biodiversity loss, and the importance of northern Australia's marine, estuarine, and freshwater environments to these species, this study aims to identify, as accurately as possible with available species records, the Australian ranges of *P. pristis*, *P. clavata*, *P. zijsron* and *A. cuspidata* and determine if Australia's current marine and terrestrial protected area networks are effective at protecting sawfish species ranges. This is accomplished by addressing the following objectives: (1) accurately mapping each species' Australian range; (2) assessing the level of protection; and, (3) assessing connectivity between protected areas across terrestrial and marine realms.

2. Methods

2.1. Data collection

Australian sawfish species location records were obtained from Commonwealth and state/territory fisheries departments, museums, the literature, and expert consultation. Records were organized by species and records attributed to unspecified species (i.e. 'sawfish') were removed. Using these records, as well as available range and habitat preference information, and various datasets describing Australia's hydrological areas and marine bioregions, EOO and AOO were determined for each species in Australian waters (state/territory and Commonwealth waters to the 200 nm limit).

Australia's hydrological area data included catchments, estuaries, floodplains, rivers, and streams. Catchment data were obtained from the National Catchment Boundaries v.1.1.4, available through the Geoscience Australia website (http://www.ga.gov.au). This dataset describes the surface drainage pattern for Australia's hydrological areas. Estuary, floodplain, river, and stream data were obtained from the Australian Hydrological Geospatial Fabric (Geofabric) Product Suite V2.1: Geofabric Surface Cartography (AHGF HydroArea). The Geofabric Surface Cartography product provides 15 types of geometric representations of Australia's surface waters for use in ArcGIS. For the purpose of this project, estuaries, mapped streams, waterbodies, and hydrological area feature types were used.

Marine bioregion and jurisdiction information was obtained from the 2005 National Marine Bioregionalisation of Australia GIS Dataset available via Geoscience Australia. This data provided coarse information about average depths of each bioregion. The 2012 version of Australia's Network of Commonwealth Marine Reserves (CMR) and the Collaborative Australian Protected Area Database (CAPAD) 2010 were obtained through the Australian Government Department of the Environment (http://www.environment.gov.au/metadataexplorer/explorer.jsp). These datasets provide spatial data and in-