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Short communication

A global gap analysis of sea turtle protection coverage

Antonios D. Mazaris [a,*], Vasiliki Almpanidou [a], Bryan P. Wallace [c,d,e], John D. Pantis [a], Gail Schofield [b]

[a] Department of Ecology, School of Biology, U.P. Box 119, Aristotle University, 54124 Thessaloniki, Greece
[b] Centre for Integrative Ecology, School of Life and Environmental Sciences, Deakin University, Warrnambool, Victoria 3280, Australia
[c] Oceanic Society, 30 Sir Francis Drake Blvd., P.O. Box 437 Ross, CA 9495, USA
[d] Duke University Marine Laboratory, Division of Marine Science and Conservation, 135 Duke Marine Lab Road, Beaufort, NC 98516, USA
[e] Stratus Consulting, 1881 Ninth Street, Suite 201, Boulder, CO, USA

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ABSTRACT

Although the number and extent of protected areas (PAs) are continuously increasing, their coverage of global biodiversity, as well as criteria and targets that underline their selection, warrants scrutiny. As a case study, we use a global dataset of sea turtle nesting sites ($n = 2991$) to determine the extent to which the existing global PA network encompasses nesting habitats (beaches) that are vital for the persistence of the seven sea turtle species. The majority of nesting sites (87%) are in the tropics, and are mainly hosted by developing countries. Developing countries contain 82% nesting sites, which provide lower protection coverage compared to developed countries. PAs encompass 25% of all nesting sites, of which 78% are in marine PAs. At present, most nesting sites in PAs with IUCN ratification receive high protection. We identified the countries that provide the highest and lowest nesting site protection coverage, and detected gaps in species-level protection effort within countries. No clear trend in protection coverage was found in relation to gross domestic product, the Global Peace Index or sea turtle regional management units; however, countries in crisis (civil unrest, war or natural catastrophes) provided slightly higher protection coverage of all countries. We conclude that global sea turtle resilience against threats spanning temperate to tropical regions require representative PA coverage at the species level within countries. This work is anticipated to function as a first step towards identifying specific countries or regions that should receive higher conservation interest by national and international bodies.

1. Introduction

GAP analysis is a quantitative approach that is used to identify gaps in actual and potential systematic conservation planning and coverage (e.g. Scott et al., 1993). The outputs of GAP analyses are based on specific conservation metrics (e.g. percentage of area or species being covered), providing an effective means of identifying unprotected areas of high biodiversity value (Margules and Pressey, 2000; Possingham et al., 2006; Rodrigues et al., 2004a). For instance, several GAP analyses have focused on the extent to which protected areas (PAs) represent species diversity, and in identifying priority regions for the expansion of this global network (e.g. Chape et al., 2005; Rodrigues et al., 2004b). Such studies have demonstrated that biodiversity hotspots are primarily concentrated in tropical regions where countries are more likely to have developing economies (Brooks et al., 2006; Myers et al., 2000). Developing countries also tend to have lower national security (i.e. increased levels of social unrest, war or vulnerability to natural catastrophes) and greater rates of habitat loss compared to wealthier countries (Myers et al., 2000; Sodhi and Ehrlich, 2010). Consequently, the national funds of developing economies are likely to be, logically, diverted towards promoting economic growth and/or mitigating disasters, rather than meeting the needs of conservation efforts (Bruner et al., 2004; James et al., 2001). In turn, wealth is assumed to increase interest (and willingness) to invest in biodiversity conservation (Amano and Sutherland, 2013; Jacobsen and Hanley, 2009). Therefore, objective evaluations of global PA performance should consider the financial capacity, policy mechanisms, quality of scientific knowledge and understanding/experience of conservation needs of countries belonging to wealthy nations versus developing economies (Amano and Sutherland, 2013; Rands et al., 2010). Such information could, therefore, contribute towards identifying specific conservation needs at social, economic, political and ecological levels to maximise the conservation coverage of threatened wildlife (Steiner et al., 2003).

* Corresponding author. Tel.: +30 2310998975; fax: +30 2310 998379.
E-mail addresses: amazaris@bio.auth.gr (A.D. Mazaris), valmpani@bio.auth.gr (V. Almpanidou), wallace@oceanicsociety.org (B.P. Wallace), pantis@bio.auth.gr (J.D. Pantis), g.schof@gmail.com (G. Schofield).

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The selection of eligible sites and the development of protected-area networks are underpinned by the fundamental goal of ensuring the representation of biodiversity features of high conservation interest (Pressey et al., 1994). Therefore, it is important to establish to what extent existing PA networks protect important habitats (i.e. breeding, foraging or migratory) used by populations of threatened species and, hence, whether the resilience of target species is safeguarded (Heller and Zavaleta, 2009). Sea turtles represent one such group of threatened species (seven species forming a single super-family: loggerhead, *Caretta caretta*, green, *Chelonia mydas*, hawksbill, *Eretmochelys imbricata*, Kemp's ridley, *Lepidochelys kempii*, olive ridley, *Lepidochelys olivacea*, flatback, *Natator depressus*, and leatherback, *Dermochelys coriacea*), which aggregate to breed and nest on the beaches of countries spanning both tropical and temperate regions (latitudinal range: −29°S to 44°N) (IUCN, 2012; Wallace et al., 2011). Edgar et al. (2008) suggested that mapping the location of threatened species that form highly aggregated populations in time or space could be used to systematically identify priority conservation targets. Accordingly, a recent global assessment of sea turtle nesting sites (seven species from two families) delineated spatially and biologically distinct regional management units (RMUs) (Wallace et al., 2010), to provide a framework for the assessment of conservation status and threats (Wallace et al., 2011). Yet, a knowledge gap remains about whether the existing global network of PAs actually safeguards the nesting habitats of the seven sea turtle species; thus, obscuring efforts to delineate effective national or international conservation policies.

The monitoring and conservation efforts of sea turtles are primarily focused on the nesting beaches, because of the relative ease of access and ability to assimilate population level datasets (Hamann et al., 2010; Hopkins-Murphy et al., 2003; Mazaris et al., 2005), compared to more broadly dispersed marine foraging sites to which turtles migrate (e.g. Hawkes et al., 2011; Schofield et al., 2013a,b, but see Scott et al., 2012). While turtles are at high risk of fisheries impact in foraging areas (Lewison et al., 2013; Wallace et al., 2011), threats to nesting habitat are primarily associated with the destruction and loss of beaches, through mechanisms such as coastal development and sea level rise due to climate change (termed coastal squeeze; Fuentes et al., 2012; Mazaris et al., 2009). In addition, poaching and the indigenous use or illegal trade of turtle products (i.e. eggs, meat, carapace) (Koch et al., 2006; Wallace et al., 2011) directly threaten sea turtle population viability and trends in many regions. Yet, many sea turtle nesting beaches remain unprotected, despite the importance of establishing PAs that contribute towards building the resilience of sea turtle populations to these various negative impacts (Fuentes et al., 2013; Hamann et al., 2010; Pike, 2013).

Hundreds of organisations (i.e. non-governmental, research groups, and public citizen groups) are involved in sea turtle monitoring and conservation activities worldwide. This phenomenal effort is exemplified by the Global Sea Turtle Network (http://www.seaturtle.org/) and the State of the World's Sea Turtles database – SWOT (http://seamap.env.duke.edu/swot), in which information about sea turtle nesting activities has been provided by more than 600 different contributors from 130 countries. Here, we used this information to identify whether sea turtle nesting sites are included in the 145,378 national and 28,004 international protected sites established to conserve biological diversity around the world (WDPA, 2013). We identify potential gaps in the spatial conservation of the seven sea turtle species, and determine whether the extent of protection is correlated to the economic status and/or security of each country. We consider this evaluation as a first step toward highlighting conservation needs and feasibility for sea turtles at a global scale.

2. Material and methods

We analysed a total of 2991 georeferenced records of nesting sites used by all seven sea turtle species in 130 countries (or 4402 nesting sites per species, because the nesting sites of several species overlap). Data on the global distribution of sea turtle nesting sites were obtained from state of the World's Sea Turtles database (Halpin et al., 2009; Kot et al., 2013; SWOT Reports volumes I–VII, 2006a,b, 2008, 2009, 2010, 2011, 2012; http://seamap.env.duke.edu/swot). Data on the global distribution of PAs were obtained from the 2013 world database on protected areas (WDPA, 2013). Currently, the database contains distributional maps of about 174000 PAs with different designation status (accessed November 2013). We determined the protection status of PAs for which the IUCN protected areas categories system (I, Ia, Ib, II, III, IV, V, VI) was available, with categories I to IV representing greater levels of restriction (Dudley, 2008).

To identify gaps in the coverage of existing protected sites, we overlaid maps showing the geographical centre of each nesting site (as this was the single parameter consistently provided by all monitoring groups) on a map containing all protected areas around the globe (Fig. 1). ArcGIS (version 9.2, ERSI, 2005) was used to overlay the digital sources. At present, the total size (lengths and widths) of nesting sites and total annual nest numbers of all sites are not available on SWOT; therefore, it was not possible to assess protection coverage in relation to the nesting effort; however, future access to this information would further refine the current analysis. We employed the Chi square test to investigate whether the number of species that visited a given nesting site was related to protection coverage. The Euclidean distance between the centre of each nesting site and the closest edge of the nearest PA was also calculated to demonstrate the proximity of nesting sites to existing PAs.

We first examined the PA coverage of nesting sites at the country-level for all seven species, combined and separately, in relation to the IUCN protected areas category system. Our assessment of species-specific protection coverage at the country level in the results is focused on countries that present the highest and lowest coverage, along with those that are known to host the greatest numbers of nest (http://www.nmfs.noaa.gov/pr/species/turtles). We then analysed the data with respect to (1) tropical, sub-tropical and temperate status, (2) the economic status of the countries, including GDP (3) the presence of existing crises (e.g. civil unrest, wars or natural catastrophes), (4) the regional-level, and (5) sea turtle regional management units (Wallace et al., 2010, 2011).

Tropical, sub-tropical and temperate nations were separated according to the Meteorological Glossary (American Meteorological Society, 2013). Economic status was assessed by grouping each country as developed or developing, according to the classification statutes provided by the United Nations Statistics Division (http://unstats.un.org/unsd/methods/m49/m49regin.htm; assessed November 2013), which are based on economic growth and stability, human wealth, the standard of living and the infrastructure. In addition, the gross domestic product (GDP) per capita was obtained for each country from the World Factbook (2013). A Spearman rank correlation test was used to investigate any potential relationship between GDP per capita and the number of protected and total nesting sites at the country-level.

Information about conflicts was obtained from the 2012 Global Conflict Barometer, published by the Heidelberg Institute for International Conflict Research (HIIK, 2012). Any country that hosts a sea turtle nesting site and is currently under at least one type of violent conflict within its borders was included in this category. Countries that were involved in diplomatic tensions, or had crises outside of their borders, were excluded. For the purposes of this