Reflections on sea turtle conservation

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Why do sea turtles garner such intense interest? The answer is visceral: they are widely loved! A cryptic life cycle spent mostly out of view lends a sense of mystery that makes them special. Yet, these large animals are highly accessible at an extremely vulnerable time, when females emerge on sandy beaches at night to lay eggs, before disappearing again into the oceans. Being nocturnal, they provide us the adventure of going out in the dark on secluded beaches to find them. Plus, the hatchlings are cute, and releasing them into the sea must be one of the most engaging activities that people can do with a protected species.

To mark World Sea Turtle Day on 16 June, we—conservation scientists working across the oceans on this small yet well-studied group of seven species—reflect on their conservation. Sea turtles have lived in the oceans, largely unchanged, for millions of years. They play important roles in their ecosystems, possibly even as ecosystem engineers, and serve as prey for other protected species (Veríssimo et al., 2012). They have been a source of sustenance and useful products for people for millennia, and these needs persist (Hancock et al., 2017; Humber et al., 2017; Delisle et al., 2018; Sardeshpande & MacMillan, 2019). Consequently, sea turtles are culturally important and the subject of myths and lore. They have also become economically important to many coastal communities through tourism (Waylen et al., 2009), although this can affect turtles or their habitats, if not correctly managed (Katselidis et al., 2013).

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The complex life history of sea turtles, including their long life span and wide patterns of dispersal, generates multiple conservation challenges, and also draws curiosity and public interest. They serve extensively as flagship species and are useful for harnessing action for marine conservation, whether for coastal protection or in campaigns against single-use plastics. There has been an extensive, and growing, worldwide network of sea turtle conservation organizations for over 50 years. Arguably, there may be more dedicated professionals and volunteers per species than for any other marine animal group.

What are we doing well in sea turtle conservation? After centuries of decline, many sea turtle populations have stabilized or are increasing (Mazaris et al., 2017). Long-term monitoring and protection of nesting sites, in some locations exceeding 50 years, have been central to recovery, understanding trends and determining the importance of previously underestimated aggregations (Kelle et al., 2009; Delcroix et al., 2014; Laloë et al., 2019; Mortimer et al., 2020). This allows researchers and management agencies to understand and mitigate the impacts of anthropogenic activities. Long-term monitoring projects further reinforce the value of protecting nesting and foraging habitats, and promote the engagement of local communities, volunteers, students and tourists, thus benefiting a wide range of stakeholders. Such projects are often showcased in *Oryx* (Godenger et al., 2009; Gaos et al., 2010; Garnier et al., 2012; Kurz et al., 2012; Rivas et al., 2016; Olendo et al., 2019; Sardeshpande & MacMillan, 2019). Control of predation by natural and introduced mesopredators (Engman et al., 2016; Madden Hof et al., 2019) and reduction of take through hatcheries, and other forms of ex situ protection (Revuelta et al., 2015), have also been prominent.

Legislation in many countries protects turtles from large-scale commercial trade and/or manages local consumption, and CITES, together with in-country support and other international agreements, has halted legal large-scale international trade of sea turtles. Although accidental catch in fishing gear remains a serious threat, various solutions have reduced bycatch in commercial fisheries; e.g. many trawl fisheries now use turtle excluder devices, which allow individuals to escape from nets. Other measures include light-emitting diodes to illuminate gillnets and circle hooks in pelagic longline fisheries.

Sea turtle researchers are often quick to adopt new technologies. Tracking data and genetic analyses have helped

reveal the spatial distribution and connectivity of populations across international borders (Metcalfe et al., 2020) and have highlighted key inter-nesting habitats (Hart et al., 2016). These findings have led to the creation of international collaborative networks, the enhancement of regional conservation actions, and supported the creation of marine protected areas. Additional novel techniques showcased in *Oryx* range from the use of ultralight aircraft for turtle surveys (Jean et al., 2010) to a radio call-in network for fishers, to support their activities and promote bycatch mitigation (Alfaro-Shigueto et al., 2012).

What should we do better for sea turtles? Rees et al. (2016) analysed a decade of publications and surmised that, although variable, progress was being made towards answering key questions identified by an international group of experts in 2010. A worrying finding was, however, that inclusion of social dimensions was still lacking in what is an arena dominated by biologists and ecologists. There has been slow progress to assess cultural, legal, and socio-economic frameworks, hindering the application of research findings in supporting legislation and management, and in designing robust interventions. This lack of incorporation of social sciences is probably hindering our ability to understand threats and adopt sound management practices with relevant stakeholders. Nevertheless, some progress is being made, and increasing attention to interdisciplinary applications in sea turtle conservation is delivering insightful results (Hancock et al., 2017; Delisle et al., 2018).

Given the magnitude of effort worldwide, there is great potential to improve our understanding of what works—or does not—in sea turtle conservation. However, monitoring and evaluation remain challenging and are often neglected despite their potential to provide much needed information. For example, assessments of the best incentives or disincentives for affecting compliance with management measures, of how to allocate efforts beneficially for outreach activities, and of how our efforts translate into behavioural change and ecological improvements, would be game changers.

Although over the last 50 years sea turtle conservation has taken a largely protectionist, non-consumptive approach, there is a clear need to adapt our conservation paradigms to be more inclusive and to consider alternative views, including sustainable use (Delisle et al., 2018, Sardeshpande & MacMillan, 2019). Lack of holistic population demographic data muddies the waters for the potential consumptive use of apparently recovering or recovered populations. Additionally, thresholds of sustainable use, even where exploitation is currently legal, are often poorly identified and lack strong scientific grounding. A key limitation relates to illegal wildlife trade, which often remains an unquantified threat because of the challenge of data collection.

There have been significant efforts to understand the compound, long-lasting effects of commercial fisheries bycatch, including direct and post-release mortality. However, research on bycatch assessments and reduction techniques for artisanal fleets and small-scale fisheries merit continued attention (Nada & Casale, 2011; Mancini et al., 2012; Wildermann et al., 2018). As the majority of the life cycle of sea turtles is spent at sea, more needs to be done to monitor and protect all life stages, beyond the more accessible eggs, hatchlings and nesting females.

Climate change remains a pervasive threat to various sea turtle populations around the globe, with much attention focused on impacts related to temperature-dependent sex determination (Hamann et al., 2013). Studies of this mainly use indirect proxies that can generate significant error, and more work is needed to quantify this phenomenon more precisely. In addition, we know little about how a changing climate will influence turtle dispersal, growth, diet and other life history parameters. Studies of reproductive success vary across species and locations and this should be addressed for a better understanding of population viability, especially in relation to changes in climate.

Attributing a meaningful conservation status to sea turtles remains a challenge, as conventional categorization systems, such as the IUCN Red List of Threatened Species, are a poor fit at both national and global levels (Seminoff & Shanker, 2008). Current Red List categories can lead to flawed conclusions. For example, a small positive change (e.g. increasing abundance trends) as a result of conservation actions following decades of decline can be perceived as cause for reduced protection. In contrast, ill-used, the system can assign an inaccurate high risk of extinction to a species numbering in the millions per ocean basin. Because the IUCN Red List is the most comprehensive global inventory of species conservation status, and highly regarded by governments and funding bodies, assessments can impact support for conservation (Campbell, 2012). Assessments of subpopulations have alleviated some issues but there remains a clear need to shift from a threatened vs not threatened paradigm to more suitable processes of assessments, such as conservation dependent. Additionally, all current assessments focus exclusively on adult cohorts.

In summary, although our reflections reveal that sea turtle conservation could be further enhanced, the accomplishments of the sea turtle conservation community are cause for optimism. There is more to do, and much will be achieved, in no small part because sea turtles are widely loved!

This Editorial and the *Oryx* articles cited herein are freely available as a virtual issue of the journal at cambridge.org/core/journals/oryx/virtual-issues.

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