

## Chapter 39. Marine Reptiles

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### 1. Assessment Frameworks

Although several other frameworks assess marine turtle status at global and sub-global scales, in this chapter we focus on results from the International Union for the Conservation of Nature (IUCN) Red List assessments and the IUCN Marine Turtle Specialist Group's conservation priorities portfolio (Wallace et al., 2011) because these are the most comprehensive and widely recognized assessment frameworks at present. For a comprehensive summary of other assessment frameworks for marine turtles, please see Chapter 35. In this chapter, we provide an overview of the two above-mentioned IUCN assessments with regard to marine turtles, and we also present available information on the conservation status of sea snakes and marine iguanas.

### 2. Status Assessments

#### 2.1 *IUCN Red List*

The primary global assessment framework for marine turtle species is the IUCN *Red List of Threatened Species*<sup>TM</sup> ([www.iucnredlist.org](http://www.iucnredlist.org)). The universally applicable criteria and guidelines of the Red List make it the most widely used and accepted framework for assessing the conservation status of species worldwide.

The IUCN Marine Turtle Specialist Group (MTSG), one of the IUCN/Species Survival Commission's specialist groups, is responsible for conducting regular Red List assessments of each marine turtle species on a global scale. However, because marine turtle population traits and trajectories can vary geographically, the global extinction risk assessment framework represented by the Red List does not adequately assess the conservation status of spatially and biologically distinct marine turtle populations (see Seminoff and Shanker, 2008 for review).

#### 2.2 *Subpopulation or regional assessments*

To address the challenges presented by the mismatched scales of global Red List assessments and regional/population-level variation in status, the MTSG developed an alternative assessment framework and a new approach to Red List assessments that better characterize variation in status and trends of individual populations (Wallace et al., 2010; Wallace et al., 2011; see next section). This new approach centres on assessing

marine turtle subpopulations, as well as the global population (i.e., species), using Red List guidelines, which results in official Red List categories for subpopulations in addition to the single global listing. This working group first developed regional management units (RMUs) (i.e., spatially explicit population segments defined by biogeographical data of marine turtle species) as the framework for defining biologically meaningful population segments for assessments (Wallace et al., 2010). RMUs are functionally equivalent to IUCN subpopulations, thus providing the appropriate demographic unit for Red List assessments. Next, the group developed a flexible yet robust framework for assessing population viability and degree of threats that could be applied to any subpopulation in any region (Wallace et al., 2011). Population viability criteria included abundance, recent and long-term trends, rookery vulnerability, as well as genetic diversity, and threats included by-catch (i.e., incidental capture in fishing gear), human consumption of turtles or turtle products, coastal development, pollution and pathogens, and climate change. The final product was a “conservation priorities portfolio” for all subpopulations globally. It includes identification of critical data needs, as well as risk and threats criteria by subpopulation, and reflects the wide variety of conservation objectives held by different stakeholders, depending on institutional or regional priorities.

### 3. Conservation Status of Marine Reptiles

#### 3.1 Marine Turtles

Currently, global Red List categories for marine turtle species are: Vulnerable (leatherback, *Dermochelys coriacea*; olive ridley, *Lepidochelys olivacea*), Endangered (loggerhead, *Caretta caretta*; green turtle, *Chelonia mydas*), Critically Endangered (Kemp’s ridley, *Lepidochelys kempii*; hawksbill, *Eretmochelys imbricata*), and DataDeficient (flatback, *Natator depressus*).

However, as mentioned above, the MTSG is actively appraising Red List assessments to include all subpopulations, as well as the global listing for each marine turtle species. In 2013, the MTSG completed the first complete suite of subpopulation assessments—in addition to the global listing—for any marine turtle species (Wallace et al., 2013a). The updated Red List assessments for leatherback turtles changed the global status for this species from Critically Endangered to Vulnerable—due to new data becoming available and to one large and increasing subpopulation (Northwest Atlantic Ocean)—and added new listings for each of the seven leatherback subpopulations, which ranged from Critically Endangered (East Pacific Ocean; West Pacific Ocean; Southwest Atlantic Ocean; Southwest Indian Ocean) to Least Concern (Northwest Atlantic Ocean) to Data-Deficient (Southeast Atlantic Ocean; Northeast Indian Ocean) (Wallace et al., 2013a). Updated global and subpopulation assessments are expected to be completed in 2016-2018.

### 3.2 MTSG's conservation priorities portfolio

Marine turtle Red List assessments have been and will continue to be informed by the MTSG's conservation priorities portfolio (Wallace et al., 2011), the results of which are presented briefly here.

Average values of population risk and threats criteria across marine turtle subpopulations assessed by Wallace et al. (2011) are presented in Table 1. Globally, long-term population trends are declining on average across marine turtle subpopulations, but are stable or perhaps even increasing in recent years (Table 1). In general, population viability criteria tend to cluster around moderate values across subpopulations.

At ocean-basin scales (i.e., Atlantic Ocean and Mediterranean Sea, Indian Ocean, Pacific Ocean), subpopulations in the Pacific Ocean had the highest average risk (i.e., population viability) score, whereas subpopulations in the Atlantic Ocean (as well as in the Mediterranean Sea) had the highest average risk and threats score (Table 2). Indian Ocean subpopulations had the highest average data uncertainty scores for both risk and threats (Table 1), as well as the most populations assessed as "critical data needs" (Table 3).

One-third of all marine turtle subpopulations were assessed as "high risk-high threats"—i.e. low, declining abundance and low diversity simultaneously under high threats—which could be considered as the world's most endangered populations (Wallace et al., 2011). Between 20 and 30 per cent of subpopulations in each ocean basin were "high risk-high threats" (Table 3). More than half of *E. imbricata* subpopulations and roughly 40 per cent of *C. caretta* and *D. coriacea* subpopulations were categorized as High Risk-High Threats (Fig. 1).

One-fifth of marine turtle subpopulations globally were categorized as "low risk-low threats"—i.e., high and stable or increasing abundance, high diversity while experiencing low to moderate threats—a pattern that was reflected at the ocean-basin scale as well (Table 2). These included five *C. mydas* subpopulations, three *E. imbricata* subpopulations, two *D. coriacea* subpopulations, and one each for *C. caretta* and *L. olivacea* (Fig. 1).

These results illustrate both the large degree of variation and level of uncertainty in the conservation status of marine turtles within and among species and regions, as well as the importance of flexible assessment frameworks capable of reflecting these sources of variation.

### 3.3 Sea snakes

Elapid sea snakes comprise two evolutionary lineages: live-bearing true sea snakes (at least 63 species) and egg-laying amphibious sea kraits (genus *Laticauda* - 8 species). True sea snakes are further divided into two monophyletic groups, the *Aipysurus* group (> 10 species in two genera, predominantly associated with coral reefs) and the

*Hydrophis* group (> 50 species in ten nominal genera, mostly associated with inter-reefal habitats) (Lukoschek and Keogh, 2006). Marine elapids are found throughout the Indian and Pacific Oceans, but do not occur in the Atlantic Ocean, Mediterranean or Caribbean Seas. Highest species richness occurs in Southeast Asia and northern Australia (Elfes et al., 2013). Marine snakes are poorly studied: new species continue to be described, and revisions to taxonomic status and geographic ranges are not uncommon, resulting in changes in the numbers of recognized species and complicating assessments of their conservation status.

In 2009, the first Red List global marine assessment of extinction risk was conducted for 67 of the 71 elapid sea snake species recognized at the time (Elfes et al., 2013). Six species were classified in one of the threatened categories (Critically Endangered, Endangered or Vulnerable) and four species were classified as Near Threatened. The three most threatened species were *Aipysurus* congeners, two of which were Critically Endangered (*A. apraefrontalis* and *A. foliosquama*) and one Endangered (*A. fuscus*). At the time of the Red List Assessments, these three species were regarded as being endemic to a small number of reefs in the Timor Sea, where they had undergone catastrophic population declines since the mid-1990s (Lukoschek et al., 2013). However, recent sightings of at least one of these three species on coastal reefs in Western Australia suggest that further research is needed to confirm their true geographic ranges (Lukoschek et al., 2013). Of the eight species of *Laticauda*, two were classified as Vulnerable and three as Near Threatened (Elfes et al., 2013). Both Vulnerable species of *Laticauda* were small-range endemics (*L. crockeri* restricted to Lake Te-Nggano in the Solomon Islands; *L. schistorhyncha* to Niue), as were two of the three Near Threatened species (*L. frontalis* occurring only in Vanuatu and the Loyalty Islands; *L. guineai* restricted to Southern New Guinea). The third Near Threatened species, *L. semifasciata*, had undergone significant historical declines in the Philippines due to harvest for skin and food. *Hydrophis semperi* (endemic to Lake Taal in the Philippines, was classified as Vulnerable, and *Hydrophis pacificus* (endemic to North-east Australian waters) was classified Near Threatened. Of the remaining 57 species, 34 were classified as of Least Concern and 23 as Data-Deficient (Elfes et al., 2013). Several species classified as Data-Deficient are known only from a few museum specimens collected many years ago and may not be valid species. At the same time, some species listed as Data-Deficient may, in fact, be threatened and clarification of threat status for Data-Deficient species is needed (Elfes et al., 2013).

### 3.4 Marine iguanas

Marine iguanas (*Amblyrhynchus cristatus*) are the world's only marine lizard species, and are endemic to the Galápagos Islands (Ecuador). Ten subpopulations occur on separate islands within the archipelago, but the status of most of these subpopulations is unknown. Marine iguanas occupy rocky coastal areas and intertidal areas, and forage on marine algae in nearshore waters (Nelson et al. 2004). Although abundance estimates are unavailable for seven of the subpopulations, abundance estimates of

three subpopulations range between 1,000-2,000 individuals (Rabida Island), 4,000-10,000 (Marchena Island), and 15,000-30,000 (Santa Fe Island) (Nelson et al. 2004). Due to their restricted distribution and area of occupancy, marine iguanas are classified as Vulnerable according to the IUCN Red List (Nelson et al. 2004).

#### **4. Threats to Marine Reptiles Globally**

##### *4.1 Marine Turtles*

Dutton and Squires (2011) highlight the need for a holistic conservation approach that addresses all sources of mortality and deals with the trans-boundary nature of these multiple threats. Decades of over-harvest of eggs on nesting beaches have driven historic declines of some breeding populations, rendering them more vulnerable to impacts from fisheries by-catch and other threats. According to Wallace et al. (2011), fisheries by-catch was scored as the highest threat across marine turtle subpopulations, followed by human consumption and coastal development (Table 1). Climate change was scored as Data-Deficient in two-thirds of all RMUs, whereas pollution and pathogens were scored as Data-Deficient in more than half of all RMUs (Table 1).

A recent global assessment of fisheries by-catch impacts documented the Mediterranean Sea, Northwest and Southwest Atlantic, and East Pacific Oceans as regions with particularly high by-catch threats to marine turtle subpopulations (Wallace et al., 2013b). This assessment also highlighted the disproportionately large impact that by-catch in small-scale fisheries in coastal areas can have on marine turtle populations. Efforts to reduce turtle by-catch have included changes in gear configuration and/or fishing method, time-area closures, and enforcement of by-catch quotas, but by-catch reduction has only been successful when tailored to local environmental factors and characteristics of fishing gear and methods (Lewison et al., 2013). At a global scale, the FAO has adopted guidelines to reduce sea turtle mortality in fishing operations and encourages States to adopt and implement sea turtle by-catch reduction measures according to the those guidelines. Human consumption of marine turtles and turtle products has occurred as traditional and subsistence use, as well as commercially, around the world for centuries. The full magnitude of the effects of this human consumption on marine turtle populations has not been quantified, but unsustainable rates of consumption have contributed to declines in abundance in several places (e.g., *C. mydas*, *D. coriacea*, *L. olivacea* in the East Pacific Ocean, Abreu-Grobois et al., 2008; Seminoff and Wallace, 2012; *E. imbricata* in the Wider Caribbean, Southeast Asia, West Pacific; Mortimer and Donnelly, 2008). Consumption of turtles and turtle products has been reduced in recent decades due to top-down enforcement of national and international regulations against trade and use of turtle products (e.g., Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), national endangered species laws), but both legal and illegal turtle harvest continues in many countries (Humber et al., 2014).

Although climate change has been suggested as a major potential threat to marine turtles globally—e.g., possible skewing of sex ratios (which are controlled by temperature), habitat alteration related to increased frequency and severity of storms affecting nesting beaches, among other effects (Hamann et al. 2013)—specific impacts have not been quantified widely to date (Wallace et al., 2011). Increased beach sand and air temperatures and decreased precipitation might negatively affect hatchling production from nesting beaches, and fluctuating oceanographic conditions might alter migratory routes and foraging areas (Hawkes et al., 2009). More quantitative analyses of potential impacts to marine turtles related to climate change are warranted.

#### 4.2 *Sea Snakes*

Sea snakes are a diverse group of meso-predators with varying habitat and prey requirements that range on a spectrum from being generalists to highly specialised. Some species of true sea snakes occur predominantly in inter-tidal and estuarine habitats, others are restricted to coral reefs, and others occur in reefal, inter-reefal and estuarine habitats. Egg-laying amphibious sea kraits require intact coral reefs for feeding, as well as intertidal and terrestrial sites for nesting and resting. In terms of diet, generalist species feed on a variety of small fish, eels, squid, and crustaceans, whereas dietary specialists, such as *Emydocephalus* spp., exclusively forage on eggs of small reef fish, and most sea kraits forage exclusively on eels. Range extents also vary enormously, with some species having extensive ranges (Persian Gulf to Australia), and others being restricted to a single island or inland lake, or a handful of coral reefs. The differing ecologies, diets and geographic ranges mean that potential threatening processes vary among species and among geographically disparate populations of the same species.

Globally sea snakes are taken as by-catch, particularly in trawl fisheries in inter-reefal and/or estuarine habitats. Most information about the nature and extent of sea snake by-catch comes from northern and eastern Australia, and indicates that species composition and abundance vary spatially, temporally and between fisheries (Courtney et al., 2009). For example, trawl fisheries on Queensland's east coast catch > 100,000 sea snakes from 12 species annually, of which approximately 25 per cent die; however, 59 per cent of all sea snake catches and ~85 per cent of deaths occur in just one fishery, due to the spatial overlap of habitats between the red-spot king prawns, *Melicertus longistylus*, being harvested and reef-associated sea snakes (Courtney et al., 2009). Nonetheless, risk assessments for Australia's Northern Trawl Fishery indicated that no sea snake species was at risk under the existing fishing effort (Milton et al., 2008). While the use of by-catch reduction devices (BRDs), which are placed the regulation 120 meshes from the codend drawstring, did not reduce sea snake by-catch (Milton et al., 2008), the use of some BRDs placed closer to the drawstring (<70 meshes) has been shown to reduce the number of snakes taken by 40-85 per cent without significant prawn loss (Milton et al., 2008).

In Southeast Asia, many reptile species are heavily harvested for the commercial food, medicine and leather trades; however, very limited information exists about the extent to which marine snakes are targeted and about potential impacts (Auliya, 2011). To some extent, this lack of information probably reflects the fact that to date no sea snake species has been CITES-listed. One anecdotal account of a tannery in West Malaysia indicates that over 6,000 spine-bellied sea snakes (*Lapemis curtus*) were harvested per month (Auliya, 2011), suggesting that the impact might be high if this account is representative of other locations. Nonetheless, *L. curtus* has a large geographic range, is a voracious generalist predator (feeding on a variety of small fish, eels, squid, crustaceans) and typically occurs in large numbers in many habitat types, so it may be able to sustain heavy harvests (Auliya, 2011).

The three most threatened sea snake species are endemic to coral reefs in the Timor Sea, including Ashmore Reef, a renowned sea snake biodiversity hotspot. Species diversity at Ashmore Reef has declined from at least nine species in 1973 and 1994 to just two species in 2010 (Lukoschek et al., 2013) and abundances have declined > 90 per cent from the estimated standing stock of > 40,000 snakes in the mid-1990s (Guinea and Whiting, 2005; Lukoschek et al., 2013). In addition to the three threatened species from the genus *Aipysurus*, two species that disappeared (*Aipysurus duboisii*, endemic to Australasia, and *Emydocephalus annulatus*, also in the *Aipysurus* group), typically occur on coral reefs, suggesting that their declines might be due to loss or degradation of reef habitats. Reef-associated sea snakes shelter and forage under ledges and within the reef matrix, where they might be affected by reductions in coral cover, diversity and habitat complexity following coral bleaching events. A mass bleaching event in 2003 caused widespread coral mortality at Ashmore Reef; however, the most pronounced sea snake declines occurred between the mid-1990s and 2002 (Lukoschek et al., 2013), preceding the 2003 coral loss. The cause of these declines is unknown (Lukoschek et al., 2013). Widespread bleaching associated with the 1998 El Niño event affected many Australian reefs, including Scott Reef in the Timor Sea, but Ashmore Reef experienced minimal coral loss in 1998 (Lukoschek et al., 2013). Moreover, two additional species that disappeared from Ashmore Reef (*Hydrophis coggeri* and *Acalyptophis peroni*) were predominantly associated with soft-sediment habitats. Illegal harvesting on Timor Sea reefs targets invertebrates and sharks, but there is no evidence that sea snakes have ever been taken (Lukoschek et al., 2013). Moreover, Ashmore Reef was declared a National Nature Reserve (IUCN Category 1a) in 1983 and a National Parks or Customs presence, maintained for much of the year since 1986, has limited illegal fishing at Ashmore Reef (Lukoschek et al., 2013). Similar declines of *Aipysurus* group species have occurred on protected reefs in New Caledonia (Goiran and Shine, 2013) and the southern Great Barrier Reef (Lukoschek et al., 2007a). Possible reasons for these apparently enigmatic declines of sea snakes include reproductive failure due to the sub-lethal or lethal effects of increased sea surface temperatures, disease, and pollution; however, compared with other marine vertebrates, limited research has been conducted quantifying the extent to which these processes affect sea snakes. There has been no research into the effects of ocean acidification on sea snakes.

Sea snakes tend to have highly patchy or aggregated distributions throughout their ranges. Genetics research on species from the *Aipysurus* group (Lukoschek et al., 2007b; Lukoschek et al., 2008; Lukoschek and Shine, 2012) suggests that dispersal (gene flow) between geographically disparate populations is limited and that local population declines or extinctions are unlikely to be reversed by dispersal over ecological time-scales relevant for conservation (Lukoschek et al., 2013).

#### 4.3 *Marine Iguanas*

Periods of extremely high water temperatures and poor nutrient availability associated with El Niño events cause declines in food resources available to marine iguanas; dramatic (60-90 per cent) population declines related to El Niño have been documented (Vitousek et al. 2007). Introduced predators could also negatively affect marine iguana populations on some islands (Nelson et al. 2004). Increased stress responses and related changes in immune function have been documented in marine iguanas subject to consistent presence of tourists, which could pose a significant sub-lethal threat, particularly when compounded by periods of low resource availability (French et al. 2010).

### **5. Assessment and Conservation Needs**

In general, an urgent need remains for enhanced monitoring and reporting of marine reptile population status and trends, as well as of threats to marine reptiles globally. For example, insufficient information was available to assess recent and long-term trends for roughly 25-30 per cent of all subpopulations, and threats such as climate change also remain poorly quantified (Wallace et al., 2011). Significant efforts to quantify fundamental marine reptile demographic rates and processes (NRC, 2010) are still required to improve assessments of marine reptile status at global, regional, and local scales. Understanding biogeographical factors that influence the biology and ecology of marine reptiles, as well as the anthropogenic pressures on marine reptile species and populations, will improve status assessments and inform conservation strategies.



Table 1. Average values of population risk and threats criteria across marine turtle subpopulations. Scores range from 1 (high abundance, increasing trends, high diversity, low threats) to 3 (low abundance, declining trends, low diversity, high threats).

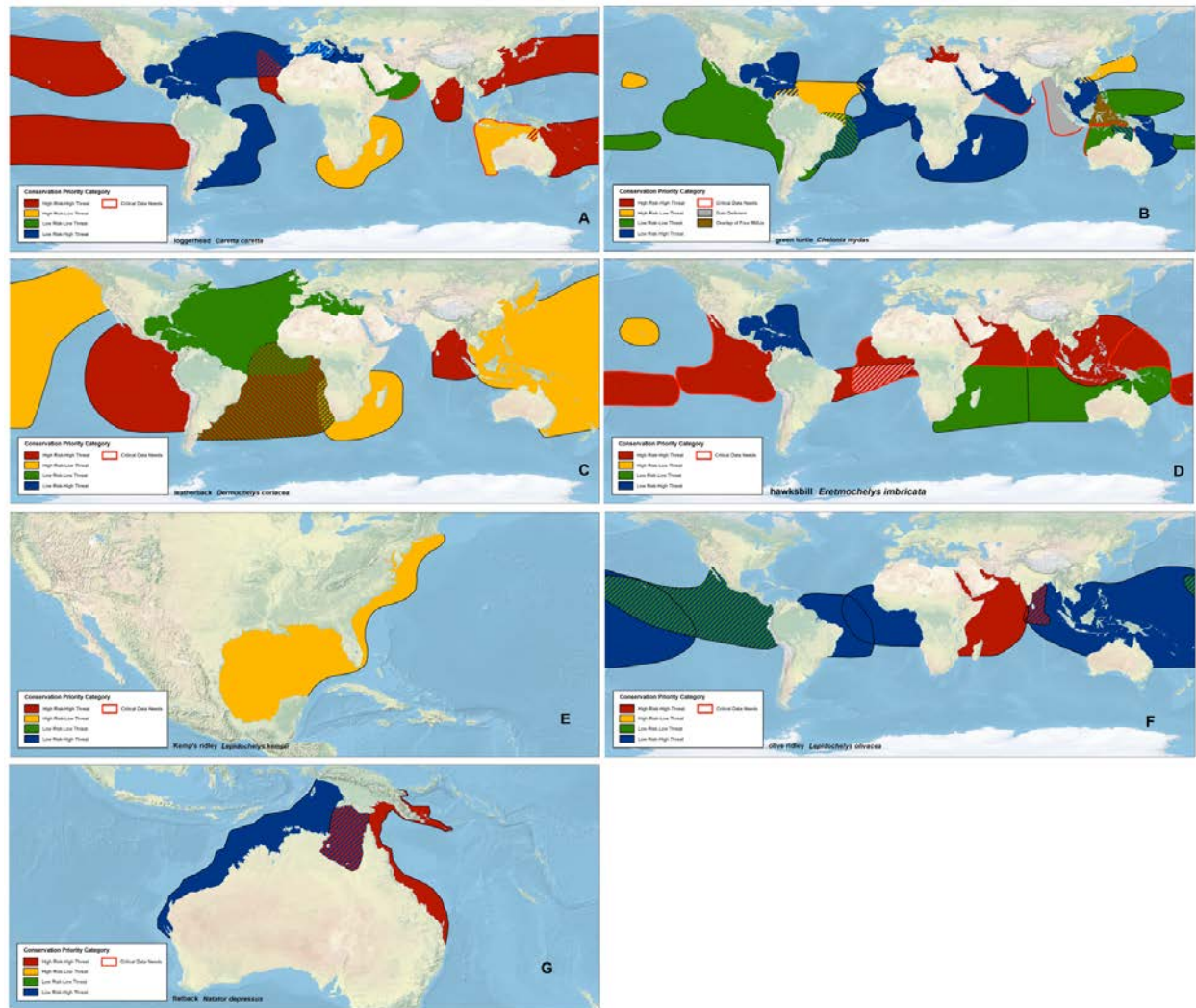
<b>RISK SCORES</b>					
	<b>population size</b>	<b>recent trend</b>	<b>long-term trend</b>	<b>rookery vulnerability</b>	<b>genetic diversity</b>
<b>mean</b>	1.95	1.81	2.47	1.72	1.90
<b>No. subpop'ns scored</b>	58	43	38	57	58
<b>THREATS SCORES</b>					
	<b>fisheries by-catch</b>	<b>human consumption</b>	<b>coastal development</b>	<b>pollution and pathogens</b>	<b>climate change</b>
<b>mean</b>	2.21	2.08	1.93	1.70	2.20
<b>No. subpop'ns scored</b>	56	57	53	25	20

Table 2. Average risk and threats scores (and accompanying data uncertainty indices) of subpopulations that occur in each ocean basin.

<b>ocean basin</b>	<b>average risk score</b>	<b>average risk score data uncertainty</b>	<b>average threats score</b>	<b>average threats score data uncertainty</b>
<b>Atlantic/Med (n=19)</b>	1.81	0.26	2.16	0.35
<b>Indian (n=18)</b>	1.92	0.78	2.08	0.68
<b>Pacific (n=21)</b>	2.03	0.32	1.96	0.48

Table 3. Categories in which RMUs occurred in each basin (including critical data needs RMUs). Categories: HR-HT=High Risk-High Threats; HR-LT=High Risk-Low Threats; LR-LT=Low Risk-Low Threats; LR-HT=Low Risk-High Threats. \* One RMU (*C. mydas*, northeast Indian Ocean) was scored critical data needs only.

ocean basin	Categories					Total
	critical data needs	HR-HT	HR-LT	LR-LT	LR-HT	
<b>Atlantic/Med (n=19)</b>	1	5	2	3	9	19
<b>Indian (n=18) *</b>	8	6	3	4	4	17*
<b>Pacific (n=21)</b>	3	8	4	5	4	21
<b>Total</b>	<b>12</b>	<b>21</b>	<b>9</b>	<b>12</b>	<b>15</b>	<b>57*</b>



The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 1. Conservation status of marine turtles: Four conservation priority categories are displayed: (red) high risk – high threat, (yellow) high risk – low threat, (green) low risk – low threat, (blue) low risk – high threat. Panels: (A) loggerheads (*Caretta caretta*), (B) green turtles (*Chelonia mydas*), (C) leatherbacks (*Dermochelys coriacea*), (D) hawksbills (*Eretmochelys imbricata*), (E) Kemp’s ridleys (*Lepidochelys kempii*), (F) olive ridleys (*Lepidochelys olivacea*), (G) flatbacks (*Natator depressus*). Subpopulations were classified as having critical data needs (outlined in red) if the data uncertainty indices for both risk and threats  $\geq 1$  (denoting high uncertainty). Hatched areas represent spatial overlaps between subpopulations. The brown area in panel B highlights an overlap of four subpopulations, and the grey area in panel B represents the *C. mydas* Northeast Indian Ocean subpopulation, which had excessive data-deficient scores and was not included in overall calculations and categorization. Figure from Wallace et al. (2011) PLoS ONE 6(9): e24510. doi:10.1371/journal.pone.0024510.

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