Indian Ocean – South-East Asian Marine Turtle Memorandum of Understanding

Assessment of the conservation status of the loggerhead turtle in the Indian Ocean and South-East Asia

IOSEA Species Assessment: Volume II

Compiled by:

Mark Hamann, Ruth L. Kamrowski and Taylor Bodine

IOSEA Marine Turtle MoU

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Preface

The *Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia* (IOSEA Marine Turtle MoU) is a non-binding framework under the Convention on Migratory Species through which States of the Indian Ocean and South-East Asia region are working together to conserve and replenish depleted marine turtle populations for which they share responsibility. The IOSEA Marine Turtle MoU took effect in September 2001 and has 33 Signatory States (as of 2013). Supported by an Advisory Committee of eminent scientists and complemented by the efforts of numerous nongovernmental and intergovernmental organisations, Signatory States are working towards the implementation of a comprehensive Conservation and Management Plan.

Aware of the importance of compiling up-to-date information on the status of species covered by the Memorandum of Understanding, particularly with a view to identifying and addressing gaps in basic knowledge and necessary conservation actions, the IOSEA Signatory States commissioned a series of region-wide species assessments.

Accordingly, in 2006 the IOSEA Secretariat published the first-ever *Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South-East Asia*, which covered legislative provisions as well as aspects of conservation related to both nesting and foraging populations. Importantly, the 166-page review also included detailed recommendations and proposals for dealing with deficiencies that had been identified. The Leatherback Assessment was comprehensively reviewed and updated in 2012 to reflect new information and developments. The resulting document was published online and remains available for download from the IOSEA website:

http://ioseaturtles.org/UserFiles/File/Leatherback_STATUS_2012_UPDATE.pdf

The IOSEA Advisory Committee determined that the loggerhead turtle should be the next species to benefit from a comprehensive assessment. Rather than approach the assessment on a country basis, as in the leatherback assessment, loggerhead turtles of the IOSEA region were grouped into their distinct management units and each were reviewed separately. To obtain information we sought published material, reports from IOSEA Signatory States IOSEA and experts within each of the regions. The following loggerhead assessment presents a synopsis of the current state of knowledge for the species in the IOSEA region.

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Loggerhead turtle synthesis

Summary – nesting

Loggerhead turtles nest in 10 nations within the Indian and Pacific Ocean basins. Seven of these nations are Signatory States of the Indian Ocean and South-East Asia Marine Turtle Memorandum of Understanding (IOSEA); one, Japan, is within the range of the IOSEA but is not a signatory; and two, New Caledonia and Vanuatu, are outside of the IOSEA region. There are records from Vanuatu that warrant verification. There were anecdotal records of nesting from Myanmar and Bangladesh; however, they are now believed to have been mis-identified olive ridley sightings. Telemetry of post-nesting turtles has been undertaken from South Africa, Oman, eastern and western Australia, New Caledonia and Japan.

Summary – foraging

Data from tag recoveries, satellite telemetry (end points), and fisheries bycatch indicate that loggerhead turtles forage within the Exclusive Economic Zones of 23 of the IOSEA Signatory States (and their Territories). In addition, loggerhead turtles have been recorded in six non-signatory range states and four non-range states. Population and biological studies on foraging turtles have only been conducted in two nations (Japan and Australia – for the north and south Pacific Ocean populations respectively. Of the 23 Signatory States in which loggerhead turtles have been recorded, specific threats to loggerhead turtles have been identified in 10.

Summary – population identification

There are six distinct populations/management units (MU) of loggerhead turtles within the IOSEA region – South-west Indian Ocean, North-west Indian Ocean, North-east Indian Ocean, South-east Indian Ocean, North Pacific Ocean and South Pacific Ocean. These have been classified as distinct based on a combination of genetic data, migration data, home range data, tag recoveries and expert opinion. While the nesting sites are distinct, individuals from more than one population may inhabit particular foraging areas.

The status of each of the populations has recently been assessed by both the United States National Marine Fisheries Service (US NMFS) and as part of the Burning Issues initiative of the Marine Turtle Specialist Group (Figure A; Wallace et al. 2011). In general the two assessments, which were conducted independently but with some experts involved in both processes, derived similar conclusions (Table 1). Two main differences exist between the assessments: (1) US NMFS included the Sri Lankan loggerheads with the North-west Indian Ocean population (Oman and Yemen) whereas Wallace et al. (2010, 2011) considered it to be separate, and classed it as a high risk-high threats population (and one of the 11 most endangered in the world); and (2) US NMFS classed the North-west Indian Ocean population as 'Endangered' whereas Wallace et al. (2011) classed it as low risk-low threats because there is a lack of empirical data on population decline and threats (Figure 1). Clearly, the different opinions expressed in the two assessments raise important questions about the population's status and condition. Of the two assessments, the US NMFS placed more emphasis on expert opinion to fill the empirical knowledge gaps than Wallace et al. (2011), hence their 'Endangered' classification. There is a well-recognised need for both data analysis and continued research and monitoring on this population to improve assessment accuracy.

Table 1. Comparison of outputs from the US NMFS determination and Wallace et al. (2011) for loggerhead turtle populations in the IOSEA region. [1] denoted by Wallace et al. 2011 as a critical knowledge gap; [2] listed as one of 11 of the world's most endangered regional management units (RMUs) (Wallace et al. 2011) and [3] is included in the NW Indian Ocean section.

Breeding location	Population	NMFS Determination	Wallace et al. 2011
Japan	North Pacific	Endangered	High Risk-High Threats[2]
Eastern Australia and New Caledonia	South Pacific	Endangered	High Risk-High Threats
Western Australia	South-east Indian	Threatened	High Risk-Low Threats[1]
South-east Africa	South-west Indian	Threatened	High Risk-Low Threats
Oman and Yemen	North-west Indian	Endangered	Low Risk-Low Threats[1]
Sri Lanka	North-east Indian	Not assessed[3]	High Risk-High Threats[1,2]

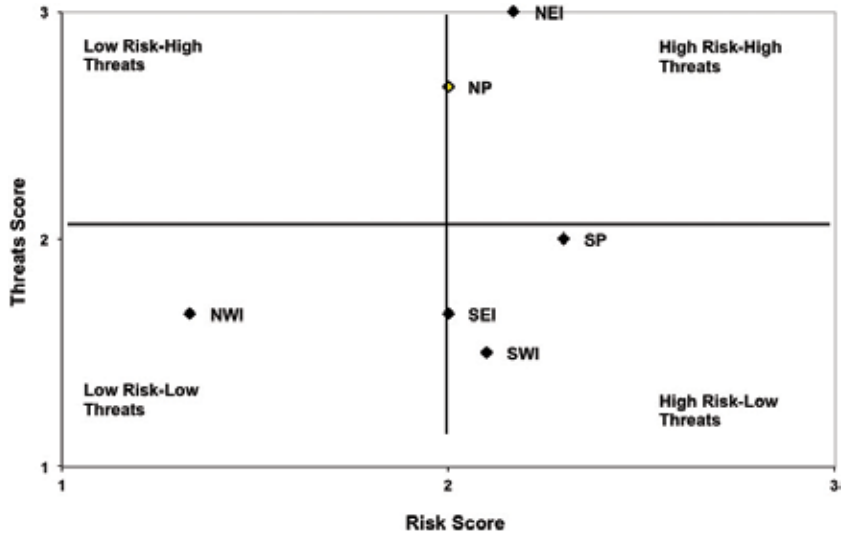

Figure 1. Conservation priority portfolio approach to displaying and interpreting paired risk and threat scores for loggerhead regional management units (RMUs) (adapted from Wallace et al. 2011)

Gaps in the basic biological information

Population structure

There are some gaps in our understanding of loggerhead turtle population genetic profiling within the IOSEA region. To address the gaps and determine the genetic structure of loggerhead turtle populations, the following rookeries need to be sampled and compared to each other, as well as to published genotypes: Sri Lanka, Yemen (Socotra) and Somalia. There is also a need to sample turtles from foraging areas, or those that have stranded or been caught in fisheries, to better understand population-specific mortality.

Life history attributes

A. Nesting populations

There are substantial gaps in our knowledge of life history attributes for several of the loggerhead turtle nesting sites in the IOSEA region. The specific gaps vary between locations, and details can be found by referring to each population section of this report. Data on life history attributes are necessary

for the development of accurate population models. It is preferential that life history parameters be collected from at least one rookery per management unit. The gaps in life history attributes evident in most management units include:

- the number of clutches per female per year/nesting season
- temperature profile and hatchling sex ratios of nesting populations
- the number of years between breeding seasons
- the rate of recruitment into the breeding population
- nest success and hatchling recruitment
- survivorship of adult females
- inter-nesting areas and habitat use.

B. Non-nesting beach aspects

Within the IOSEA region there are substantial gaps in our knowledge of loggerhead turtle foraging areas, habitat use (oceanic and coastal), inter-nesting area habitats, diet, growth, age and survivorship for all except the two Pacific Ocean populations. Additionally, while there have been substantial tracking and foraging area studies in the North and South Pacific, and the South-west and North-west Indian Ocean populations, few data on migration and home range exist for the North-east and South-east Indian Ocean populations.

Gaps in management

Reporting gaps

It was evident during the writing of this assessment that much of the threat, mortality and management information contained within the IOSEA website and the Signatory States reports is not species specific. It could be that "species" level information is not collected, or that it is not reported on. In terms of threats such as bycatch it is most likely the former. Improving species-specific data collection about threats and mortality will improve management.

Bycatch and fisheries-associated mortality

Incidental catch of marine turtles was reported to occur at varying levels of intensity in all nations in the IOSEA region; however, species-specific data is often not available. Bycatch has not been quantified in most countries, and fewer bycatch data exist for the high seas fisheries, especially species-specific data. There are also gaps in the ecological, social and economical aspects of marine turtle bycatch. Bycatch and fisheries-based mortality needs to be addressed by fisheries and/or government organisations. This will take a coordinated international effort similar to those undertaken in the Atlantic and Pacific Ocean fisheries. Recent initiatives have aimed to quantify bycatch from several fisheries: South African longline fisheries (Petersen et al. 2008), gillnet fisheries (Gilman et al. 2010) and a multi-fishery ecological risk assessment (Nel et al. in press). A summary of the previous 15 years of data for the European Union Purse Seine Fisheries sea turtle interactions can be found at http://ioseaturtles.org/pom_detail.php?id=123, and IOSEA reports relevant to Indian Ocean fisheries-turtle interactions can be found at http://ioseaturtles.org/pom_detail.php?id=127.

Hatchling production

Aside from the South-west Indian Ocean and the two Pacific Ocean populations there have been no detailed assessments of the hatchling production at other rookeries in the IOSEA region. Without these data it is impossible to conduct meaningful population assessments and design management strategies.

Climate change

Rising beach temperatures associated with climate change can be expected to negatively impact on population sex ratio and incubation success of loggerhead turtle eggs. Sand temperature loggers have been deployed on index beaches for the South-east Indian Ocean and South Pacific Ocean populations; however, no adequate monitoring appears to be in place in any of the other IOSEA countries to guide rookery management in response to climate change.

Standard monitoring

Monitoring of several of the rookeries in the IOSEA region has been initiated relatively recently. There is a need for managers in each location to develop standard monitoring protocols that remain consistent year to year, and which complement existing projects. Most importantly, if whole season monitoring is not possible at all rookeries, index beaches and standard monitoring periods need to be determined and used annually. The introduction of standard practices will substantially improve the ability to use the data effectively in the future.

Additional issues for loggerhead turtles in the IOSEA region

Climate change

Climate change is becoming a ubiquitous issue throughout the world. While marine turtles have coped with changing climates over past millennia, the rate of current and predicted change, coupled with additional threats and pressures (e.g. coastal development, pollution, fisheries etc.), is unprecedented. While it may be a ubiquitous issue, the degree to which various species or populations of marine turtle are exposed, and how they are able to adapt, will vary considerably. For loggerhead turtles, Chaloupka et al. (2008) demonstrate that increased sea surface temperatures could negatively influence the numbers of females breeding each year, and studies from the US indicate that shifts in the nesting season or impact of threats could change with a warming climate (Pike and Stiner 2007). Key research gaps include the conversion of global/ocean-scale climate models down to smaller scales so they are relevant to local scale (e.g. for nesting beaches or foraging areas), understanding sensitivity and thresholds of concern (e.g. pivotal temperatures and sand temperature ranges) and understanding adaptive capacity (see Hamann et al. 2007, 2010).

Marine debris and plastic pollution

Marine debris, in particular plastic pollution, is emerging as an important and widespread threat to marine turtle populations globally. Although most of the published accounts of impacts on sea turtles come from the Pacific and Atlantic oceans, it is becoming clear that the South-East Asian and Indian Ocean regions contain substantial levels of plastic pollution. The main threats that plastics pose to turtles occur when turtles ingest plastic fragments, become entangled in discarded nets (ghost nets), or have their nesting habitats impacted by them. Key research gaps include quantification of the impact across populations and life stages, the oceanographic features that disperse the pollution, understanding the social and economic drivers behind the pollution, and the barriers and opportunities for management.

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Recommendations for loggerhead turtle conservation

Gap	Project context/relevance	Expected outcomes	Nations/agencies targeted
Species-specific bycatch data from fisheries in coastal and oceanic zones of the Indian Ocean. Particularly, but not limited to, Indian Ocean tuna fisheries, longline, gillnet and bottom trawl fisheries Mortality data related to bycatch, and skin samples for genetic analysis on stock contributions	Work with national and regional fisheries bodies (e.g. IOTC) to promote programs and activities such as onboard observer programs, and bycatch assessment/ quantification and mitigation projects (including actual implementation of gear modification and improved fishing practices at national level to reduce bycatch) There is a particular need for the development of gear modification and/or use to achieve reduction in turtle mortality in gill nets [c.f. achievements such as TEDs and work in progress with long line fisheries] Advocate for national fisheries bodies' policies to incorporate turtle bycatch assessment and mitigation strategies, and for monitoring of progress through regional fisheries management organisations Investigate/ advocate for investigation of seasonal and spatial closures as a potential management tool for reducing bycatch – especially in coastal fisheries Assess the impact of fisheries on inter-nesting, migrating & foraging turtles	National bycatch observer, assessment and quantification programs established National and/or regional bycatch mitigation projects established Coordinated regional approaches to bycatch management and illegal fishing Improved understanding of bycatch "hotspots" which will aid in fisheries bycatch management Improved understanding of the impacts that bycatch may have on turtles at particular life history stages. Reduced mortality of marine turtles	Nations of the IOSEA region and nations (outside IOSEA) deploying foreign fishing fleets into the region. International fisheries management agencies

Understanding of hatchling and post-hatchling dispersal in the Indian Ocean	Compared with the Pacific and Atlantic (esp. northern) little is known about the distribution and migration routes of post-hatchling turtles in the Indian Ocean	Identification of important dispersal mechanisms and routes for hatchlings for each of the Indian Ocean management units	Each nation within the Indian Ocean with nesting loggerhead turtles (e.g. South Africa, Oman, Western Australia). Strategies could include combinations of active tracking, development of oceanographic models and genetic studies.
Assessment of the vulnerability of loggerhead turtle management units to climate change	Climate change is a global issue for marine turtles. For most of the management units there is a lack of data on key parameters such as beach temperature, nesting season length, vulnerability to sea level rise and extreme weather, and the influence of climate factors on key biological traits	Baseline data on sand and beach temperatures for index sites for each management unit. Improved understanding of the vulnerability of each management unit to climate change (temperature, sea level rise and extreme weather)	Each nation with nesting loggerhead turtles to collect baseline data as a contribution to broader modelling exercises
Quantification of abundance and demography of loggerhead turtles in coastal waters	There is a lack of information about non-nesting biological attributes for most of the management units. Understanding growth rates, survivorship, recruitment, and habitat use of foraging turtles will help improve population assessments	Improved understanding of population dynamics and function	Each nation with foraging loggerhead turtles to conduct foraging area surveys. Priority areas: Western Indian Ocean nations, nations of the Northwest Indian Ocean and Western Australia
Assessment of the vulnerability of loggerhead turtles to marine debris (in particular plastic pollution)	Marine debris, in particular plastic pollution, is emerging as a global issue for marine turtles. It can impact foraging turtles at all size classes, yet very few data exist to quantify the issue, or determine hotspots. Key research could focus on understanding aspects such as distribution, transport and abundance of marine debris in the Indian Ocean, marine debris ingestion rates, and vulnerability	Improved understanding of the vulnerability of each management unit to marine debris (plastic pollution) Improved understanding of the sources and sinks of marine debris in the Indian Ocean	National, regional, international organisations concerned with marine debris (cooperative studies, modelling etc.)
Genetics and population identification in Sri Lanka – including national assessment (by sampling/analysis)	It is not known whether the loggerhead turtles breeding in Sri Lanka are a distinct management unit, or part of other Indian Ocean units	Resolution of discrete management units for loggerhead turtles in the IOSEA region	Sri Lanka (Dept. of Wildlife and/or NGOs; and cooperating countries for sample analysis)
Analysis of existing data from the Northwest Indian Ocean management unit (acknowledging that significant amounts of annual nesting turtle data exist)	Recent assessments of loggerhead turtles (Wallace et al. 2011) and US NMFS both acknowledge long-term monitoring of loggerhead turtles of Masirah Island. These reports plus the present assessment indicate that the conservation status of loggerhead turtles in Oman is not known	Resolution of the current conservation status of loggerhead turtles in the NW Indian Ocean	Oman (Ministry of Environment and Climate Affairs, cooperating organisations)

Introduction

The loggerhead turtle (*Caretta caretta*) occurs in all of the world's tropical and temperate oceans. As a widely distributed and long-lived marine species, a challenge has been the determination of loggerhead turtle conservation status at scales appropriate for management (Wallace et al. 2010). The global stock of loggerhead turtles consists of numerous populations, which possess separate nesting locations and often display distinct life cycle characteristics (Dodd 1988). Yet different nesting populations may also share nursery and foraging areas (Bowen and Karl 2007). As a result, the separation of populations into distinct entities for management purposes has proved difficult. However, for conservation strategies to be effective, it is crucial that the relationships between the geographic areas utilised by each population are identified, to permit impacts from anthropogenic sources to be determined at the population level (Wallace and Saba 2009; Hamann et al. 2010).

There have been several attempts to categorise marine turtles into independent population units below the species level, but above the nesting population level. The first initiatives used population genetics to determine genetically distinct populations, and then classed these populations as stocks or management units (Moritz et al. 2002; Dethmers et al. 2006). More recently, the United States Government's National Marine Fisheries Service (NMFS) assembled a loggerhead Biological Review Team (BRT) in 2008 to describe turtle management units and complete a status review of the loggerhead turtle. The NMFS based their review around what they consider to be 'distinct population segments' (DPS), which are defined as populations distinct from other populations of the same taxon due to physical, physiological, ecological or behavioural factors; or due to differences in control or management as a result of international government boundaries. Simultaneously, in an attempt to address the challenges of data poor areas, migratory behaviour and foraging areas with mixed stocks, Wallace et al. (2010) described regional management units (RMU) for not only loggerhead turtles but all seven species of marine turtle. Thus precise demographic information about sea turtle population distributions was provided in a spatial format to enable analysis in combination with other geo-referenced data sets. Together these approaches identify the most appropriate management units (MUs) for loggerhead turtles.

For the loggerhead turtle, genetic-based studies from nesting turtles have identified a distinct population structure across the globe – Mediterranean, North-east Atlantic, South-east USA, Brazil, Japan, Eastern Australia, Western Australia, South-east Africa, Oman and possibly Sri Lanka. The NMFS-appointed BRT agreed with these classifications in their assessment of global loggerhead turtles; however, they renamed them, and combined Sri Lankan loggerheads into the same management unit as those in Oman (Table 2). Similarly, Wallace et al. (2010) also described 10 RMUs globally (Figure 2), but in the absence of necessary biological information (e.g. genetic analysis) they considered the putative RMU suggested for the North-east Indian Ocean (Sri Lanka) to be separate from those in the North-west Indian Ocean. Thus, each review has identified similar populations and management unit structure.

Table 2. Geographic locations of global loggerhead turtle populations and the descriptors used by the NMFS and Wallace et al. (2010, 2011) in their assessments.

Breeding location	**NMFS descriptor**	**RMU descriptor**
Japan	North Pacific	North Pacific
East Australia, New Caledonia	South Pacific	South Pacific
Western Australia	South-east Indo Pacific Ocean	South-east Indian
South-east Africa	South-west Indian	South-west Indian
Oman and Yemen	North-west Indian	North-west Indian
Sri Lanka	Inc. in North-west Indian	North-east Indian
Mediterranean	Mediterranean Sea	Mediterranean
South-east USA	North-west Atlantic	North-west Atlantic
Brazil	South-west Atlantic	South-west Atlantic
Cape Verde Islands	North-east Atlantic Ocean	North-east Atlantic Ocean

With regard to identifying status of marine turtle species there has been considerable debate about the most effective scale to undertake the review, such as species level as in the IUCN, regional level as in ocean basin or at a national level (i.e. Hamann et al. 2006 – leatherback assessment). One aim of the NMFS BRT was to review all existing information and data focussed on loggerhead populations around the globe, to assess the threats posed to each population and to determine the appropriate conservation status of each loggerhead turtle DPS (NMFS et al. 2011). Using a different approach Wallace et al. (2011) assessed each of the RMUs in terms of population risk level (population size, recent trend, long-term trend, rookery vulnerability and genetic diversity) and existing threats (fisheries bycatch, take, coastal development, pollution and pathogens, and climate change), identified those RMUs which could be considered most endangered at a global scale, and also highlighted existing gaps in necessary conservation information. Combining these two approaches, and considering that some of the same people were involved in both processes, we get an overall perspective of the status of each of the loggerhead turtle management units globally and within the IOSEA Memorandum of Understanding.

In compiling our assessment on loggerhead turtles in the IOSEA region we followed the same population boundaries as previous assessments. We then (1) collated data from the Signatory State reports which were downloaded from the IOSEA website (ioseaturtles.org), and (2) reviewed the assessments of Wallace et al. (2010, 2011) and NMFS (Conant et al. 2009; NMFS et al. 2011), to summarise the status of five loggerhead populations of the Indian and Pacific oceans – we also considered the Sri Lankan loggerhead turtles as separate from those elsewhere in the Indian Ocean.

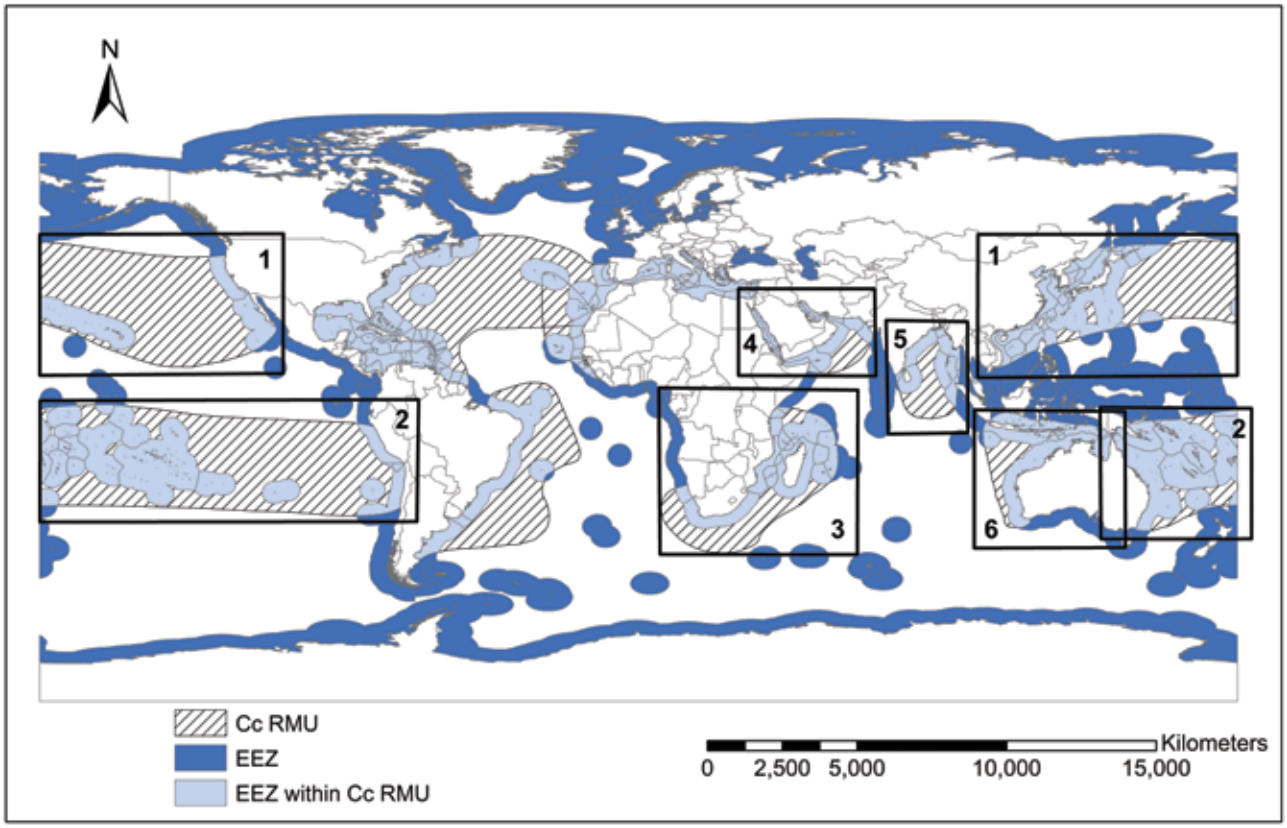

Figure 2. Distribution of Global RMUs/populations of loggerhead turtles, plus a putative population in central Indian Ocean (Sri Lanka). Numbers refer to RMUs that lie within the IOSEA region and the maps within each section of the report (based on data from Wallace et al. 2010).

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South-west Indian Ocean management unit

Ecological range

The extent of the management unit, which approximates ecological range, was calculated based on existing data from molecular studies, migration behaviour, tag recoveries and expert opinion, and its spatial extent matches its RMU (Wallace et al. 2010). The boundary of its ecological range indicates that turtles from the population occur within the Exclusive Economic Zones of 17 nations (Figure 3).

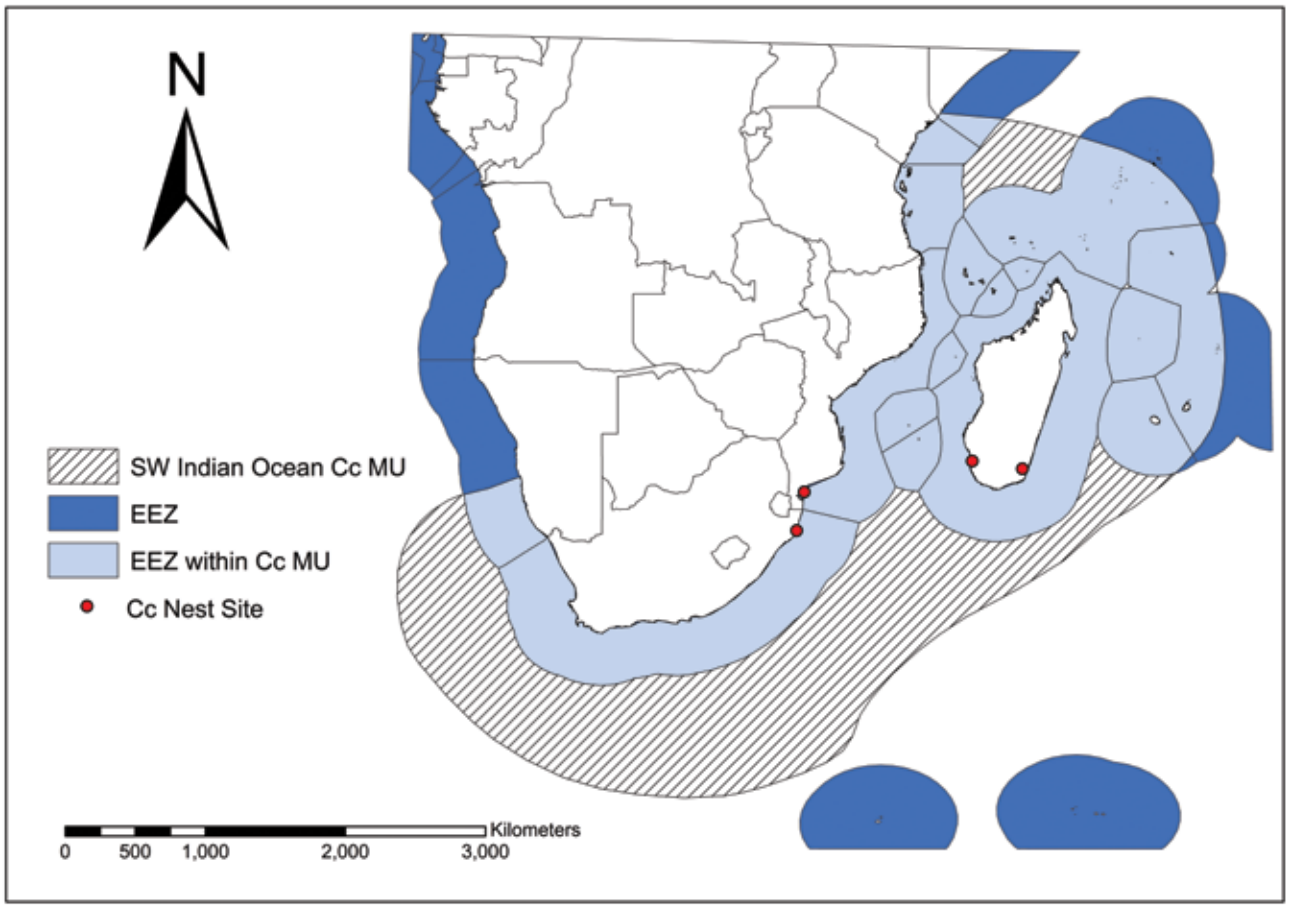

Figure 3. Distribution of the South-west Indian Ocean loggerhead turtle population/RMU (mesh) (Wallace et al. 2010), with the exclusive economic zones (light blue) of inclusive nations.

Geographic spread of foraging sites

Loggerhead turtles from the South-west Indian Ocean management unit have been recorded along the east coast of Africa, as far north as southern Somalia. A combination of fisheries bycatch data, sightings and expert opinion indicate that loggerhead turtles from this management unit also move west into the south-eastern Atlantic (Namibian waters) and north-east into the waters of La Réunion, Comoros, Seychelles and possibly Chagos (British Indian Ocean Territory). Overall it is possible that loggerhead turtles from this management unit forage in the EEZs of eight nations plus their territories (Figure 3).

Geographic spread of nesting

Loggerhead turtle nesting in the south-west Indian Ocean has been reported in South Africa, Mozambique and Madagascar, Kenya, Réunion Island (France), and Seychelles. Most nesting occurs on the south-eastern coast of Africa, from the Paradise Islands in Mozambique south to the St Lucia Estuary in South Africa, with scattered low density nesting occurring along the south and west coasts of Madagascar (Figure 3; Rakotonirina and Cooke 1994; Walker and Roberts 2005).

Index nesting beaches:

- *South Africa – iSimangaliso National Park. Within the 12.8 km index beach "loggerhead abundance has increased from ~250 to >1,700 nests per year" – Nel et al. (2013)*
- *Mozambique – Ponta do Ouro*

South Africa: iSimangaliso National Park (previously Greater St Lucia Wetland Park), KwaZulu-Natal (27º0'45"S; 32º51'59"E) World Heritage Site. Both terrestrial and marine protected areas exist within this park; the marine component extending 3 nautical miles into the ocean and the terrestrial component spanning ~56 km of coastline. In this park loggerhead turtle nesting monitoring has been in place since 1963 and the magnitude of nesting has been estimated to range from 1,000 to 5,000 nests laid per year.

Madagascar: Abohazo (part of the Barren Islands), West-Madagascar Melaky Region (18º33'0"S; 43º48'0"E) is located approximately 52 kilometres south-west of Maintirano. Beaches between Fort-Dauphin and Manantenina, and at Besambay and Maromena (SWOT database). This habitat consists of coral and rocky reefs. This area is of high importance to loggerheads for nesting, feeding and developmental habitats. No regular monitoring has occurred.

Mozambique: Loggerhead females nest predominantly in the south of Mozambique, from the Bazaruto Archipelago National Park to Ponto do Ouro. The highest density nesting occurs at the Maputalan Marine Reserve and in the vicinity of Ponta Malongane (Hughes 1971; Louro et al. 2006). Other minor sites include Inhaca Island Special Control Zone, Ponta Chemucane, Milimangalala Beach and Paradise Islands (SWOT database). There has been monitoring on various beaches since 1996 (Costa et al. 2007).

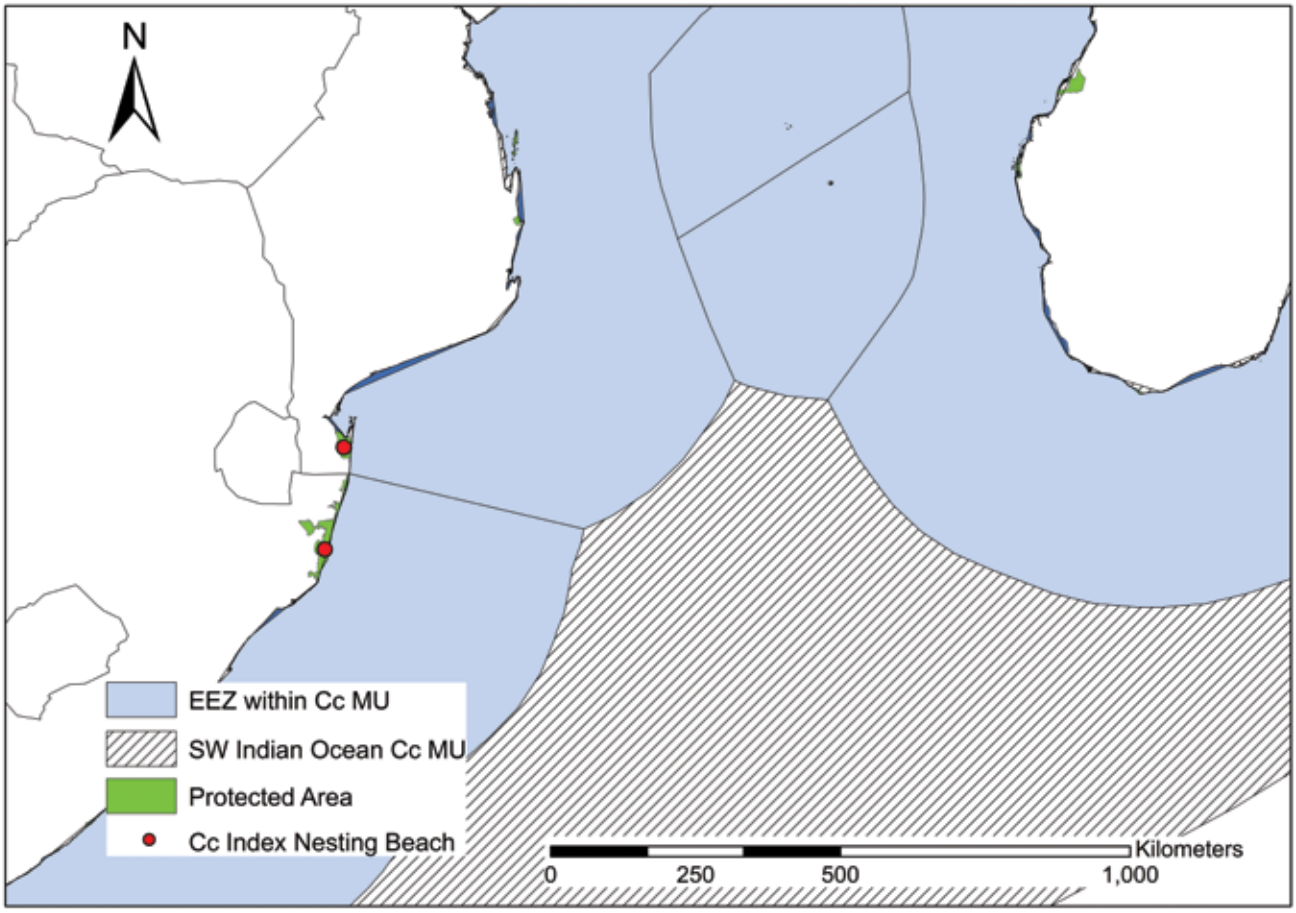

Figure 4. Loggerhead turtle nesting region for the South-west Indian Ocean population, with designated protected area information shown: nesting occurs all along the south-east African coast and in southern Madagascar. Index nesting sites for this population are marked, occurring in South Africa and Mozambique.

Trends in nesting data

Nesting trends for this population are described for the 12.8 km index beach within the iSimangaliso National Park, in the area now known as Maputaland (formally Tongaland; Hughes 2010). Annual monitoring has occurred since 1965 and data have been reported to 2010 (Nel et al. 2013). Annual numbers of nests in the index beach have increased from ~250 to >1,700 nests per year (Nel et al. 2013).

Migration and distribution of foraging areas

Evidence from stranded turtles, tag returns, and observations indicate loggerhead turtle foraging grounds are located in the waters surrounding Réunion Island (France), Mauritius, Madagascar, United Republic of Tanzania (hereafter referred to as Tanzania), Kenya, Seychelles, South Africa and Mozambique.

Tagging data shows that post-nesting female loggerheads from Maputaland, South Africa, migrate eastward to Madagascar, northward to Mozambique, Tanzania (especially southern Tanzania) and Kenya, and southward to Cape Agulhas at the southernmost point of Africa and some enter the Atlantic Ocean (Baldwin et al. 2003; Luschi et al. 2006).

Threats to the population

No monitoring programme exists for in-water species counts for this region; however, fisheries bycatch data are compiled by government agencies.

South Africa: Fisheries (longline and bather protection nets) pose the greatest quantified threat to this population. Trawling and ghost fishing may also pose significant threats, but these require more monitoring. Egg harvest and urban, agricultural and tourism driven habitat degradation are considered to pose a low threat level to this population. Other threats including marine debris, boat strike and natural threats (such as egg predation and disease) remain unassessed. An assessment of loggerhead turtle bycatch in longline tuna and swordfish fisheries was conducted in 2009 using data from 1998 to 2005. The authors report that loggerhead turtles were the most common species caught (60% of captures as 0.02 captures per 1,000 set hooks), comprising 780 captures at an average of 100 per year for these fisheries (Petersen et al. 2009). The shark control program reports turtle capture and mortality within the shark nets set out for bather protection. Between 1981 and 2008 an average of 41 loggerhead turtles were caught per year with average annual mortality of 22 individuals (Brazier et al. 2012).

Madagascar: A high level of egg harvest occurs on the western coast, and nests and females are at high risk from natural threats such as predation and disease. The consumptive use of nesting loggerhead turtles and the rate of incidental bycatch in artisanal fisheries are considered to be moderate risks. Loggerhead turtles are found foraging in high density in the waters of Madagascar.

Mozambique: A low level of egg harvest and exploitation of females occurs on the main nesting beaches within the Ponto do Ouro coast. However in central Mozambique, high use of eggs occurs on several of the beaches with low nesting density. Overall, the consumptive use of nesting loggerhead turtles and the rate of incidental bycatch in coastal and artisanal fisheries are considered to be medium level risks.

Tanzania: Loggerhead turtles are reported to be rare in Tanzanian waters. Low level bycatch has been reported, and turtles tagged while nesting in South Africa have been caught in Tanzania. In particular, since 2001 at least five tagged turtles have been caught in coastal fisheries. It has been estimated that 54 turtles per year are caught in trawl based fisheries, with 12% of these being loggerhead turtles.

Kenya: Loggerhead turtles are rarely caught or sighted in Kenya.

French territories: The indirect capture of animals in fisheries is deemed a considerable threat. It has been recorded in La Réunion and Mayotte.

Seychelles: A low density feeding habitat exists in the Cosmoledo, Astove, Assomption, Aldabra Group and de facto nature reserves Anonyme, Bird, Cousine, Denis, Fregate, North, and Inner Islands. Developmental life stages are also present in this area. There is a high level (in proportion to the size of the Seychelles foraging aggregation) of direct harvest occurring in coastal waters of this region.

Additional threats: We obtained information on additional threats, their degree of management and data from reports to the IOSEA MoU from Signatory States (see online reporting at http://www.ioseaturtles.org/report.php), published literature and unpublished monitoring program reports (http://www.ioseaturtles.org/bibliography.php). We searched the literature for mentions of loggerhead turtle nesting, migration and foraging for each nation within the range of the population and scored threats for their location, whether they were managed and the availability of quantifiable data. The data on addition threats are summarised in the table below.

Summary of threats to the population - as per data contained within the Signatory States reports to IOSEA MoU.

Type of threat	Location 1=nesting beach 2=migration zone 3=foraging area (local) 4=foraging area (widespread)	Managed 1=managed at most sites 2=managed at some sites 3=main nesting sites mostly protected 4=no, or little, management 5=not documented	Quantified 1=comprehensive documentation across population 2= comprehensive documentation for some of the population 3=anecdotal only 4=no reliable data
Egg predation/collection	1	2,3	2
Beach erosion	1	5	2
Increasing beach temperature	1	4	2
Coastal development (urban)	1	2,3	4
Coastal development (industrial)	1,3	2,3	4
Light horizon disorientation	1	4	4
Bycatch in inter-nesting zone	2,3	2	2
Bycatch in migration zone	2	4	3
Bycatch in foraging habitat	3,4	2	2
Entanglement in discarded fishing gear	2,3,4	5	3
Impact to benthic ecology from fisheries	2,3,4	5	3
Solid pollution (e.g. plastics)	2,3,4	4	4
Water quality	2,3,4	2	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
iSimangaliso National Park, KwaZulu-Natal, South Africa	Nesting and foraging	Y	High	• Monitoring, protection, education, awareness programmes • Designation / management of protected areas, sanctuaries, exclusion zones • Regulations on building location, design, artificial lighting • Removal of debris, beach clean up • Vehicle restrictions
Abohazo, Barren Islands, Madagascar	Nesting, foraging and developmental stages	Y	High	• Monitoring, protection, education, awareness programmes • Requirements for modification of fishing gear or fishing practices • Designation and management of protected areas, sanctuaries, exclusion zones etc. • Predator control
Mozambique	Ponto do Ouro	Y	Med	• Monitoring, protection, education, awareness programmes • Designation and management of protected areas, sanctuaries, exclusion zones etc.

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	unknown	
Remigration interval	2.6 years	Hughes 1982
Clutches per season	3.6 - 4.4	Hughes 1974
Mean size of nesting adult (first breeding)	unknown	
Age at maturity	20.6 years	Hughes 2010

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging)	unknown	
Growth rates	unknown	
Survivorship estimates	unknown	

Summary from Wallace et al. 2010, 2011

Loggerheads in the South-west Indian Ocean RMU were given a risk matrix score of 2.10, obtained from expert opinion that loggerheads in this region have an annual nesting abundance of 101–1,000 females, an increasing recent population trend, an increasing long-term population trend, a high

likelihood of complete loss of nesting rookeries, and comprise only one genetic stock. A threats matrix score of 1.50 was determined from expert opinion that loggerheads in the South-west Indian Ocean RMU faced a medium threat from fisheries bycatch, a low-medium threat from take, and a low threat from coastal development, pollution and climate change. Overall Wallace et al. (2011) categorised this RMU as High Risk-Low Threats.

Summary from US NMFS (2011)

Similar to Wallace et al. (2011), the US NMFS found that loggerheads in the South-west Indian Ocean have shown an increasing population trend since the 1960s, and also that the magnitude of the threat of climate change for loggerheads in this region was impossible to establish. However the NMFS also determined that population declines could occur in the foreseeable future as a result of fisheries bycatch affecting mainly juvenile loggerheads. The BRT consider it unlikely that mortality due to bycatch can be adequately reduced or eliminated due to limitations in enforcement capabilities, geopolitical complexities, and not enough information regarding fishing efforts and distribution. The authors also recognise that significant conservation efforts are likely to have benefited this loggerhead population. Given the increasing population trend observed, but also the small nesting population and likely continuing impacts from fisheries, the NMFS have determined that the South-west Indo-Pacific Ocean DPS of the loggerhead sea turtle is not currently in danger of extinction, but is likely to become so in the foreseeable future throughout its range. It is currently listed by the NMFS as 'Threatened'.

2012 update

Annual monitoring of the South African and Mozambique nesting beaches continues and data are published up to and including 2010. A recent publication by Ronel Nel and colleagues has identified that loggerhead turtle abundance at the South African index beach has increased since 1965, especially in the last decade. The same study identified links between turtles nesting in South Africa and Mozambique. The analysis of the long-term data set indicates that the maximum reproductive life span was around 18 years (Nel et al. 2013).
In Mozambique, annual monitoring continues and annual reports are produced. The Mozambique Government and local NGOs conduct and/or support regular monitoring of nesting beaches, turtle consumption and turtle sightings at popular dive sites.

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North-west Indian Ocean management unit

Ecological range

The extent of the management unit, which approximates ecological range, was calculated based on existing data from molecular studies, migration behaviour, tag recoveries and expert opinion and its spatial extent matches its RMU (Wallace et al. 2010). The boundary of its ecological range indicates that turtles from the population occur within the Exclusive Economic Zones of 15 nations (Figure 5).

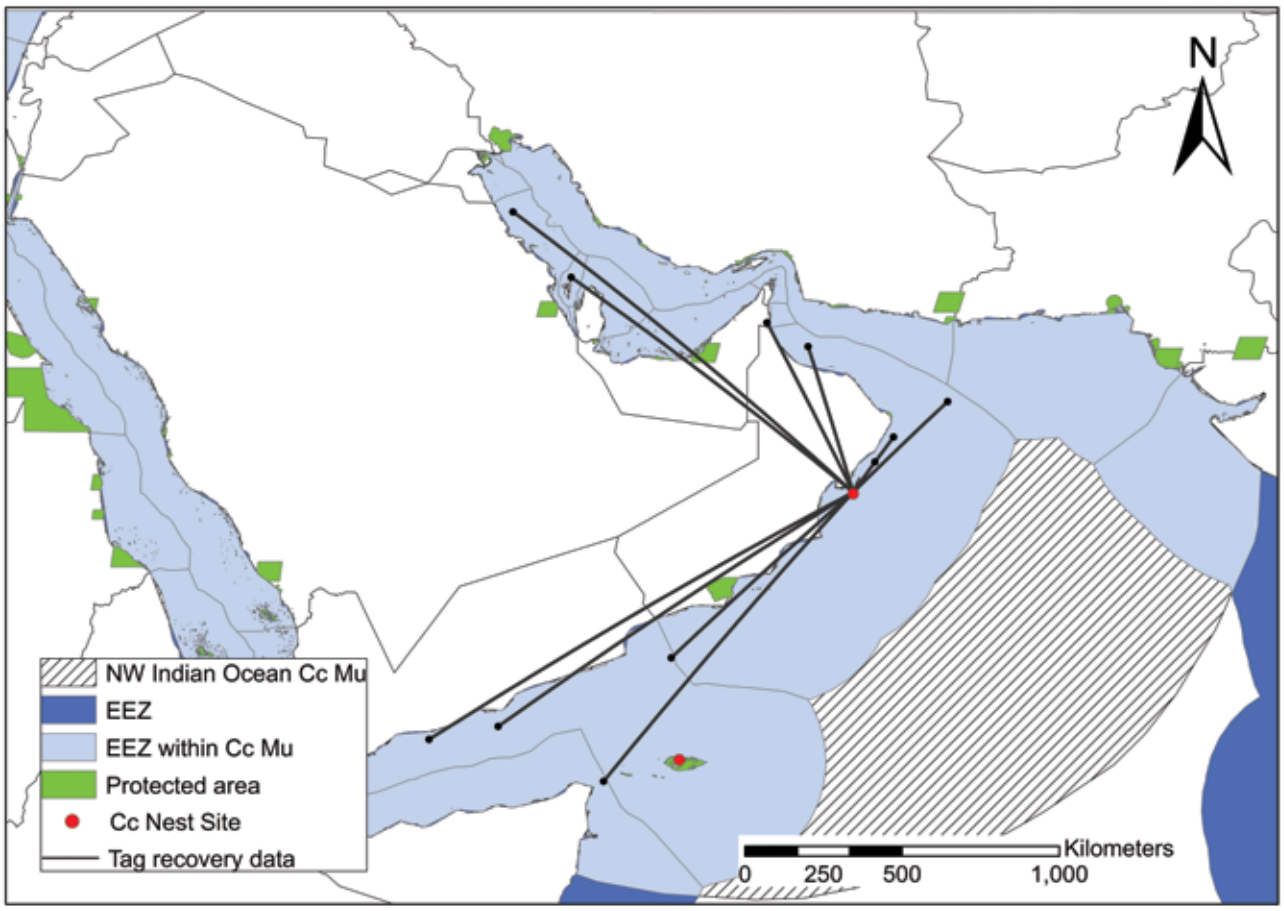

Figure 5. Overlay of the North-west Indian Ocean loggerhead turtle MU (mesh), with the exclusive economic zones (light blue) of inclusive territories and designated protected areas. Tag recovery data for turtles tagged at Masirah Island is also shown.

Geographic spread of foraging sites

Overall the EEZs of 15 nations lie within the ecological range of the North-west Indian Ocean management unit (Figure 5). Loggerhead turtles from this management unit have been recorded in the coastal waters of six nations (United Arab Emirates, Oman, Pakistan, Yemen, Eritrea and Djibouti). A combination of fisheries bycatch data, sightings and expert opinion indicate that loggerhead turtles from this management unit migrate and utilise waters to the south into northern Somalia, north/east into the waters of the Islamic Republic of Iran (hereafter referred to as Iran), India and possibly the Maldives, and east to other nations within the Persian Gulf.

Geographic spread of nesting

In the north-west Indian Ocean, Oman hosts the vast majority (over 10,000 females nesting per year, and some figures indicate over 15,000 females per year) of loggerhead nesting on Masirah Island, the Al Halaniyat Islands, and on mainland beaches south of Masirah Island all the way to the Oman-Yemen border (IUCN 1989a, 1989b; Salm 1991). Nesting has also been recorded on Socotra, an island off the coast of Yemen, and some nesting is thought to occur on mainland Yemen beaches of the Arabian Sea (Pilcher and Saad 2000).

Index nesting beaches:

- *Oman – Masirah Island*

Oman: The main nesting site is Masirah Island. Low density nesting occurs on the Al Halaniyat Islands, mainland Omani beaches south of Masirah Island and north of Khor Khafort, and on the Oman-Yemen border (IUCN 1989a).

Yemen: Nesting occurs in the Abalhan Protected Area, Socotra Island and the Biosphere Reserve on the mainland Arabian coastline (Pilcher and Saad 2000).

Somalia: Unquantified records of low density nesting.

Trends in nesting data

Nesting trends are unknown for the North-west Indian Ocean population apart from Masirah Island in Oman, which has not recently been evaluated. It has been estimated that Masirah Island received 30,000 nesting females in 2005, however this needs confirmation.

Migration and distribution of foraging areas

Limited information exists on the foraging habitats for the North-west Indian Ocean population; however, turtles tagged at Masirah Island have been recorded within the Persian Gulf, Pakistan and in the Gulf of Aden (Figure 5; Baldwin et al. 2003). In 2006 10 female loggerhead turtles were tracked by satellite following nesting at Masirah Island. Eight of the 10 tracked animals migrated south-west towards the Gulf of Aden and used the oceanic and coastal habitats between the Yemen/Oman border and Socotra Island (Rees et al. 2010). In 2012 the Environment Society of Oman and the Oman Ministry of Environment and Climate Change tracked the migration of a further 12 turtles. Similar to Rees et al. (2010) the results reveal extensive use of both neritic and oceanic waters off the Arabian Peninsula, with the majority of tracked turtles travelling south-west, following the shoreline of southern Oman and Yemen, and circling anticlockwise well offshore in nearby oceanic waters between the Oman and Yemen border region and Socotra Island (Environment Society of Oman and Ministry of Environment and Climate Change, Oman, unpublished data). The oceanic circling by the turtles tracked in both studies occurs in the same region as the Somali current rings – large, approximately circular, westward translating, anticlockwise movements of water that occur near the entrance to the Gulf of Aden (Fratantoni et al. 2006). These data suggest that post-nesting migrations and adult female foraging areas may be centred within the region. Low density feeding has been reported, but not quantified, in Bahrain waters (Abdulqader and Miller 2012).

Threats to the population

Eritrea: Incidental capture in fisheries is a low level threat for loggerhead turtles. Of 3,342 turtles incidentally caught in Eritrean shrimp trawls, 30 were loggerhead turtles.

Oman: Predation of eggs and coastal development (and associated light pollution) are seen as the main threats in Oman. At Masirah Island two high level threats are vehicle damage to nesting beaches and bycatch in fisheries activities. Egg harvest is a low level threat.

Somalia: Pirate attacks and political instability in Somalia have caused safety concerns for outside conservation organisations, such as NGOs, making it risky to conduct monitoring and research programmes in this region. No fishery protection vessels are present in Somalia, making bycatch in longline fisheries and drowning in nets a high level threat for loggerheads.

The IOSEA Signatory States reports for Bahrain, Iran, Jordan, Saudi Arabia, United Arab Emirates and Yemen do not mention threats to loggerhead turtles explicitly.

Additional threats: Refer to page 15 for details on how the threats in the following table were obtained and scored.

Summary of threats to the population - as per data contained within the Signatory States reports to IOSEA MoU.

Type of threat	Location 1=nesting beach 2=migration zone 3=foraging area (local) 4=foraging area (widespread)	Managed 1=managed at most sites 2=managed at some sites 3=main nesting sites mostly protected 4=no, or little, management 5=not documented	Quantified 1=comprehensive documentation across population 2= comprehensive documentation for some of the population 3=anecdotal only 4=no reliable data
Egg predation/collection	1	2	3
Beach erosion	1	4	3
Increasing beach temperature	1	5	4
Coastal development (urban)	1	2	2
Coastal development (industrial)	1	2	3
Light horizon disorientation	1	2	3
Bycatch in inter-nesting zone	3	4	3
Bycatch in migration zone	2	4	3
Bycatch in foraging habitat	3,4	4	3
Entanglement in discarded fishing gear	2,3,4	4	4
Impact to benthic ecology from fisheries	2,3,4	5	3
Solid pollution (e.g. plastics)	2,3,4	5	4
Water quality	2,3,4	4	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Masirah Island, Oman	Nesting and foraging	Y	High	Monitoring, protection, education, awareness programmes Designation / management of protected areas, sanctuaries, exclusion zones etc. 1 km sectors of nesting habitat identified for monitoring purposes

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	unknown	
Remigration interval	2.6 – 3 years	Hughes 1982
Clutches per season	3.6 - 4.8	Hughes 1974; Rees et al. 2010; Ross 1998
Mean size of nesting adult (first breeding)	unknown	
Age at maturity	unknown	

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging)	unknown	
Growth rates	unknown	
Survivorship estimates	unknown	

Summary from Wallace et al. 2010, 2011

Loggerheads in the Northern Indian Ocean were divided by Wallace et al. (2010) into two RMUs: the North-west Indian Ocean RMU, and a putative North-east Indian Ocean RMU. In the North-west, loggerheads were given a risk matrix score of 1.33, obtained from expert opinion that loggerheads in this region have an annual nesting abundance of 5,001–10,000, a low-medium likelihood of complete loss of nesting rookeries, and comprise more than two genetic stocks. Recent and long-term population trends could not be determined due to data deficiency. A threats matrix score of 1.67 was determined from expert opinion that loggerheads in the North-west Indian Ocean RMU were highly threatened by fisheries bycatch (mainly in longline, gillnet, trawl and IUU fisheries), and faced a low threat from take, pollution and coastal development. The threat posed by climate change could not be determined due to data deficiency. Overall Wallace et al. (2011) categorised this RMU as Low Risk-Low Threats.

Summary from US NMFS (2011)

Unlike Wallace et al. (2011), the NMFS only acknowledge one population of loggerheads in the Northern Indian Ocean, yet this is recognised as being highly threatened by fisheries bycatch (as both NE Indian and NW Indian are). The NMFS determined that fishing pressure in this region is likely to increase in the future, which is likely to increase loggerhead mortality. Similar to Wallace et al. (2011), the NMFS were unable to obtain reliable data on population trends in this region; however, expert opinion, nesting estimates and local observations suggest a marked population decline over the last 30 years. The NMFS also found it impossible to determine the magnitude of the threat of climate change for loggerheads in the Northern Indian Ocean. Further, consistent low threats across all the factors listed above may affect a significant portion of the early life stages of loggerheads in this region, and therefore warrant attention; particularly as these threats are considered likely to increase in the future. Higher mortality in the neritic environment is due to fishery bycatch. The NMFS consider it unlikely that mortality due to bycatch can be adequately reduced or eliminated due to the existence of illegal, unregulated and unreported fisheries, in addition to limitations in enforcement capabilities, geopolitical complexities and not enough information regarding fishing efforts and distribution.

Other natural or man-made risk factors, including climate change and sea level rise, as well as fisheries bycatch, boat strike and marine debris, were considered to be of low risk to eggs/hatchlings, oceanic juveniles, oceanic adults and nesting females, but a medium risk factor for neritic juveniles and adults.

Given that impacts from fisheries and threats to nesting beaches are likely to increase in the future, in addition to the marked decline observed in nesting females in the last 30 years, the NMFS have determined that the North Indian Ocean DPS is in danger of extinction throughout its range. It is currently listed as 'Endangered'.

2012 update

In 2012 twelve satellite trackers were deployed on female loggerhead turtles ashore for nesting at Masirah Island (see the tracking maps at:
http://www.seaturtle.org/tracking/?project_id=733). Clearly, the different opinions expressed in the two assessments summarised above raise important questions about the population's status and condition. Of the two assessments, the US NMFS placed more emphasis on expert opinion to fill the empirical knowledge gaps than Wallace et al. (2011), hence their 'Endangered' classification. There remain few empirical data on turtle trends or threat impact for the population. Expert advice continues to support the NMFS conclusion that the population has declined, and that threats are widespread and pervasive. There is, therefore, a well-recognised need to take precaution with regard to managing potential and existing threats to the population and there is a clear need for both data analysis and the continuation of research and monitoring activities to improve assessment accuracy.

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North-east Indian Ocean management unit

Ecological range

The extent of the management unit, which approximates ecological range, was calculated based on existing data from molecular studies, migration behaviour, tag recoveries and expert opinion and its spatial extent matches its RMU (Wallace et al. 2010). The boundary of its ecological range indicates that turtles from the population occur within the Exclusive Economic Zones of five nations. Continued molecular research will determine its phylogenetic relationship with either the North-west Indian Ocean or the South-east Indo Pacific populations.

Geographic spread of foraging sites

There have been no studies to identify the foraging sites for the North-east Indian Ocean management unit. There is one record of a loggerhead turtle being caught by fishers in coastal Myanmar. It is likely that they use coastal waters of other nations in the Bay of Bengal (India, Sri Lanka, and Thailand), plus the reef systems around the Maldives.

Geographic spread of nesting

The only verified loggerhead nesting on the Indian subcontinent occurs on mainland beaches of southern and south-eastern Sri Lanka (Figure 6) and no index beaches have been formally identified. There is no evidence for loggerhead turtle nesting occurring on either the far western or northern coastlines. Clutch counts remain unquantified, and only a small number of females use the beaches of Sri Lanka to nest each year (Kar and Bhaskar 1982; Dodd 1988).

Nesting reported at the following locations:

- *Butawa to Patanangala, Yala Nature Preserve, Southern Sri Lanka*
- *Bundala Modara to Kirindi Modara (Bundala NP), Southern Province*
- *Hambantota to Malala Modara, Southern Province (not confirmed)*
- *Ussangoda to Welipatanwila, Southern Province*
- *Tangalle*
- *Unawatuna*
- *Balapitiya*
- *Kosgoda/Bandarawatta.*

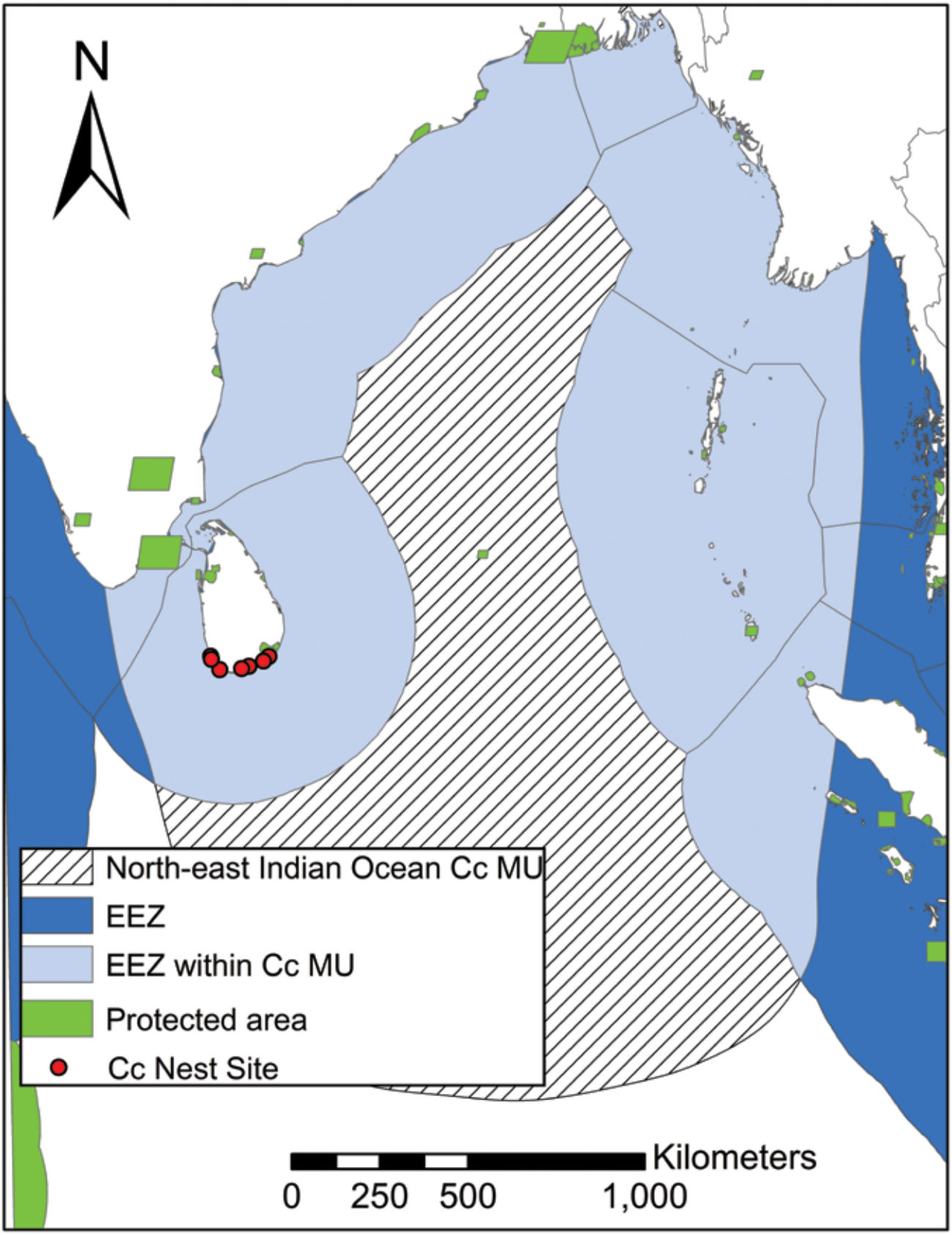

Figure 6. Map of loggerhead turtle nesting sites for the North-east Indian Ocean population with the exclusive economic zones (light blue) of inclusive territories and designated protected areas.

Trends in nesting data

There are no data to indicate population trends.

Migration and distribution of foraging areas

The information on loggerhead migration and the distribution of foraging habitats in the central Indian Ocean is minimal. However there have been reports of foraging turtles along the Gulf of Mannar which could provide foraging habitat for both juveniles and post-nesting adults (Tripathy 2005; Kapurusinghe 2006).

Threats to the population

Sri Lanka: Egg collection and natural threats (such as predation and disease) in southern Sri Lanka (from Kalutata to Yala Nature Preserve) are considered medium to low-level threats. Direct harvest in coastal waters, incidental bycatch and nesting female exploitation are low-level threats along with marine debris, boat strike, water quality and habitat degradation. These low-level threats are reported to be absent in sections of southern Sri Lankan coastline (Bundala Modara to Kirindi, Modara (Bundala NP), Southern Province). Meanwhile, egg collection from Ussangoda to Welipatanwila, Southern Province, is considered a high-level threat and habitat degradation and incidental capture are considered medium-level threats. Coastal development and artificial lighting in Tangalle are considered severe threats to nesting turtles coming ashore. Vehicle disturbance and marine debris in Unawatuna are considered high-level threats in this location. The challenge for loggerhead conservation and management is that most of the threats in Sri Lanka are not considered on a species level, rather generic across all species.

Additional threats: Refer to page 15 for details on how the threats in the following table were obtained and scored. The IOSEA Signatory States reports for Bangladesh, India, Myanmar, Maldives, Pakistan and Thailand do not mention threats to loggerhead turtles explicitly.

Summary of threats to the population - as per data contained within the Signatory States reports to IOSEA MoU.

Type of threat	Location 1=nesting beach 2=migration zone 3=foraging area (local) 4=foraging area (widespread)	Managed 1=managed at most sites 2=managed at some sites 3=main nesting sites mostly protected 4=no, or little, management 5=not documented	Quantified 1=comprehensive documentation across population 2= comprehensive documentation for some of the population 3=anecdotal only 4=no reliable data
Egg predation/collection	1	2	3
Beach erosion	1	2	3
Increasing beach temperature	1	5	4
Coastal development (urban)	1,3	2	3
Coastal development (industrial)	1,3	2	3
Light horizon disorientation	1	2	3
Bycatch in inter-nesting zone	3	2	3
Bycatch in migration zone	2	4	3
Bycatch in foraging habitat	3,4	2	3
Entanglement in discarded fishing gear	2,3,4	5	4
Impact to benthic ecology from fisheries	2,3,4	5	3
Solid pollution (e.g. plastics)	2,3,4	5	4
Water quality	2,3,4	2	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Butawa to Patanangala, Yala Nature Preserve, Southern Sri Lanka	Nesting and foraging	Y	unknown	• In-situ nest protection by Department of Wildlife Conservation • Designation / management of protected areas
Bundala Modara to Kirindi Modara (Bundala NP), Southern Province	Nesting, foraging and developmental stages	Y	unknown	• In-situ nest protection by Department of Wildlife Conservation • Designation / management of protected areas.
Hambantota to Malala Modara, Southern Province	Nesting	?	unknown	• Education / awareness programmes
Rekawa	Nesting	Y		• First sea turtle sanctuary in Sri Lanka. Declared in August 2006.
Unawatuna	Nesting	Y	unknown	• Vehicle restrictions • Designation / management of protected areas, sanctuaries, exclusion zones etc.

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	unknown	
Remigration interval	unknown	
Clutches per season	unknown	
Mean size of nesting adult (first breeding)	CCL 91.4 cm and CCW 83.1 cm (n=8)	Rekawa site, Turtle Conservation Project (TCP) – Sri Lanka (unpublished data)
Age at maturity	unknown	

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging)	unknown	
Growth rates Survivorship estimates	unknown unknown	

Summary from Wallace et al. 2010, 2011

In the North-east Indian Ocean RMU, loggerheads were given a risk matrix score of 2.17, obtained from expert opinion that loggerheads in this region have an annual nesting abundance of 101–1,000, a high likelihood of complete loss of nesting rookeries, and comprise more than two genetic stocks. Recent and long-term population trends could not be determined due to data deficiency. A threats matrix score of 3.00 was determined from expert opinion that loggerheads in the North-east Indian RMU were highly threatened by fisheries bycatch (mainly in gillnet and trawl fisheries), and coastal development (mainly from construction). The threat posed by take, climate change and pollution could not be determined due to data deficiency. Overall Wallace et al. (2011) categorised this RMU as High Risk-High Threats (Figure 1), and concluded it was one of the world's most endangered RMUs (out of 58 RMUs including all turtle species).

2012 update

The Sri Lankan Turtle Conservation Project remains active on a variety of monitoring and conservation measures. Nightly nesting patrols occur on several beaches, and hatcheries are managed by the Sri Lankan Government and local turtle NGOs.

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North Pacific Ocean management unit

Ecological range

The extent of the management unit, which approximates ecological range, was calculated based on existing data from molecular studies, migration behaviour, tag recoveries and expert opinion and its spatial extent matches its RMU (Wallace et al. 2010). The boundary of its ecological range indicates that turtles from the population occur within the Exclusive Economic Zones of 9 nations (Figure 7).

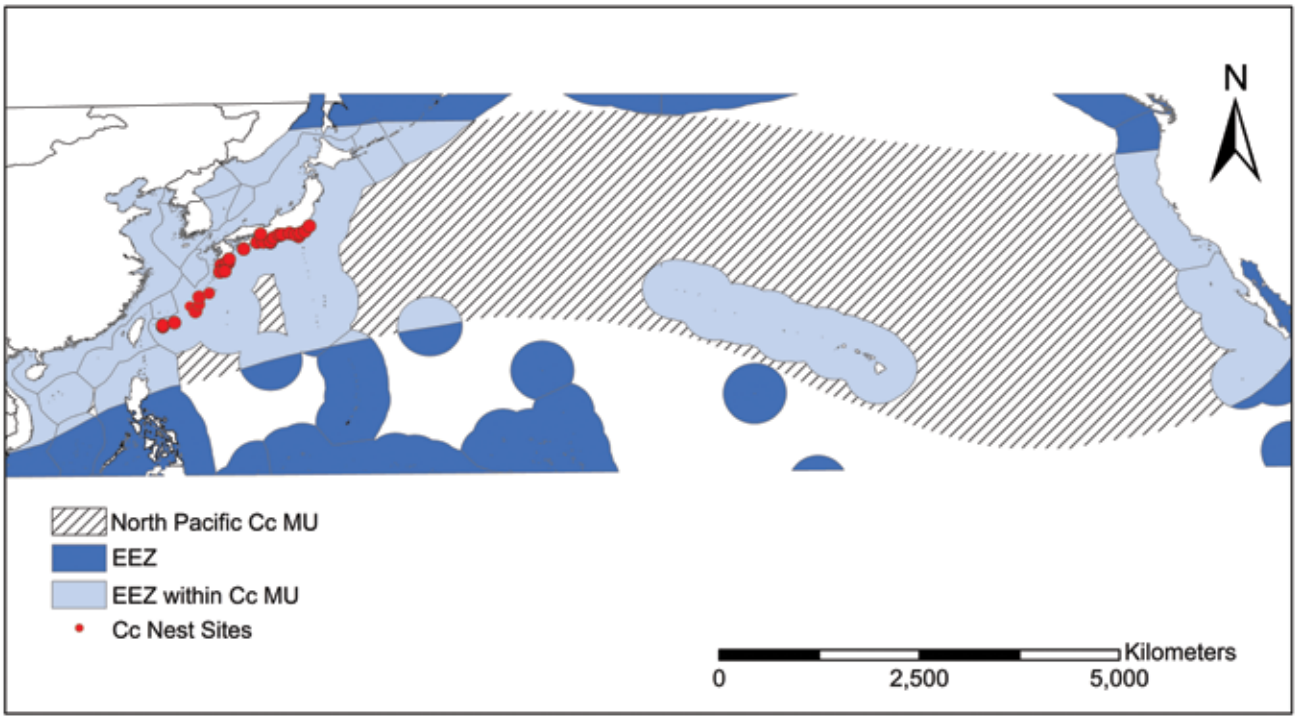

Figure 7. Overlay of the North Pacific Ocean loggerhead turtle RMU (mesh), with the exclusive economic zones (light blue) of inclusive nations.

Geographic spread of foraging

Similar to the South Pacific Ocean management unit, there is considerable knowledge about the foraging distribution of loggerhead turtles in the North Pacific Ocean. A combination of fisheries bycatch data, sightings and expert opinion indicate that loggerhead turtles from this management unit migrate and utilise waters throughout the North Pacific Ocean. Overall the EEZs of 9 nations lie within the ecological range of the North Pacific Ocean management unit (Figure 7) and loggerhead turtles from the management unit have been recorded in the coastal waters of eight of them (Japan, Philippines, China, Viet Nam, Republic of Korea, USA and Mexico). All but Mexico are range states of the IOSEA MoU; while China and Republic of Korea not yet signatory states.

Geographic spread of nesting

Loggerhead nesting within the North Pacific area occurs only in Japan (Figures 7 and 8). Nesting beaches can be separated into five geographic locations (Kamezaki et al. 2003): the Nansei Shoto Archipelago, Kyushu, Shikoku, the Kii Penisula and east-central Honshu, distributed between 24°N and 37°N.

Index nesting beaches:

- *Inaka Hama (Yakushima Island)*
- *Mae Hama (Yakushima Island)*
- *Miyazaki (Kyushu Island)*
- *Kamouda (Shikoku)*
- *Hiwasa (Shikoku)*
- *Minabe Senri Beach (Kii Peninsula)*
- *Omaezaki (Honshu)*

Nesting Locations

Nansei Islands: Found south of Kyushu and north of Taiwan, this archipelago consists of numerous islands. Approximately 30% of loggerhead nesting occurs on Yakushima Island at two beaches: Inaka Hama and Mae Hama (Kamezaki 1989). Minor nesting occurs on the Pacific-facing side of many islands in the Amami, Miyako and Yaeyama island groups (Kamezaki 1989). Within the North Pacific, the Yaeyama Islands appear to be the southernmost limit of loggerhead nesting.

Kyushu: Approximately 70% of nesting occurs on the south of this island, along both the western and eastern coasts. Fukiagehama, found in the west, is the most well-known nesting location. Loggerheads also nest at Nagasakibana Beach, in the south, and at Miyazaki, Nobeoka, Nichinan and Shibushi beaches in the east.

Shikoku: Nesting occurs across the Ashizuri Cape, the Muroto Cape and along the south-eastern beaches: Kamoudo and Hiwasa.

Kii Peninsula: The majority of loggerhead nesting takes place at Minabe Senri Beach.

East Central Honshu: The Enshunada region, stretching 130 km and including Omaezaki beach, is the major nesting site for loggerheads on Honshu. Minor nesting also occurs on smaller beaches around the Chita Peninsula, Izu Peninsula, Izuoshima Island, Nijima Island and Boso Peninsula.

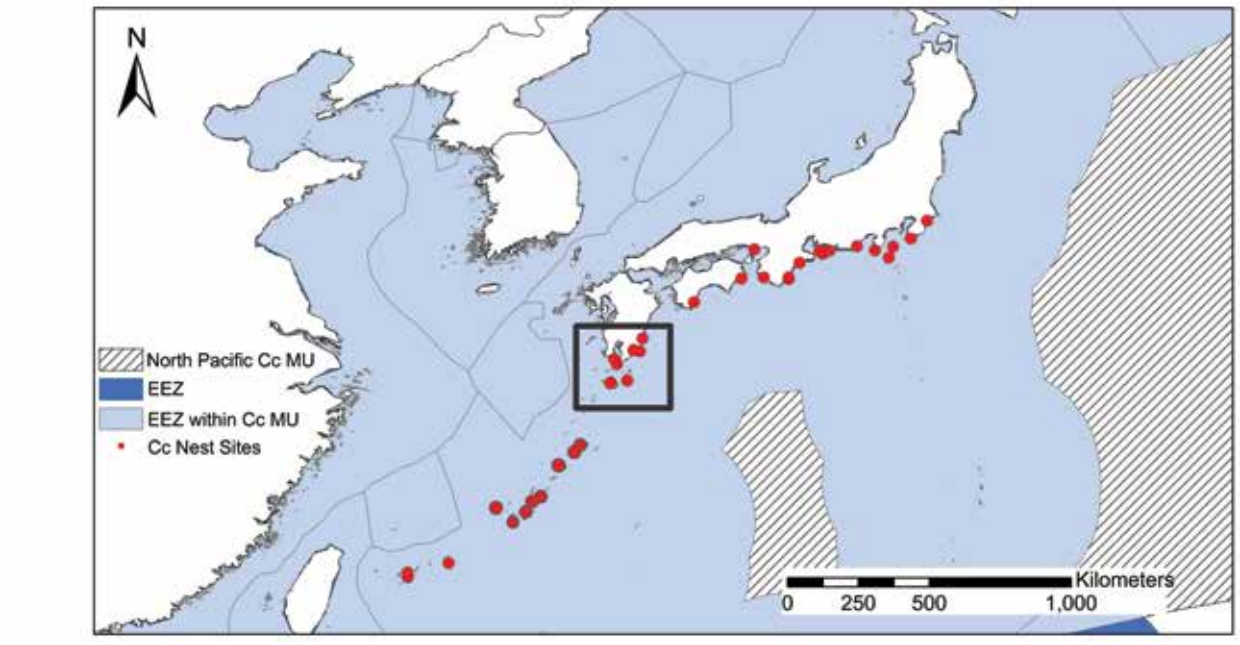

Figure 8. Loggerhead turtle nesting sites within the North Pacific Ocean management unit. Box indicates 70% of nesting in this region.

Trends in nesting data

Nesting census data are available from most Japanese nesting beaches: Omaezaki, Minabe, Kamouda, Hiwasa, Miyazaki, Inakahama and Maehama. From the early 1990s to 1999 there was a decline in the annual nesting population, resulting in the North Pacific Ocean loggerhead management unit being accorded an 'Endangered' status in the 1994 IUCN Red List (Kamezaki et al. 2003). Lowest numbers were recorded in the years 1997–1999. Since then nesting appears to have increased at Omaezaki, Minabe and Kamouda, with current numbers higher than recorded in the early 1990s. Nesting at the other sites does not appear to have increased but instead appears to be stable, with no further declines evident (Kamezaki 2012). Given multiple re-nesting, current nesting figures suggest less than 1,000 females breed annually within this population.

Migration and distribution of foraging areas

Tag returns and satellite tracking have confirmed that post-nesting females leave nesting areas in Japan as hatchlings, and migrate across the Pacific Ocean, via the Hawaiian archipelago, to reach developmental and foraging habitats in the eastern Pacific (Uchida and Teruya 1988; Bowen et al. 1995). Following many years foraging offshore from California, USA, and Baja California, Mexico, the loggerheads return to Japanese nesting areas for breeding (Resendiz et al. 1998; Nichols et al. 2000).

Threats to the population

Japan: Fisheries bycatch mortality may pose the greatest threat to this population (Kamezaki et al. 2003). Gill and pound nets are widely used along the Japanese coast, and anchovy trawl fisheries occur offshore from major loggerhead rookeries. The dramatic decline in nesting appears to have coincided with the increase in longline and driftnet fisheries in the North Pacific, yet the lack of bycatch mortality data has prevented quantification of the extent of this problem. Beach erosion is a serious problem in Japan due to the combination of coastal armouring and extreme weather during the winter (typhoon season) (Matsuzawa and Kamezaki 2012). In 2004 and 2005, the Western Pacific Regional Fishery Management Council provided funding assistance to the Sea Turtle Association of Japan to allow management activities aimed at maximising hatchling production in erosion-prone locations. Hundreds of nests were relocated and an estimated 149,478 hatchlings produced that would otherwise have been lost (Matzuzawa 2005). Egg predation from raccoon dogs and weasels is a minor threat, however quantitative data is lacking. Turtle eggs were a traditional food source in Japan, however this has substantially decreased through education efforts.

Viet Nam: Low level fisheries bycatch of loggerhead turtles has been recorded in central Viet Nam (Hamann et al. 2006). These turtles could be from the North Pacific Ocean population.

Baja California: The direct harvest of loggerheads occurs here at high levels, with juveniles and subadults being taken most frequently.

The development of several Liquid Natural Gas facilities has been proposed off southern California and Baja California, Mexico. This could result in the degradation of the pelagic habitat in the eastern North Pacific due to oil trans-shipment.

The IOSEA Signatory States reports for Philippines, Malaysia and Indonesia do not mention threats to loggerhead turtles explicitly.

Climate change: Chaloupka et al. (2008) demonstrate that the frequency of nesting is related to sea surface temperatures, such that in warmer years fewer turtles nest. This has implications arising from climate change with predictions that the Pacific Ocean will increase in temperature by 1 to 5 °C over the next 20 to 100 years (IPCC 2007).

Additional threats: Refer to page 15 for details on how the threats in the following table were obtained and scored.

Summary of threats to the population - as per data contained within the Signatory States reports to IOSEA MoU.

Type of threat	Location 1=nesting beach 2=migration zone 3=foraging area (local) 4=foraging area (widespread)	Managed 1=managed at most sites 2=managed at some sites 3=main nesting sites mostly protected 4=no, or little, management 5=not documented	Quantified 1=comprehensive documentation across population 2= comprehensive documentation for some of the population 3=anecdotal only 4=no reliable data
Egg predation/collection	1	2,3	2
Beach erosion	1	2	4
Increasing beach temperature	1	5	4
Coastal development (urban)	1	2	4
Coastal development (industrial)	1,3	2	4
Light horizon disorientation	1	2	4
Bycatch in inter-nesting zone	3	2	3
Bycatch in migration zone	2	4	2
Bycatch in foraging habitat	3,4	2	2
Entanglement in discarded fishing gear	2,3,4	5	3
Impact to benthic ecology from fisheries	2,3,4	5	3
Solid pollution (e.g. plastics)	2,3,4	5	4
Water quality	2,3,4	2	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Yakushima	Nesting	Y	High (30% of pop)	• Monitoring, tagging
Nansei Shoto Archipelago	Nesting	N	High	• Monitoring
Kyushu	Nesting	Y	High	• Monitoring, education & Regulations for Sea Turtle Conservation
Shikoku	Nesting	Y	High	• Monitoring, education
Kii Peninsula	Nesting	Y	High	• Monitoring, tagging, satellite tagging
Honshu	Nesting	Y	High	• Monitoring

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	29.7 ℃	Matsuzawa et al. 1998
Remigration interval	2.7 years	Hatase et al. 2004
Clutches per season	Several (max. 5)	Hatase et al. 2002; Sato et al. 1998
Mean size of nesting adult (first breeding)	SCL 784 ± 31 mm (oceanic foragers) SCL 840 ± 40 mm (neritic foragers)	Hatase et al. 2010
Age at maturity	Estimated 25 years	Van Houtan and Halley 2011

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging)	Not known	
Growth rates Survivorship estimates	2.5 ± 4.0 mm/year Not known	Hatase et al. 2004 Peckham et al. 2008

Summary from Wallace et al. 2010, 2011

Loggerheads in the North Pacific Ocean RMU were given a risk matrix score of 2.00, obtained from expert opinion that loggerheads in this region have an annual nesting abundance of 1,001–5,000 females, an increasing recent population trend, a decreasing long-term population trend, a low likelihood of complete loss of nesting rookeries, and comprise only one genetic stock. A threats matrix score of 2.67 was determined from expert opinion that loggerheads in the North Pacific RMU were highly threatened by fisheries bycatch (mainly in longline and gillnet fisheries), faced a medium threat from take, and faced a high threat from coastal development (mainly beach armouring). The threat posed by both pollution and climate change could not be determined due to data deficiency. Overall Wallace et al. (2011) categorised this RMU as High Risk-High Threats (see Figure 1), and concluded it was one of the world's most endangered RMUs (out of 58 RMUs including all turtle species).

Summary from US NMFS (2011)

NMFS findings (Conant et al. 2009; NMFS et al. 2011) aligned with those of Wallace et al. (2011), with coastal fisheries in Baja California, Mexico, and Japan (Kamezaki et al. 2003; Peckham et al. 2007) found to be the most significant threat to loggerheads in this region – particularly for neritic juveniles and neritic adults. Coastal development was also similarly highlighted as a major threat to loggerhead survival, mainly from seawall construction (Kamezaki et al. 2003; Kudo et al. 2003). In addition the NMFS found beach debris to be an important cause of hatchling and nesting adult deaths, and also noted that in recent years there has been low hatching success at many important nesting beaches.

The threats to critical habitats were considered to be of medium risk for eggs and hatchlings, but only low or very low risk for other life cycle stages. This is because coastal development and coastal armouring is continuing on nesting beaches in Japan. The risk of overuse for commercial, scientific, educational or recreational purposes, as well as risk of disease or predation, was considered to be low to very low for all life stages. Other natural or man-made risk factors, including climate change and sea level rise, as well as fisheries bycatch, boat strike and marine debris, were considered to be of medium

risk to eggs/hatchlings, neritic juveniles and neritic adults, whilst other life stages were only considered at low to very low risk from these factors. This is due mainly to bycatch mortality from the coastal pound net fisheries in Japanese waters, as well as coastal fisheries near Baja California, Mexico, and other undescribed fisheries which potentially impact loggerheads elsewhere in the North Pacific. The BRT consider it unlikely that mortality due to bycatch can be adequately reduced or eliminated due to the existence of illegal, unregulated and unreported fisheries, in addition to limitations in enforcement capabilities and not enough information regarding fishing efforts and distribution. Sea level rise as a result of climate change is also considered likely to become a substantial threat if coastal armouring continues without consideration. This is in contrast with the findings of Wallace et al. (2011) who found there were insufficient data to determine any climate change impacts on loggerheads in this region.

Although the nesting population in this region has increased recently, current nesting levels are low compared to those that occurred prior to the 1950s. Moreover, despite the recent increase, the population of loggerheads in the North Pacific is considered to be small. Given that the North Pacific Ocean DPS shows evidence of a long-term decline, and is at significant risk from fisheries bycatch and coastal development, making further population declines likely, the NMFS have determined that the North Pacific Ocean DPS is in danger of extinction throughout its range. It is currently listed as 'Endangered'.

2012 update

Nesting beach studies are continuing on all index beaches. Monitoring is run by local NGOs and community groups who then supply data to universities and the Sea Turtle Association of Japan. The Japanese Sea Turtle Association hold an annual symposium at which data updates are provided. There is a strong focus on sea turtle research by several university staff and they generate several publications per year.

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South-east Indian Ocean management unit

Ecological range

The management unit which approximates ecological range for the South-east Indian Ocean population was calculated based on existing data from molecular studies, migration behaviour, tag recoveries and expert opinion and its spatial extent matches its RMU (Wallace et al. 2010). The boundary of its ecological range indicates that turtles from the population occur within the Exclusive Economic Zones of six nations (Figure 9).

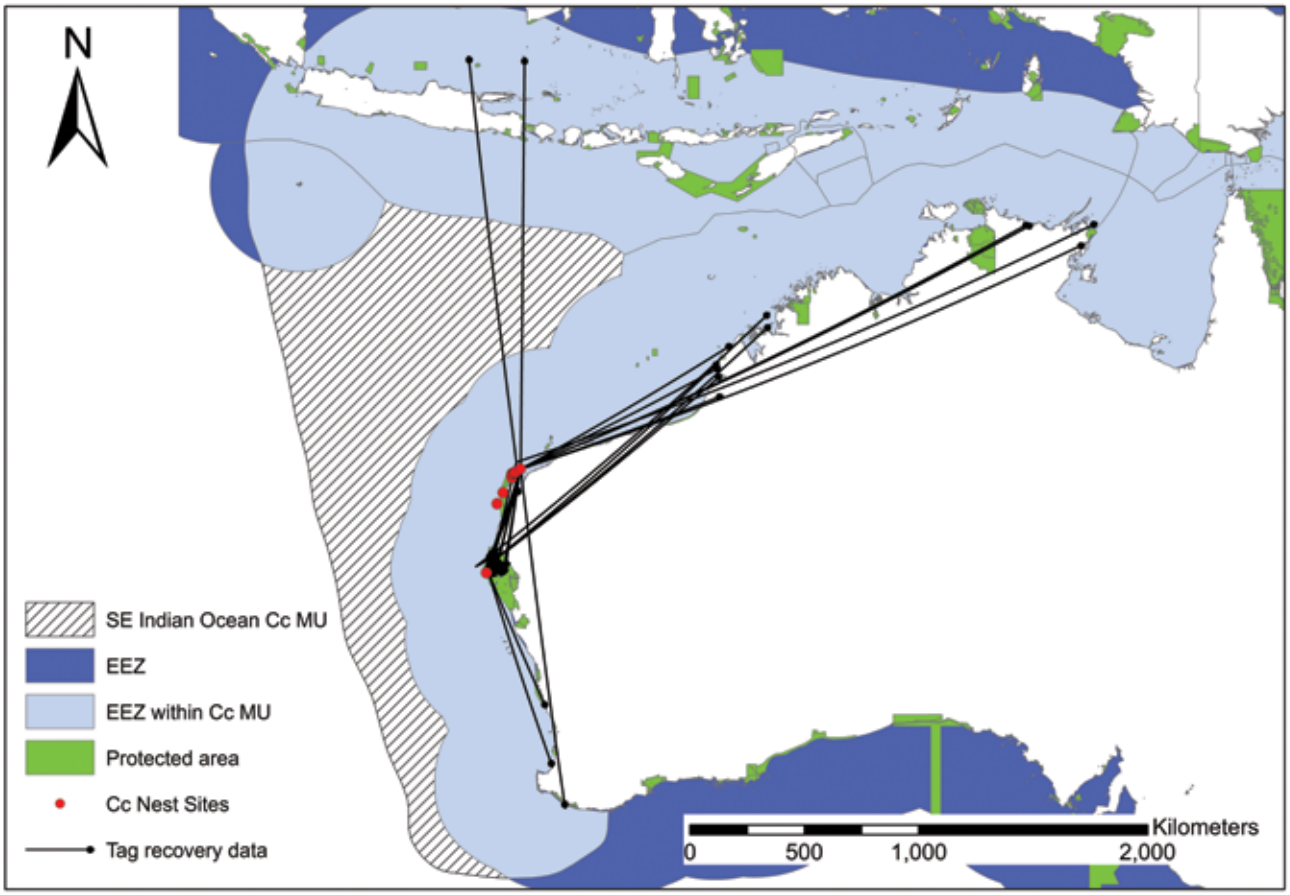

Figure 9. Overlay of the South-east Indian Ocean loggerhead turtle MU (mesh), with exclusive economic zones (light blue) of inclusive territories, designated protected areas and tag recovery data for turtles tagged in Western Australia shown (black dots and lines).

Geographic spread of foraging

Loggerhead turtles from the South-east Indian Ocean management unit forage in the coastal waters of Australia and Indonesia. It is also possible that they use the coastal waters of Timor Leste and Papua New Guinea for foraging and/or migration. Within Australia they utilise the coastal zone from ~ 26°S (Shark Bay in Western Australia) northwards and across the northern coast of Australia as far east as western Torres Strait (141°E). Little is known about the foraging ecology of this management unit (see review by Limpus 2009).

Geographic spread of nesting

Loggerhead nesting in the south-east Indian Ocean is confined to Western Australia (WA) (Figure 10; Dodd 1988). Nesting occurs along the coast of WA, from the Shark Bay World Heritage Area (26.5°S) in the south to the North West Cape and Muiron Islands (21.5°S) further north (Baldwin et al. 2003).

The major location for nesting is the northern beach of Dirk Hartog Island. Other important locations include the Muiron Islands, the Gnaraloo coast and sections of the Ningaloo Marine Park on the mainland (Limpus 2009; Hattingh et al. 2012). Minor nesting occurs over a wider area – including the Ashmore Reef National Nature Reserve (Guinea 1995).

Index nesting beaches:

Dirk Hartog Island
Gnaraloo Station

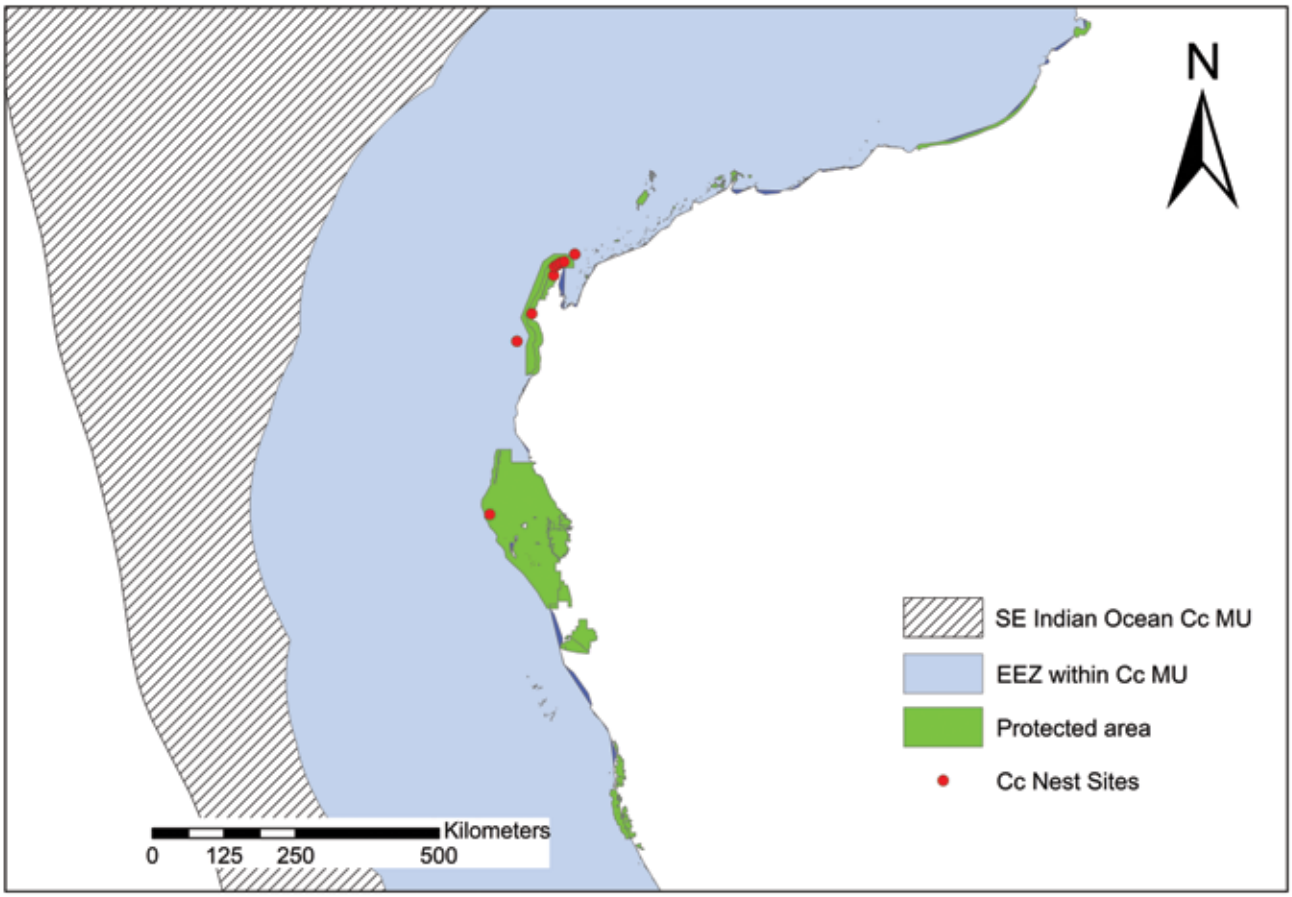

Figure 10. Nesting sites for loggerhead turtles from the South-east Indian Ocean management unit.

Trends in nesting data

Long-term nesting census data does not exist for this population. Nesting data was not collected until the early 1990s, and there are insufficient data for trends in loggerhead nesting to be determined (Limpus 2009). However, the annual nesting population for this stock is considered to consist of several thousand females, with approximately 1,000–3,000 nesting annually at Dirk Hartog Island (Baldwin et al. 2003; WA Department of Environment and Conservation, personal communication). A four-year,

whole of nesting season, data set exists for the Gnaraloo rookery, and although a short time series, it indicates a stable trend (Hattingh et al. 2011, 2012).

Migration and distribution of foraging areas

Distribution of foraging areas for the Western Australian population has been determined from the recovery of tagged loggerheads. Feeding areas for these loggerheads are located offshore from the WA nesting sites and extend northwards from Shark Bay to locations off the Arnhem Land coast of the Australian Northern Territory and into Indonesia's Java Sea (Prince 1998; Baldwin et al. 2003). The foraging area off Arnhem Land is likely shared between loggerheads from Western Australia and eastern Australian rookeries (Limpus et al. 1992; Limpus 2009).

Threats to the population

Australia: The major threats to this population impact the nesting habitat. In the past, the European red fox (*Vulpes vulpes*) has preyed extensively on loggerhead nests (Mack 2000) and this is speculated to be a potential cause for the reduction in loggerhead nesting along the mainland (the islands where loggerheads nest do not have foxes) (Baldwin et al. 2003). In addition, vehicular traffic over the mainland beaches has been common in this region. Vehicles driven over nesting areas can compact nests causing egg mortality, and hatchlings may be trapped in tyre tracks whilst traversing the beach (Limpus 2009; van de Merwe et al. 2012). The magnitude of the impact that fox predation and vehicular traffic has had on this population has not been quantified, yet it is likely that egg loss has gone beyond a level that can be sustained (Limpus 2009). In addition, the beaches affected by these issues are assumed to be the major female producing rookeries for this population (Limpus 2009).

Industrial development along the coast has the potential to be a significant threat to this population. Altered light horizons from coastal development can disorient hatchlings, increasing mortality from predation and dehydration (Witherington and Martin 2000), and can deter nesting females. At present no studies have quantified the extent of this problem with respect to hatchling disorientation for this population (Limpus 2009), but analyses of light pollution using satellite data indicate that 34% of this nesting population is potentially affected by light pollution (Kamrowski et al. 2012). This is of further concern as the affected nest sites identified in this analysis include the mainland coast of Ningaloo, the region identified as being important for producing female loggerheads.

Additional threats to this population include fisheries interactions from longlines, trawling and lobster fisheries. To date, these interactions have not been quantified but data indicate that crayfish pots in south Western Australia are responsible for the mortality of small numbers of loggerheads, and large immature loggerheads are vulnerable to longline fisheries from Japan offshore from WA, and in Indonesian waters (Limpus 2009).

Additional threats: Refer to page 15 for details on how the threats in the following table were obtained and scored. The IOSEA Signatory States reports for Indonesia and Papua New Guinea do not mention threats to loggerhead turtles explicitly.

Summary of threats to the population - as per data contained within the Signatory States reports to IOSEA MoU.

Type of threat	Location 1=nesting beach 2=migration zone 3=foraging area (local) 4=foraging area (widespread)	Managed 1=managed at most sites 2=managed at some sites 3=main nesting sites mostly protected 4=no, or little, management 5=not documented	Quantified 1=comprehensive documentation across population 2= comprehensive documentation for some of the population 3=anecdotal only 4=no reliable data
Egg predation/collection	1	2	2
Beach erosion	1		
Increasing beach temperature	1	4	2
Coastal development (urban)	1	2	2
Coastal development (industrial)	1,3	2	2
Light horizon disorientation	1	2	2
Bycatch in inter-nesting zone	3	1	2
Bycatch in migration zone	2	2	3
Bycatch in foraging habitat	3,4	2	3
Entanglement in discarded fishing gear	2,3,4	5	4
Impact to benthic ecology from fisheries	3,4	5	4
Solid pollution (e.g. plastics)	2,3,4	4	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Dirk Hartog Island	Nesting and foraging	Y	High	• Shark Bay World Heritage Area provides protection • Compulsory use of TEDs on prawn and scallop trawls in WA
Ningaloo Coast			High	• Monitoring, protection, education, awareness programmes • Designation / management of protected areas. • Fox baiting programme • Vehicle access restrictions • Compulsory use of TEDs on prawn and scallop
Muiron Islands			High	• Designation / management of protected areas. • Compulsory use of TEDs on prawn and scallop trawls
Gnaraloo Station	Nesting	Y	Med	• Around 100 females breeding annually, access to beach through private land (Gnaraloo Station). Restricted access toturtle nesting beaches.

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	Unknown	
Remigration interval	Unknown	
Clutches per season	Unknown	
Mean size of nesting adult (first breeding)	Unknown	
Age at maturity	Unknown	

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging)	Unknown	
Growth rates	Unknown	
Survivorship estimates	Unknown	

Summary from Wallace et al. 2010, 2011

Loggerheads in the South-east Indian Ocean RMU were given a risk matrix score of 2.00, obtained from expert opinion that loggerheads in this region have an annual nesting abundance of 1,001–5,000 females, a low likelihood of complete loss of nesting rookeries and comprise only one genetic stock. Recent and long-term population trends could not be determined due to data deficiency. A threats matrix score of 1.67 was determined from expert opinion that loggerheads in the South-east Indian Ocean RMU faced a medium threat from fisheries bycatch and coastal development, and a low threat from take. The threat posed by both pollution and climate change could not be determined due to data deficiency. Overall Wallace et al. (2011) categorised this RMU as High Risk-Low Threats.

Summary from US NMFS (2011)

Similar to Wallace et al. (2011) the NMFS determined that population data in this region was insufficient to determine recent or long-term trends, but inferred from available evidence that population declines are likely to occur in the future, with the greatest threat to loggerheads in this region coming from fisheries bycatch of juvenile and adult loggerheads throughout the region. The NMFS also found it impossible to determine the magnitude of the threat of climate change for loggerheads in the South-east Indian Ocean. The BRT conclude that uncertainty regarding loggerhead status in this region is considerable, but that significant conservation strategies have been implemented. Given the uncertainty that exists regarding the status of loggerheads in this region, the NMFS have determined that the South-east Indo-Pacific Ocean DPS of the loggerhead sea turtle is not currently in danger of extinction, but is likely to become so in the foreseeable future throughout its range. It is currently listed as 'Threatened'.

2012 update

Since the Wallace et al. (2011) and US NMFS assessments additional studies have commenced. These include projects to understand whole season nesting numbers at Dirk Hartog Island and pivotal temperature studies. A local community-based group conduct annual monitoring of the loggerhead turtles at Gnaraloo and the annual trend data from Gnaraloo is being used to understand seasonal trends and patterns at the main nesting sites of Dirk Hartog Island.

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South Pacific Ocean management unit

Ecological range

The management unit which approximates ecological range for the South Pacific Ocean population was calculated based on existing data from molecular studies, migration behaviour, tag recoveries and expert opinion and its spatial extent matches its RMU (Wallace et al. 2010). The boundary of its ecological range indicates that turtles from the population occur within the Exclusive Economic Zones of 23 nations (Figure 11).

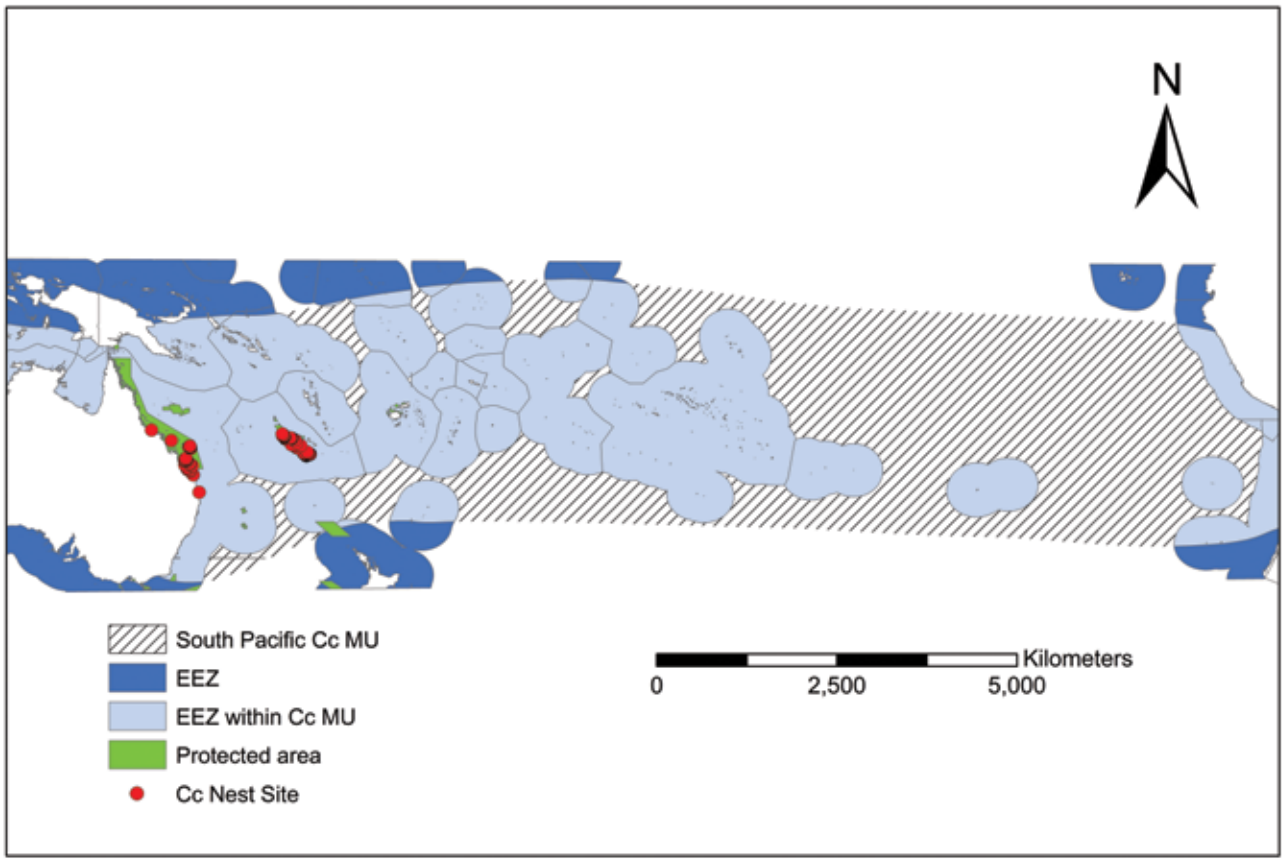

Figure 11. Overlay of the South Pacific Ocean loggerhead turtle RMU (mesh), with the exclusive economic zones (light blue) of inclusive nations.

Geographic spread of foraging

Similar to the North Pacific Ocean management unit, there is considerable knowledge about the foraging distribution of loggerhead turtles in the South Pacific Ocean, especially in eastern Australia. A combination of fisheries bycatch data, sightings and expert opinion indicate that loggerhead turtles from this management unit migrate and utilise waters throughout the South Pacific Ocean. Overall there are EEZs of 23 nations that lie within the ecological range of the South Pacific Ocean management unit (Figure 11) and loggerhead turtles from this management unit have been confirmed (tag recoveries, satellite telemetry and/or genetics) in the coastal waters of five of them (Australia, Papua New Guinea, New Caledonia, Solomon Islands and Peru). In eastern Australia considerable data has been collected on foraging loggerhead turtles, including home range studies, diet and foraging ecology, and population dynamics (see review by Limpus 2009).

Geographic spread of nesting

Loggerhead nesting in the South Pacific occurs mainly in eastern Australia (Figure 12). There are three principal breeding areas: the south-east coast of Queensland, the Capricorn-Bunker Islands in the southern Great Barrier Reef and the islands of the Swain Reefs (Limpus 2009). A substantial widely dispersed nesting population also occurs in southern New Caledonia and Vanuatu (Pritchard 1982; Atuary 1994; Limpus et al. 2005; Limpus unpublished data).

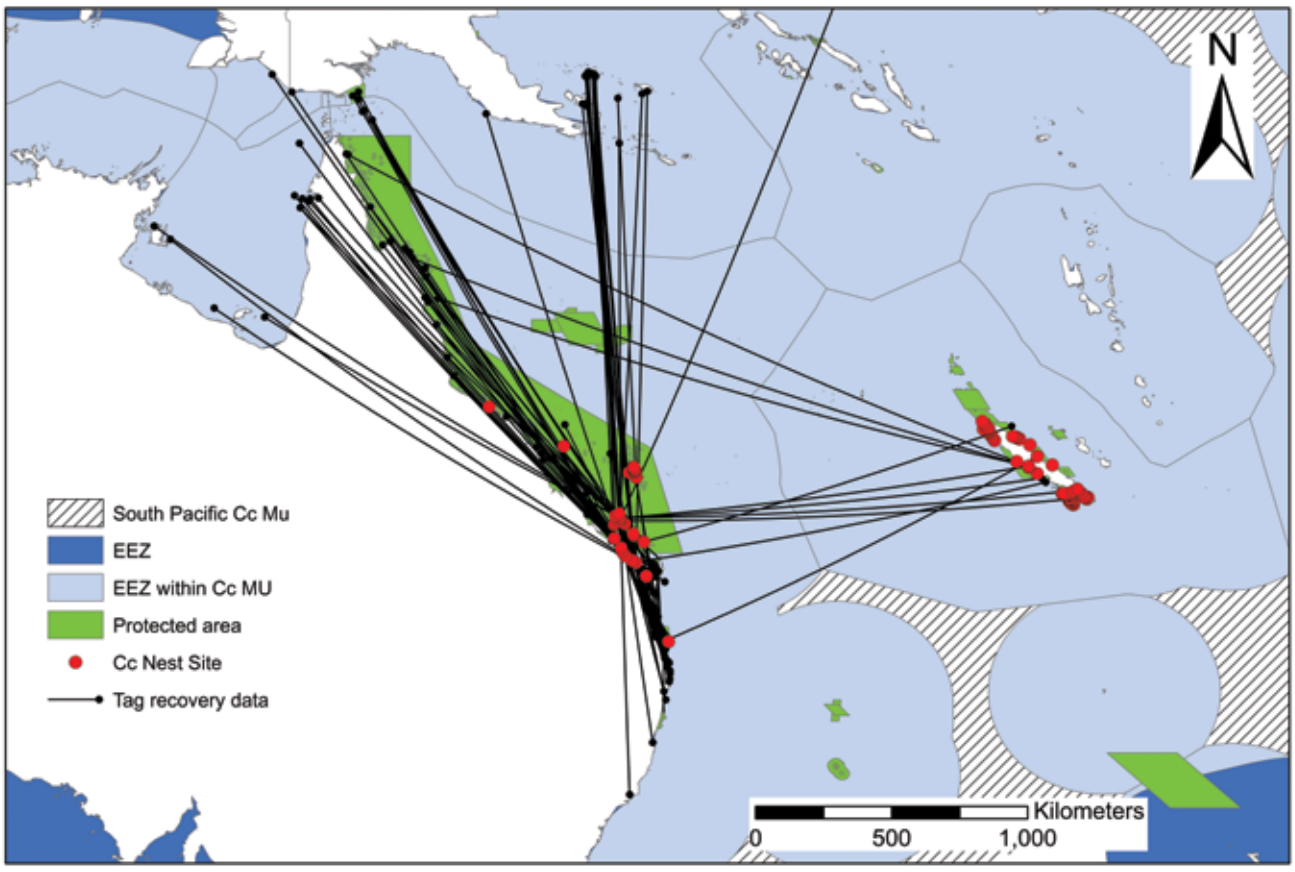

Figure 12. Map of nesting sites within the South Pacific Ocean population (red dots), with tag recoveries from Queensland and New Caledonia rookeries shown (black dots and lines).

Trends in nesting data

This population has been monitored at many locations, with long-term data collected from the Bundaberg coast since 1968, and Heron Island since 1974 (Limpus and Limpus 2003). In the 1970s the eastern Australian nesting population was estimated to be approximately 3,500 females annually (Limpus and Reimer 1994), however the population declined substantially through the 1980s and early 1990s before management intervention within the trawl fishery sector. Since TED use was mandated the population has indicated signs of recovery and current estimates put the annual nesting population at around 500 females (Limpus 2009).

Migration and distribution of foraging areas

Tagged loggerheads from south-east Queensland have been located in foraging areas to the south in New South Wales, east to New Caledonia, and north to the Solomon Islands, Papua New Guinea, the Australian Gulf of Carpentaria (where their feeding distribution overlaps with Western Australian loggerheads; Limpus et al. 1992) and Indonesian waters (Limpus 2009). A small number of tagged turtles from the New Caledonia breeding stock have been recorded foraging off eastern Australia, in the Heron Reef lagoon in the southern Great Barrier Reef and in Moreton Bay (Limpus and Limpus 2003; Limpus 2009; Queensland Government Marine Turtle Database).

Threats to the population

Australia: The most likely threats are occurring to turtles in the pelagic zone. They include international oceanic fisheries, coastal fisheries in South America and ingestion of plastic pollution. Fisheries bycatch is considered to be the biggest cause of mortality for loggerheads in the south Pacific Ocean (Poiner and Harris 1996; Limpus 2009). Oceanic gillnet fisheries potentially killed numerous loggerhead post-hatchlings when operational (Wetherall et al. 1993), and oceanic longlines in the south Pacific Ocean potentially cause high levels of post-hatchling loggerhead mortality today (Chaloupka 2003).

Predation by the European red fox (*Vulpes vulpes*) destroyed large numbers of nests along the mainland coast of east Australia in the 1970s and 1980s (Limpus 1985). Whilst baiting has controlled this problem at many of the affected nesting locations at present, minor nesting areas between the Burnett River and Deepwater Creek remain unprotected (Limpus 2009).

Harvest of loggerhead turtles has been documented in a number of South Pacific countries, including Fiji (Guinea 1993), New Caledonia (Limpus et al. 1992) and Australia (Limpus 1985). Consumption of loggerheads has not been as intense as for green and hawksbill turtles in this ocean basin (Limpus and Limpus 2003), and the loggerhead take within Australia is considered to be of minor significance to the population (Limpus and Reimer 1994). Consumption rates in New Caledonia and Fiji, however, have not been quantified (Pritchard 1982; Guinea 1993).

Other threats in eastern Australia include boat strikes, ingestion of plastic waste, entanglement and bycatch from shark control programs, all of which are thought to cause the deaths of up to 60 loggerhead turtles each year (Limpus 2009).

Additional threats: Refer to page 15 for details on how the threats in the following table were obtained and scored. The IOSEA Signatory States reports for Indonesia and Papua New Guinea do not mention threats to loggerhead turtles explicitly.

Summary of threats to the population - as per data contained within the Signatory States reports to IOSEA MoU

Type of threat	Location 1=nesting beach 2=migration zone 3=foraging area (local) 4=foraging area (widespread)	Managed 1=managed at most sites 2=managed at some sites 3=main nesting sites mostly protected 4=no, or little, management 5=not documented	Quantified 1=comprehensive documentation across population 2= comprehensive documentation for some of the population 3=anecdotal only 4=no reliable data
Egg predation/collection	1	2,3	2
Beach erosion	1	2	2
Increasing beach temperature	1	2	2
Coastal development (urban)	1	2	2
Coastal development (industrial)	1,3	2,3	2
Light horizon disorientation	1	2	2
Bycatch in inter-nesting zone	3	1,3	1
Bycatch in migration zone	2	2	2
Bycatch in foraging habitat	3,4	2	2
Entanglement in discarded fishing gear	2,3,4	2	3
Impact to benthic ecology from fisheries	3,4	2	2
Solid pollution (e.g. plastics)	2,3,4	2	4
Water quality	2,3,4	2	2

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Woongarra Coast (inc. Mon Repos)	Nesting and foraging	Y	High	• Long-term monitoring, protection, education, awareness programmes • Designation / management of protected areas. • Seasonal control of tourist activities • Relocation of at-risk nests to protected area • Fox baiting programmes • Vehicle restrictions • Seasonal closure to trawling • Compulsory use of TEDs on Qld trawls
Capricorn-Bunker Islands	Nesting and foraging		High	• Long-term monitoring • Designation / management of protected areas. • Compulsory use of TEDs on all trawls in Queensland
Swain Reef Islands	Nesting and foraging		High	• Long-term monitoring • Designation / management of protected areas, sanctuaries, exclusion zones etc. • Compulsory use of TEDs on all trawls in Queensland

Biological data – breeding

Parameter	**Value**	**Reference(s)**
Pivotal temperature	28.6 °C	Limpus 1985
Remigration interval	3.82 years	Limpus 1985
Clutches per season	3.41	Limpus 1985
Mean size of nesting adult (first breeding)	CCL 93.7 + 4.3 cm	Limpus 1991
Age at maturity	29 + years	Limpus 2009

Biological data – foraging

Parameter	**Value**	**Reference(s)**
Mean size at recruitment (to inshore foraging)	CCL 78.6 + SD 4 cm	Limpus and Limpus 2003
Growth rates	Slow. Three decades from hatchlings to breeding adults.	Limpus 2009
Survivorship estimates	0.782	Heppel et al. 1996

Summary from Wallace et al. 2010, 2011

Loggerheads in the South Pacific Ocean RMU were given a risk matrix score of 2.30, obtained from expert opinion that loggerheads in this region have an annual nesting abundance of 101–1,000 females, an increasing recent population trend, a decreasing long-term population trend, a medium likelihood of complete loss of nesting rookeries, and comprise only one genetic stock. A threat matrix score of 2.00 was determined from expert opinion that loggerheads in the South Pacific RMU were highly threatened by both fisheries bycatch (mainly in longline and trawl fisheries) and climate change (mainly due to increased temperatures and sea level rise), faced a medium threat from coastal development, and a low threat from take. The threat posed by pollution could not be determined due to data deficiency. Overall Wallace et al. (2011) categorised this RMU as High Risk-High Threats (Figure 1).

Summary from US NMFS (2011)

In line with Wallace et al. (2011), the NMFS (Conant et al. 2009; NMFS et al. 2011) found that the greatest threat to loggerheads in the South Pacific region was bycatch in oceanic fisheries (Limpus and Reimer 1994; Poiner and Harris 1996; Robins et al. 2002a, b; Kelez et al. 2003; Donoso and Dutton 2006; Alfaro-Shigueto et al. 2008; Limpus 2009), making oceanic juveniles and adults the two life stages particularly susceptible to mortality.

In contrast to Wallace et al. (2011), the threat posed by take was considered by the NMFS to be a medium threat to nesting females, due to aboriginal harvest of approximately 40 adult females annually (Limpus 2009). Moreover, although climate change is recognised as having the potential to affect loggerheads in this region, unlike Wallace et al. (2011), the NMFS found it was not possible to determine the magnitude of this threat.

In eastern Australia, the number of females breeding annually declined by approximately 86% between the mid-1970s and 1999. Fisheries bycatch of juvenile and adult loggerheads, occurring throughout the South Pacific Ocean, was the major driver of this decline. Given that the South Pacific Ocean DPS showed evidence of a marked decline (~86%) in nesting females between the mid-1970s and the late 1990s, the NMFS have determined that the South Pacific Ocean DPS is in danger of extinction throughout its range. It is currently listed as 'Endangered'.

2012 update

The Queensland Government continues to conduct standardised monitoring of the index beaches in South-Eastern Queensland and the foraging populations in Moreton Bay. There has been an improvement in the numbers of turtles nesting each year since the TEDs were introduced to commercial fisheries. However, foraging area studies continue to show that few young turtles are recruiting to coastal waters. The most likely threats are occurring to turtles in the pelagic zone. They include international oceanic fisheries, coastal fisheries in South America and ingestion of plastic pollution. Since 2010 several post-graduate students have completed, or are currently undertaking, research projects on this population.

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The **Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia** (known as the IOSEA Marine Turtle MoU) puts in place a framework through which States of the Indian Ocean and South-East Asia region, as well as other concerned States and partners, can work together to conserve and replenish depleted marine turtle populations and habitats for which they share responsibility.

The **Assessment of the conservation status of the loggerhead turtle in the Indian Ocean and South-East Asia** is the second in a series of species assessments published by the IOSEA Marine Turtle MoU Secretariat. A similar review, focussing on the leatherback turtle, was published in 2006 and updated in 2012. Each of these reports provides a comprehensive review of the available information on the species, together with insightful recommendations aimed at addressing gaps in knowledge and proposals for practical conservation and research actions.

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