ASSESSMENT OF THE CONSERVATION STATUS OF THE HAWKSBILL TURTLE IN THE INDIAN OCEAN AND SOUTH-EAST ASIA REGION

IOSEA
Marine Turtle MOU

Assessment of the Conservation Status of the Hawksbill Turtle in the Indian Ocean and South-East Asia Region

AUTHORS

Mark Hamann[1,2], Freya Flavell[1], Jack Frazier[2,3], Colin J. Limpus[2,4], Jeff D. Miller[2,5], Jeanne A. Mortimer[6]

AFFILIATIONS

1. College of Science and Engineering, James Cook University, Townsville, Australia
2. Advisory Committee, IOSEA Marine Turtle MOU
3. National Museum Natural History, Smithsonian Institution, New York, USA
4. Queensland Department of Environment and Science, Brisbane, Australia
5. Biological Research and Education Consultant, Montana, USA
6. Turtle Action Group of Seychelles (TAGS), P.O. Box 1443, Victoria, Mahé, Seychelles; Department of Biology, University of Florida, Gainesville, Florida, USA

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Robert Baldwin*	Five Oceans Environmental Services	Muscat, Oman
Katia Ballorain	CEDTM - Centre d'Etude et de Découverte des Tortues Marines	Saint Leu, La Réunion
Jérôme Bourjea*	IFREMER	Sète Cedex, France
Stephane Ciccione	Kelonia	Saint Leu, La Réunion
Andrew Cooke	RESOLVE sarl	Antananarivo, Madagascar
Heidrun Frisch-Nwakanma	Secretariat, IOSEA Marine Turtle MOU	Bonn, Germany
Christine Madden Hof	WWF Australia	Brisbane, Australia
Emi Inoguchi	Everlasting Nature of Asia	Kanagawa, Japan
Nicole Esteban	Swansea University	Swansea, Wales
Jarina Mohd Jani*	Universiti Malaysia Terengganu	Terengganu, Malaysia
Claire Jean	Kelonia	Saint Leu, La Réunion
Kongkiat Kittiwattanawong	Thailand Government	Thailand
Deasy Lontoh	Abun Leatherback Project, University of Papua,	Manokwari, Indonesia
Muralidharan Manoharakrishnan	Dakshin Foundation	Bangalore, India
Naveen Namboothri	Dakshin Foundation	Bangalore, India
Ronel Nel*	The Nelson Mandela University	Port Elizabeth, South Africa
Kimberly Riskas	University of Queensland	Brisbane, Australia
Rizza Araceli F. Salinas	Philippines Biodiversity Management Bureau	Philippines
Kartik Shanker	Centre for Ecological Sciences	
Indian Institute of Science	Bangalore, India	
Manjula Tiwari*	Ocean Ecology Network, Research Affiliate of: NOAA-Fisheries	La Jolla, USA
Casper Van De Geer	University of Exeter	Cornwall, England
Ryan Walker	The Ecology Co-op	West Sussex, England
Lindsey West	Sea Sense	Dar es Salaam, Tanzania
Scott Whiting*	Department of Biodiversity, Conservation and Attractions	Perth, Australia

* Member of the Advisory Committee for the IOSEA Marine Turtle MOU

LAYOUT

Dunia Sforzin, CMS Secretariat

PROOFREADING

Ana Berta Garcia

COVER IMAGE

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1. 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), with its associated Conservation and Management Plan (CMP), is a non-binding framework under the Convention on the Conservation of Migratory Species of Wild Animals (Convention on Migratory Species, CMS). Through the MOU, states of the Indian Ocean and South-East Asia (IOSEA) region work 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 as of May 2021 has 35 Signatory States. Supported by an Advisory Committee (AC) of eminent scientists and complemented by the efforts of numerous citizens' groups, nongovernmental, and intergovernmental organisations, Signatory States are working towards the implementation of a comprehensive Conservation and Management Plan, which is an integral part of the MOU.

Aware of the importance of compiling and making available up-to-date information on the status of marine turtle species covered by the MOU, particularly in order to identify and address gaps in basic knowledge and necessary conservation actions, the IOSEA Signatory States have commissioned a series of region-wide species assessments.

Accordingly, in 2006 the IOSEA Secretariat published the first-ever species report: *Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South-East Asia,* which not only provided a comprehensive review of biological and ecological aspects of the leatherback, *Dermochelys coriacea* (Vandellius, 1761), but also covered legislative provisions as well as aspects of conservation related to nesting, foraging, and migratory phases. This was followed in 2013 by the release of the *Assessment of the conservation status of the loggerhead turtle in the Indian Ocean and South-East Asia*. Importantly, both the leatherback and loggerhead, *Caretta caretta* (Linnaeus, 1758), assessments also included detailed recommendations and proposals for addressing deficiencies in both basic information and conservation measures that had been identified. The leatherback assessment was thoroughly reviewed and updated in 2012 to reflect new information and developments. Both the updated leatherback assessment and the loggerhead assessment are published online and remain available for free download from the CMS/IOSEA Marine Turtle MOU website[1].

The IOSEA Advisory Committee recommended that the hawksbill turtle, *Eretmochelys imbricata* (Linnaeus, 1766) should be the next species to be treated by a comprehensive assessment, a decision which was approved by the Signatory States. Similar to the assessment of the loggerhead turtle, we herein review the status of the hawksbill turtle with regard to its distinct management units. We collated and synthesised information from the scientific and grey literature, national reports from Signatory States to the IOSEA, and experts within each of the four IOSEA sub-regions, namely: Western Indian Ocean (WIO), North-western Indian Ocean (NWIO), Northern Indian Ocean (NIO), and South-East Asia and Australia (SEA +).

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[1] https://www.cms.int/iosea-turtles/en/publications/technical-reports

2. Introduction

The hawksbill turtle (*Eretmochelys imbricata* (Linnaeus, 1766)) occurs in all of the world's tropical and temperate oceans. Hawksbill turtle nesting is widespread and in some areas abundant within the Indian Ocean and South-East Asia (IOSEA) region. As is common for widely distributed and long-lived marine species, determining the hawksbill's conservation status at management-relevant scales has been challenging (Meylan and Donnelly 1999; Mortimer and Donnelly 2008; Wallace et al. 2011; FitzSimmons and Limpus 2014). Similar to other marine turtle species, the hawksbill turtle is comprised of numerous individual populations, which nest in separate locations to one another and often display distinct life cycle characteristics (FitzSimmons and Limpus 2014). Yet different nesting populations may also share nursery and foraging areas (Vargas et al. 2016; Bell and Jensen, 2018). As a result, conducting global status assessments (e.g. IUCN Red List framework) has proven challenging and sometimes controversial (Godfrey and Godley 2008). However, for conservation strategies to be effective, it is crucial to identify the relationships between the geographic areas used by each population, thereby allowing the identification of anthropogenic threats and impacts at the population level (FitzSimmons and Limpus 2014) and the implementation of effective management.

There have been several attempts to categorise marine turtles into distinct population units below the species level, but above the nesting population level. The development of population genetics was used to determine genetically distinct populations, and subsequently to classify these populations as stocks or management units (as per Moritz 2002). The IOSEA region hosts at least eight hawksbill management units that nest within the region; a ninth management unit nests just outside the IOSEA, although non-reproductive individuals occur within the region (FitzSimmons and Limpus 2014; Vargas et al. 2016). Moreover, additional management units could potentially occur in various locations throughout the IOSEA region where hawksbills nest but where no genetic data are available (FitzSimmons and Limpus 2014). Given that knowledge gaps in genetic structure exist for many regions of the world, Wallace et al. (2010a) introduced the concept of regional management units (RMUs) for all seven marine turtle species.

Table 2.1. Outputs from the Wallace et al. (2010a) designations in the IOSEA region and the genetic stocks (management unit) designation by FitzSimmons and Limpus (2014).

Regional Management Unit (RMU)	IOSEA Signatory States with documented hawksbill turtle nesting	Genetic stocks included as per FitzSimmons and Limpus (2014)
Northwest Indian Ocean	Djibouti, Egypt, Eritrea, India (Lakshadweep Islands), Iran, Kuwait, Maldives, Oman, Qatar, Saudi Arabia, Sudan, United Arab Emirates, Yemen	Of the turtle rookeries in Persian Gulf, only Iran and Saudi Arabia rookeries have been sampled for genetics. Persian Gulf MU Turtles from rookeries in India, Maldives, Oman, Yemen and from countries in the Red Sea are yet to be sampled.
Southwest Indian Ocean	Seychelles, Chagos, Madagascar, Mozambique, Tanzania, Kenya, Comoros, Mauritius, French Overseas Departments of La Réunion and Mayotte	Only rookeries in the Seychelles and Chagos were sampled for genetic population structure. Western/Central Indian Ocean MU.
Northeast Indian Ocean	Sri Lanka, India (Nicobar and Andaman Islands), Thailand, Myanmar, Bangladesh	No sampling for genetic population structure.
Southeast Indian Ocean	Australia (Western Australia)	One management unit identified (eastern Indian Ocean, Western Australia) (Eastern Indian Ocean (MU).
West Pacific/Southeast Asia	Thailand, Malaysia, Indonesia, Philippines, Viet Nam, plus Singapore (not an IOSEA MOU signatory state)	Sulu Sea (Malaysia) MU, Gulf of Thailand (Kho Kram) (possible MU) and western Peninsular Malaysia MU have been assessed. Rookeries in Indonesia, Singapore, Viet Nam, and Phil-ippines have not been assessed for genetic population structure.
West Central Pacific	Indonesia (West Papua)	No sampling for genetic population structure.
Southwest Pacific	Australia (Northern Territory and Queensland), Papua New Guinea, plus Solomon Islands (not an IOSEA MOU signa-tory state)	Three management units identified: North Queensland MU, Northeast Arnhem Land MU, and outside the IOSEA region Solomon Islands MU. No sam-pling for genetic population struc-ture has occurred in Papua New Guinea.

They identify seven RMUs for hawksbill turtles in the IOSEA, although six of them were considered putative (i.e. based on nesting records but lacking other biological or genetic evidence) and may require modification as more data become available. Together, these approaches identify the most appropriate management units (MUs) for hawksbill turtles (Table 2.1).

There has been considerable debate about the most effective scale at which to undertake this review. The approach used by Wallace et al. (2011) aimed to assess each of the RMUs in terms of population risk levels (based on current population size, recent and long-term trends in nesting population size, rookery vulnerability, and genetic diversity) and existing threat levels (e.g. fisheries bycatch, direct take, coastal development, pollution and pathogens, and climate change). In doing so, they identified RMUs which could be considered the most threatened at a global scale, and also highlighted existing gaps in necessary conservation information. Two of the hawksbill turtle RMUs that were scored as both High Risk and High Threat (HR-HT) were within the IOSEA region: 1) the Northeast Indian Ocean RMU, comprising management units in the Persian Gulf and also putative rookeries in the Red Sea and 2) the West Pacific/Southeast Asia RMU.

In compiling our assessment on hawksbill turtles in the IOSEA region, we organised the region into RMUs and then use the genetic stocks approach as per the loggerhead assessment (see Hamann et al. 2013a)) based on the designations in FitzSimmons and Limpus (2014). For each of the recognised stocks, we harmonise information from the scientific and grey literature, national reports from Signatory States to the IOSEA, and expert opinion.

3. Hawksbill turtle synthesis

The hawksbill turtle has a global distribution and occurs in at least 97 countries, 45 of which are within the IOSEA region and 35 of which are Signatory States to the IOSEA Marine Turtle MOU. In 1996 and again in 2008, the species was assessed at the global level as Critically Endangered by the IUCN Species Survival Commission. Meylan and Donnelly (1999) and Mortimer and Donnelly (2008) provide the supporting information for the 1996 and 2008 assessments, respectively.

Summary – population identification

There are seven RMUs for hawksbill turtles in the IOSEA region: four in the Indian Ocean, one in South-East Asia, and two in the Indo-Pacific (Wallace et al. 2010a)). Within these RMUs, there are at least nine currently identified distinct populations/management units of hawksbill turtles that nest within the IOSEA region, and at least one management unit that occurs in the IOSEA region but contains hawksbills that nest in adjacent habitat (i.e. Solomon Islands) (see Figure 3.1 adapted from FitzSimmons and Limpus (2014) and Vargas et al. 2016; 2020 and Table 2.1). These nine management units have been classified as distinct based on a combination of genetic data and knowledge of reproductive behaviour. While the nesting populations are distinct, individuals from more than one population may use the same foraging areas. Research on hawksbill population genetics is ongoing, so it is likely that additional management units exist and are awaiting identification and further study.

Summary – nesting

Hawksbill turtles currently nest in at least 32 nations within the IOSEA region. All of these countries are Signatory States to the IOSEA Marine Turtle MOU except Singapore, Qatar, Djibouti, and Kuwait. There are no recent records to indicate whether hawksbill turtles still nest in Somalia, Viet Nam, Cambodia, or Bangladesh. Hawksbill turtle nesting also occurs in the Solomon Islands—which is outside of the IOSEA region—but nesting turtles from the Solomon Islands are known to migrate into Australian and Papua New Guinean waters.

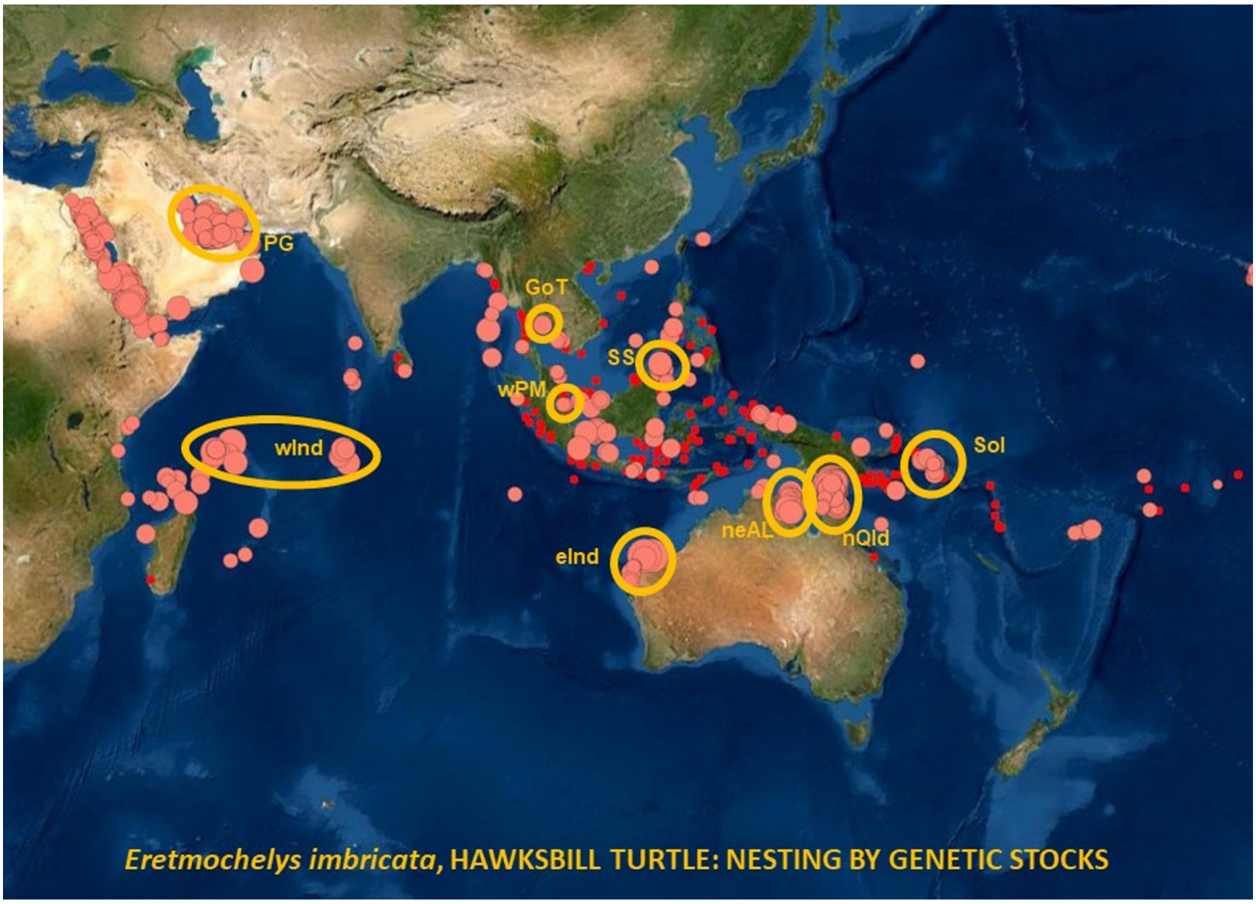


Figure 3.1. Distribution of hawksbill turtle nesting within the IOSEA region (after FitzSimmons and Limpus, 2014). Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote beaches where unquantified nesting has been recorded. Yellow circles indicate genetically distinct management units. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Summary – foraging

Data from capture-mark-recapture studies, tag recoveries, satellite telemetry, and fisheries bycatch indicate that hawksbill turtles have been recorded within the Exclusive Economic Zones (EEZs) of most of the Signatory States of the IOSEA Marine Turtle MOU. In addition, hawksbill turtles have been recorded in the waters of most neighbouring countries (e.g. non-Signatory States China, Japan, Solomon Islands). Population and biological studies on foraging turtles have been conducted in Australia, Seychelles, Chagos, Europa Island, the Persian Gulf region, and Indonesia.

4. Areas within the IOSEA region of known importance for hawksbill turtles

Important nesting sites

Index nesting beaches

Nesting beaches, or Index nesting beaches, can be used as a first level approach to designate areas of importance for hawksbill turtles. An "Index Site/Beach" as broadly defined by Eckert and Eckert (2012: 7) is "[a] nesting beach (or series of nesting beaches) where the consistent application of standardized population monitoring protocols ensures that data collected are suitable for long-term analyses of population abundance and/or trend. Sampling strategies at each index site should be structured in a manner that allows inference to the entire nesting population of interest" and the ability to detect changes with a prescribed level of confidence. However, while this broad definition is a useful starting point for the determination of important nesting sites, the diligent, consistent long-term application of standardised monitoring protocols for some index beaches could, if employed alone, be of limited use for inferring "entire nesting population" size and/or trends. Monitored index beaches are typically sites that are well protected (for example, strict nature reserves or national parks) and so do not usually represent the status or health of other nesting sites where protection is more limited or non-existent. In fact, simply the presence of monitoring personnel at a nesting beach will provide an added level of protection for nesting turtles. Because there are numerous critical questions for hawksbill turtles across the IOSEA region, a better understanding of population dynamics is needed. In particular, reproductive ecology (e.g., aspects of nesting site fidelity, clutch frequency and size), recruitment, sex ratios at different life stages, survivorship, mortality, and the relationship(s) between these factors and bio-physical factors need to be studied further. Acquiring knowledge about these will require long term systematic survey programs that will aid in the ability to use abundance data from nesting beaches to make defensible population inferences.

Index beaches have been established for six of the seven known genetically distinct hawksbill populations (Management Units) and at the same time for each of the five Regional Management Units (RMUs) in the IOSEA region (Table 4.1). Two or more known management units, and thus multiple index sites, commonly comprise a single RMU. And while RMUs are a useful first-order classification, which are used in IUCN Red List assessments, focused management decisions rely on genetically distinct populations or management units. Signatory States of the IOSEA Marine Turtle MOU generally focus management at the genetic stock level. Importantly, as genetic-based research continues to expand in geographic scope and sample sizes, and as techniques improve, the number of known genetically distinct populations in each RMU, and more specifically in the IOSEA region, is likely to grow in number.

IOSEA Site Network localities

Hawksbill turtles are listed as one of the key values/assets used in the designation of nine of the 11 Sites in the IOSEA Marine Turtle MOU's Network of Sites of Importance for Marine Turtles in the Indian Ocean – South-East Asia Region (IOSEA Site Network), because the presence of hawksbill turtles has ecological, social, cultural, and/or economic importance for the sites. These nine sites in the Network are Europa Island (French Southern and Antarctic Lands), Sheedvar Island (Islamic Republic of Iran), Turtle Islands Wildlife Sanctuary (Philippines), Aldabra Atoll (Seychelles), Bu Tinah Shoal and Sir Bu Na'air (UAE), Rufiji-Mafia Seascape (United Republic of Tanzania), Itsamia (Comoros), and Con Dao National Park (Viet Nam)[2].

Important non-nesting sites

Migration

Despite common perceptions, hawksbills disperse and migrate over different areas. The most extensive work on hawkbill turtle migration in the IOSEA region is from the Persian Gulf. Between 1999 and 2015 post-nesting female turtles were tracked from ten rookeries in four countries (n=90 turtles) by Pilcher et al. (2014a), three rookeries in Qatar (n=14 turtles) by Marshall et al. 2020 and two rookeries in Kuwait (n=4) by Rees et al. (2019). The turtles demonstrated high individual variation in their migration routes and revealed foraging destinations around the south and southwest Persian Gulf and Omani coast of the Arabian Sea, including a confluence of routes around Ras Al Hadd in Oman. Migration routes were predominantly coastal. In addition, Pilcher et al. (2014b) and Marshall et al. (2020), but not Rees et al. (2019), found that turtles use cool water refuge areas during the summer months. Pilcher et al. (2014a,b) used data collected between 1999 and 2012 on migration routes to identify important turtle areas for hawksbill turtles in the Persian Gulf. In addition, data from other satellite tracking, recovery of flipper tags, and genetic sampling from turtles in foraging areas in the IOSEA region indicate turtles are migrating across national and international boundaries, and turtles from more than one management unit can share foraging sites. Continued use of satellite tracking will improve understanding of important migratory routes and genetic-based research on turtles in foraging sites will help identify patterns of

[2] https://www.cms.int/iosea-turtles/en/activities/site-network.

Table 4.1. Index nesting sites within the IOSEA region

Index nesting sites	**Country (or territory)**	**Management unit (MU)** as per FitzSimmons and Limpus (2014), Tabib et al. (2014) and Vargas et al. 2016)	**RMU (Wallace et al. 2010a)**
Milman Island	Australia	North Queensland	Pacific southwest
Northeast Island (Groote Eylandt) (established but not currently monitored)	Australia	Northeast Arnhem Land	Pacific southwest
Rosemary Island	Australia	East Indian Ocean	Southeast Indian Ocean
Pulau Momperang/ Peserat, P. Kimar (Belitun Is), P. Segama, P. Penambun	Indonesia	Not yet defined. Given Indonesia straddles the equator and extends east-west over ~45 degrees of longitude it is likely more than one MU will be iden-tified.	Southeast Asia
Pulau Gulisaan P. Selingan, P. Bakkangan	Malaysia (Sabah)	Sulu Sea	Southeast Asia
Terengganu and Pahang States (e.g. Pulau Redang, P. Tioman).	Malaysia (Peninsula – east)	Not yet defined	Southeast Asia
Ko Kram	Thailand	Gulf of Thailand [postulated]	Southeast Asia
Beaches in Melaka State	Malaysia (Peninsula – west)	Western Peninsula Malaysia	Southeast Asia
All beaches of Singapore	Singapore	Not yet defined	Southeast Asia
Sheedvar, Qeshm and Kish	Iran	Persian Gulf. The Persian Gulf possibly includes more than one MU	Northwest Indian Ocean
Jana, Karan	Saudi Arabia	Persian Gulf	Northwest Indian Ocean
Sir Bu Na'ir, Jebel Ali	UAE	Persian Gulf	Northwest Indian Ocean
Fuwairit	Qatar	Persian Gulf	Northwest Indian Ocean
Diego Garcia	Chagos Archipelago	Western Indian Ocean	Southwest Indian Ocean
Beaches across the granitic and outer islands.	Seychelles	Western Indian Ocean. Sampling turtles from other rookeries in the southwest Indian Ocean could identi-fy additional genetically distinct populations, or link them to presently recog-nised MU(s)	Southwest Indian Ocean
Beaches across the granitic and outer islands.	Seychelles	Western Indian Ocean. Sampling turtles from other rookeries in the southwest Indian Ocean could identi-fy additional genetically distinct populations, or link them to presently recog-nised MU(s)	Southwest Indian Ocean

connectivity among and between foraging and nesting sites (which has been done for the south-west Pacific by Bell and Jensen 2018).

Important foraging and refuge sites

The concept of index sites can also be applied for standardised monitoring of designated sites for refuge and/or foraging turtles. Within the IOSEA region monitoring of foraging hawksbill turtles occurs in Australia (e.g. the Great Barrier Reef and Cocos (Keeling) Island), Chagos (Diego Garcia), and the Seychelles (granitic and outer islands). In addition, there are dive-industry based “citizen-scientist” sightings projects being initiated/underway in Egypt, Malaysia, Maldives, Mayotte, Mozambique, Philippines, Seychelles and Thailand, which all collect data on in-water sightings of hawksbill turtles (e.g. Williams et al. 2015; Hudgins et al. 2017; Long and Azmi 2017; Mancini and Elsadek 2019). However, while the non-nesting distribution, abundance and biological characteristics of hawksbill turtles are knowledge gaps for most of the IOSEA region, it is generally recognised that hawksbills are generally associated with coral or rocky reef habitats. Although recent research in the eastern Pacific Ocean and Galapagos has identified confined inshore estuarine bays, even mangrove habitats, as important for foraging and nesting hawksbill turtles (e.g. Alarcon et al. 2019; Gaos et al. 2012; 2016), this habitat association is not well described from the IOSEA region. Therefore, at present, we can use just the presence of coral or rocky reef habitats in tropical waters as a starting proxy for the distribution of potentially important foraging and refuge habitats for hawksbill turtles.

Since at least 2000, the distribution and status of coral reef habitats across the IOSEA has received increasing attention and has been well mapped across most of the region using combinations of satellite imagery, aerial photos and field-based surveys (UNEP-WCMC, WorldFish Centre, WRI, TNC (2021). Coral reef habitats occur in all IOSEA nations except Iraq (Wilkinson 2008; GCRMN 2021) and vary in their size (spatial area – Spalding et al. 2001; Wilkinson 2008; GCRMN 2021), status and condition (generally measured as a change in the percentage of hard coral cover) (Wilkinson 2008). In addition, non-coral, rocky-reef systems also occur throughout the IOSEA region, however these are less commonly mapped (e.g. north-western Australia). Coral reefs throughout the IOSEA region face combinations of common threats, from rising sea surface temperatures, pollution, fisheries-related impacts, tourism, breakage, and coastal development (Wilkinson 2008; GCRMN 2021). The status of the world's coral reefs and summaries for all regions can be downloaded from (https://gcrmn.net/).

5. Gaps in the biological information

Population structure

In the IOSEA region, there is a key need for genetic research to be done on hawksbill turtle rookeries in Comoros, Djibouti, Egypt, Eritrea, France (La Réunion), India, Indonesia, Kenya, Madagascar, Maldives, Mauritius, Mozambique, Myanmar, Oman, Philippines, Saudi Arabia (Red Sea), Sri Lanka, Sudan, Tanzania, Timor Leste, and Yemen to identify a complete suite of genetic-based management units. Such research would provide a foundation for future status assessments and conservation activities. Additionally, several IOSEA Signatory States whose sovereignty covers vast maritime areas and numerous islands separated by great distances—such as France (La Réunion), Indonesia and Seychelles—may be found to host more than one management unit, each of which may require different conservation plans and actions. In the Asia-Pacific region, a Marine Turtle Genetic Working Group was established in 2020 to enhance the technical capacity, standardise methodologies, identify research priorities, and establish a regional collaborative network to facilitate genetic studies in support of national and international marine turtle management and protection efforts. This Working Group currently has >60 members, with genetic sample collection and analysis underway in some of the priority areas noted above. In the southwest Indian Ocean, the continued genetic sampling of turtle rookeries under the INTERREG V (Reunion Island and Mayotte; Indian Ocean) project is collecting important information about genetic population structure and could possibly reveal new hawksbill management units.

Life history attributes

A. Nesting populations

There are substantial gaps in our knowledge of life history attributes for most hawksbill turtle nesting sites in the IOSEA region. The specific gaps vary between locations, and details can be found for each population by referring to the corresponding section of this report. Data on life history attributes are necessary for the development of accurate population models used in designing and implementing effective management plans. It is preferable that life history parameters be collected from at least one rookery for each management unit. Common gaps in life history attributes, evident in most management units, are attributable to missing or limited data on the following:

- Sampling for genetic mtDNA profiles
- Annual census figures at representative nesting beaches to quantify the number of females nesting per season, or the number of clutches laid per season, or the number of tracks (nesting attempts) made per season
- Quantified mortality estimates from anthropogenic and non-anthropogenic sources across all life history stages
- Quantified key demographic parameters including:
  - the average number of clutches laid per female per year/nesting season
  - the average number of years between breeding/nesting seasons for individual turtles
  - the rate of female and male recruitment into the breeding population
  - survivorship of adult females
  - incubation success and hatchling recruitment
- Temperature profiles for incubation and hatchling sex ratios
- Information on habitat use during migration and inter-nesting periods

B. Non-reproductive populations

Within the IOSEA region, there are substantial gaps in our knowledge of hawksbill turtle foraging areas, habitat use (oceanic and coastal), diet, growth, age, and survivorship. Additionally, while there have been numerous tracking and foraging area studies undertaken on populations in Australia, Seychelles, and the Persian Gulf, few published data on migration and home range exist for other populations.

C. Oceanic post-hatchling populations

Within the IOSEA region, there is a major knowledge gap regarding the distribution and abundance of these small, planktivorous hawksbill turtles and the threats associated with this life history stage. In other ocean basins, it is now being recognised that ingestion of fragmented hard plastic debris is a significant threat to post-hatchling turtles of all species. Within the Arafura Sea region, post-hatchling hawkbill turtles are among the most common turtles found entangled in ghost nets. Larger post-hatchling hawksbill turtles are at risk of being hooked in longline fisheries of the oceanic IOSEA region.

6. Key pressures on hawksbill turtles of the IOSEA region

The tortoiseshell trade – a summary

The information and status of hawksbill turtles summarised in this report needs to be considered in the context of the large-scale commercial trade in tortoiseshell products that has existed across the Indian Ocean region for some 2,000 years, with the trade intensifying in scope and volume since the 18th century. The global trade and its impact on hawksbill turtle populations has been well summarised by Milliken and Tokunaga (1987), Groombridge and Luxmoore (1989), Meylan and Donnelly (1999), and Mortimer and Donnelly (2008). While it is recognised that the international and domestic commercial trade of hawksbill turtles and/or their eggs dates back to the 9th century, demand for hawksbill turtle shell (scutes) to make tortoiseshell products rapidly expanded in the 17th century. For example, data on the trade of hawksbill turtle shell from the Seychelles between 1884 and 1982 indicate an annual trade of around 1,079 kg per year (Figure 6.1b). In the 20th century, the manufacture of products from hawksbill turtle shell became an established industry, which was largely concentrated in Japan but also occurred in most developed nations (Mortimer and Donnelly 2008). In the latter half of the 20th century, trade was well documented in national trade records (see Groombridge and Luxmoore (1989) for a summary). Around 1.3 million large-sized hawksbill turtles and 310,598 kg (8,394 per year) of raw hawksbill shell (bekko) was imported by Japan from countries in the IOSEA region between 1950 and 1992 (Figure 6.1a). There are various weights cited in the literature to convert a kilogram of hawksbill turtle shell to the number of whole turtles. Using the conversions of 0.92 kg and 1.5 kg as equivalents for one turtle, between 285,000 (7,722 per year) and 465,000 (10,500 per year) hawksbill turtles were killed in the IOSEA region from 1950 and 1992 in order to supply Japan with raw turtle shell. At least 20 countries exported turtles for the trade, predominantly Indonesia, Tanzania, and the Philippines. Trade from IOSEA nations into Hong Kong, Korea, Sri Lanka, Taiwan, Europe, and the USA also occurred. In addition to the raw shell trade, there was considerable trade of other hawksbill turtle products (e.g. eggs, skin, stuffed turtles, processed shell). The hawksbill turtle was included on Appendix I of the Convention on International Trade in Endangered Species (CITES) in 1977. By 1990, Japan began to reduce its imports under international pressure, and in 1992 withdrew its reservation for marine turtles under CITES Appendix II and officially ceased its involvement in the international trade of marine turtle products.

Following the closure of the Japanese bekko industry, there was an increase in the capture of hawksbill turtles to produce stuffed turtles with polished carapaces. Vessels from China and Viet Nam have been apprehended in the Philippines, Malaysia, Indonesia, and Australia for illegally taking, trading, or storing hawksbill turtles (IOSEA 2014; Miller et al. 2019).

Bycatch in legal fisheries

Incidental capture (bycatch) in legal fisheries is recognised across the world as a significant threat to marine turtle populations (Alverson et al. 1994; Lewison

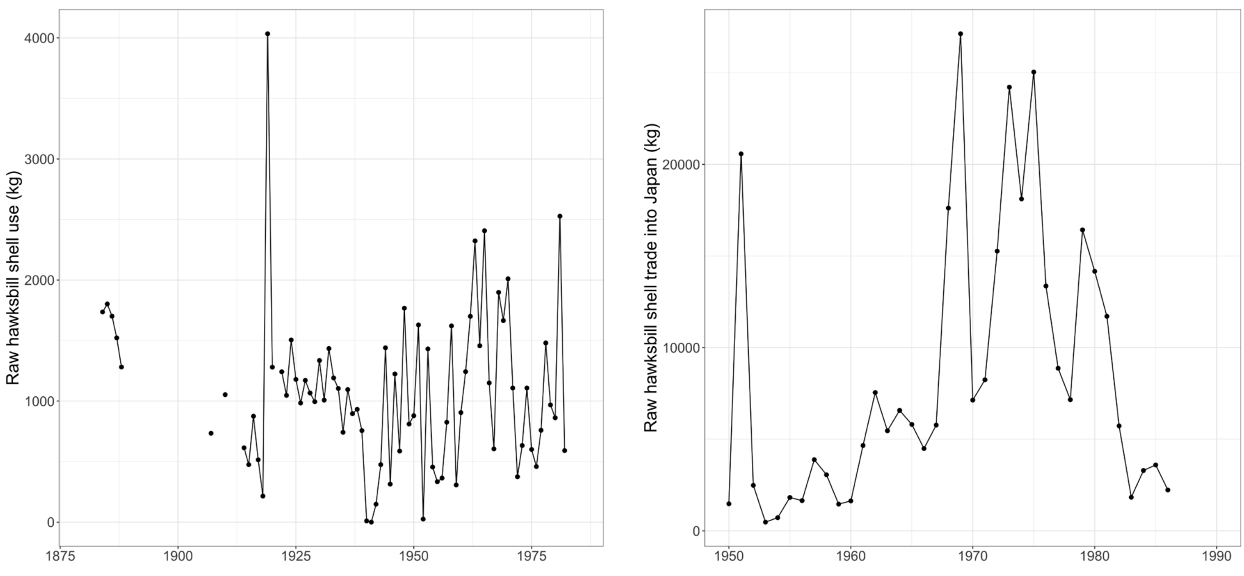


Figure 6.1. (a) Kilograms of raw hawksbill shell use per year exported from the Seychelles and (b) Kilograms of unworked bekko (hawksbill shell) imported into Japan from IOSEA nations per year between 1950 and 1986. Data extracted from Groombridge and Luxmoore (1989), tables 102 and 177, respectively.

et al. 2004; Bourjea et al. 2008; Wallace et al. 2010b). In general, the three major gear types shown to have the highest impact on marine turtles are gillnets, bottom trawls, and longlines. However, for most fisheries and especially artisanal fisheries, there are few quantitative studies from which to understand the severity of the threat. The same generality applies to the IOSEA region, where legal fisheries are considered to be a key threat to marine turtles, although quantitative data are not common (Bourjea et al. 2008; Williams et al. 2019). The governments of Signatory States of the IOSEA Marine Turtle MOU and fisheries regulatory bodies (e.g. IOTC, SIOFA, SPRFMO, WCPFC) have implemented bycatch reduction and/or observer programmes aimed at mitigating the issue and understanding the scale of impact. Management measures include a suite of operational controls (e.g. turtle excluder devices (TEDs), limits to trawl length and set times, fixed set depths, setting restrictions, bait and hook type) and spatial and temporal closures. However, the effectiveness of mitigation is rarely evaluated, and bycatch records are usually examined at the level of individual fisheries, making cumulative impacts hard to understand (Riskas et al. 2016). We found 15 publications on marine turtle bycatch in the IOSEA region that were published during the past 12 years. Eleven of these described bycatch in fisheries operating in the southwest Indian Ocean, two in South-East Asia, and two in the northern Indian Ocean. Collectively, the papers indicate that bycatch of hawksbill turtles from longline and purse seine fisheries (oceanic fisheries) is very low, while bycatch from gillnets and coastal artisanal fisheries are likely to have the highest impact. The studies also indicate that bycatch is spatially and temporally variable and usually low in magnitude, making statistical analysis challenging. Two of the key challenges are to quantify the bycatch in coastal fisheries and to couple bycatch monitoring with tissue sampling to enable genetic-based stock assessments of IOSEA hawksbill turtles. Purse seine fisheries, however, involve two sources of sea turtle mortality. While turtle by-catch in the purse seines themselves appears relatively low, damage caused by drifting Fish Aggregating Devices (dFADs) used to attract their catch is more significant (Esteban et al. 2021). The use of FADs has expanded greatly since the turn of the millennium, and tens of thousands of FADs are dumped into the Indian Ocean each year and in most cases are not recovered. One of the dangers of FADs is that once they are lost they continue to fish at full potential (Stelfox et al. 2016). Because most FADs are constructed from discarded fishing net they are associated with large amounts of bycatch involving several species of pelagic shark, and turtles, including hawksbills, which become entangled by ropes and netting beneath FADs and drown. FADs also inflict considerable environmental damage when they wash onto coral reefs where they become virtually impossible to remove. In a review of the effects of ghost gear on cetaceans, elasmobranchs and marine reptiles, all hawksbills (n=43, 3 studies) reported entangled in ghost gear worldwide were from Indian Ocean fisheries (Stelfox et al. 2016), indicating the severity of the issue of ghost gear.

Illegal use and Illegal, Unreported and Unregulated (IUU) Fishing

In response to increasing concern about the illegal use and sale of hawksbill turtles and the role of illegal, unreported and unregulated (IUU) fisheries in the turtle trade (IOSEA 2014), CITES commissioned a study on the legal and illegal international trade in marine turtles, which included case studies from Mozambique, Madagascar, Indonesia, Malaysia and Viet Nam (CITES 2019). In addition, Riskas et al. (2018) conducted an IOSEA-wide survey of experts in marine turtle conservation and fisheries management to examine the threat of IUU fishing on marine turtles and identify barriers and opportunities for mitigation. Likewise, Williams et al. (2019) examined the illegal capture and commercial use of marine turtles in Mozambique (see also Miller et al. (2019)). Importantly, all studies reach complementary conclusions:

1. IUU fishing is likely to have significant impacts on hawksbill turtle populations throughout the IOSEA region through targeted exploitation and international wildlife trafficking.
2. Where use relates to eggs or meat, it is often not known which species are involved.
3. The motivations for use of turtles differ across the region. In the southwest Indian Ocean, illegal use of hawksbill turtles is predominantly for local domestic consumption or domestic trade. In South-East Asia, the illegal use of hawksbill turtles is more likely to supply both local and international markets, such as in the production of handicrafts and stuffed turtles. CITES seizure records also show trade occurs between countries of the South-East Asia sub-region.
4. An organised domestic trade network was found in Madagascar, involving the movement of turtles or turtle meat (unspecified species) from coastal to inland areas. In South-East Asia, there was increased evidence of hawksbill turtles being caught, stored in pens, and then traded when a certain quantity of turtles had been reached.
5. Individual fishers generally understood that the capture, retention, and selling of turtles was not legal, but the benefits of doing so were perceived to outweigh the risk of getting caught.
6. Lack of enforcement of legislation is an issue that requires attention and improvement across the region.
7. Increased attention on the turtle trade, especially the international trade, has largely driven the trade underground. In Indonesia and Malaysia, online

platforms are increasingly being used to sell turtle products, including hawksbill turtle shell.

8. The illegal trade in hawksbill turtles—particularly in China and Viet Nam—provides an incentive for other countries in the IOSEA region (and outside) to continue harvesting turtles illegally.
9. Collectively, the illegal trade involves several nations, and threatens the recovery of depleted hawksbill turtle populations.
10. There are considerable cultural, social, and economic drivers underpinning the illegal use and trade of marine turtles. These drivers are not well understood and likely intersect with multiple governance and social structures.
11. There is a demonstrable need to strengthen monitoring, control, and surveillance (MCS) to combat IUU fisheries and to employ regional coordination to help build enforcement capacity in less-developed nations.
12. More research is needed to better understand the social dimensions of socioecological systems, including the reasons for individual and group involvement in illegal use, their resilience to change, and opportunities to develop alternatives to illegal use and trade.
13. There is a recognized need to improve scientific study of hawksbill products seized by customs agencies, such as the collection and analysis of samples taken from scutes (e.g. LaCasella et al. 2021). These efforts are underway in Australia and the Philippines, with likely uptake in Viet Nam, Malaysia, and Indonesia later in 2021.

Human interactions

Marine turtles, including hawksbills, are key attractions for tourism activities on beaches and dive areas. Appropriate management programmes must be developed and executed to reduce any potential negative impacts on turtles and their habitats. Turtle tourism is often closely coupled with citizen science activities, especially where scuba diving is involved. Important advances to understand and manage human interactions from tourism have been made, especially for green and loggerhead turtle conservation, but these could also be applied to hawksbills (e.g. Tisdell and Wilson 2001; Busaidi et al. 2019).

For nearly a century, the farming (i.e. captive breeding or rearing) of hawksbill and green turtles has occurred within and outside the IOSEA region. Attempts have been initiated for a variety of reasons, but since the 1960s and 70s, farming has been used primarily to investigate its potential as an alternative to consuming wild-caught turtles. Farming of turtles is difficult to achieve at scale, with most initiatives failing for a combination of reasons, including: 1) complex technical and husbandry challenges in long-term rearing of large numbers of turtles across multiple age classes; 2) uncertain economic viability, especially if access to valuable markets is prohibited by trade regulations; 3) numerous unresolved issues associated with providing optimal diet and dealing with health, condition and disease outbreaks; 4) negative public perception; and 5) legal issues related to the collection of initial stock, rearing of protected species, and sale of products.

Climate change

Climate change is a ubiquitous global issue. While marine turtles have coped with changing climates over past millennia, the rate of current and predicted change, coupled with additional and cumulative threats and pressures (e.g. coastal development, pollution, fisheries), is unprecedented. While climate change is pervasive, the degree to which various species or populations of marine turtle are exposed and able to adapt to climate effects will vary considerably (Hamann et al. 2013b). In our review of the recent literature (from 2009 to 2021), we found six publications focused on aspects of climate change related to hawksbill turtles in the IOSEA region. Four of these research papers focused on beach/sand temperatures or sea level rise (Butt et al. 2016; Esteban et al. 2016; Tanabe 2018; Chatting et al. 2018; 2021) and two focused on in-water behaviour (Pilcher et al. 2014; Marshall et al. 2020). Rising sand temperatures can negatively impact marine turtle population function by biasing hatchling sex ratios to be excessively female (i.e. feminising the population) and by causing excessive mortality of eggs and/or hatchlings.

Butt et al. (2016) used predictive climate models to examine the effects of increased air temperature and sea level rise on hawksbill turtle nesting sites in Australia. They found that by 2100 some of the current nesting habitats in Western Australia, Northern Territory, and Queensland are likely to be become unsuitable for nesting, either through increased sand temperatures or rising sea levels. Regarding temperature, there is potentially suitable nesting habitat to the south of existing sites, or turtles could begin nesting earlier or later in the season to avoid the warmest temperatures. Similarly, Chatting et al. (2021) used combinations of sand and air temperatures to forecast future sex ratios of hawksbill turtle hatchlings from rookeries in Qatar. They predict female bias in current and 2100 populations to be around 75% and >85%, respectively.

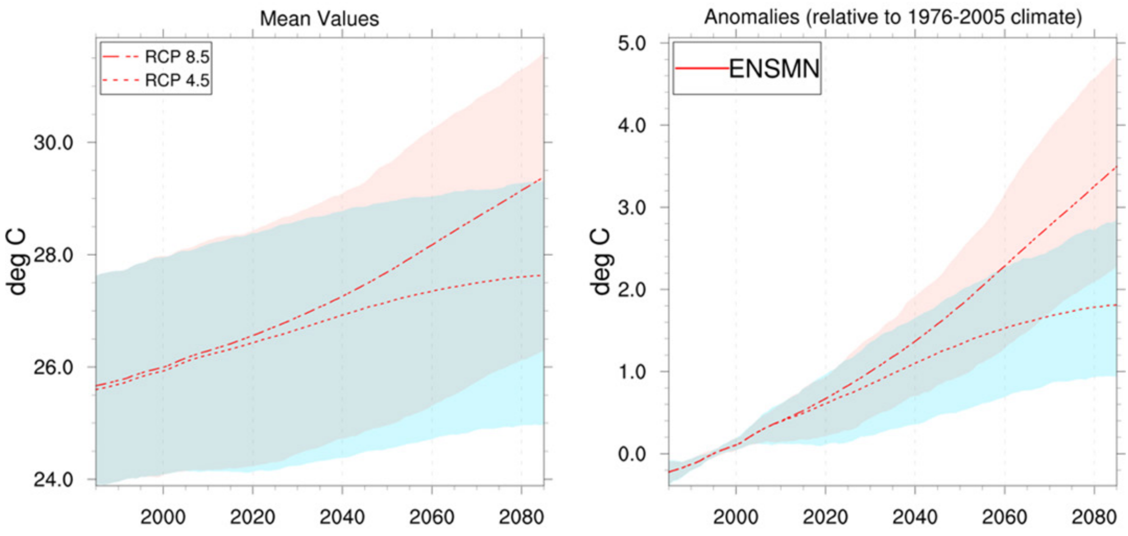
Esteban et al. (2016) examined sand temperatures at depths comparable to incubating green and hawksbill clutches on Diego Garcia Island in the Chagos Archipelago. In Chagos, although hawksbills nest during the warmest period of the year (October-February) nests located under heavily shaded coastal vegetation (which is preferred by the species) would produce a balanced primary sex ratio. It follows that the Chagos Archipelago (especially Diego Garcia) provides a temperature-resistant nesting sanctuary for hawksbill turtles in the Western Indian Ocean (Hays et al. 2020) and undeveloped nesting beaches for up to 20-50% of the nesting population of the SWIO region (Mortimer et al. 2020). Nevertheless, extreme weather events such as anomalously warm temperatures during marine heatwaves (MHWs) are an increasing threat in the

IOSEA region. MHWs strongly influence sand temperatures on beaches as shown by the 2016 MHW in the Indian Ocean which caused high nest incubation temperatures that were unprecedented in the last 70 years and resulted in the most extreme female-biased hatchling sex ratio and lowest hatchling survival nests modelled for the last 70 years in the Chagos Archipelago (Hays et al. 2021a).

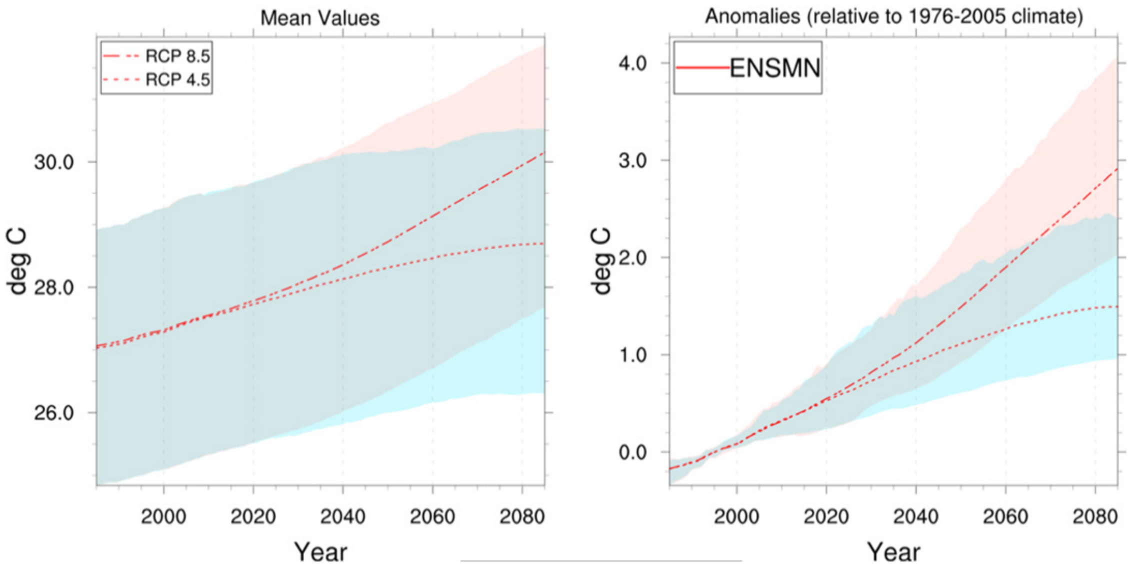
In the Seychelles, temperature data loggers were inserted into nests or buried at mid-nest depth between 1999 and 2003. Nest incubation temperature during the middle third of incubation was used to predict hatching sex ratios. The average incubation temperature varied significantly between nests, suggesting that these hawksbills can produce a variety of hatchling sex ratios, depending on the location and timing of nesting (Park et al. 2003).

Tanabe (2018) examined sand temperature profiles for hawksbill turtle rookeries in the northern region of the Red Sea between May and September 2018. Her research indicates that, with the exception of Small Gobal Island in the far northern section of the Red Sea, sand temperatures at the average depth of hawksbill turtle clutches are always above 29^{O}C, and during the nesting season (late July to mid-September), they are above 33^{O}C. Although this study spanned five months in a single year, it highlights a need to continue similar monitoring over longer time periods and multiple nesting seasons.

Pilcher et al. (2014a,b) and Marshall et al. (2020) used satellite telemetry of hawksbill turtles in the Persian Gulf, where surface water temperatures during summer were found to average 33^{O}C and peak at 34^{O}C. During the summer months, the turtles made temporary movements



Persian Gulf



Sulu/Celebes Seas

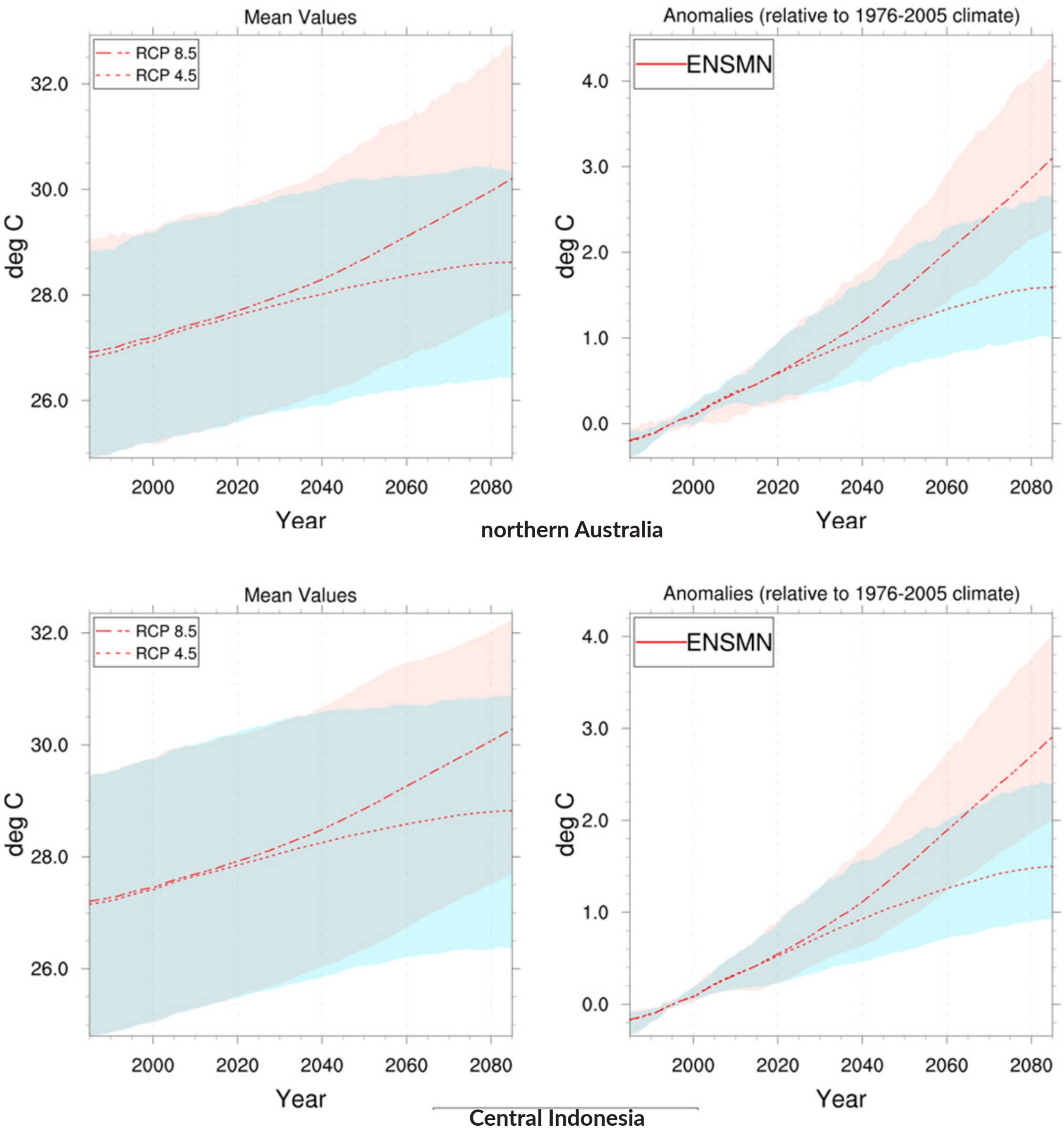


Figure 6.2. Predicted change to air temperatures over the next 80 years in four regions of the IOSEA. Data are derived from the average of CMIP5 climate model outputs (https://www.esrl.noaa.gov/psd/ipcc/ocn/timeseries_lens.html). Left panels are predicted changes to mean annual temperatures and right panels are predicted changes to the anomaly relative to 1976-2005. Panels depict findings for the Persian Gulf (top), Sulu/Celebes Seas (second), northern Australia (third), and Central Indonesia (bottom). RCP4.5 assumes that global annual greenhouse gas emissions peak around 2040 and then decline, and RCP8.5 assumes that emissions continue to rise throughout the 21st century. Red and blue shades are 95% confidence intervals for RCP8.5 and RCP4.5, respectively.

into waters that were deeper and around 2^{o}C cooler, moving back once the surface water temperatures had cooled down. To our knowledge, this is the first time a behavioural response has been linked to increased sea surface temperature.

It is becoming clear from climate change research and the models used to predict future climate-related changes that the IOSEA region will be ecologically, socially, and economically vulnerable to increased air and sea surface temperatures as well as to sea level rise. There are several published accounts of documented changes in the region's climate (e.g. Al-Rashidi 2009; Shirvani et al. 2015; McGregor et al. 2016) and the impacts of climate change on ecological systems, such as coral reef habitats (Descombes et al. 2015; Wabnitz et al. 2018; Ben-Hasan and Christensen 2019; Bryndum-Buchholz et al. 2019; Kubicek et al. 2019). Modelling conducted by NOAA's Earth Systems Research Laboratory[3] indicates that air temperatures across the IOSEA region are expected to rise by 0.9 to 2.2^{o}C (Representative Concentration Pathway (RCP) 4.5) or 2.0 to 4.2^{o}C (RCP8.5) by 2100 (Figure 6.2). Sea levels are also expected to rise by 0.3 to 0.47 m (RPC4.5) or 0.3 to 0.63 m (RCP8.5) by

2100. Precipitation is also likely to change; however, the change is likely to be spatially and temporally variable, making it particularly challenging to predict in the long-term without using locally-derived weather data.

There are currently no studies collecting hawksbill turtle sex ratio data from foraging areas. Such studies would enable comparisons to be made to examine changes over time. In 1996, at Diego Garcia in the Chagos Archipelago, Mortimer and Crain (1999) used androgen concentrations as indicators of the sex of immature foraging hawksbills (40-70 cm carapace length) and reported a sex ratio heavily skewed towards female. While there have been some published studies of beach-related impacts of climate change, such as increased incubation temperatures and sea level rise, a structured approach is required for each genetic stock so the situation can be monitored over the coming decades. A useful starting point would be to implement standardised collection of sand and air temperatures and baseline elevation mapping of nesting habitats.

Marine debris and plastic pollution

Marine debris, particularly plastic pollution, has been recognised in recent years as a serious and widespread threat to marine turtle populations globally (Schuyler et al. 2014, 2016; Wilcox et al. 2013; Duncan et al. 2019; 2021). Although most of the published accounts of impacts on marine turtles come from the Pacific and Atlantic Oceans, it is becoming clear that the IOSEA region contains substantial levels of plastic pollution (e.g. Hoarau et al. 2014; Stelfox et al. 2015; Schuyler et al. 2016; Imhof et al. 2017; Esteban et al. 2021). The main threats that plastics pose to turtles are ingestion of plastic fragments, entanglement in abandoned, lost or otherwise discarded fishing gear (ALDFG) (also called ghost gear), and contamination of nesting habitat. Studies have investigated how heavy metals and chemical contaminants accumulate in turtles (Leusch et al. 2020; Kittle et al. 2018), but little is known about how plastic pollution affects turtle health. Key research gaps include: 1) quantification of health impacts across populations and life stages; 2) toxicological impact on turtle health; 3) understanding how debris particles can act as vectors for heavy metals and chemical contaminants (Clukey et al. 2018); 4) identifying the oceanographic forces that disperse pollution; 5) understanding the social and economic drivers contributing to the creation of pollution; and 6) the barriers and opportunities for improved management of marine debris and plastic pollution (see Vegter et al. 2014; Nelms et al. 2015; Duncan et al. 2017).

[3] https://www.esrl.noaa.gov/psd/

7. Southwest Pacific Ocean

There are two distinct management units for hawksbill turtles in the Southwest Pacific RMU: the North Queensland management unit and the Northeast Arnhem Land management unit.

North Queensland management unit

The North Queensland management unit was assessed using IUCN Red List criteria by the Threatened Species Technical Advisory Group, Queensland Department of Environment and Science (DES). This management unit is currently listed as Endangered under the Queensland Nature Conservation Act 1992. Limpus and Miller (2008), Limpus (2009), and Dobbs et al. (2010) provide a comprehensive review of the biology of this management unit. A recent analysis of the populations status is provided by Bell et al. (2020).

Ecological range

The nesting distribution of this management unit and the neighbouring management unit in northeast Arnhem Land has been mapped (see Limpus et al. 2008a) and genetic studies have been conducted on rookeries across northern Australia. Although hawksbill turtles in the two management units have similar mtDNA profiles, the turtles breed at different times of the year and are thus considered to be separate management units (FitzSimmons and Limpus 2014).

Geographic spread of foraging sites

Hawksbill turtles in this management unit have been recorded foraging on a wide range of habitats: coral reefs, rocky reefs, seagrass flats, and inter-reef habitats over the continental shelf (Limpus, 1992; Limpus et al. 2008b). Migration data obtained from satellite tracking and flipper tag returns indicate that turtles from the North Queensland management unit occur throughout the Gulf of Carpentaria, southern Indonesia, Torres Strait, Papua New Guinea, and the northern Great Barrier Reef (Figure 7.1) (DES Turtle Conservation Database; Limpus and Miller, 2008; Limpus, 2009; Barr et al. 2021). A recent genetic-based study conducted on a foraging aggregation of hawksbill turtles on the Howick Reefs (northern Great Barrier Reef) found that 70 to 92% (mean 83%) of hawksbill turtles sampled came from rookeries in the Bismark-Solomon Sea region; only 15% were from the North Queensland management unit (Bell and Jensen 2018).

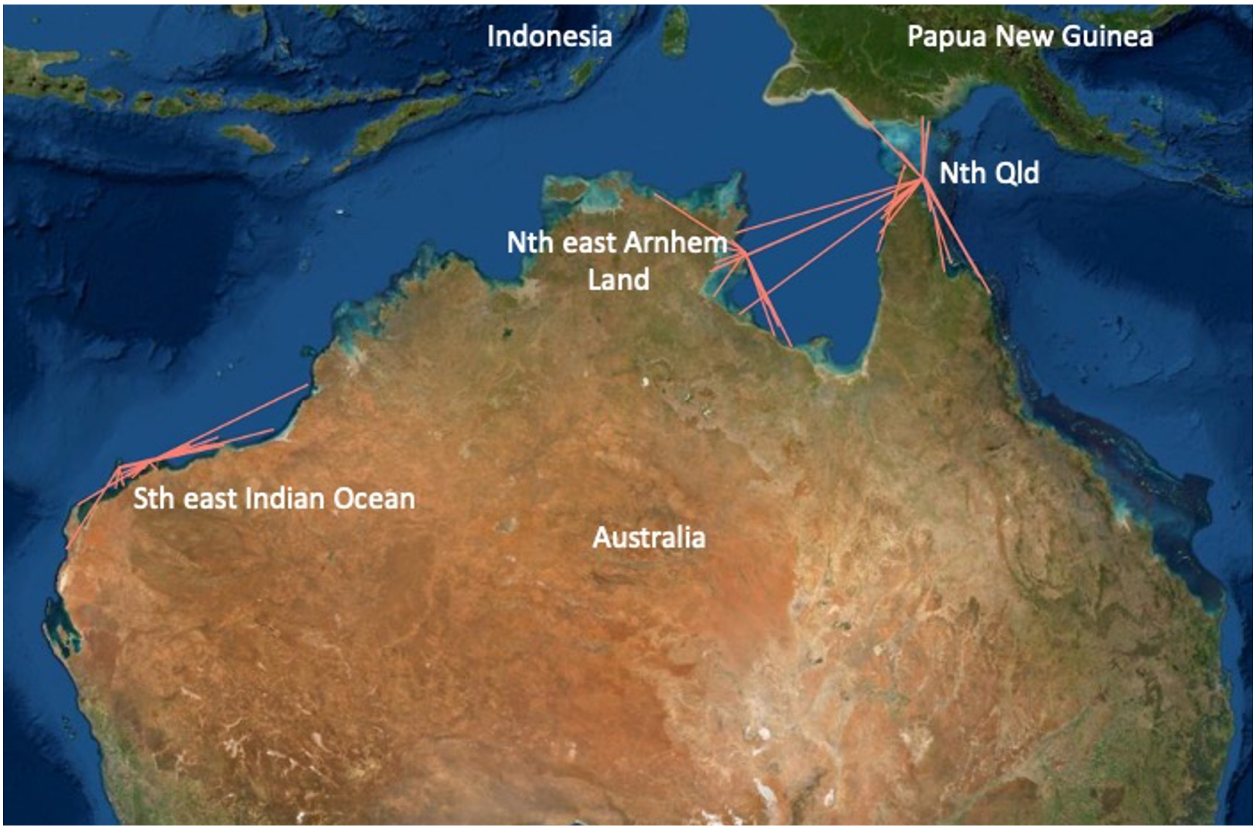


Figure 7.1. Foraging areas linked to the northern Australia management units, based on satellite telemetry tracking and flipper tag recoveries for the three management units in Australia. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Index foraging area: Howick Group of reefs, northern Great Barrier Reef

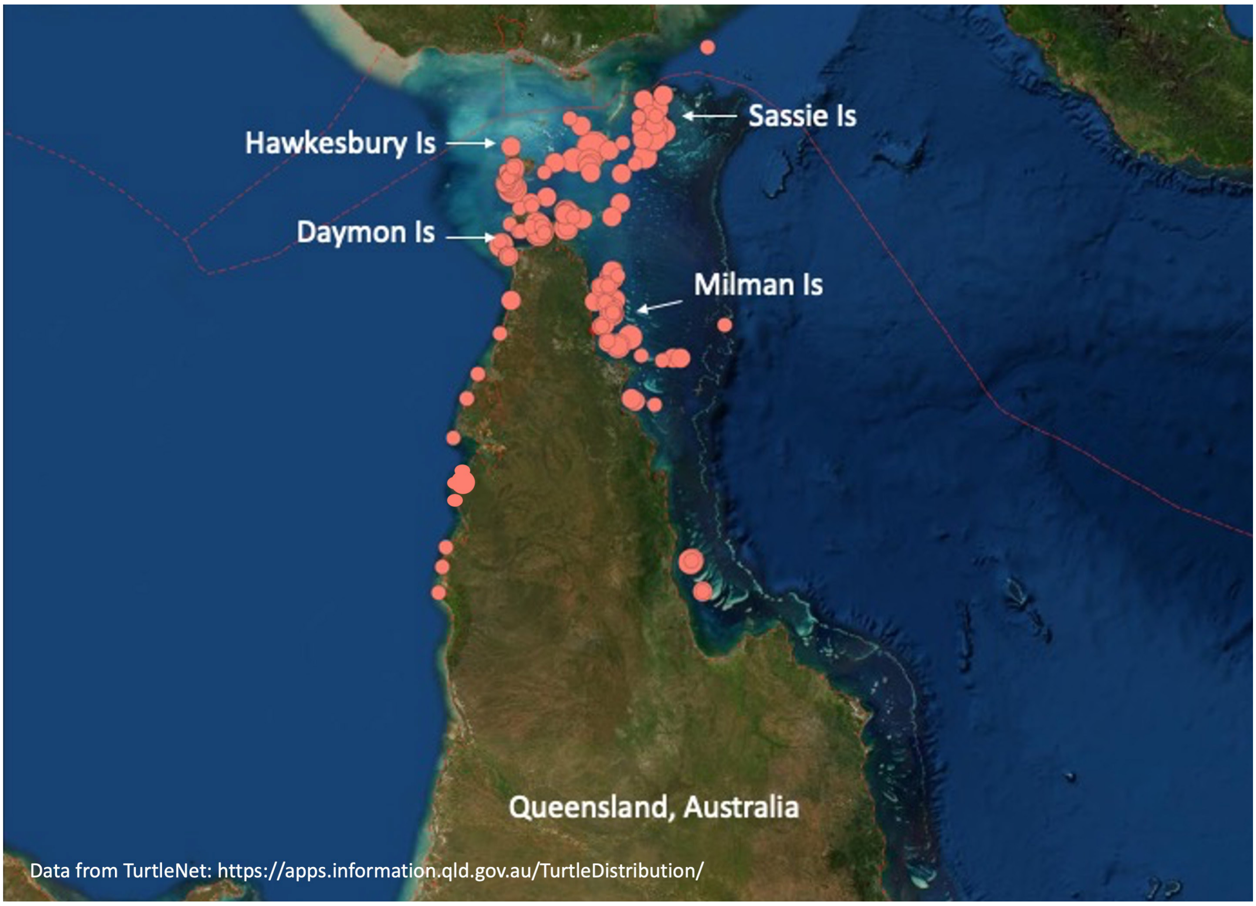


Figure 7.2. Distribution of hawksbill turtle nesting beaches for the North Queensland management unit. Pink dots denote rookeries with quantified nesting and the size of the dot indicates relative abundance. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Table 7.1. Summary of annual hawksbill turtle nesting population size at 103 recorded nesting beaches in Queensland. Based mostly on data collected up until 2000 and collated within the DES Queensland Turtle Conservation Database.

Estimated size of annual nesting population	Number of beaches	Nesting beaches
501-1,000 females/year	1	Sassie (Long Island) – no recent data
101-500 females/year	19	Hawksbury, Daymon, Milman, Boydong, Woody Wallace, Mt Adolphus Islands …
11-100 females/year	46	
1-10 females/year	37	
Unquantified nesting	4	

Index nesting beaches: Milman Island (northern Great Barrier Reef) (Limpus and Miller, 2008, Dobbs et al. 2010, Bell et al. 2020)

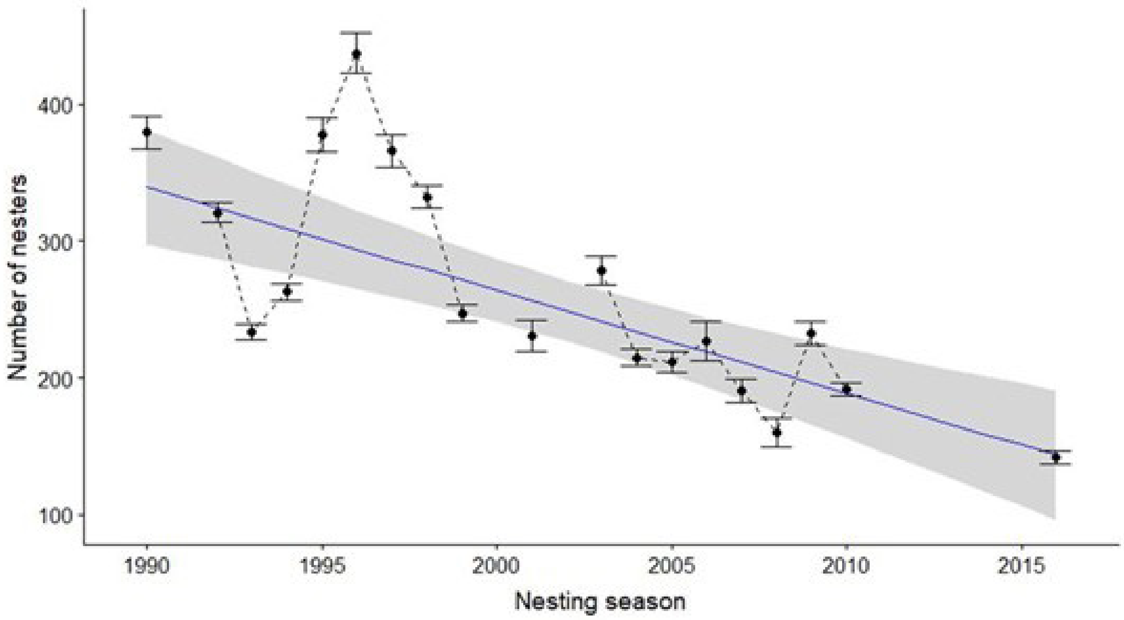


Figure 7.3. Trend analysis of hawksbill turtle nesting census data from Milman Island between 1990-91 to 2015-16 (unpublished data, DES Aquatic Threatened Species Program): Note: The multistate open robust design model (MS-ORD) was used to analyse the abundance and survival of the nesting population of hawksbill turtles at Milman Island on the northern Great Barrier Reef. The two states in this multistate framework were 'nesters' and 'unobservable', where the latter state represents turtles that have skipped nesting and are therefore unobservable at the rookery (Kendall and Bjorkland 2001). The primary sampling consisted of annual austral summer nesting seasons, and secondary sampling occasions consisted of 12 successive sampling periods, each 14 days long. Model parameters included survival probability, temporary emigration probability, entry/arrival probability, departure probability and capture probability. The final model was used to estimate nester abundance in each season (number of nesters ± 1 standard error). The blue line represents the long-term trend modelled using GAM weighted by the inverse standard error with 95% confidence intervals in grey.

Table 7.2 Summary of key threats related to the cumulative loss of turtles and eggs from the North Queensland management unit (based on the DES Hawksbill Turtle Threatened Species Assessment)

1	Excessive legal harvest of eggs by Indigenous Australians in Torres Strait and on western Cape York Peninsula beaches.
2	Excessive loss of eggs to feral and native predators in Torres Strait and on western Cape York Peninsula beaches.
3	Legal take of hawksbill turtles in foraging areas by Indigenous communities in the Northern Territory, Indonesian New Guinea, and Papua New Guinea.
4	Substantial loss of post-hatchling hawksbill turtles in ghost nets, particularly in the Arafura Sea region.
5	Presumed substantial but unquantified mortality of foraging hawksbill turtles in the commercial fisheries of eastern Indonesia (Arafura Sea) and southern Papua New Guinea (Gulf of Papua).
6	Failure of CITES Signatory States to enforce CITES regulations banning the export of Appendix I listed species, such as hawksbill turtles (see also Vuto et al. 2019).
7	Illegal trade in hawksbill turtles, particularly in China and Vietnam, which provides an incentive for developing countries in the IOSEA region to continue illegally harvesting turtles and their scutes illegally (see also Vuto et al. 2019).

Summary of threats to the North Queensland management unit of hawksbill turtles

Type of threat	Known or likely location of impact 1=nesting beach 2=oceanic/high seas 3=coastal foraging areas	Quantified 1=comprehensive documentation across population 2=comprehensive documentation for some of the population 3=non-published/anecdotal evidence only 4=not quantified
Consumption – nesting beach		
Egg collection for food	1	4
Commercial use of turtles		2
Non-commercial use of turtles		2
Predation of eggs by non-native fauna	1	2
Predation of eggs by native fauna	1	2
Consumption – foraging turtles		
Commercial use of turtles	3	4
Non-commercial use of turtles	3	4
Climate change impacts		
Increasing beach temperature	1	2
Beach erosion	1	2
Sea level rise	1	3
Coastal development		
Habitat modification (urban)		2
Habitat modification (industrial)		4
Light horizon disorientation		2
Fisheries impacts		
Bycatch – trawl		2
Bycatch – longline	2	2
Bycatch – gillnet	3	3
Impact to benthic ecology from fisheries	3	4
IUU fishing	3	3
Pollution		
Water quality	3	4
Entanglement in discarded fishing gear	2,3	2
Ingestion of marine debris	2,3	3
Noise pollution	3	4
Disease and pathogens	3	4

Geographic spread of nesting

Nesting by this North Queensland management unit occurs within the eastern Arafura Sea – eastern Gulf of Carpentaria region (Torres Strait and western Cape York Peninsula) and the northern Great Barrier Reef within the Coral Sea (Limpus et al. 2008a) (Figure 7.2; Table 7.1).

Trends in nesting data

The hawksbill turtle nesting population at Milman Island, the chosen index nesting beach for the North Queensland genetic stock, has been monitored almost continuously for a quarter of a century, commencing in the 1990-1991 breeding season. The most recent published data is from the 2016/2017 breeding season. In the absence of data from a second index site, it is presumed that this nesting population has undergone a significant decline in recent years (Figure 7.3). This decline is occurring even though this rookery and its surrounding waters are within the most highly protected areas for marine turtles globally, i.e. the Great Barrier Reef Marine Park, and the associated World Heritage Area.

Threats to the population

The threats to this management unit have been well described in the Australian Government's Recovery Plan for Marine Turtles in Australia (Australian Government 2017). Residual risk was determined for each threat, i.e. risk remaining after existing management efforts are considered. Two very high risk threats were identified: entanglement in marine debris and international take (occurring outside of Australia's jurisdiction). Two high risk threats were identified: climate change (increased temperatures and sea level rise) and predation by terrestrial predators. Ingestion of marine debris, impacts from pollution, domestic and international bycatch, and Indigenous take were all considered moderate-level risks.

In addition, the largely unquantified cumulative loss of turtles and eggs via multiple significant threats to the North Queensland management unit was summarised in the Queensland Government's Hawksbill Turtle Threatened Species Assessment (unpublished) (Table 7.2). There are currently no clear indications of when or how these can be addressed; therefore, the current trends in negative impacts are likely to continue (Bell et al. 2020).

Given that almost all of these impacts have been occurring and have not been controlled for extended periods and that many lie outside of Queensland's direct legislative control, the likelihood of a timely reversal of the significant decline in the North Queensland management unit is extremely poor.

Management status and governance

Nesting rookeries for the North Queensland management unit are located within a single state of Australia (Queensland). The management unit is listed as Endangered under Queensland's Nature Conservation Act 1994, and the species is listed as Vulnerable under the Australian Government's Environment Protection and Biodiversity Conservation Act 1999, classifying it as a Matter of National Environmental Significance. The index site for the management unit (Milman Island) and many other nesting islands within the Great Barrier Reef are national parks and managed by the Queensland Parks and Wildlife Service. Foraging habitats in Great Barrier Reef waters are protected under the Great Barrier Reef Marine Park Act 1975. Rookeries and waters within the Torres Strait or western Cape York Peninsula regions, while outside of protected areas, fall under ownership of Indigenous groups. However, under the Torres Strait Treaty, Papua New Guineans are allowed to take turtles throughout much of the Torres Strait.

Australia is a signatory to several international agreements aimed at minimising harm to the environment: the Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) [CITES], the Convention on Biological Diversity (1992) [CBD], Convention on the Conservation of Migratory Species of Wild Animals (1979) [CMS], Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971) [RAMSAR], Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia [IOSEA], International Convention for the Prevention of Pollution from Ships (1973/78) [MARPOL], Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972) and United Nations Convention on the Law of the Sea (1982) [UNCLOS].

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Milman Island and numerous nesting islands of the northern Great Barrier Reef	Nesting	Y	Very high	Queensland Nature Conservation Act 1992
Great Barrier Reef Marine Park	Nesting and foraging	Y	Very high	Great Barrier Reef Marine Park Act 1975

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	29.2 °C	Dobbs et al. 2010
Remigration interval	5 ±1.54 years	Limpus 2009
Clutches per season	2.4 (1.4)	Limpus 2009
Mean size of nesting adult (CCL)	81.5 ± 3.7 cm	Limpus 2009
Age at maturity	Estimated 30 years	Limpus 2009

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging) (CCL)	~35 cm	Limpus 2009
Growth rates	Max 2.2 cm/year at 60 cm	Limpus 2009
Bell and Pike 2012	2.4 (1.4)	Limpus 2009
Sex ratio – in foraging populations		
adults	71% female	Limpus et al. 2008a
pubescent immature	74% female	Limpus et al. 2008a
large pre-pubescent immature	74% female	Limpus et al. 2008a
small pre-pubescent immature	73% female	Limpus et al. 2008a

Northeast Arnhem Land management unit

Ecological range

Genetic-based research has been conducted on rookeries across northern Australia and the nesting distribution of this management unit and the North Queensland management unit has been mapped (see Limpus et al. 2008a). Although hawksbill turtles in the two management units have similar mtDNA profiles, the turtles breed at different times of the year and are thus considered to be separate management units (FitzSimmons and Limpus 2014). The ecological range for the management unit has not been well studied. Aside from their habitat in Australia, turtles from this management unit may also occur in southern Indonesia or Timor Leste.

Geographic spread of foraging sites

Based on satellite telemetry (Hoenner et al. 2016), known foraging sites occur within the Gulf of Carpentaria (Queensland and Northern Territory) and coastal waters of Arnhem Land, Northern Territory (Figures 7.1 and 7.4). It is also likely that hawksbill turtles forage along most of the coral and rocky reef habitats of the Northern Territory (e.g. Fog Bay near Darwin; see Whiting and Guinea (1997a)). No tag recoveries from this management unit have been reported from overseas; however, hawksbill turtles reside in the coastal waters of Timor Leste, Indonesia, and Papua New Guinea and international connections therefore are possible.

Geographic spread of nesting

Nesting locations for the management unit have been reasonably well surveyed, and while some low-density sites may not yet have been described, it is likely that all higher-density sites are known (Table 7.3). Nesting occurs predominantly on islands from the northeast Arnhem Land coast (e.g. Truant and Bromby Islands) and the Groote Eylandt region (e.g. North East Island). The majority of nesting events occur on the beaches of Hawk, Lane, and North East Islands, which are located off the northeastern coast of Groote Eylandt (Chatto and Baker 2008; Limpus et al. 2008a).

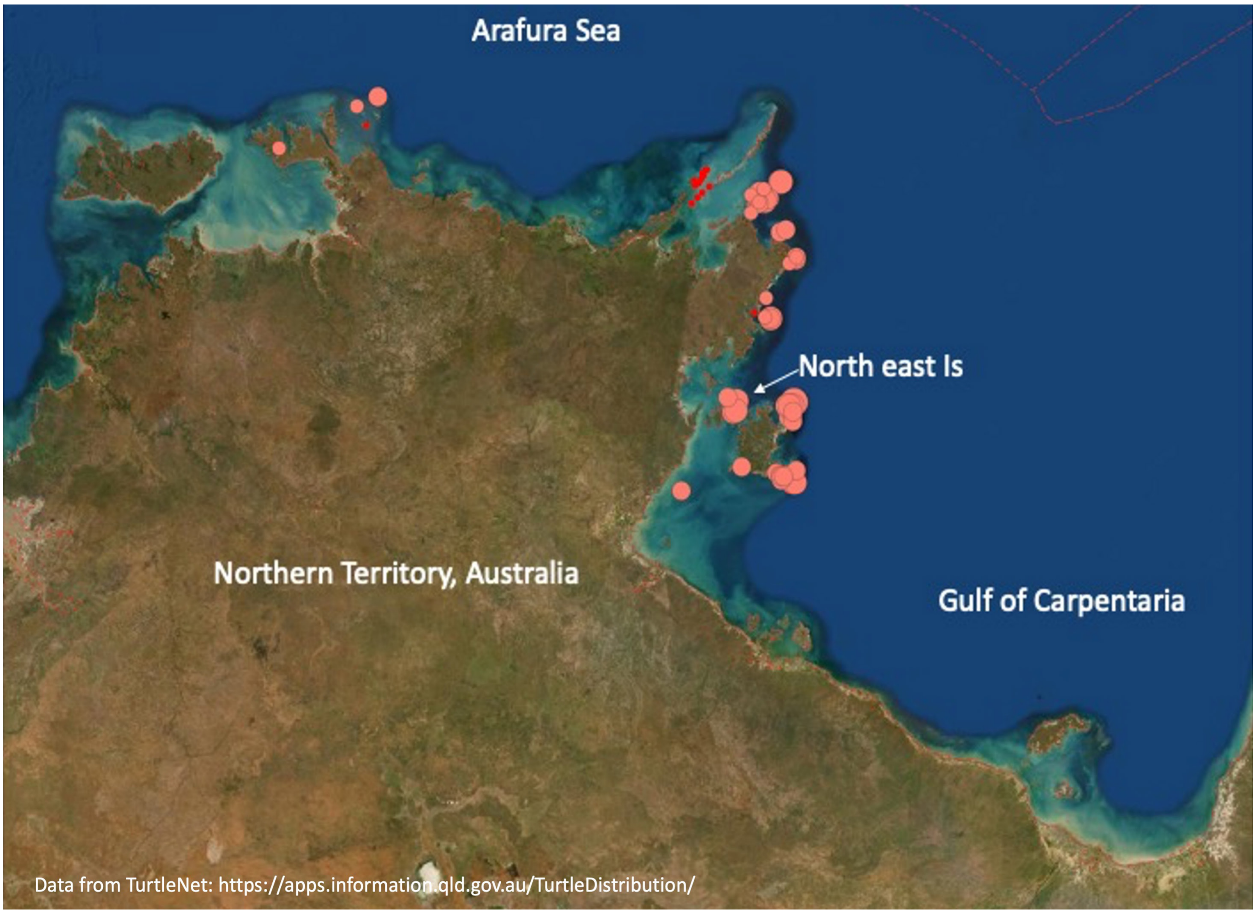


Figure 7.4. Distribution of hawksbill turtle nesting beaches for the northeast Arnhem Land management unit. Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote unquantified nesting. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Table 7.3. Summary of the estimated size of annual hawksbill turtle nesting population at 39 recorded nesting beaches in the northeast Arnhem Land management unit, mostly based on data Chatto and Baker 2008; Limpus et al. 2008a).

Estimated size of annual nesting population	Number of beaches	Nesting beaches
501-1,000 females/year	0	
101-500 females/year	1	North East Island
11-100 females/year	11	e.g. Truant Island, Hawk Island, Bromby Islands
1-10 females/year	19	
Unquantified nesting	8	

Index nesting beaches: Nil. There has been aperiodic monitoring at North East Island (Groote Eylandt) and Truant Island.

Trends in nesting data: The status and trend of the management unit has not been determined.

Summary of threats to the Northeast Arnhem Land management unit of hawksbill turtles

Type of threat	Known or likely location of impact 1=nesting beach 2=oceanic/high seas 3=coastal foraging areas	Quantified 1=comprehensive documentation across population 2=comprehensive documentation for some of the population 3=non-published/anecdotal evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	1	4
Commercial use of turtles		2
Non-commercial use of turtles		2
Predation of eggs by non-native fauna	1	4
Predation of eggs by native fauna	1	4
Consumption – foraging turtles		
Commercial use of turtles	3	4
Non-commercial use of turtles	3	4
Climate change impacts		
Increasing beach temperature	1	2
Beach erosion	1	4
Sea level rise	1	4
Coastal development		
Habitat modification (urban)		2
Habitat modification (industrial)		2
Light horizon disorientation		2
Fisheries impacts		
Bycatch – trawl		2
Bycatch – longline	2	2
Bycatch – gillnet	3	3
Impact to benthic ecology from fisheries	3	4
IUU fishing	3	3
Pollution		
Water quality	3	4
Entanglement in discarded fishing gear	2,3	2
Ingestion of marine debris	2,3	3
Noise pollution	3	4
Disease and pathogens	3	4

Migration and distribution of foraging areas

Ten adult hawksbill turtles were tracked using satellite tags from the index beach of North East Island. Each of them migrated to coastal habitats within northern Australia from northeast Arnhem Land to the southern coast of the Gulf of Carpentaria (Figures 7.1 and 7.4; Hoenner et al. 2015). Lagrangian particle modelling conducted on virtual hatchling dispersal from North East Island indicates that hatchlings would disperse throughout the northwestern Gulf of Carpentaria and westwards into the Arafura Sea towards Western Australia's Kimberly region, Indonesia, and Timor Leste. No field data has been collected to verify these Lagrangian models.

Threats to the population

The threats to this management unit have been well described in the Australian Government's Recovery Plan for Marine Turtles in Australia (Australian Government 2017). Residual risk was determined for each threat, i.e. risk remaining after existing management efforts are considered. Two very high risk threats were identified: entanglement in marine debris and international take (occurring outside of Australia's jurisdiction). However, for the latter, there is no evidence of any international migration by turtles from this stock. Two high risks were identified: climate change (increased temperatures and sea level rise) and predation by terrestrial predators. Ingestion of marine debris, impacts from pollution, domestic and international bycatch were all considered moderate-level risks. It is likely that the issues related to the cumulative loss of turtles and eggs from the North Queensland management unit are also relevant to the northeast Arnhem Land management unit. However, quantitative data on these threats do not currently exist.

Management and governance

Nesting rookeries for the northeast Arnhem Land management unit are located within the Northern Territory of Australia. The species is listed as Vulnerable under *Northern Territories Territory Parks and Wildlife Conservation Act 1974*, and Vulnerable under the Australian Government's *Environment Protection and Biodiversity Conservation Act 1999*, classifying it as a Matter of National Environmental Significance. Most of the rookeries lie outside of national parks or other protected areas; however, most are located on islands with access and use restrictions managed by local Aboriginal Groups.

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
North East Island (Groote Eylandt)	Island, nesting	Y	Very high	Not protected, not inhabited; access controlled by local Aboriginal custodians. Beach not currently monitored.
Truant	Island, nesting	Y	Very high	Not protected, not inhabited; access controlled by local Aboriginal custodians. Beach not currently monitored.

Biological data – breeding

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

Biological data – foraging

Foraging hawksbill turtles have been caught in the Fog Bay region, near Darwin in Australia's Northern Territory. The aggregation is predominantly comprised of sub-adult age classes (average CCL 49 cm; Whiting and Guinea (1997b)) and adult-sized animals are believed to have moved into adjacent deeper water habitats.

Parameter	Value	Reference(s)
Minimum size caught (CCL)	27.3 cm	Whiting and Guinea (1997b)
Growth rates - overall	2.3 cm/year	
CCL 35 to 39.9 cm	2.8 cm/year (n=1)	
CCL 40 to 44.9 cm	2.3 cm/year (n=4)	
CCL 45 to 49.9 cm	2.1 cm/year (n=6)	
CCL 50 to 54.9 cm	2.4 cm/year (n=2)	
CCL 55 to 59.9 cm	2.4 cm/year (n=5)	
CCL 60 to 64.9 cm	No data	
CCL 65 to 69.9 cm	2.8 cm/year (n=1)	

8. West Pacific/Southeast Asia

There are at least three distinct management units for hawksbill turtles within the West Pacific /Southeast Asia RMU: the Sulu Sea management unit, the western Peninsular Malaysia management unit, and the Gulf of Thailand management unit (this could be more than one). It is likely there are additional management units in Indonesia, Singapore, and the Philippines.

Sulu Sea management unit

Ecological range

The samples used to identify the Sulu Sea management unit were collected from Malaysian rookeries (FitzSimmons and Limpus, 2014; Nishizawa et al. 2016). There are rookeries in close proximity which remain to be sampled, e.g. in southern Philippines and islands in Indonesian waters of the Sulu Sea. Turtles from this management unit may occur throughout the Coral Triangle and South China Sea regions.

Geographic spread of foraging sites

There has been limited genetic-based research on foraging turtles in the region. Based on genetic analysis, flipper tag recoveries, and three satellite telemetry tracks from nesting hawksbill turtles tagged in Sabah, foraging turtles from this management unit are found in Sabah (Malaysia), the Sulu Sea (Philippines), and widely along the east coast of Kalimantan (Indonesia) (Nishizawa et al. 2016) (Figure 8.1). It is likely that turtles from this management unit occur in coastal areas within the Sulu Sea and Coral Triangle region, including coastal waters of Malaysia, Philippines, and Indonesia.

Geographic spread of nesting

Hawksbill turtles in the Sulu Sea management unit primarily nest on the beaches of the Turtle Islands Heritage Protected area (TIHPA) (Figure 8.2), including Pulau Gulisaan (~90% of clutches), Pulau Selingan (~8% of clutches) and Pulau Bakungan (~5% of clutches) in Malaysia (Table 8.1). Nesting occurs year round, with a peak between March and August. A lesser degree of nesting occurs on many of the islands in the Semporna

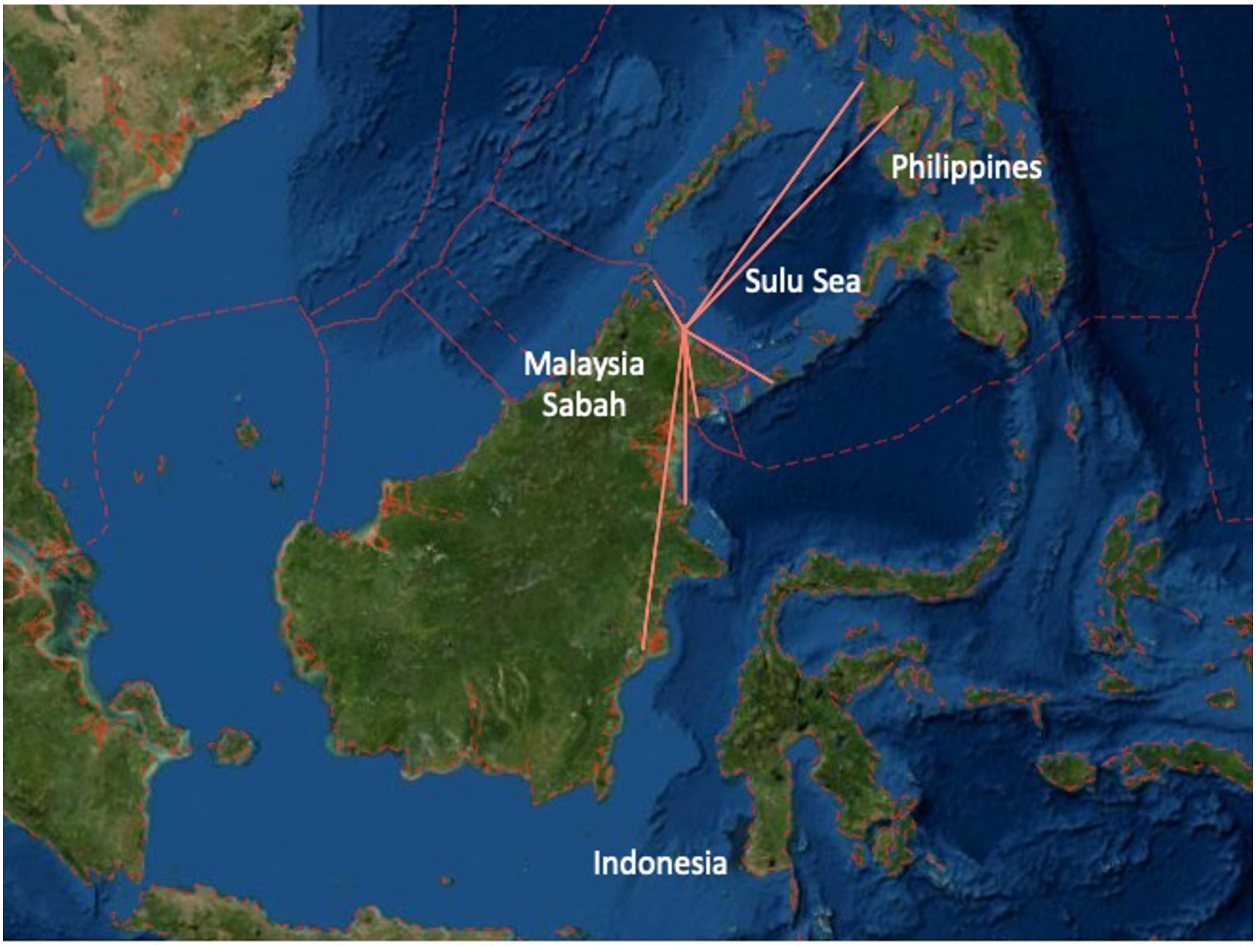


Figure 8.1. Migration of adult female hawksbill turtles from Sulu Sea nesting sites to dispersed foraging areas, based on flipper tag recoveries. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Table 8.1. Summary of the estimated size of annual hawksbill turtle nesting at eight recorded nesting beaches in the Sulu Sea management unit.

Estimated size of annual nesting population	Number of beaches	Nesting beaches
501-1,000 females/year	0	
101-500 females/year	1	Pulau Gulisaan
11-100 females/year	1	Pulau Lankayan
1-10 females/year	6	Pulau Selingaan, Pulau Bakkungan, Pulau Libaran
Unquantified nesting	0	

Index nesting beaches: Pulau Gulisaan, Sabah, Malaysia

Figure 8.2. Main hawksbill turtle nesting sites for the Sulu Sea management unit and adjacent rookeries. Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote unquantified nesting.

region of Sabah, in the Sulu and Celebes Seas in Malaysia, Philippines, and Indonesia (Jolis 2014; Joseph 2017; Haziq and Hamid 2018; Migliaccio et al. 2020), and within the 900,000 ha Tun Mustapha Marine Park, located between the South China and Sulu Seas (Jolis, personal communication).

Trends in nesting data

The hawksbill turtles of the TIHPA have been monitored since the 1970s (de Silva 1986); however, early efforts were hampered by poor tag retention and variability in survey effort. Chan et al. (1999) summarised the monitoring data from 1979 to 1996 and Joseph (2017)

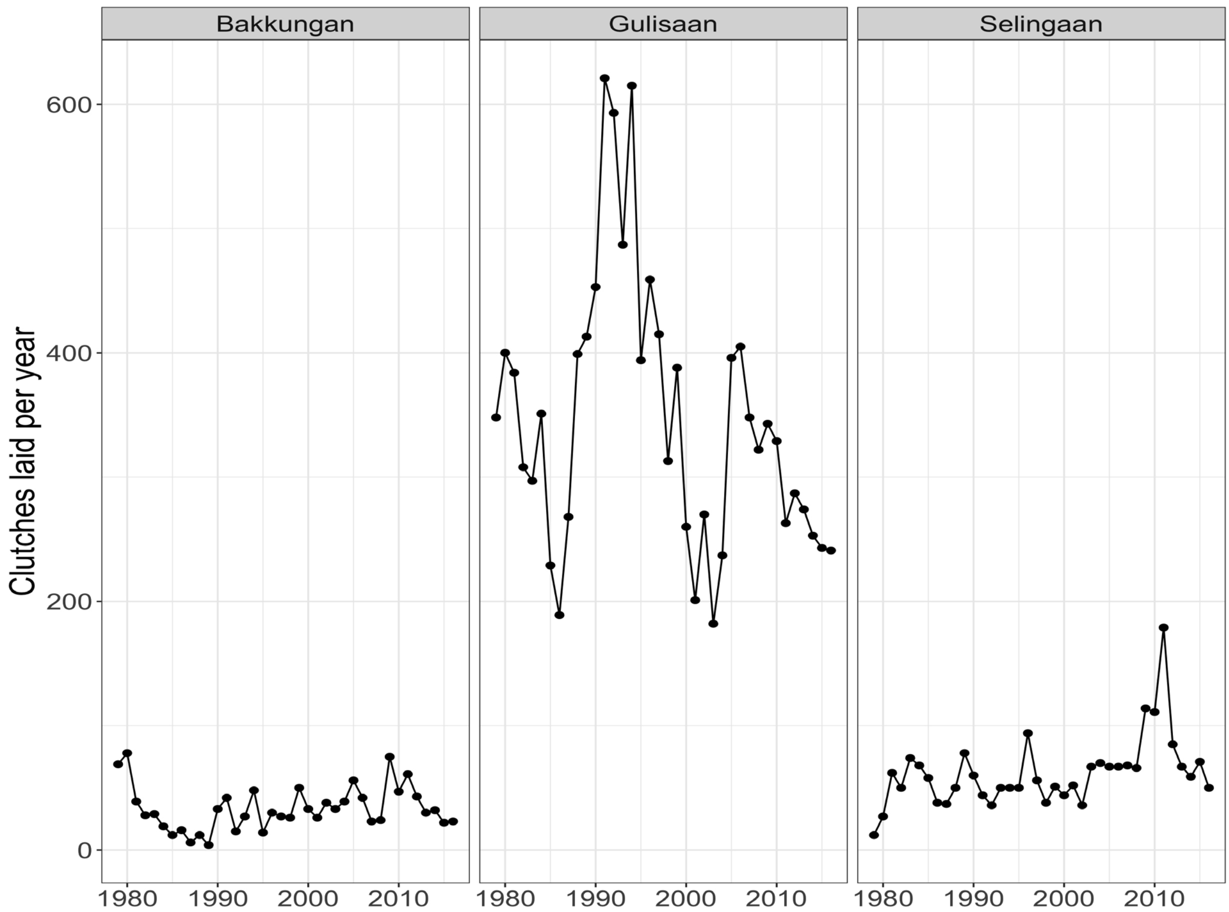


Figure 8.3. Number of hawksbill clutches recorded per year between 1979 and 2016 at the three islands within the Turtle Islands Heritage Protected Area, Sabah, Malaysia. Data from Joseph (2017).

reported data from 1979 to 2016. Across the three nesting beaches in TIHPA, the number of clutches recorded annually varied from 243 to 713 (Figures 8.3 and 8.4). Combined, the figures indicate a cyclical but overall declining trend from 1979 to 2016 (Figure 8.3). At Pulau Gulisaan, the number of clutches reported in the most recent five years of available data (2012 to 2016) are lower (~275 clutches per year) than the levels recorded between 1979 and 1983 (Figure 8.4). Nesting trends and biological data have been summarised in detail by Joseph (2017). Data from 1999 to 2018 are available from a minor rookery (Pulau Lankayan) and this data shows a stable trend of around 50 clutches laid per year. Pulau Libaran, another nearby island in the Sulu Sea, is also known to support hawksbill nesting. On the islands of the Semporna region (outside of the management unit), data from 2006 to 2018 indicate that 11 clutches are laid per year at Pulau Mataking, Pulau Pom-Pom, Pulau Pandanan, Pulau Boheyan, Pulau Kulapuan, and Pulau Timba-Timba (Haziq and Hamib 2018). Low numbers of nests are also documented in Tun Mustapha Park (Jolis, personal communication). Less than 10 clutches per year are laid on Pulau Sipadan. The short-term monitoring at Pulau Mataking, Pulau Pom- Pom, Pulau Pandanan, Pulau Boheyan, Pulau Kulapuan, and Pulau Timba-Timba indicates an increasing trend in the number of clutches laid (Haziq and Hamid, 2018; Migliaccio et al. 2020).

Migration and distribution of foraging areas

Since 2000, around 4,000 nesting turtles have been double flipper tagged on the TIHPA islands (Joseph 2017). Tag returns from hawksbill turtles tagged while nesting in the Turtle Islands have been recovered in Sabah, in the southern Philippines, and along the east coast of Kalimantan in Indonesia. Pilcher et al. (2019) summarised the satellite tracking projects from Malaysia and reported on three females tracked after nesting in the Turtle Islands. One moved northward along the Sabah coastline and remained in Sabah's waters, and two moved southward along the Sabah and Kalimantan (Indonesia) coastline and remained in Indonesia. It is likely that foraging sites for this management unit occur in Indonesia, Philippines, and Malaysia.

Threats to the population

The threats to the Sulu Sea management unit have not been comprehensively assessed (Table 8.2).

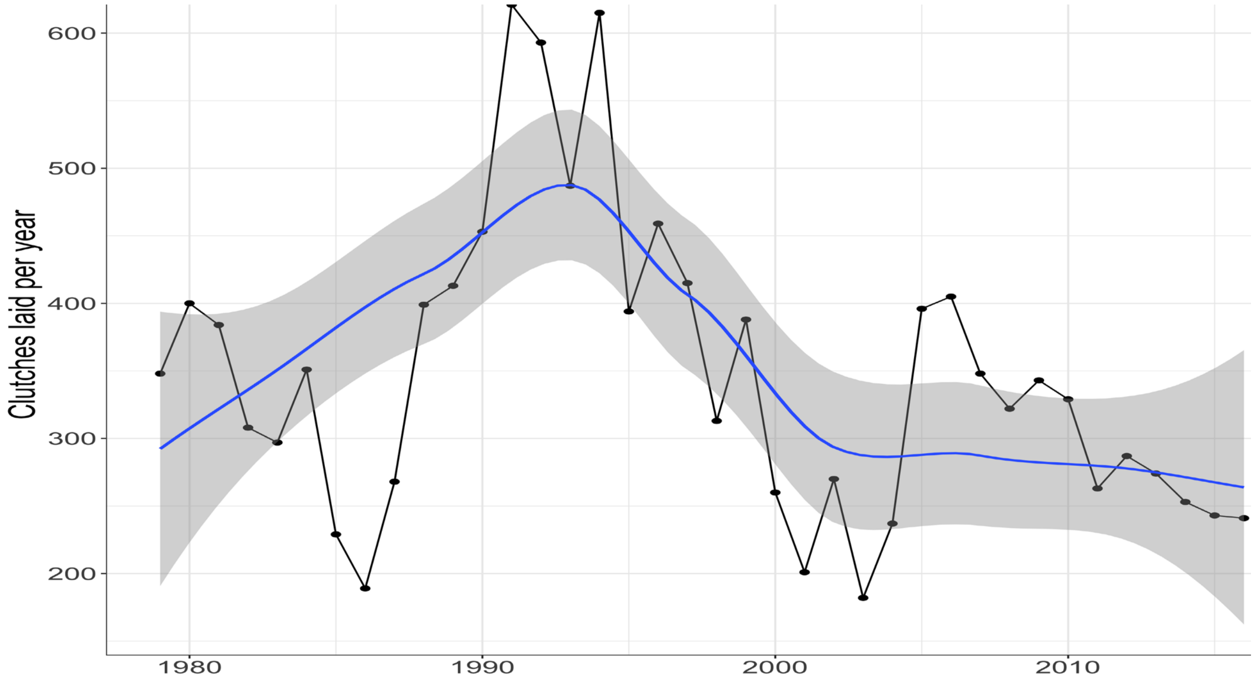


Figure 8.4. Number of hawksbill clutches recorded per year between 1979 and 2016 at Pulau Gulisaan, Sabah, Malaysia. Data from Joseph (2017).

Table 8.2. Summary of key issues related to the cumulative loss of turtles and eggs from the Sulu Sea management unit

1	Illegal harvest of eggs for consumption or sale by people living or visiting islands.
2	Low and variable emergence success of clutches transferred to protective hatcheries.
3	Potential loss of post-hatchling (immature) hawksbill turtles in ghost nets.
4	Presumed substantial but unquantified mortality of foraging hawksbill turtles in the commercial fisheries of Indonesia, Philippines, and Malaysia.
5	The direct capture, and retention of bycatch, of hawksbill turtles for consumption or sale.
6	Failure of CITES Signatory States to enforce CITES regulations banning the export of Appendix I listed species, such as hawksbill turtles (CITES 2019; Vuto et al. 2019).
7	Illegal trade in hawksbill turtles, particularly in China and Vietnam, which provides an incentive for developing countries in the IOSEA region to continue illegally harvesting turtles and their scutes (e.g. CITES 2019; Riskas et al. 2018; Gomez and Krishnasamy 2019).
8	Habitat change/loss and coastal development (Haziq and Hamid 2018).

Issues of concern include egg poaching, habitat loss and development, climate change (sex ratios and sea level rise), and ingestion of, or entanglement in, marine debris. Examination of the degree to which each of these threats individually or collectively may impact hawksbill turtles from the Sulu Sea management unit is required. There is anecdotal and local expert knowledge to suggest that coastal erosion is impacting the quality of nesting habitat on Pulau Gulisaan (Joseph 2017).

Nearly all clutches for this management unit are moved to protected hatcheries and the average emergence success of clutches is low (67%, range 50 to 85%). It is unknown why the emergence success is low and variable across years, or what impact this may have on population recovery. Following concerns about beach stability of Pulau Gulisaan, all clutches laid on Pulau Gulisaan since 2015 have been transferred to hatcheries on Pulau Selingaan during the morning following laying (Joseph 2017). This process involves a boat ride of 5-10 minutes in duration. While this is current best practice in the TIHPA, it is likely that the transfer of the eggs is

Summary of threats to the Sulu Sea management unit of hawksbill turtles

Type of threat	Known or likely location of impact 1=nesting beach 2=oceanic/high seas 3=coastal foraging areas	Quantified 1=comprehensive documentation across population 2=comprehensive documentation for some of the population 3=non-published/anecdotal evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	1	2,3
Commercial use of turtles	1	3
Non-commercial use of turtles	1	3
Predation of eggs by non-native fauna	1	2
Predation of eggs by native fauna	1	2
Consumption – foraging turtles		
Commercial use of turtles	3	3
Non-commercial use of turtles	3	2,3
Climate change impacts		
Increasing beach temperature	1	4
Beach erosion		3
Sea level rise		3
Coastal development		
Habitat modification (urban)	1,3	4
Habitat modification (industrial)		4
Light horizon disorientation	1	4
Fisheries impacts		
Bycatch – trawl	3	3
Bycatch – longline	3	4
Bycatch – gillnet	3	3
Impact to benthic ecology from fisheries		4
IUU fishing	3	3
Pollution		
Water quality		4
Entanglement in discarded fishing gear	3	3
Ingestion of marine debris	3	3

Type of threat	Known or likely location of impact 1=nesting beach 2=oceanic/high seas 3=coastal foraging areas	Quantified 1=comprehensive documentation across population 2=comprehensive documentation for some of the population 3=non-published/anecdotal evidence only 4=not quantified
Noise pollution		4
Disease and pathogens		4
Hatchery management (and egg collection)	1	2

reducing the emergence success. Increased research on the processes involved could help identify the specific issues and allow corrective action to be taken to increase emergence success to consistently reach > 80%.

Although not recently quantified, the cumulative loss of turtles and eggs via multiple significant impacts on the Sulu Sea management unit is of primary concern (e.g. Table 8.2). There are currently no clear indications of when or how these can be addressed; therefore, the current trends in negative impacts are likely to continue.

Management and protection

In Malaysia, turtles fall under the jurisdiction of individual states. In Sabah, hawksbill turtles are listed as a totally protected species and the nesting sites are protected as part of TIHPA. The ban of turtle egg consumption and sale covers the whole state of Sabah. The two government bodies that oversee the management and protection of turtles in Sabah are Sabah Parks (only in marine protected areas) and the Sabah Wildlife Department.

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Pulau Gulisaan	Island, nesting	Y	Very high	TIHPA
Pulau Selingaan	Island, nesting	N	High	TIHPA
Pulau Bakkungan	Island, nesting	N	High	TIHPA
Pulau Lankayan	Island, nesting	N	Medium	MPA, Sabah Parks

Table 8.3. Life history traits published for hawksbill turtles from the Sulu Sea Management Unit

Parameter	Value	Reference(s)
Pivotal temperature	unknown	
Remigration interval	1.8 years	Pilcher and Ali (1999)
	1.8 years	Joseph (2017)
Clutches per season	2.7	Pilcher and Ali (1999)
	1.9	Joseph (2017)
Clutch size	120.4	Chan et al. (1999)
	119.5	Joseph (2017)
	120	Haziq and Hamib (2018)
	95.8	Migliaccio et al. (2020)
Mean size of nesting adult (CCL)	76.3 cm	Chan et al. (1999)
	79.8 cm	Joseph (2017)
	79.8 cm	Jolis (2014)
	80.6 cm	Migliaccio et al. (2020)
Emergence success of clutches	67% (50 to 83%)	Joseph (2017)
	70% to 77%	Jolis (2014)
	72.2%	Migliaccio et al. (2020)
Age at maturity	unknown	

Biological data – breeding

Several of the basic life history parameters have been described for this management unit (Table 8.3). Although several decades have passed since the initial studies on marine turtles in the Malaysian region, the pivotal temperature and the sex-determining range of temperature have not been determined for any nesting population. Of interest is the relatively low emergence success of clutches and the high variability of emergence success across years (Joseph 2017). It would be worthwhile examining the variation in relation to hatchery management practices or other environmental conditions.

Biological data – foraging

Of 15 hawksbill turtles captured at Pulau Mabul near Semporna juveniles were the dominant size class. The mean size of sampled juveniles was 51.1 cm (CCL) and an adult was 74.3 cm (Palaniappan and Haziq Harith, 2017).

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

Western Peninsular Malaysia management unit

Ecological range

The rookeries of the western Peninsular Malaysia management unit were first surveyed in the early 1990s (Mortimer et al. 1993). The samples used to identify the management unit were collected from rookeries in Melaka (FitzSimmons and Limpus, 2014; Nishizawa et al. 2016). There are unsampled rookeries in close proximity, for example in islands of Singapore, the Java Sea, southern Kalimantan (Indonesia), eastern Peninsular Malaysia (including islands), and the Riau Islands (Indonesia). Turtles from this management unit may occur throughout the Coral Triangle region; however, this remains to be determined.

Geographic spread of foraging sites and migration

Between 2006 and 2013, WWF-Malaysia tracked 15 hawksbill turtles from Melaka nesting beaches (one island and two mainland sites). Nearly all of these tracked turtles migrated southwards along the Malaysian coastline towards Singapore or the Riau Islands (Pilcher et al. 2019). It is likely that turtles from the western Peninsular Malaysia management unit migrate to foraging areas in Indonesia, Singapore, elsewhere in Malaysia and possibly the Indian Ocean coast of Thailand.

Geographic spread of nesting

Hawksbill turtles from the western Peninsular Malaysia management unit primarily nest on mainland and island beaches of the state of Melaka (Figure 8.5). Nesting on these beaches occurs all year, with a peak between June and August (Salleh et al. 2017; 2018). Nesting is distributed along 21 recognised beaches in Melaka, with approximately 20% of clutches occurring at Padang Kemunting, 12% at Kem Terendak, and 10% each at Balik Batu, Pulau Upeh, and Meriam Patah (Mortimer et al. 1993; Salleh et al. 2018). Lower-level regular or aperiodic nesting occurs along the coast of Penang and the islands of Singapore (Figure 8.5, Table 8.4). There are also several rookeries in the Java Sea region of Indonesia, although it is yet to be determined which management unit they belong to (see section on Indonesia).

Trends in nesting data

The first surveys for the management unit took place in 1991, when the population was first scientifically documented. These surveys revealed the abundance of hawksbill clutches laid on beaches of Melaka to be around 330 (Mortimer et al. 1993), and the most recent published data (from 2006 until 2014) revealed yearly nesting ranged from 353 to 568 clutches per year (Salleh et al. 2018). Hawksbill turtle monitoring in Melaka is coordinated by the Department of Fisheries Melaka. In terms of a trend, annual nesting data indicate that approximately 245 clutches were transferred to the hatchery each year between 1991 and 2004, and from 2004 onwards there has been an average of 419 clutches intercepted and protected per year, representing a 4% annual increase in the number of clutches being intercepted and protected per season on the beaches of Melaka (Figure 8.6). These figures may not in fact reflect an increase in the actual size of the nesting population, but rather an increase in protection effort. Rates of egg exploitation were probably higher prior to 2000. It follows that the current abundance is still likely to be below the pre-harvest baselines.

Threats to the population

The threats to the western Peninsular Malaysia management unit have not been comprehensively assessed. Issues of concern include habitat change and development. A survey conducted by WWF-Malaysia in 2012 (J.A. Mortimer and WWF-Malaysia, unpublished data) indicated that habitat destruction due to unregulated coastal development threatened most of the nesting sites, with the possible exception of the beaches of Kem Terendak, which is a military base. Most of the nesting beaches in Melaka are either developed, adjacent to

Table 8.4. Summary of size of annual hawksbill turtle nesting populations and recorded nesting beaches in western Peninsular Malaysia

Estimated size of annual nesting population	Number of beaches	Nesting beaches
11-100 clutches/year	5	Padang Kemunting, Kem Terendak Balik Batu, Pulau Upeh, Meriam Patah, Tanjung Dahan, Tanjung Serai
1-10 clutches/year	2	Penang State, Singapore
Unquantified nesting	0	

Index nesting beaches: Melaka beaches

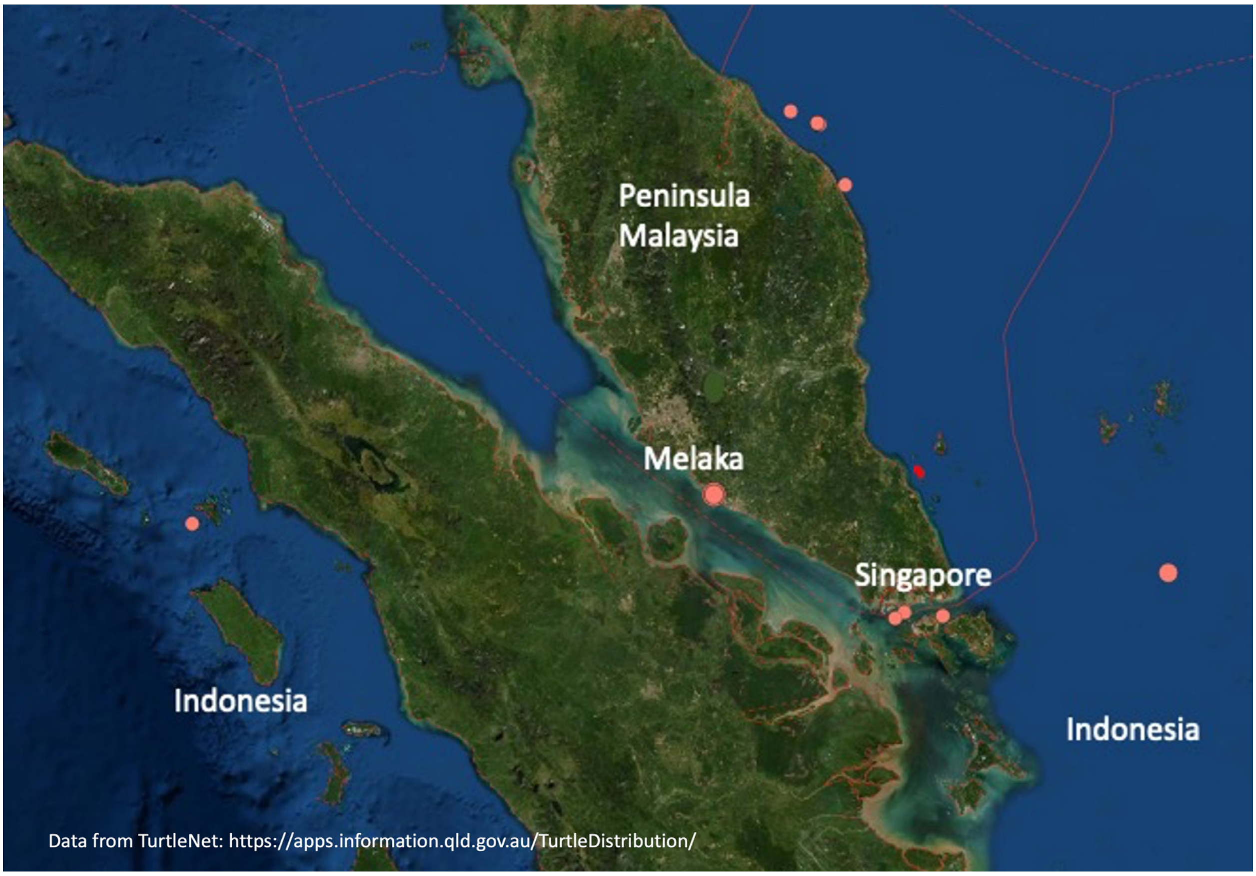


Figure 8.5. Distribution of hawksbill turtle nesting sites for the western Peninsular Malaysia Management unit and adjacent rookeries. Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote unquantified nesting. Melaka beaches are combined and included as a single one location. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

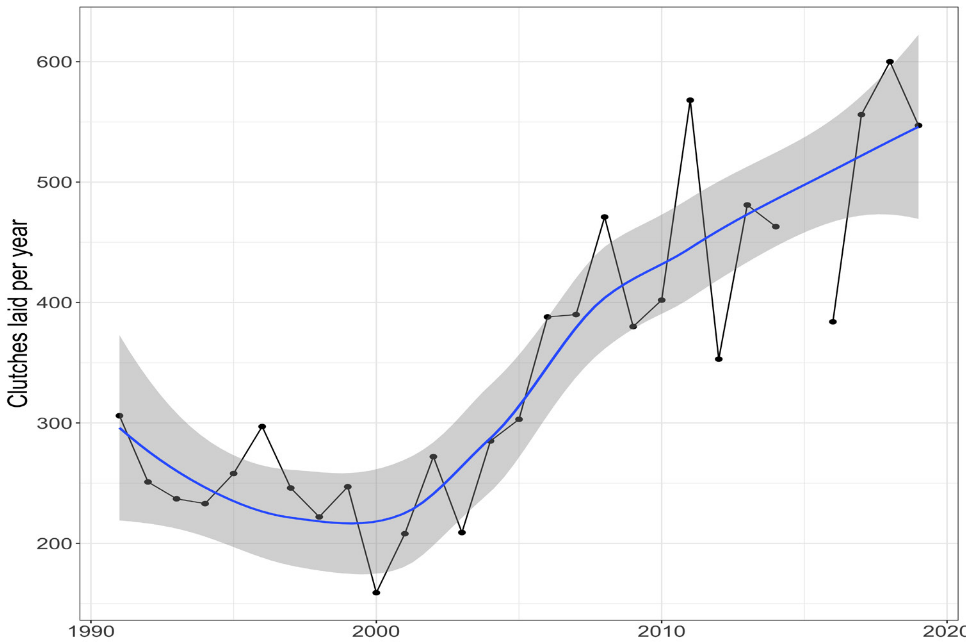


Figure 8.6. Number of hawksbill clutches recorded per year at Melaka in Peninsular Malaysia. Data from the Department of Fisheries Melaka and Salleh et al. (2018).

Summary of threats to the western Peninsular Malaysia management unit of hawksbill turtles

Type of threat	Known or likely location of impact 1=nesting beach 2=oceanic/high seas 3=coastal foraging areas	Quantified 1=comprehensive documentation across population 2=comprehensive documentation for some of the population 3=non-published/anecdotal evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	1	1
Commercial use of turtles		3
Non-commercial use of turtles	3	4
Predation of eggs by non-native fauna		4
Predation of eggs by native fauna		4
Consumption – foraging turtles		
Commercial use of turtles	3	4
Non-commercial use of turtles	3	4
Climate change impacts		
Increasing beach temperature		4
Beach erosion		4
Sea level rise		4
Coastal development		
Habitat modification (urban)	1	2
Habitat modification (industrial)	1	2
Light horizon disorientation	1	3
Fisheries impacts		
Bycatch – trawl	3	4
Bycatch – longline	3	4
Bycatch – gillnet	3	4
Impact to benthic ecology from fisheries	3	4
IUU fishing	3	4
Pollution		
Water quality	3	4
Entanglement in discarded fishing gear	3	4
Ingestion of marine debris	3	4
Noise pollution	3	4
Disease and pathogens	3	4
Hatchery management (and egg collection)	1	2

Table 8.5. Summary of key issues related to the cumulative loss of turtles and eggs from the western Peninsular Malaysia management unit of hawksbill turtles

1	Small-scale local harvest of eggs by people living adjacent to rookeries for consumption or sale (Salleh et al. 2017; 2018)
2	Unregulated coastal development along the Melaka coastline is a serious threat to most of the hawksbill nesting habitat of Melaka.
3	Potential loss of post-hatchling (immature) hawksbill turtles in ghost nets
4	Presumed substantial but unquantified mortality of foraging hawksbill turtles in the commercial fisheries of Indonesia and Malaysia.
5	Direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale.
6	Failure of CITES Signatory States to enforce CITES regulations banning the export of Appendix I listed species, such as hawksbill turtles (CITES 2019; Vuto et al. 2019).
7	Illegal trade in hawksbill turtles, particularly in China and Vietnam, which provides an incentive for developing countries in the IOSEA region to continue illegally harvesting turtles and their scutes (e.g. CITES 2019; Riskas et al. 2018; Gomez and Krishnasamy 2019).

developed areas, or close to planned development zones. Further, most beaches are exposed to threats such as light pollution, climate change (sex ratios and sea level rise), and the ingestion of, or entanglement in, marine debris. Examination of the degree to which these threats may impact hawksbill turtles from the western Peninsular Malaysia management unit is required.

Although not recently quantified, the cumulative loss of turtles via multiple significant impacts on the western Peninsular Malaysia management unit is of primary concern (see Table 8.5). There are currently no clear indications of when or how they can be resolved; therefore, the current trends in negative impacts are likely to continue.

Management and protection

In Malaysia, turtles fall under the jurisdiction of individual states. The legislation in Melaka mainly prescribes the procedures and fees to secure a license to collect eggs and to operate turtle watching areas. Turtle clutches in Melaka are transferred to protected hatcheries. In Pulau Upeh, where all turtle clutches were previously transported to mainland hatcheries for

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Padang Kemunting	Mainland, nesting	Y	Very high historically, but degraded	Not protected, not inhabited; access controlled by local Aboriginal custodians. Beach not currently monitored.
Kem Terendak	Mainland, nesting	Y	High (most important nesting site remaining in 2012)	Not protected, not inhabited; access controlled by local Aboriginal custodians. Beach not currently monitored.
Balik Batu	Mainland, nesting	Y	High historically, but degraded	
Pulau Upeh	Island, nesting	Y	High historically, but significantly degraded by 2012	
Meriam Patah	Mainland, nesting	Y	High historically, but degraded	

protection from predation or human influence, major reclamation projects made the area unsuitable for turtle nesting by 2012 (J.A. Mortimer and WWF-Malaysia, unpublished data).

Biological data – foraging

There has been no research or monitoring studies on foraging hawksbill turtles known to be from the western Peninsular Malaysia management unit.

Biological data – breeding

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

Gulf of Thailand management unit(s) (putative)

Ecological range

There are records of hawksbill turtle nesting on the islands off the east coast of Peninsular Malaysia, Thailand, and Cambodia (for a summary, see Meylan and Donnelly 1999). Collectively, these rookeries are believed to constitute a management unit (FitzSimmons and Limpus 2014; Nishizawa et al. 2016); however, sampling has been constrained by low levels of nesting, while low sample sizes for genetic-based research have impeded the description of population genetics (Arshaad and Kadir, 2009; Nishizawa et al. 2016). Recent research by Nishizawa et al. (2016) indicate that the hawksbill turtles nesting at Pulau Redang in eastern Peninsular Malaysia are genetically distinct from those nesting in Sabah and Melaka in western Peninsular Malaysia. Based on a small sample size, the hawksbill turtles nesting in Johor (southeastern Peninsular Malaysia) could also be genetically distinct from those in Melaka. However, analysis of Johor turtles also revealed a haplotype common to hawksbill turtles in Ko Khram (Thailand) (Arshaad and Kadir, 2009). Thus, it is not clear whether there is more than one management unit in the Gulf of Thailand. In this section, we treat all of the rookeries in the Gulf of Thailand as a possible management unit.

Geographic spread of foraging sites

The limited satellite telemetry tracking from this management unit indicates a population with a restricted foraging range within the waters of Thailand (Monanunsap et al. 2002). However, it is possible that foraging occurs throughout the Gulf of Thailand, including national waters of Cambodia, Viet Nam, Malaysia, and into the South China Sea.

Geographic spread of nesting

In Thailand, the islands of Ko Khram and Ko Kra have been recognised as important rookeries for hawksbill turtles (Chantrapornsyl 1996). In Cambodia, nesting activity has been reported from Koh Tang, Koh Pring, Koh Kong, and Koh Rong; however, no hawksbill turtle nesting has been recorded in Cambodia in recent decades. In Malaysia, hawksbill turtles nest on the islands of the states of Terengganu, Pahang, and Johor, in particular Pulau Redang, Pulau Tioman, and the islands of Johor (Table 8.6, Figure 8.7). The nesting season occurs primarily from May to October.

Trends in nesting data

In Thailand, data from nest counts and the egg trade in the 1950s indicated that around 100 female hawksbill turtles nested on Ko Kram each year. Between 1973 and 1995, these levels declined to around 11 to 18 females (around 55 clutches) per year and then stabilised (Monanunsap 1997, summarised in Meylan and Donnelly 1999). In recent years, nesting has increased to between 100 to 150 clutches per year (Figure 8.8). The most recent data from monitoring at Malaysia's Chagar Hutang (Pulau Redang) show a small and stable nesting population, which produces around 10 clutches per year (Figure 8.9). At Pulau Tioman in the state of Pahang, monitoring by the Juara Turtle Project has occurred since 2006 and they report relatively stable numbers of nesting turtles, with around 5 to 20 clutches per year (Horcajo-Berna et al. 2018).

Table 8.6. Summary of size of annual hawksbill turtle nesting populations at nesting beaches in the Gulf of Thailand

Estimated size of annual nesting population	Number of beaches	Nesting beaches
101-500 females/year	0	
11-100 females/year	1	Ko Khram (Thailand)
1-10 females/year	4	Ko Kra (Thailand), Pulau Redang, Pulau Tioman, Johor Islands (Malaysia)
Unquantified nesting	At least 4	Koh Tang, Koh Pring, Koh Kong, Koh Rong (Cambodia)
Unquantified nesting	0	

Index nesting beaches: Ko Khram, Thailand; Pulau Redang (Chagar Hutang), Malaysia; Pulau Tioman, Malaysia; Johor Islands, Malaysia

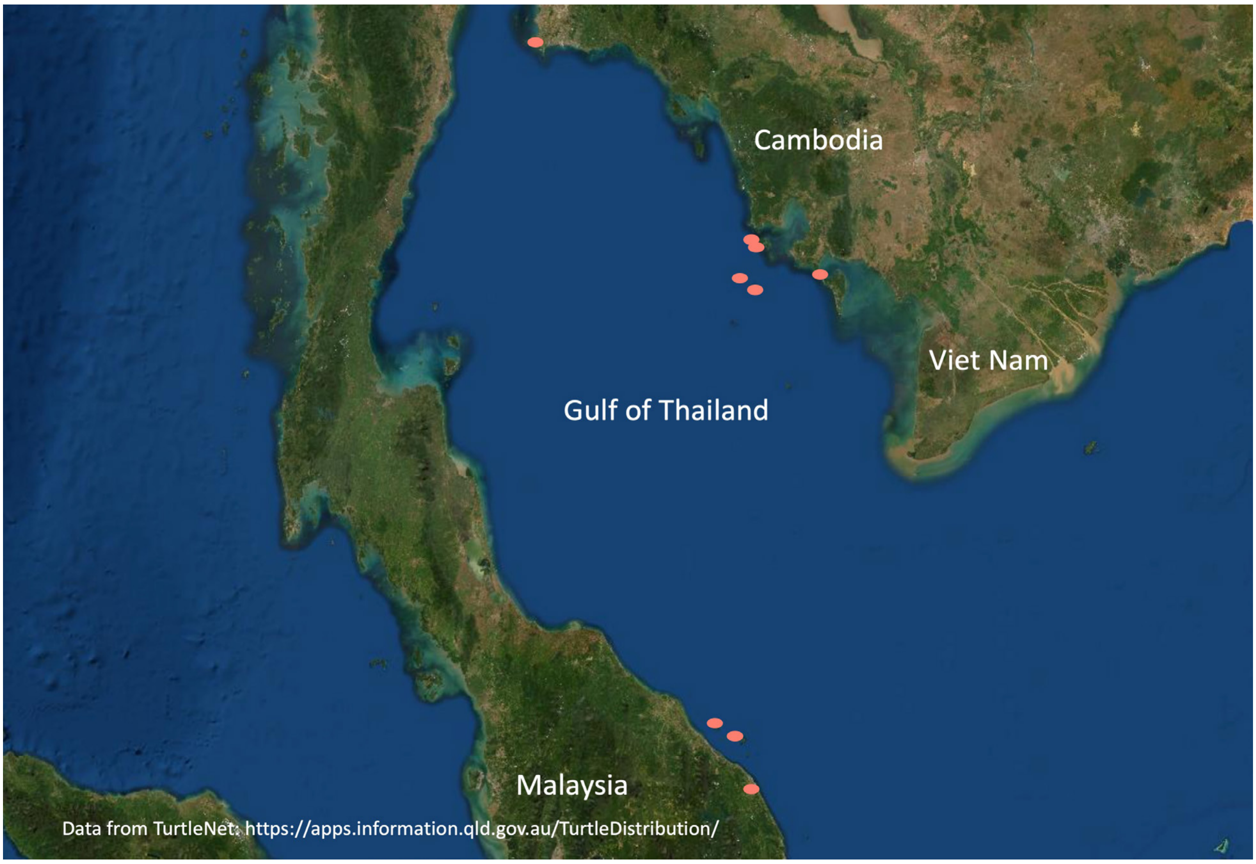


Figure 8.7, Main hawksbill turtle nesting sites for the possible Gulf of Thailand management unit, and adjacent rookeries. Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote unquantified nesting. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Migration and distribution of foraging areas

Five female hawksbill turtles from Ko Ira and Ko Charn (Thailand) were tracked using satellite tags during their nesting season and up to six months after the nesting season. All tracked turtles had short migrations and their foraging areas were located <50 km away from the nesting beach (Monanunsap et al. 2002).

Threats to the population

The threats to the Gulf of Thailand management unit for hawksbill turtles are well described, but they have not been comprehensively assessed. Issues of concern include habitat change and habitat development, climate change related to increased air temperatures and their likely influence on hatchling sex ratios, and

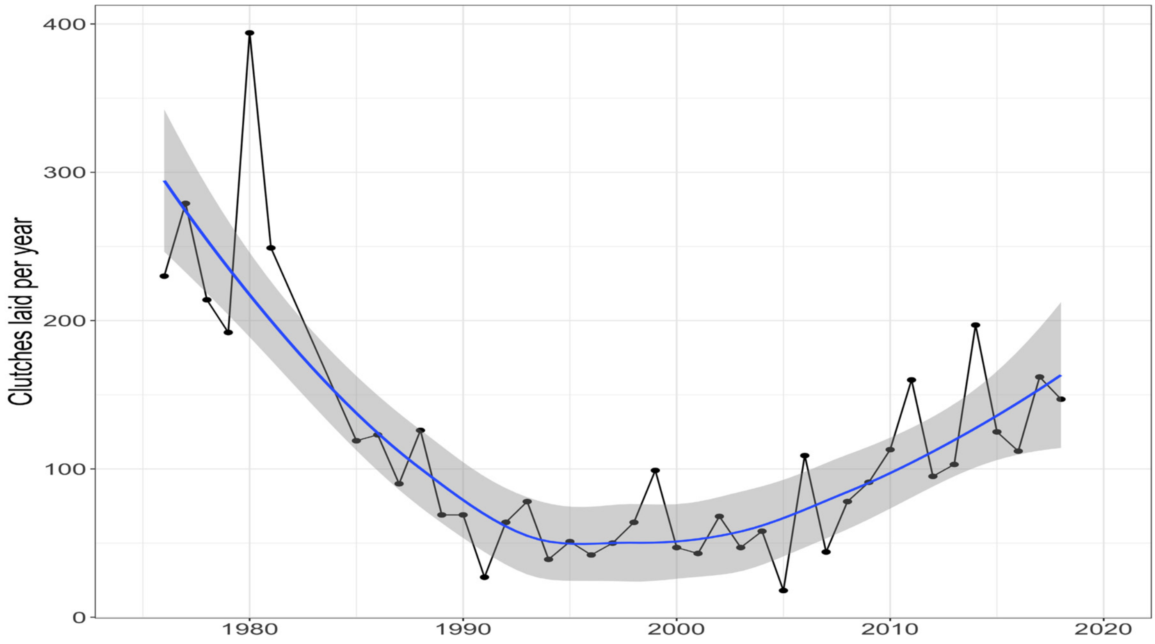


Figure 8.8. Number of hawksbill clutches recorded per year at Ko Kram, Thailand. Data from 1976 to 1981 are estimated from Table 201 in Groombridge and Luxmoore (1989), data from 1985 to 1995 is from Chantrapornsyl (1996) and unpublished data from 1995 to 2018 was provided by the Thailand Government.

the ingestion of, or entanglement in, marine debris. Examination of the degree to which these threats may impact hawksbill turtles from the Gulf of Thailand management unit is required. Although not recently quantified, the cumulative loss of turtles and eggs via multiple significant impacts on the Gulf of Thailand management unit has been and continues to be of primary concern (e.g. Table 8.7). There are currently no clear indications of when or how they can be resolved; therefore, the current trend of negative impacts is likely to continue.

Biological data – foraging

There have been no research or monitoring studies on foraging hawksbill turtles known to be from the Gulf of Thailand management unit; however, foraging hawksbills are known to occur at most of the islands in the Gulf of Thailand, eastern Peninsular Malaysia, and the South China Sea.

Philippines

Nesting

Hawksbill turtles have been documented to nest on Panikian Island (Sagun 2002) and the Calamian Islands (Poonian et al. 2016). In 2002, less than five hawksbill turtles were reported to nest per year in the Philippine Turtle Islands (Cruz 2002). In the Calamian Islands, the most important beaches are located on the islands of Pamalican and Galoc, and Linamodio on the north coast of Coron. (Poonian et al. 2016). Scattered, aperiodic nesting occurs on several other islands (e.g. beaches in Lawi on Guimaras Island). Based on data from Panikian Island, the peak of the nesting season occurs between April and June (Cruz 2002). Nesting incidence was also reported in the Caramoan Islands and at Roughton Island (Balabac Strait, Palawan) in 2007 (Antonio and Matillano, 2016).

Foraging

The Calamian Islands provide important foraging grounds for marine turtles due to their diversity in habitats, including coral reefs, beaches, and seagrass beds, which support multiple life history stages of marine turtles (Poonian et al. 2016).

Hawksbill turtles can also be found foraging on reefs within the El Nido-Taytay Managed Resource Protected Area (ENTMRPA), the Tubbataha Reefs Natural Park (TRNP), and the Turtle Islands Wildlife Sanctuary (TIWS) (DENR Biodiversity Management Bureau 2019). Lagonoy Gulf in the Bicol region has been identified as a developmental habitat of hawksbill turtles (Cruz 2002). Aggregations of hawksbill turtle may also be found in significant areas like Romblon Island, Magsaysay in Misamis Oriental, and the Davao Gulf (Marine Wildlife Watch of the Philippines 2014).

Migration

Hawksbill turtles found foraging on reefs between

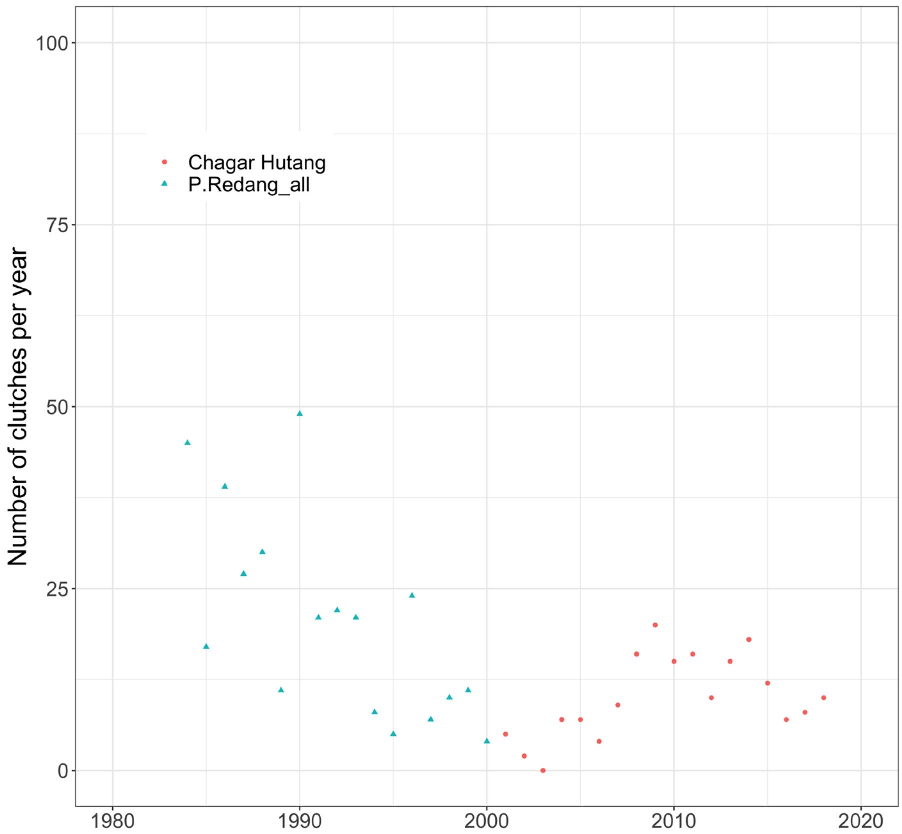


Figure 8.9. Number of hawksbill clutches recorded per year at Pulau Redang and Chagar Hutang (single beach on Pulau Redang) in Peninsula Malaysia. Data from Chan (2006) and unpublished data from SEATRU (2008 to 2018).

Table 8.7 Summary of key issues related to the cumulative loss of turtles and eggs from the Gulf of Thailand management unit of hawksbill turtles

1	Illegal harvest of eggs by people living on or visiting islands, especially those with low-density nesting, for consumption or sale. Nearly all eggs laid between the 1940s and 1980s on the beaches of southern Viet Nam and Cambodia are believed to have been collected and used to supply the hawksbill turtle farms at Ha Tien (Viet Nam) (Hamann et al. 2006).
2	Potential loss of post-hatchling (immature) hawksbill turtles in ghost nets or through ingestion of marine debris.
3	Presumed substantial but unquantified mortality of foraging hawksbill turtles in the commercial fisheries of Thailand, Viet Nam, Cambodia, and Malaysia.
4	Direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale. Indeed, throughout the 1970s, 1980s, and 1990s, the coastal waters of Cambodia and southern Viet Nam were among the main locations supplying hawksbill turtle shell (Hamann et al. 2006). While trade has likely declined in magnitude, the legacy of past trade is likely to continue.
5	The failure of CITES Signatory States to enforce CITES regulations banning the export of Appendix I listed species, such as hawksbill turtles (CITES 2019; Vuto et al. 2019).
6	Illegal trade in hawksbill turtles, particularly in China and Vietnam, which provides an incentive for developing countries in the IOSEA region to continue illegally harvesting turtles and their scutes (CITES 2019; Riskas et al. 2018; Vuto et al. 2019).

Summary of threats to the Gulf of Thailand management unit of hawksbill turtles

Type of threat	Known or likely location of impact 1=nesting beach 2=oceanic/high seas 3=coastal foraging areas	Quantified 1=comprehensive documentation across population 2=comprehensive documentation for some of the population 3=non-published/anecdotal evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	1	4
Commercial use of turtles		2
Non-commercial use of turtles		2
Predation of eggs by non-native fauna	1	4
Predation of eggs by native fauna	1	4
Consumption – foraging turtles		
Commercial use of turtles	3	4
Non-commercial use of turtles	3	4
Climate change impacts		
Increasing beach temperature	1	2
Beach erosion	1	2
Sea level rise	1	4
Coastal development		
Habitat modification (urban)		2
Habitat modification (industrial)		2
Light horizon disorientation		2
Fisheries impacts		
Bycatch – trawl		2
Bycatch – longline	2	2
Bycatch – gillnet	3	3
Impact to benthic ecology from fisheries	3	4
IUU fishing	3	3
Pollution		
Water quality	3	4
Entanglement in discarded fishing gear	2,3	2
Ingestion of marine debris	2,3	3
Noise pollution	3	4
Disease and pathogens	3	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Ko Kram (Thailand)	Island, nesting	Yes	Very high	Protected and access restricted
Pulau Redang - Chagar Hutang beach (Malaysia)	Island, nesting	Yes	Very high	Protected
Pulau Tioman (Malaysia)	Island, nesting	Yes	Very high	Not protected but access to some beaches is restricted

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	unknown	
Remigration interval	unknown	
Clutches per season	3.5	Chan and Liew 1999
Clutch size	103.5	Chantrapornsyl 1996
Mean size of nesting adult (CCL)	82.3 cm	Chan and Liew 1999
Age at maturity	unknown	

Panay and Guimaras in the southern Philippines are part of the Sulu Sea management unit. No studies of migration have been conducted on turtles nesting or foraging in the Philippines, nor has there been any genetic-based research to identify the spread of foraging habitats.

Work has begun to reclassify the Balabac Strait in Palawan a marine protected area. The strait provides passage for turtles from the Indonesian and Malaysian parts of the Sulu-Sulawesi Seascape, but also for those entering the Sulu Sea from adjacent regional seas (DENR 2019).

It is clear that critical nesting and foraging habitats for hawksbill turtles are linked across the Philippines, Malaysia, and Indonesia, and thus marine resources should be jointly managed (e.g. the Turtle Islands Heritage Protected Area (TIHPA)) (Ramirez de Veyra 1994). The TIHPA is comprised of three islands of the Turtle Islands Park of Sabah, Malaysia and islands of the Turtle Islands Wildlife Sanctuary of Tawi-Tawi Province, Philippines (Sagun 2002; DENR Biodiversity Management Bureau 2019): Boan, Lihiman, Langaan, Great Bakkungan, Taganak, and Baguan (Philippines National Commission for UNESCO).

Threats

Turtle populations in the Philippines are subject to threats from unsustainable commercial practices. Traditionally, turtle eggs have been harvested by local and Indigenous communities as a source of livelihood, food, and medicine. The Pawikan Conservation Project (PCP) tracks domestic trade of turtle products (Trono 1991). In the Philippines, many educational campaigns around turtle conservation have focused on local fishers, who are often encouraged to record bycatch data (e.g. history of capture), take photos, and measure turtles before releasing them (Sagun 2002). In 2011, an album including photographs of 68 turtles and the threats they face was published by the Southeast Asian Fisheries Development Center (SEAFDEC FishWorld) to build empathy within the community and encourage support of conservation efforts (Bagarinao 2011). The reliance on turtle hunting and egg harvesting in the Philippines is closely linked to tradition, and variable economic resources. Local governments and organisations such as PCP have had success at reducing threats to turtle populations by educating and mobilising local residents, providing health services, education, and alternative livelihoods as a means to reduce reliance on egg harvesting and turtle hunting as a source of income.

Similarly, in 1996 WWF-Philippines aimed to understand the socioeconomic, sociocultural, and political drivers of turtle consumption by island communities in conjunction with a biological and social assessment. The goal was to formulate a long-term, integrated conservation plan to end unsustainable use of marine resources and to relieve pressure on hawksbill turtle populations (Poonian et al. 2016). However, the success or failure of these projects is rarely examined or documented.

Eliminating the commercial trade and export of turtles requires more effective enforcement of existing laws (Poonian et al. 2016). Since 2002, the Department of Environment and Natural Resources (DENR) have stopped issuing permits to collect marine turtle eggs in the Turtle Islands and Tawi-Tawi (Marine Wildlife Watch of the Philippines 2014). Data from the PCP showed that between 1979 and 1991, around 266 businesses were engaged in the trade of marine turtle products (Trono 1991), and in 2002 all turtle eggs laid on the islands, except those laid in the protected sanctuary of Baguan, were reportedly collected and sold (WWF 2005).

Between 1989 and 1991, 171 stuffed turtles and 20 turtle carapace guitars were confiscated; 20% were hawksbill turtles (Trono 1991). Hunting and egg collection is still very prevalent and remains a major threat to marine turtles in the Calamian Islands (Poonian et al. 2016). However, anecdotal evidence from local communities mentioned that hawksbill turtles were not hunted, as eating their meat "causes all your previous sicknesses to come back" and the eggs are unpalatable because of their strong flavour of fish (Poonian et al. 2016). Formed in 2000, Bantay Pawikan is a people's organisation in Bataan, comprised of previous licensed egg collectors who are supported by the provincial government to protect clutches and nesting beaches (Sagun 2002).

Philippine turtle populations are also under threat from local and international illegal use and fisheries. Direct catches and bycatch figures are not well documented, so estimating numbers is not possible; however, there are documented cases of illegal use. In September 2007, a Chinese vessel boarded for routine inspection was found to be holding more than 200 turtles (mainly green) and 10,000 turtle eggs (Fabinyi 2012). In 2008, more than 100 hawksbill turtles were found dead on a Vietnamese fishing vessel near Malampaya, and in November 2005, nine sacks of dried hawksbill scutes from about 640 butchered turtles were found in a container van from Zamboanga, allegedly bound for Viet Nam (Bagarinao 2011). In 2016, a shipment of 100 hawksbill turtles en route to Viet Nam was seized in Palawan (Gomez and Krishnasamy, 2019). In 2017, a Philippine National Police operation seized 70 dead hawksbill turtles from a boat from Taytay, Palawan headed to Balabac Island (Mayuga, 2017). Balabac has been identified as one of the hotspots for illegal wildlife trade in the Philippines (Cruz et al. 2007).

Gillnets, longlines, skimming nets, beach seines, and bamboo fish corrals operate around Panay and Guimaras almost daily. Consequently, hawksbills are caught sporadically by various gears and often opportunistically landed, eaten, or sold by fishers (Bagarinao 2011). The Turtle Islands and other coastal areas of the Philippines also experience the effects of cyanide and dynamite fishing (Cruz 2002). Over a 10-year period, 109 marine turtles (15 hawksbills) were captured by fisheries or stranded around Panay and Guimaras Islands (and reported to SEAFDEC FishWorld).

Management and Protection

As an active Party to CITES, the Convention on Biological Diversity (CBD), the Convention for the Conservation of Migratory Species of Wild Animals (CMS), the Ramsar Convention, the IOSEA MOU, and the Coral Triangle Initiative on Coral Reefs Fisheries and Food Security (CTI-CFF)—among other regional and international commitments—the Philippines has been steadfast in working alongside its national agencies and with local governments and various sectors to protect marine turtles from extinction. The Wildlife Resources Conservation and Protection of 2001 (Republic Act No. 9147) has helped further mobilize efforts to support biodiversity research and implement stronger enforcement interventions to save wildlife from various anthropogenic threats, especially the illegal wildlife trade.

The Department of Environment and Natural Resources – Biodiversity Management Bureau (DENR-BMB) is the government authority mandated to formulate policies and guidelines on wildlife and ecosystems conservation, and to provide technical assistance in the enforcement of wildlife laws and regulations at the local level. The DENR-BMB oversees the management of the TIWS, among other nationally-recognised parks across the country. Other private or non-profit entities also work with the government to conduct marine turtle conservation efforts in select parts of the country—such partners include the Pawikan Conservation Center in Morong (Bataan Province) and the Aboitiz Cleanergy Park (Davao City).

Indonesia

Indonesia, an equatorial national within the Coral Triangle region, is well known for its globally significant marine turtle populations. Hawksbill turtles have been reported nesting across the breadth of the nation, mostly in the Java Sea region (Shultz 1987; Groombridge and Luxmoore 1989; Adnyana et al. 2014) (Figure 8.10). Much of Indonesia's coral reef ecosystems could potentially provide suitable habitat for foraging hawksbill turtles. However, Indonesia was one of the main countries supplying hawksbill turtle shell to Japan in the late 20th century and this, in combination with customary use of eggs, led to widespread declines in hawksbill populations at many locations. Thus, it is likely that current population sizes are a fraction of their 17th century size, with some rookeries possibly extirpated or severely reduced. Indeed, in a 2008 assessment, there were approximately only 3,126 hawksbill nests per year in Indonesia (Mortimer and Donnelly, 2008). While it is likely that there is more than one genetic stock within the country, there have been no genetic-based studies on hawksbill turtles from Indonesian rookeries, so genetic stock partitioning is not possible (Adnyana et al. 2014). Similarly, there are few projects collecting data on population dynamics at foraging grounds, which could serve as proxies for stock stability. In this assessment, we summarise what is known about hawksbill turtles on a regional basis, following a similar approach to Groombridge and Luxmoore (1989) and Mortimer and Donnelly (2008).

Indonesia – South China Sea, Java Sea, West and South Sulawesi

In this region of Indonesia, most provinces have areas of known nesting sites for hawksbill turtles. Some of the island groups were surveyed in the 1980s and estimated nesting abundance data are summarised in Groombridge and Luxmoore (1989) (Table 8.8). There is a long (and variously quantified) history of egg collection and supply of turtles for the tortoiseshell trade (Groombridge and Luxmoore 1989). In more recent years, Suganuma et al. (1999) and Tanaka et al. (2010) conducted nesting-beach surveys at 15 of the 30 known hawksbill turtle nesting rookeries. Although several of the region's sites are protected, the illegal use persists.

Riau, Riau Islands, South Sumatra, Bangka Belitung, and West Kalimantan Provinces

There have been several studies to update the status of hawksbill turtles in these provinces. Using counts of body pits as a proxy for nesting activity, nesting effort was examined in the provinces' rookeries in the late 1990s (South Natuna, Tambelan) or early 2000s (Bintan Linnga, Singkep), and then followed up again in 2009. These counts all show similar number of body pits between their initial survey and the 2009 survey (Table 8.8). In addition, there are four protected beaches which have been surveyed since 1999, and annually with similar effort since 2012 by communities and the NGO Everlasting Nature of Asia (ELNA) at Momperang (including Momperang and Pesemut), Pesambung, and Kimar (Table 8.8; Figure 8.11). Unquantified hawksbill nesting is also reported from Pantai Paloh.

Lampung and Jakarta Provinces

The islands of the Kepulauan Seribu Islands National Park in Jakarta Bay are important for hawksbill turtle nesting. In the early 1990s, it was estimated that around 500 females nested per year on at least five islands of the national park: Peteloran Timur, Penjaliran Timur, Gosong Pengat, Penjaliran Barat, and Peteloran Barat. The most recent estimates are 50 nests per year across these islands (unpublished data from Indonesian Fisheries Department). Monitoring at Segama, a protected beach, occurred in 1999 and then annually with consistent effort since 2012 by the community and NGOs (Table 8.8; Figure 8.11).

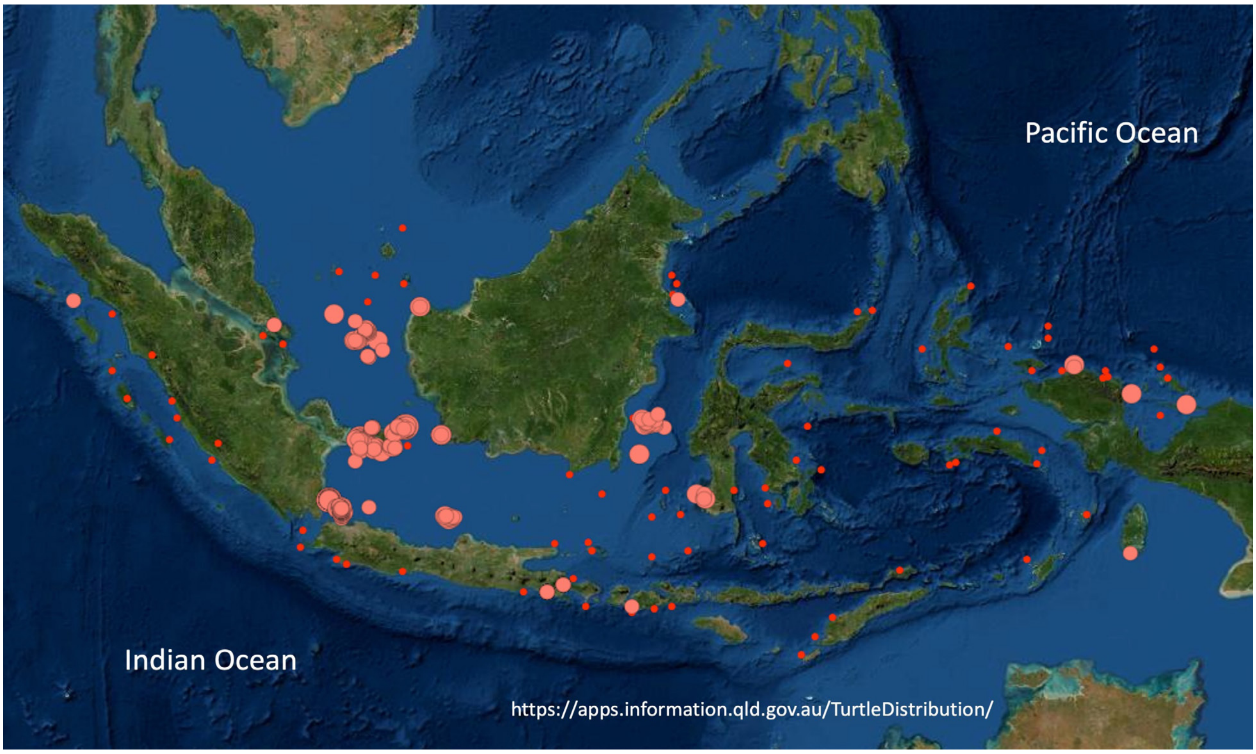


Figure 8.10. Distribution of hawksbill turtle nesting sites in Indonesia. Red lines indicate Exclusive Economic Zone (EEZ) boundaries. Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote unquantified nesting. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

East Java, South Kalimantan, and South Sulawesi Provinces

In the 1980s, these three provinces—especially South Kalimantan—were believed to support important rookeries for hawksbill turtles (Table 8.8) (Groombridge and Luxmoore 1989). In South Kalimantan, ELNA conducted interviews with island residents between 2006 and 2010 on Pulau Samber Gelap. There, the resident egg collector reported between 672 and 838 clutches per year on the island (Tanaka et al. 2010). There are no additional data for the other rookeries in these provinces.

Nesting

Hawksbill turtles nest year-round in this region of Indonesia, with the peak of nesting varying slightly among island groups (Table 8.9). At Pesemut, Momperang, Kimar, and Segama Besar, monitoring is coordinated by NGOs ELNA and Yayasan Penyu Laut Indonesia (YPLI).

Foraging

There are no data on foraging turtles in the region. However, there are thousands of coral reefs and atolls in this region that are likely to support foraging aggregations of hawksbill turtles.

Migration

There have been no hawksbill turtles tracked from nesting beaches in the Java Sea or Seribu regions. However, turtles tracked from Melaka in Malaysia have migrated into the Java Sea.

Indonesia – Aceh, West Sumatra, Bengkulu, East Java, West Java, and Nusa Tenggara Provinces

Surveys in the 1980s highlighted these provinces as important areas for hawksbill turtle nesting. However, the number of turtles using the area has not been quantified since the area was first surveyed in the 1980s (see Table 88 of Groombridge and Luxmoore 1989). Nesting is known to occur at Pulau Selaut (Simelue, Aceh), Pulau Simuk (Nias, North Sumatra), Lahewa (Nias, North Sumatra), Telok Dalam (Nias, North Sumatra), Sorkam (Tapanuli Tengah, North Sumatra), Gosong Pandan (TWP Pieh, West Sumatra) – approximately 25 clutches per year (unpublished https://kkp.go.id/djprl/lkkpnpekanbaru/page/4082-data-penyu-twp-pieh1) , Pulau Pieh (TWP PiehWest Sumatra), Pulau Sipora (Mentawai, West Sumatra), Pulau Sanding (Mentawai, West Sumatra). More recent anecdotal surveys indicate considerable declines are likely to have occurred or continue to occur.

Foraging

There are no data on foraging hawksbill turtles in the region. However, there are thousands of coral reefs and atolls in this region that are likely to support foraging aggregations of hawksbill turtles.

Migration

There have been no hawksbill turtles tracked from nesting beaches in this region of Indonesia.

Indonesia – East Kalimantan and Celebes Sea regions

Nesting

Low-level nesting was reported on the Berau Islands in the 1980s, with an estimated 50 nests laid per year (Groombridge and Luxmoore 1989). Recent data from the monitoring programmes focussed on green turtles indicate that fewer than 10 nests per year are currently laid by hawksbills (Maulida et al. 2017) and in 2019 YPLI began to locate and protect hawksbill turtle clutches on Pulau Belambangan (see YPLI website http://yayasanpenyu.org).

Foraging

Maulida et al. (2017) conducted a survey of hawksbill turtle foraging and health status at Maratua Island. Eleven juvenile turtles were caught during a 13-day survey period. The average size of the turtles was 43.1 cm in straight carapace length, which is consistent with immature-sized turtles.

Indonesia – North and Central Sulawesi

Surveys in the 1980s highlighted these provinces as important areas for hawksbill turtle nesting. However, the number of turtles using the region has not been quantified since the area was first surveyed in the 1980s (see Table 88 of Groombridge and Luxmoore 1989). Local NGO Manengkel Solidaritas has initiated a project to locate and protect marine turtle nests in the Minahasa District.

Foraging

There are no data on foraging turtles in the region. However, there are thousands of coral reefs and atolls in this region that are likely to support foraging aggregations of hawksbill turtles.

Migration

There have been no hawksbill turtles tracked from nesting beaches in this region of Indonesia.

Table 8.8. Estimated number of clutches laid per year by hawksbill turtles in the South China Sea, Java Sea, West and South Sulawesi provinces. Asterisks (*) indicate sites listed as index sites in Mortimer and Donnelly (2008)

Location	Clutches laid per year		
	1980 estimates (Table 88 of Groombridge and Luxmoore 1989)	2008/2009 estimate (Tanaka et al. 2010; Suganuma et al. 1999; Akil et al. 2004; Mortimer and Donnelly 2008)	Most recent estimate (year) (ELNA unpublished data)
Riau and Riau Island Provinces			
Senayang	400		
Natuna Besar	200	50	
Natuna Selatan	620	285 (2009)*	
Anambas	800	300	
Tambelan	1000	300 (2004)	
South Sumatra and Bangka Belitung Provinces			
Momperang/Peserat*	400	357 (2009)	915 (2016-18)
Gresik	650	219 (1996)	203 (2008)
Kimar		290 (2009)	666 (2016-18)
Momperak and Pesambung	1250		
Tengah and Sembilan	800		
Other islands (P. Manggar, P. Plemah, P.Seliu, P Lima, P.Panjang, P. Lengkuas, Belitung	1100		
Lampung and Jakarta Provinces			
Kepulauan Seribu Islands NP	500 (~300 in 1992 by Suwelo 1992)	50 (1994)*	
Segama		191 (1996 to 2000) and 463 (2009)	1347 (2016-18)
South Kalimantan Province			
Samber Gelap area		672 (2009)	
West Kalimantan Province			
Paloh region	300		
Kendawangan region		165 (2009)*	112 (2015-18) (Penambun)
South Sulawesi Province			
Islands in Makassar and P. Kayadi, Islands south of South Suluwesi	3000 to 4000		

Table 8.9. Estimated peak months of the hawksbill turtle nesting season

Nesting site	Peak nesting months of hawksbill
Tambelan Islands	December to March
Lima islands	December to July
Gresik Island	February to August
Tiga Islands	December to August
Ayermasin	September to May
Segama Islands	December to April
Seribu Islands	January to April (plus September)

Indonesia – Southeast Sulawesi, Maluku, North Maluku, West Papua, and Papua Provinces

Nesting

Surveys in the 1980s highlighted these provinces as important areas for hawksbill turtle nesting (see Table 88 of Groombridge and Luxmoore 1989). More recent surveys show considerable declines are likely to have occurred.

Bird's Head Peninsula, Cenderawasih Bay, and Raja Ampat

Low numbers of hawksbill turtles nest on the beaches and islands of the Bird's Head Peninsula region. In particular, Putrawidjaja (2000) reports 13 clutches being laid on Batu Rumah and Warmamedi beaches, which are primarily used by leatherback turtles, between May and October 1999. A survey in this region by Setyadi (1997; cited in Putrawidjaja (2000)) found hawksbill turtle clutches on six of eight beaches surveyed: Iwari, Matas, Rorebo, Tridacna Atoll, Kabaui, and Nutabari. Hitipeuw (2003) reports nesting on three islands in Raja Ampat: Waigeo (around four clutches per year), Kofiau (two beaches and around two clutches per year), and Misool (six beaches and around 40 clutches per year).

Maluku, North Maluku, and Southeast Sulawesi

There are no quantitative updates on the nesting sites, or the number of hawksbill turtles breeding in this region. In 2018, the Marine and Fisheries Agency (DKP) of Sula Islands, North Maluku Province began a project to understand and protect hawksbill turtles on Sulabesi Island (Fatkauyon Village).

Foraging

No studies on foraging hawksbill turtles have been conducted in this region. Cenderawasih Bay has around 80,000 hectares of coral reef systems and is likely to contain important habitat for foraging hawksbill turtles.

Migration

No migration records exist for hawksbill turtles in this region.

Threats to the turtles of Indonesia

Hawksbill turtles are currently protected in Indonesia from consumptive use. It is likely that the significant harvest of hawksbill turtle eggs throughout the 20th century could have contributed to declines in the nesting and foraging populations. Current threats to hawksbill turtles in Indonesia include egg collection, incidental bycatch, opportunistic retention of bycatch, and deliberate take of turtles for the sale of shell are still considered threats to Indonesia's hawksbill turtles (see van Dijk and Shepherd 2004; Mortimer and Donnelly 2008). However, there are no quantifiable data to indicate the magnitude of these threats. Over the past 10 to 20 years several authors have indicated that the collection of eggs for sale or non-commercial consumption continues to occur on most unprotected islands, as well as on some protected islands (Putrawidjaja 2000; Hitipeuw 2003; Adnyana et al. 2014; Tapilatu et al. 2017). Levels of take are unquantified, but take is believed to occur across most of Indonesia. Similarly, there are no quantitative data on the incidental, or deliberate, capture of hawksbill turtles and the sale of hawksbill turtle products (Table 8.10). In 2004, take was considered to be substantial relative to local and regional population sizes (van Dijk and Shepherd 2004). A growing number of species and habitat (e.g. MPA) conservation and protection areas exist or are being designated by governments, communities, and NGOs in Indonesia. However, there are still sound reasons for expecting that there will continue to be negative impacts in the short-term on the recovery of hawksbill turtles in Indonesia.

Viet Nam

The status of hawksbill turtles in Viet Nam was described by Hamann et al. (2006). Hawksbill turtles were reported as common in Viet Nam in the early decades of the 20th century (Bourret 1941); however, the situation is very different today. It is clear from several studies that widespread commercial harvest of hawksbill eggs and turtles occurred for many decades. Coupled with widespread use of wildlife for food during periods of military conflict, this harvest has severely impacted local populations of hawksbill turtles (TRAFFIC Southeast Asia-Indochina 2004). In the 1970s and 1980s, there were at least three island groups where local egg collectors could collect around 10 clutches per night, plus adult turtles, to be sold or used for food (Hamann et al. 2006). Recent surveys in these same areas have not found any recent evidence of hawksbill turtle nesting.

Throughout the 1970s and 1980s (and possibly prior), there was a dedicated fishing and collection of wild turtles from inshore waters to supply local or international markets. Indeed, between 1982 and 1985, an average of 17,000 kg of raw turtle shell was exported out of Viet Nam into Hong Kong; an unknown percent of this was hawksbill turtle shell (Groombridge and Luxmoore 1989). In the last 15 years, hawksbill turtles have been considered rare on nearshore reefs, but are often taken opportunistically if caught as bycatch or encountered during the collection of crustaceans and molluscs (Hamann et al. 2006).

The Viet Nam Government has recognised the significance and declining status of hawksbill turtles in Viet Nam, as well as the role of Viet Nam in supporting the international trade. The Vietnamese Government became a signatory to CITES in 1994, the IOSEA MOU in 2001, and prohibited the domestic use of marine turtles in 2002 (Decree 48/2002/ND-CP). In 2004, the Vietnamese Ministry of Fisheries launched the Marine Turtle Conservation Action Plan for Viet Nam to 2010 and a revised plan for 2016 to 2025. The Vietnamese Government and certain NGOs have also implemented several large-scale public awareness and education campaigns, strengthened the monitoring and compliance capacity of regional fisheries staff, and instigated projects to restore habitat and protect hawksbill turtles from capture. In 2019, the Con Dao Islands were included as a site in the IOSEA MOU Network of Sites of Importance for marine turtles in the IOSEA region (see https://www.cms.int/iosea-turtles/en/activities/site-network). One of the stated values was its importance as a site for foraging hawksbill turtles.

Singapore

Singapore National Parks Board (NParks) has recently begun to monitor turtle nesting. In 2018, there were 65 recorded sightings of nesting hawksbill turtles in Singapore: 18 on both East Coast Parkway sections F/G/H and Small Sister Island, 16 on Big Sister Island, five on East Coast Parkway sections B/C, and three on Changi. Data to date indicates that tens of hawksbill turtles breed annually in Singapore. The nesting locations of Singapore are located between rookeries in Melaka and Johor states (Malaysia) and rookeries of the western Java Sea (Indonesia). Genetic-based research is needed to assign these rookeries to a management unit.

The nesting in Singapore predominantly occurs on artificial beaches, which have been created from dredging spoil (C. Limpus, personal communication). Hawksbill turtle nesting is influenced by beach type, vegetation, and light pollution (Wen 2019), and adjacent development, and future security of the nesting sites will need active management of light pollution, and human use of the adjacent waters.

There have not been any other studies on hawksbill turtles in Singapore; however, NParks has initiated a monitoring programme to collect data on nesting parameters, sand temperatures, and genetics, as well as place clutches into protective hatcheries to ensure hatchling production (see https://www.nparks.gov.sg/gardens-parks-and-nature/dos-and-donts/animal-advisories/hawksbill-turtles).

In Singapore hawksbill turtles are protected by National legislation which prohibits the use of turtles or their eggs. Nesting sites are managed and monitored by National Parks Board staff. Each clutch of eggs is recorded and monitored.

Timor Leste

Hawksbill turtles live in the waters of Timor Leste, especially along the northern coastline and islands, which have coral reefs along the shoreline. NGO community turtle monitoring records report hawksbill turtle nesting at Com, Tutuala-Jaco Island, Muapitine, and Lore 1 (in Nino Konis Santana NP) and at Atauro Island. Although it remains unpublished and unquantified it is likely to be low density. No surveys of marine turtles have been conducted in Timor Leste.

Table 8.10. Summary of key issues related to the cumulative loss of turtles and eggs from Indonesia

1	Illegal harvest of eggs by people living or visiting islands for consumption or sale.
2	Potential loss of post-hatchling (immature) hawksbill turtles in ghost nets.
3	Presumed substantial but unquantified mortality of foraging hawksbill turtles in the commercial fisheries of Indonesia, and surrounding nations.
4	Direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale (see CITES).
5	Failure of CITES Signatory States to enforce CITES regulations banning the export of Appendix I listed species, such as hawksbill turtles (CITES 2019; Vuto et al. 2019).
6	Illegal trade in hawksbill turtles, particularly in China and Vietnam, which provides an incentive for developing countries in the IOSEA region to continue illegally harvesting turtles and their scutes (e.g. CITES 2019; Riskas et al. 2018; Gomez and Krishnasamy 2019).

9. Southeast Indian Ocean

Eastern Indian Ocean management unit (Western Australia)

Ecological range

Genetic-based research has been conducted on hawksbill turtle rookeries across northern Australia (Fitzsimmons and Limpus, 2014). The rookeries located along the Western Australian coast form the Eastern Indian Ocean management unit (Figure 9.1). Although all existing data indicate that the management unit is contained within Western Australia, it remains possible that the management unit extends into Timor Leste and southern Indonesia.

Geographic spread of foraging sites

To date, all tag returns from turtles originally tagged at a Western Australian nesting beach and satellite telemetry data from post-breeding female turtles indicate that foraging could be constrained to the Western Australian coastline (i.e. Figure 9.1). However, continued genetic-based research is required to confirm this, especially from foraging areas in Timor Leste and southern Indonesia.

Geographic spread of nesting

The distribution of hawksbill turtle breeding sites in the southern part of the management unit's range has been well investigated over the past three decades. The most significant rookeries are found within the Dampier Archipelago and Montebello Islands. Rosemary Island in the Dampier Archipelago may support the largest number of breeding of hawksbill turtles in the Indian Ocean (Limpus 2009; Pendoley et al. 2016; Fossette et al. 2021a,b). Pendoley et al. (2016) report on 20 years of beach surveys and found 45 nesting sites (Table 9.1). Low density nesting occurs along the Ningaloo coastline (Rob et al. 2019) and low density unquantified nesting has been recorded in the Kimberly coast (Tucker et al. 2018). Genetic analysis has not been conducted on both of these aggregations to ascertain their relatedness to other populations. Hawksbill turtles occasionally nest at Ashmore Reef, but genetic-based analysis has not been conducted to determine if they belong to the Eastern Indian Ocean management unit or a management unit from southern Indonesia (Limpus 2009).

Trends in nesting data

An analysis of capture-mark-recapture data at Rosemary Island suggests that this large nesting population has been approximately stable over recent decades (Prince and Chaloupka 2012; Chaloupka 2013). Twenty years of flipper tagging data also show a stable trend for hawksbill turtle nesting at Varanus Island, a low-density rookery (Prince and Chaloupka 2012). Collectively, monitoring data collected over three decades indicate that the Eastern Indian Ocean management unit is a very large and stable population of hawksbill turtles.

Threats to the population

The threats to this management unit have been well described in the Australian Government's Recovery Plan for Marine Turtles in Australia (Australian Government 2017). Residual risk was determined for each threat, i.e. risk remaining after existing management efforts are considered. One very high risk threat was identified: international take (occurring outside of Australia's jurisdiction). Two high-risk threats were identified: climate change (increased temperatures and sea level rise) and habitat modification. Marine debris entanglement, impacts from pollution, international take within Australia's jurisdiction, domestic and international bycatch, terrestrial predation, light pollution, Indigenous take, noise pollution, and vessel disturbance were all considered moderate-level risks.

Table 9.1. Summary of size of annual hawksbill turtle nesting populations at 45 known nesting beaches in Western Australia (based on Pendoley et al. 2016).

Estimated size of annual nesting population	Number of beaches	Nesting beaches
101-500 tracks/night	1	Rosemary Island
11-100 tracks/night	4	Trimouille Island, Sholl Island Lowendal Islands, Enderby Island, Legendre Island
1-10 tracks/night	23	Ningaloo coastline
Unquantified nesting	17	North Kimberley

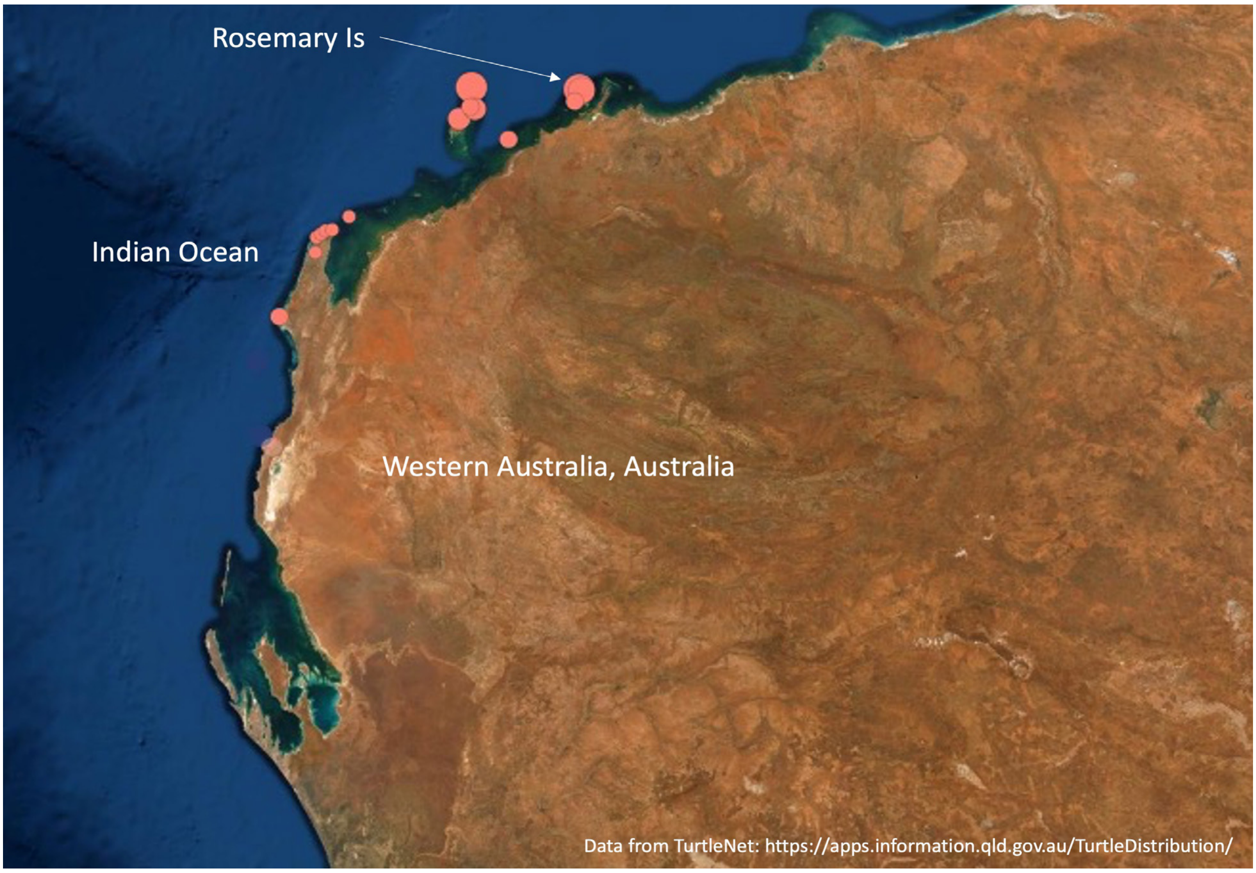


Figure 9.1. Distribution of hawksbill turtle nesting beaches for the Eastern Indian Ocean management unit. Red lines indicate Exclusive Economic Zone (EEZ) boundaries. Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote unquantified nesting. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Management and governance

Nesting rookeries for Eastern Indian Ocean management unit are located within a single state of Australia (Western Australia). The management unit listed as Vulnerable under *Western Australia's Wildlife Conservation Act 1950* and the species is listed as Vulnerable under the *Australian Government's Environment Protection and Biodiversity Conservation Act 1999*, classifying it as a Matter of National Environmental Significance. The index site for the management unit is Rosemary Island.

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Rosemary Island	Island, nesting	Y	Very important	Class A Nature Reserve
Montebello Islands	Islands, nesting	N	Very important	Class A Nature Reserve

Summary of threats to the Eastern Indian Ocean management unit of hawksbill turtles

Type of threat	Known or likely location of impact 1=nesting beach 2=oceanic/high seas 3=coastal foraging areas	Quantified 1=comprehensive documentation across population 2=comprehensive documentation for some of the population 3=non-published/anecdotal evidence only 4=not quantified
Consumption – nesting beach		
Egg collection		3
Commercial use of turtles		2
Non-commercial use of turtles		2
Predation of eggs by non-native fauna		3
Predation of eggs by native fauna	1	4
Consumption – foraging turtles		
Commercial use of turtles		4
Non-commercial use of turtles		4
Climate change impacts		
Increasing beach temperature	1	4
Beach erosion	1	4
Sea level rise	1	4
Coastal development		
Habitat modification (urban)		2
Habitat modification (industrial)	1	2
Light horizon disorientation	1	2
Fisheries impacts		
Bycatch – trawl		4
Bycatch – longline		4
Bycatch – gillnet		4
Impact to benthic ecology from fisheries	3	4
IUU fishing		4
Pollution		
Water quality	3	4
Entanglement in discarded fishing gear	2,3	2
Ingestion of marine debris	2,3	3
Noise pollution	3	4
Disease and pathogens	3	4

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	unknown	
Remigration interval	3.7 (1.2) years	Limpus (2009)
Clutches per season	unknown	
Mean size of nesting adult (CCL)	unknown	
Age at maturity	~30 years	Limpus (2009)

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging) (CCL)	unknown	
Growth rates	unknown	
Survivorship estimates	Adult female annual survivorship 95%	Prince and Chaloupka (2012)

10. Southwest Indian Ocean

This RMU encompasses immense maritime and coastal areas including 10 geopolitical entities. In three cases, in-country distances between distant islands exceed 1,000 km: Mauritius – Mauritius to Agalega > 1,100 km; Seychelles – Mahé to Aldabra > 1,130 km; French Overseas Territory – Tromelin to Europa > 1,020 km. If it is common for hawksbill rookeries separated by at least 500 km to be genetically distinct (Vargas et al. 2016), then certain island nations (or territories) could potentially support multiple hawksbill turtle management units. However, that conclusion requires further detailed genetic analysis of rookeries that have yet to be studied, particularly given limitations when relying solely on the usual analysis of mtDNA control region (Shamblin et al. 2017, 2020).

The Southwest Indian Ocean area has been recognised as an important region for hawksbill turtles (Frazier 1982; Meylan and Donnelly 1999; Mortimer and Donnelly 2008; Mortimer et al. 2020). Genetic-based research on hawksbills from this region has identified at least one genetically-distinct management unit comprising rookeries in the granitic Amirante Islands (Seychelles) as well as the Chagos Archipelago (Vargas et al. 2016); this population accounts for around 97% of known hawksbill turtle nesting in the Southwest Indian Ocean (Mortimer et al. 2020). Turtle monitoring surveys over the past four decades have also identified hawksbill turtle nesting in Comoros, Madagascar, Mozambique, Tanzania, Kenya, Mauritius, two French Overseas Departments (Mayotte and La Réunion), and the French Overseas Territory of Scattered Islands and Banks (Frazier 1984). There has been insufficient genetic research on hawksbills from these sites to know whether they form a separate genetic stock or whether they are aligned to the Seychelles/Chagos management unit (Vargas et al. 2016; Mortimer et al. 2020). One study by Anastácio et al. (2017) sampled 57 turtles from the Vamizi nesting population in northern Mozambique and reported 14 different mtDNA haplotypes, of which 12 were new and 2 were already reported (Ei_15 and Eij14). The continued sampling of rookeries in this region of the Southwest Indian Ocean under the INTERREG V project is likely to reveal important information about genetic population structure, and possibly new hawksbill management units.

Western/Central Indian Ocean management unit

Ecological range

The Western/Central Indian Ocean management unit was identified using samples collected from rookeries in Chagos and Seychelles (Vargas et al. 2016; Arantes et al. 2020), which collectively hold over 90% of the nesting in the region. Thus, it is possible that more than one management unit exists in the Southwest Indian Ocean. It is likely that turtles from this management unit reside and forage at sites throughout the Southwest Indian Ocean.

Geographic spread of foraging sites

Genetic-based studies indicate that most of the turtles foraging at Chagos and Seychelles also nest in these countries (Mortimer and Broderick 1999).

Geographic spread of nesting

In Seychelles, hawksbill turtle nesting distribution and abundance has been documented since the 1970s (Frazier 1975; Mortimer 1984). Hawksbill nesting occurs primarily in the Inner Islands and the Amirante Islands groups of Seychelles but also in lower numbers in the remote southern islands (Mortimer 1984; Groombridge and Luxmoore 1989; Mortimer and Day 1999; Mortimer 2004; Mortimer 2020a; Mortimer 2020b; Mortimer 2020c; Mortimer 2020d; Mortimer et al. 2020) (Table 10.1, Figure 10.1).

In the Chagos Archipelago, hawksbill nesting occurs across all the island atolls, but 90% of nesting occurs on Diego Garcia and Peros Banhos atolls (Sheppard et al. 2012; Mortimer et al. 2020). Low levels of hawksbill nesting have been observed in most of the countries and territories in the Southwest Indian Ocean, such as Kenya, Tanzania, Mozambique, Madagascar, Mauritius, Comoros, Mayotte, La Réunion, Tromelin, and Europa (Figure 10.1). It is not yet known whether these rookeries are part of the same management unit.

Trends in nesting data

In the 1980s, an estimated 1,230 to 1,740 female hawksbill turtles bred each year in the Seychelles (Mortimer 1984). However, 30 years of near-total harvest of nesting turtles severely impacted the status of the population, with an estimated 47 to 71% of the estimated annual nesting population killed between 1980 and 1982 (Meylan and Donnelly 1999). But turtles received a degree of protection at two special reserves, Aride Island and Cousin Island, within the Marine Parks of Sainte Anne and Curieuse Islands, and at Aldabra Atoll in the southern islands (Mortimer 1984). The number of turtles breeding at Cousin Island in the 1970s and 1980s averaged 32 females per year (Mortimer 1984; Allen et al. 2010) and, in response to the end of the legal Japanese import of hawksbill shell in 1992 (Mortimer and Donnelly 2008), this increased to an average of 248 turtles (714 clutches) per year between 2007 and 2008 (Allen et al. 2010). On nearby Cousine Island (privately owned), hawksbill monitoring began in 1992 and indicated that around 64 clutches (from around 30 females) were laid per year (range 21 to 103) between 1995 and 1998 (Hitchins

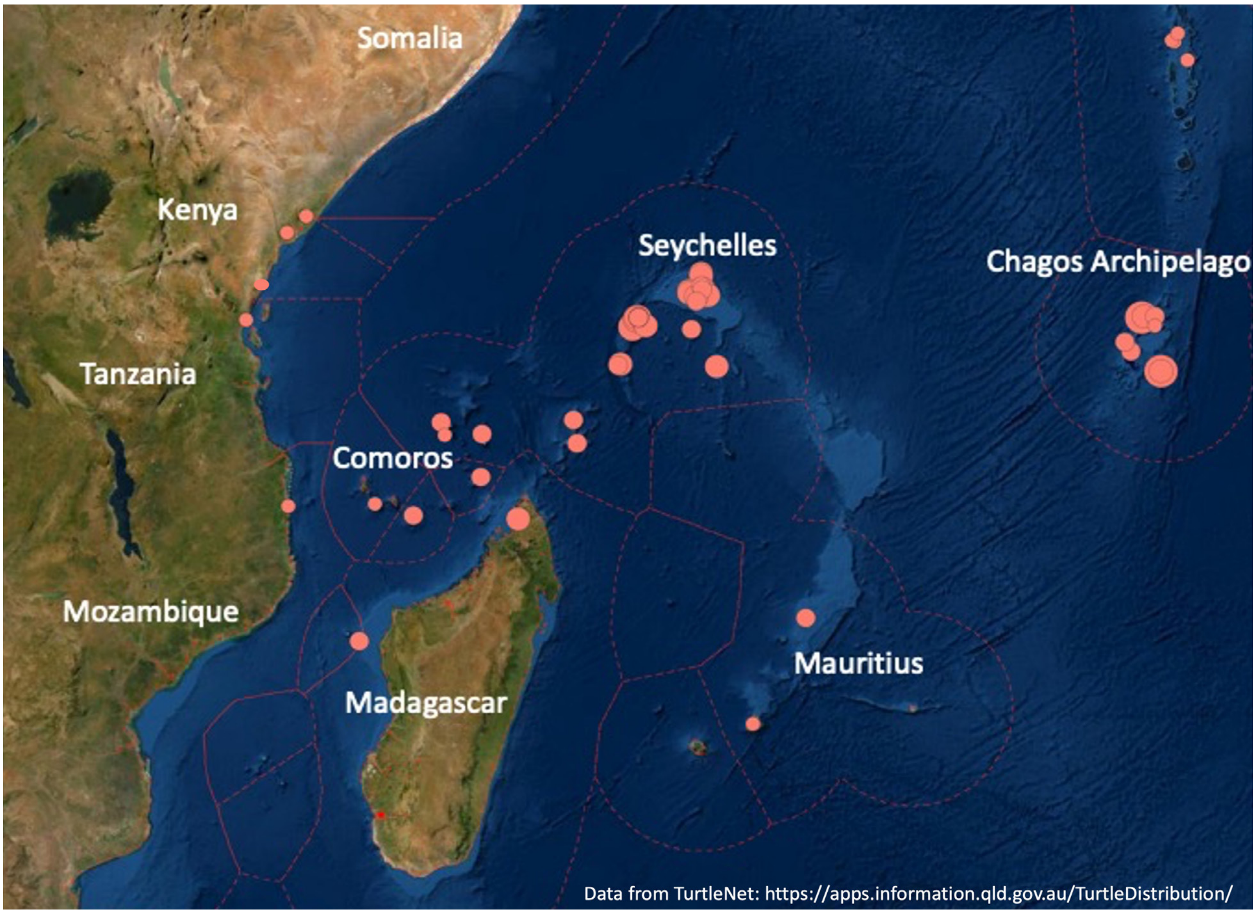


Figure 10.1. Distribution of hawksbill turtle nesting beaches for the Western/Central Indian Ocean management unit and additional hawksbill turtle rookeries of the South and West Indian Ocean. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Index nesting beaches: Seychelles: There are more than 20 sites (>11 islands in the Granitic Group; >9 islands in the outer islands) with long-term, year-round projects that monitor nesting hawksbills (and green turtles). Most of these projects have been operating for 10 to 50 years (see Table 10.1). New sites are regularly added to the monitoring programme with more planned in the outer islands.

Chagos: Diego Garcia – published from 1996 to 2021 (described in Mortimer et al. (2020)).

et al. 2004a, b), 104 clutches per year (range 60 to 230) between 2004 and 2013 (Gane et al. 2020) and 150 clutches per year in 2018 and 2019. On Curieuse Island, data collected from 2010 to 2015 indicate around 380 nesting emergences annually (Burt et al. 2015), which is an increase of about 50% over numbers recorded in 1983 (Mortimer 2004). However, this apparent increase may not reflect an actual increase in the turtle population so much as a decline in poaching (i.e. enabling more turtles to lay a full complement of egg clutches within a season). On Aride Island Special Reserve, hawksbill turtles have been monitored since 1976 and with consistent methods since 1981. The number of clutches recorded annually at Aride Island between 1976 and 2000 ranged from 2 to 25 (Mortimer 2004), but in recent years has been more than 75 in some years (Island Conservation Society, unpubl. data).

D'Arros Island and adjacent St Joseph atoll, in the Amirantes Group of the Seychelles, are managed as a unit by Save Our Seas Foundation, and year-round surveys of nesting turtles between 2004 and 2017 indicate an upward trend with almost 1,000 clutches laid annually by an estimated 250-325 females (Mortimer et al. 2011; Mortimer 2017). D'Arros/St Joseph are thus among the most important sites for nesting hawksbills in the western/central Indian Ocean region.

Summarising data from the Seychelles, Mortimer and Donnelly (2008) highlight the value of protection. They report on data collected across the 22 inner islands of the Seychelles between 1981 and 2003, indicating that the number of females nesting each year declined from an estimated 820 in the early 1980s to 625 in the early 2000s. However, the number of nesting turtles increased by 389% at the two well-protected strict nature reserve

Table 10.1. Index nesting sites within the IOSEA region.

Index Sites	Years monitored	Trend (I=Increasing, D=Decreasing, S=Stable)	Importance: # clutches/yr: 1-100; 101-500; 501-1,000.	Citations
Inner Islands				
Aride Island	45: 1976-2021	I	1-100	a, b, m, l
Cousin Island	51: 1970-2021	I to S?	501-1,000	a, b, d, l
Cousine Island	29: 1992-2021	I to S?	101-500	a, b, c, h, l
Sainte Anne MP	38: 1981-2019	S	101-500	a, b, l, u
Curieuse Island MP	40: 1981-2021	I	101-500	a, b, f, l
Bird Island	24: 1995-2019	I	101-500	a, b, l. n
Denis Island	8: 2010-2018	S?	101-500	a, b, l, o
North Island	23: 1998-2021	I	101-500	a, b, l, p
Silhouette Island	16: 2005-2021	S?	101-500	a, b, l, m
Fregate Island	15: 2006-2021	S?	101-500	a, b, l, q
Praslin Island (NW)	21: 1998-2019	D	1-100	a, b, l, r
Mahé Island (S)	26: 1995-2021	D	1-100	a, b, s, l
Amirantes Group				
Desroches island	12: 2009-2021	I	101-500	a, j, l, m
D'Arros Island	17: 2004-2021	I	101-500	a, e, g. l
St Joseph Atoll	17: 2004-2021	I	501-1,000	a, g, l
Alphonse Island	15: 2006-2021	I	1-100	a, i, l, m
Saint Francois Atoll	15: 2006-2021	I	101-500	a, i, l, m
Southern Islands				
Farquhar Atoll	8: 2014-2021	D?-S?	1-100	a, k, l , m
Aldabra Atoll	38: 1981-2021	S?	1-100	a, b, t, l

Citations: [a]Mortimer 1984; [b]Mortimer 2004; [c]Hitchins et al. 2004a, b; [d]Allen et al. 2010; [e]Mortimer et al. 2011; [f]Burt et al. 2015; [g]Mortimer et al. 2017; [h]Gane et al. 2020; [i]Mortimer 2020a, [j]Mortimer 2020b, [k]Mortimer 2020c, [l]Mortimer et al. 2020; [m]Island Conservation Society, unpubl. data; [n]Bird Island Lodge, unpubl. data; [o]Denis Island, unpubl. data; [p]North Island, unpubl. data; [q]Fregate Island Private, unpubl. data; [r]Lemuria Hotel, unpubl. data; [s]Marine Conservation Society Seychelles, unpubl. data.; [t]Seychelles Islands Foundation, unpubl. data.; [u]Franc 2018.

islands, and the size of the nesting population declined by 21% and 59% at the seven intermediately-protected islands and the 13 non-protected islands, respectively. These disparities highlight both the value of site-based protection of beach habitats and turtles, and the lengthy temporal delays between initiation of conservation interventions and population recovery. Current monitoring of hawksbill turtle nesting sites occurs and is managed through several governmental, NGO, tourist industry, private island owners, and community partnerships across some 20 sites (across more than 30 islands).

In the Chagos Archipelago, the nesting population was substantially impacted by the direct killing of nesting turtles to supply the global trade in turtle shell. Indeed, according to Mortimer (2009; cited in Sheppard et al. (2012)) a reported average of 222 kg of hawksbill turtle shell was exported annually from Chagos between 1900 and 1946 (equivalent to ~111 adult-sized hawksbill turtles per year) (Mortimer 2009; Sheppard et al. 2012). Mortimer and Day (1999) estimated the annual nesting population to be between 300 and 700 in the 1990s. Mortimer (2007) reported little change in the numbers of hawksbill turtles nesting in four atolls between 1996 and 2006 (and a slight increase at Diego Garcia), and Mortimer et al. (2020) report an estimate of 6,308 clutches laid annually between 2011 and 2018, an increase of two to five times above the estimated 1996 nesting abundance. Mortimer et al. (2020) estimate that the Chagos Archipelago accounts for 39 to 51% of hawksbill turtle nesting in the Southwest Indian Ocean.

When combined, the Seychelles and Chagos Archipelagos account for 97% of known hawksbill nesting in the Southwest Indian Ocean. While there are positive signs regarding current and predicted recovery and status, the nesting populations of Chagos and Seychelles likely have not yet fully recovered to pre-1900 baseline levels.

Migration and distribution of foraging areas

To date all adult post-nesting hawksbill turtles satellite-tracked from nesting beaches in the southwest Indian Ocean rookeries have remained in the southwest Indian Ocean. Adult females tracked from islands in Seychelles tended to remain in Seychelles waters (Mortimer and Balazs 2000; unpublished data Save Our Seas Foundation and Island Conservation Society). Similarly, adult post-nesting hawksbills satellite tracked from nesting beaches in the Chagos Archipelago have remained within the Chagos Marine Protected Area. Satellite tracking studies of hawksbill turtles are currently demonstrating the importance of the Great Chagos Bank and submerged banks for hawksbills nesting in the Chagos Archipelago. The relatively deeper (>10 m depth) submerged banks (e.g., Pitt Bank, Centurion Bank) also provide important foraging habitat for hawksbills (Esteban et al. 2021).

Satellite and flipper tagging of immature hawksbills in the region have provided evidence of some long-distance habitat shifts. An immature turtle tagged on the reefs of Cocos Keeling in 2003 was recorded stranded, dead, 6000 km away in Tanzania (Whiting et al. 2010). Similarly, a juvenile hawksbill tagged on St Joseph Atoll in 2013 and last recorded there in 2014, was recaptured 11 months later in Kenya. Two immature hawksbills tagged at Aldabra Atoll were later recaptured ~1000 km away as adult-sized animals. These records suggest long-distance developmental migration (Mortimer et al. 2010, Von Brandis et al. 2017). Likewise, in the Chagos Archipelago, satellite tracking of immature hawksbills at Diego Garcia atoll indicated that while most of the 21 tracked turtles remained within a very restricted area, three of them travelled distances of 100s of km from the tagging site (Hays et al., in 2021b). In the absence of genetic-based research these movements indicate connectivity between rookeries of Seychelles, Chagos, and the broader southwest Indian Ocean.

Threats to the population

The widespread and systematic harvest of hawksbill turtles for shell has essentially been controlled in the Seychelles and Chagos Archipelagos (Allen et al. 2010; Mortimer et al. 2020).

Although the threats to the Western/Central Indian Ocean management unit of hawksbill turtles are known, they have not been comprehensively assessed in most of the region. Issues of concern vary across the region and beaches, and they include predation of eggs by predators such as rats, habitat change and development, climate change impacts related to increased air temperatures and their likely influence on hatchling sex ratios, sea level rise and its influence on beach/dune systems, and the ingestion of, or entanglement in, marine debris. Important nesting sites in Seychelles are threatened by planned coastal development. Examination of the degree to which these threats may impact hawksbill turtles from the Western/Central Indian Ocean management unit is required.

While protection and management of hawksbill turtles within the Seychelles and Chagos Archipelagos are sound, the long-term security of the management unit could be affected by the cumulative loss of turtles and/or eggs across the probable range of the Western/Central Indian Ocean management (Table 10.2) or loss of nesting habitat. There are currently no clear indications of when or how these threats can be addressed; therefore, continued conservation and monitoring attention is warranted.

Management and protection

Hawksbill turtles and their nesting habitats are protected by domestic legislation in the Seychelles and Chagos Archipelagos. In Seychelles, killing of any marine turtle has been illegal under national legislation since 1994 (Mortimer and Collie 1998). Except for Diego Garcia, islands of the Chagos Archipelago have been uninhabited since the early 1970s. In 2010, the Chagos islands were included in a very large and successful no-take marine protected area, the British Indian Ocean Territory Marine Protected Area (BIOTMPA) (see Mortimer et al. 2020 and Hays et al. 2020), which protects turtles from human use and helps mitigate other pressures. However, as turtles from this stock use foraging areas outside of Seychelles and Chagos, legal protection from use, or enforcement of legislation, is not always afforded.

Biological data – breeding

Although nesting activity has been recorded in all months of the year, the nesting season for hawksbill turtles in Seychelles and Chagos primarily occurs from October to February (approximately 85% of nesting activity) with a peak in November/December (Mortimer and Bresson 1999; Gane et al. 2020; Mortimer et al. 2020). The peak of nesting roughly coincides with the northwest monsoon, which brings higher monthly rainfall to the region (Mortimer and Bresson 1999). In terms of annual variation in the onset of the nesting season, 10 years of monitoring at Cousine Island in the Seychelles indicates that the first clutch of the season is typically laid between 4 August and 16 October, and the last clutch is laid between 26 January and 21 April (Gane et al. 2020); and similar patterns have been recorded elsewhere in both Seychelles and Chagos. Unlike most other hawksbill turtle populations, nesting activity in the region occurs primarily during the day. Using monitoring data from 1976 to 1992, Mortimer and Bresson (1999) report 85% of clutches are laid during the day, with a peak between 1400 and 1600 hours.

Biological data – foraging

The ecology of foraging hawksbill turtles was the topic of a 2010 PhD project (see von Brandis 2010; et al. 2010). Individual turtles had small home ranges and showed strong site fidelity. On the reef slope they foraged on sponges, primarily two species of demosponge and four species of algae. Turtles typically used one of three techniques to obtain food: lifting (using the head to shift substrate), beak crushing, and flipper ripping. Lifting and beak crushing are the most commonly-used techniques. Von Brandis et al. (2010) investigated diving behaviour of juvenile hawksbill turtles and found dive times averaged approximately 30 minutes (range 10 to 62 minutes) and were relatively shallow (<20 m), with the turtles spending approximately 75% of their underwater time stationary and foraging. Other foraging turtle data is summarised below.

Broader Southwest Indian Ocean

(Comoros, Kenya, French Overseas Department of Mayotte, French Overseas Department of La Réunion, French Overseas Territory of Scattered Islands and Banks, Madagascar, Mauritius, Mozambique, Tanzania, Seychelles outer Islands)

Geographic spread of foraging sites

Each of the countries (and many of the islands) in the Southwest Indian Ocean have considerable areas of coral or rocky reefs, which offer the type of habitat used by hawksbill turtles. Thus, hawksbills probably occur in most coastal waters and coral reef-fringed

Table 10.2. Summary of key issues related to the cumulative loss of turtles and eggs from the Western/Central Indian Ocean management unit of hawksbill turtles

1	Illegal slaughter of females or harvest of eggs by people living or visiting non-protected islands for consumption or sale, or loss of eggs from predation by native or introduced species across the range of the management unit
2	Potential loss of post-hatchling (immature) hawksbill turtles in ghost nets or other discarded fishing gears, including FADs
3	Presumed substantial but unquantified mortality of foraging hawksbill turtles in the commercial fisheries of the Southwest Indian Ocean and eastern Africa
4	Direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale, particularly in Madagascar and Mozambique (CITES 2019)
5	Presumed substantial but unquantified mortality arising from ingestion of plastic marine debris, or interference to nesting activity or hatchling emergence or incubation of egg clutches caused by plastic debris on nesting beaches.
6	Destruction of nesting habitat caused by unregulated coastal development for tourism (Seychelles) and sea level rise (especially Chagos).

Summary of threats to the Western/Central Indian Ocean management unit of hawksbill turtles

Type of threat	Known or likely location of impact 1=nesting beach 2=oceanic/high seas 3=coastal foraging areas	Quantified 1=comprehensive documentation across population 2=comprehensive documentation for some of the population 3=non-published/anecdotal evidence only 4=not quantified
Consumption – nesting beach		
Egg collection		
Commercial use of turtles		
Non-commercial use of turtles		
Predation of eggs by non-native fauna	1	2
Predation of eggs by native fauna	1	2
Consumption – foraging turtles		
Commercial use of turtles		
Non-commercial use of turtles		
Climate change impacts		
Increasing beach temperature	1	4
Beach erosion	1	3
Sea level rise	1	3
Coastal development		
Habitat modification (urban)	1	2
Habitat modification (industrial)		-
Light horizon disorientation	1	3
Fisheries impacts		
Bycatch – trawl	3	3
Bycatch – longline	2,3	3
Bycatch – gillnet	3	3
Bycatch – FADs	2,3	2,3
Impact to benthic ecology from fisheries	3	4
IUU fishing	4	4
Pollution		
Water quality	2	4
Entanglement in discarded fishing gear	2,3	2,3
Ingestion of marine debris	2	4
Noise pollution	2	4
Disease and pathogens	2	3

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	unknown	
Remigration interval	2 to 3 years	Mortimer and Bresson 1999
	3.7 years (n=9)	Dugdale 2001
Clutches per season (mean/median/mode)	3.6/4/5	Mortimer and Bresson 1999
	3 to 5	Hitchins et al. 2004
Mean size of nesting adult (SCL)	81.2 cm	Hitchins et al. 2004
Clutch size	176 eggs	Hitchins et al. 2004
Incubation period (days)		
1995 to 1999	58.1 (50 to 69)	Hitchins et al. 2006
2004 to 2013 clutches in full sun	57.8 (54 to 61)	Gane et al. 2020
2004 to 2013 clutches in partial sun	59.2 (57 to 68)	Gane et al. 2020
2004 to 2013 clutches in full shade	59.8 (57 to 66)	Gane et al. 2020
Hatching success (natural nests)	61%	Hitchins et al. 2006
Emergence success (natural nests)	57%	Hitchins et al. 2006
	60%	Gane et al. 2020
Predation of eggs by crabs (natural nests)	19.3%	Hitchins et al. 2006
	7% (0.4 to 25)	Gane et al. 2020
Age at maturity	unknown	

habitats throughout the region (Bourjea et al. 2008; Chassagneux et al. 2013; PNA TM SOOI 2014; Williams et al. 2015). While there are few studies (not yet published, e.g. La Réunion, Mayotte) on foraging hawksbill turtles in the region, there are several dive industry-based citizen science projects that collect sightings data on marine megafauna, such as hawksbills (e.g. Mozambique; Williams et al. 2015), and there is a growth in the use of photo-identification techniques to identify individual turtles foraging at dive sites. In Watamu (Kenya), a local NGO runs a bycatch mitigation programme; juvenile hawksbill turtles make up a significant portion (>15%) of the rescued turtles and data suggests that there is a resident population (Zanre 2005; Oman 2013; C. van de Geer, personal communication). Fishers in the Quirimbas Archipelago and the Primeiras and Segundas Archipelago (Mozambique) also incidentally catch hawksbill turtles on a regular basis, indicating that hawksbills may be foraging in these areas (Costa et al. 2007; Garnier et al. 2012; Anastacio et al. 2017). Stomach contents of an immature individual from Mohéli (Comoros) revealed four types of sponges (Frazier 1985). Unpublished evidence and research by Humber indicate that Madagascar is likely to be far more important for foraging than it is for nesting for all marine turtle species. Despite nesting populations generally declining as a result of collection pressure, there have been no detectible declines in catch rates over the last few decades.

Geographic spread of nesting

Mozambique: In the past, hawksbill nesting on Vamizi Island in the Quirimbas Archipelago supported an estimated 1 to 10 nesting females per year and key beaches were Comissette and Farol (Garnier et al. 2012; Anastácio et al. 2017). However, no new nesting has been reported since the 2012/13 season (Louro and Fernandes 2013). On Vamizi Island, both Comissette and

Parameter	Value	Reference(s)
Smallest size of foraging turtles (CCL)	32.6 cm	Mortimer et al. (2003)
Growth rates (Seychelles) (CCL)		Mortimer et al. (2003)
30-40	2.8 cm/year (n=1)	
40-50	2.3 cm/year (n=4)	
50-60	2.1 cm/year (n=6)	
60-70	1.5 cm/yr	
2.7 cm/yr	2.4 cm/year (n=5)	
3.2 cm/yr	No data	
3.7 cm/yr		
70-80	1.6 cm/yr	
Mixed size classes	1.14 cm/yr	von Brandis (2010)
Chagos CCL	0.7 to 2.7 cm/yr	Mortimer et al. (2002)
Survivorship estimates	unknown	

Farol were monitored between 2002 and 2010 during the peak months of the nesting season (December and January). The number of clutches laid on each beach averaged 2.2, the average clutch size was 128 eggs, and the average incubation period (from 35 clutches) was 60.9 days (Garnier et al. 2012). Interestingly, the clutches laid on the north-facing Comissette beach had a shorter incubation period (56.9 days) than those laid on the south-facing Farol beach (62.7 days) (Anastácio et al. 2017). Lower level, scattered nesting has been known to occur on the other islands in the Quirimbas National Park, such as Rongui Island (Barr and Garnier 2005; Humber et al. 2017), the Bazaruto Archipelago (Fernandes et al. 2018a; Leeney et al. 2020), and at Cabo de São Sebastião (Fernandes et al. 2017).

Comoros and Mayotte: The islands of Comoros and Mayotte are likely to support small numbers of nesting hawksbill turtles: Comoros (10 to 50 females per year) and Mayotte (10 to 50 females per year) (Project Biodiversity 2000). Mortimer et al. (2020) provide a similar estimate for Mayotte of 11 to 100 clutches per year. Current abundance of nesting females is likely to be lower than it was in the 1970s (Mortimer and Donnelly 2008).

Scattered Islands (Îles Éparses): Juan de Nova supports around 50 nesting females per year (Lauret-Stepler et al. 2010), also reported by Mortimer et al. (2020) as 11 to 100 clutches per year (literature review). Hawksbill turtles nest all year, with a distinct summer (December and January) peak. Occasional nesting by hawksbill turtles has been recorded on Tromelin and Îles Glorieuses.

The Comoro Archipelago, comprising four major volcanic islands, includes the Union of the Comoros (including Grand Comore, or Ngazija; Mohéli, or Mwali; and Anjouan, or Ndzuani) and the French Overseas Department of Mayotte. These islands are thought to support small to moderate numbers of nesting hawksbill turtles. In 1972, signs of nesting were recorded from at least 14 beaches on Mohéli, primarily in the south, over the five-month period during field work, and from 4 beaches at Mayotte (Frazier 1985). Occasional hawksbill nesting is still observed on beaches of Itsamia, Mohéli (Innocenzi et al. 2010). Mayotte is estimated to have 10 to 50 females nesting per year (Mortimer and Donnelly 2008); Mortimer et al. (2020) provide a similar estimate for Mayotte. Current abundance of nesting females is likely to be lower than it was in the 1970s (Mortimer and Donnelly 2008). Hawksbill nesting in the Comoro islands is concentrated in the first four metres above the high tide line, and typically in areas of low vegetation (Frazier 1985).

Mauritius: Hawksbill turtles were heavily exploited in Mauritius until they were legally protected in 1998. There appear to be no recent records of nesting on either Mauritius or Rodrigues. St Brandon is estimated to support 150 clutches per year (Mortimer et al. 2020). It is unlikely that more than a few hawksbills nest annually on Agalega Island, but when encountered, nesting turtles are killed (Webster et al. 2016).

Madagascar: As with other marine turtle species, the number of hawksbill turtles nesting in Madagascar is likely to have declined due to consistent commercial exploitation of turtles and eggs (Humber et al. 2017). Indeed, Hughes (1973) estimated mortality at around 600 adult hawksbill turtles per year in the early 1970s. From survey data collected in 1989 estimating a total annual catch of 11,061 turtles (all species) (Rakotonirina 1989), Rakotonirina and Cooke (1994) report that hawksbill turtles were the 'most represented' of an estimated 5,880 annual turtle captures in Antsiranana (far north), 'rarely caught' in Toliara (southwest, 1,918 captures) and Mahajanga (northwest, 3,990 captures) and absent from Morondava (west, 273 captures). These figures suggest total annual captures of hawksbill turtle are in the 3,000-4,000 range, subject to correction for fisher exaggeration. Nosy Iranja Kely, an island in the northwest of Madagascar, was surveyed between August 2000 and November 2004 (with a 10-month hiatus in 2002). A total of 76 hawksbill nests were found (~17 per year), and thus the island is likely to support <10 females per year (Bourjea et al. 2006). Metcalf et al. (2007) report an estimated 230 hawksbill turtle nesting sites in northwest Madagascar, including in the Nosy Hara region (between 101 and 500 clutches per year) and the Radama Islands (<50 clutches per year). On Nosy Ankazoberavina, (close to Nosy Iranja), analysis of hawksbill turtle nesting data collected by the island's manager between 2009 and 2016 indicate a total of 534 nests, ranging from 56 to 111 annually (M. Felici/A. Cooke/Kelonia, unpublished data). Low abundance of hawksbill turtle nesting was reported in the west (Maintirano and Soalala), and northeast (Vohémar and Tanambao) (Rakotonirina and Cooke 1994). Extrapolating from available habitat, it was estimated that fewer than 3,000 hawksbill clutches are laid per year in Madagascar (Mortimer et al. 2020), although an earlier estimate based on a variety of indirect evidence gave a figure of just 220 annual hawksbill clutches (Humber et al. 2017). It is worth noting that these northwestern islands represent some of the best managed and protected turtle nesting beaches in Madagascar.

Tanzania: Hawksbill turtles nest along the coast from north to south, but particularly on offshore islands such as Misali, Pemba, small islands off Dar es Salaam, small islands such as Mnemba off Unguja (Zanzibar), Shungimbili (Thanda) northwest of Mafia Island, and Songo Songo in the south of the country (Muir 2005). A total of 42 hawksbill nests were reported on Misali Island between 1998 and 2002: nesting was year-round but peaked in March, clutch size averaged 155, and average hatching success was 78% (Pharaoh et al. 2003). From 2002 to 2016, annual hawksbill nests on Misali varied from 0 to 10, showing a decreasing trend (Giorno and Herrmann 2016). At Mafia Island, 12 hawksbill nests were recorded between 2001 and 2004, 10 of which were on Shungimbili (Muir 2005). Limited nesting may occur on smaller, uninhabited islands such as those in the Songo Songo Archipelago, but nests are likely to go unreported (West 2010). Other hawksbill nesting records from Tanzania show similar or even lower numbers (e.g. Khatib 1998; Muir 2005). Maziwe Island, offshore of Pangani, was formerly considered to be the most important nesting site (Frazier 1976), but this was washed over in 1992, and Misali Island (off Pemba Island) has since been regarded as one of the most important hawksbill sites (Bourjea et al. 2008). Details of reproductive biology of Maziwe Island hawksbills are summarised in Frazier (1984).

Hawksbill turtles nest on the coastal islands but no reports of hawksbill nesting on the mainland exist. These coastal islands include Misali, Mafia, and Shungimbili (Pharaoh et al. 2003; Muir 2005; Giorno and Hermann 2016). Combined data from Pharaoh et al. (2013) and Giorno and Herrmann (2016), which spans 1998 to 2015, demonstrate that Misali Island hosts a small and decreasing nesting population. For most recent available data (2011-2016), an average of 6 clutches were reported per year (range: 3-10) (Giorno and Herrmann 2016).

Kenya: Hawksbill turtle nesting has been recorded along much of the coast, but especially the Kiunga region, Watamu, and the Lamu Archipelago (Okemwa et al. 2004; Olendo et al. 2017a). However, nesting activity was low and possibly declining. The last recorded hawksbill nesting events in Mombasa and Watamu were in 2009 and 2002, respectively (Haller and Singh 2018; Local Ocean Conservation, unpublished data). In Kiunga, 31 nests were recorded during 10 years of surveys between 2002 and 2012, primarily on the beaches of Kiwayu, Mkokoni, and Rubu (Olendo et al. 2017a).

Migration and distribution of foraging areas

In 2008, a single adult female hawksbill turtle was tracked using a satellite tag from the Kiungu region of Kenya by a local NGO. She migrated south to a coastal foraging area adjacent to the Kenya/Tanzania border—a distance of around 450 km. Another inshore migration was recorded from Watamu to Funzi, which is approximately 150 km south (Zanre 2005). There are three records of migrations from Seychelles to the continental African east coast, namely to Kenya (von Brandis et al. 2017), Tanzania (J. Mortimer, unpublished data), and northern Mozambique (unpublished data quoted in von Brandis et al. 2017). It is likely that hawksbill turtles in this region of the Indian Ocean are from the larger nesting aggregations in Seychelles and Chagos. A juvenile hawksbill turtle tagged in the Cocos Keeling

Islands (Australia) in 2003 was found dead in a fishing net in southern Tanzania five years later, over 6,100 km from the original capture location (Whiting et al. 2010). One turtle was tagged in South Africa in 2013 and later migrated to the northeastern coast of Madagascar, where it was tracked for about one year, when the satellite tag stopped working (R. Nel, unpublished data). There is an unpublished account (contact David Rowat, MCSS) of a nesting female satellite tracked from Seychelles (Mahé) to the northwest of Madagascar.

Threats to the population

Incidental and intentional capture in various fishing operations is widespread in this region. Accidental capture in gillnets from commercial and artisanal fisheries is a significant threat to hawksbill turtles of the region. At Vamizi Island in Mozambique, Anastácio et al. (2017) indicate that 104 juvenile hawksbill turtles (average SCL of 42 cm) were caught by hand or accidentally in nets between 2004 and 2009. Similarly, analysis of the data from market and fisheries surveys in Madagascar indicates that most of the 24 hawksbill turtles caught and retained by fishers were immature (mean CCL of 50.6 cm, range 31 to 89 cm). Around half of the turtles in the Madagascar sample were caught using spears or harpoons and 30% were caught by nets designed to catch turtles and elasmobranchs (Humber et al. 2011). Net fishing accounts for >80% of the bycatch incidents (Zanre 2005) and marine turtle strandings in Tanzania between 2007 and 2013, which included 76 hawksbills (West and Hoza 2014). In Madagascar, Kenya, Mozambique, and Tanzania, coastal development is impacting existing and possible future nesting habitats, and accidental capture in gill and bottom trawl nets from commercial and artisanal fisheries is a significant threat. Threats in Mayotte and La Réunion include commercial and artisanal coastal fisheries and boat strikes, and at least 13 poached turtles have been observed in Mayotte from 2011 to 2019. Products made from hawksbill scutes are reported regularly at curio/souvenir markets (IOSEA 2014; Olendo et al. 2017b; Fernandes et al. 2018b).

11. Northwest Indian Ocean

The Northwest Indian Ocean includes the Persian Gulf management unit (FitzSimmons and Limpus 2014; Tabib et al. 2014; Vargas et al. 2016; Natoli et al. 2017), plus likely management unit(s) in the Red Sea and the Maldives.

Persian Gulf management unit

The first systematic survey of marine turtles in the Persian Gulf was conducted by Kinunen and Walczak (1971). Later, Ross and Barwani (1982) and Groombridge and Luxmoore (1989) reviewed the status of hawksbill turtles in the Persian Gulf and the Gulf of Oman/Arabian Sea. Gasperetti et al. (1993) summarised the older records from the region, including museum specimens. Miller (1989) and Pilcher (1999) conducted the initial biological studies of hawksbill turtles in the Persian Gulf. Since these reports were published, information on hawksbill turtles in the Gulf has been increasing (Phillott and Rees 2020).

Ecological range

Within the relatively small geographic area of the Persian Gulf and the Gulf of Oman/coastal Arabian Sea, there may be more than one management unit of hawksbill turtles. Three nesting areas in the Persian Gulf have been sampled for genetic composition: two in Iran and one in Saudi Arabia. The two rookeries sampled in Iran are genetically distinct, but both are not distinct from the Jana Island rookery in Saudi Arabia (FitzSimmons and Limpus 2014; Tabib et al. 2014; Vargas et al. 2015, Natoli et al. 2017). More sampling is required to define the genetic relationships in this region. No studies have been conducted to determine the extent of hatchling and post-hatchling dispersal for this management area.

Geographic spread of foraging sites

In the Persian Gulf, foraging areas occur in coastal and offshore waters of United Arab Emirates (UAE; Al Ameri et al. 2020), Saudi Arabia (Miller 2020), Qatar (Rees 2020), Bahrain (Abdulqader and Miller 2012), Kuwait (Papathanasopoulou and Rees 2020), and Iran (Mobaraki 2020), plus wherever coral reef-fringed islands and submerged rocky reef suitable habitats occur (Groombridge and Luxmoore 1989).

In the Gulf of Oman/Arabian Sea, foraging habitats are spread along a narrow coastal belt of Oman's coastline (Pilcher et al. 2014a). Although there are few coral reefs in the area, coral growth on the rocky substrate and the biomass of benthic organisms suggest suitable habitat for hawksbill foraging (Ross 1981). Pilcher et al. (2014a) identified two main foraging areas: Shannah and Quwayrah. Both were small in size and turtles using them had core use areas (around 3 km^2) focused on shallow patches of coral reef habitats and home range areas of 40 to 60 km^2. Along the Iranian coast of the Gulf of Oman, foraging is distributed along the coastal reef and rocky areas where suitable food occurs.

Geographic spread of nesting

Low-density nesting by hawksbill turtles occurs in all except two countries (Iraq and Bahrain) that border the Persian Gulf (Figure 11.1, Table 11.1) (Phillott 2020; et al. 2020). Although most nesting is low density (1-10 nesting females per year), Iran, Saudi Arabia, Qatar, and UAE have at least one site where medium density (11-100 nesting females per year) nesting occurs. The aggregation of low numbers of turtles nesting at the widespread sites means the general area is very important to the regional population.

Iran: Hawksbill turtle nesting in Iran occurs predominantly on offshore islands of Ommolkaram, Nakhiloo, Hengam, Faror, Shidvar (Sheedvar), Kharg, Hendorabi (Hendourabi), and Kish Islands in the Persian Gulf and Qeshm (Queshm), Shib Deraz, Larak and Hormuz Islands in the Strait of Hormuz (Mobaraki 2004a, 2020; Nabavi et al. 2012; Hensi et al. 2016) (Figure 11.1). Infrequent nesting may occur along the mainland, especially in areas adjacent to islands where nesting occurs on a regular basis. Low-density nesting by hawksbill turtles has been reported from the Karate (mainland) coast of the Oman (Arabian) Sea (Fadakar 2008) and infrequent nesting may occur elsewhere along the coast.

Kuwait: Scattered, low-density nesting by hawksbill turtles has been reported at three locations (four beaches) (Rees et al. 2013; Papathanasopoulou and Rees 2020) (Figure 11.1).

Saudi Arabia: Nesting sites for hawksbill turtles occur on four off-shore islands: Jana, Karan, Kurayn, and Juraid (Figure 11.1) (Miller 1989, 2020a; Pilcher 1999; Al-Merghani et al. 2000). Recently, hawksbill nesting has been recorded at Ras Tanura on the mainland (Miller and Maneja, unpublished data). Nesting in this area occurred in the early 1950s (Gasperetti, personal communication) and was noted in 1987 (Miller 1989). No other areas of nesting on the mainland have been recorded (Miller et al. 2019). Neither Harqus Island nor Al-Arabiyah Island support nesting. Harqus Island is a low-lying sand cay that is subject to tidal wash-over and Al-Arabiyah Island is ringed by rocky cliffs with only a few small crescent beaches.

Bahrain: No nesting has been reported on the main island of Bahrain or on the Hawar Islands (Miller and Abdulkadar 2009; Phillott et al. 2020a). Although the main island of Bahrain and/or the Hawar Islands may be used for nesting very infrequently, a search in 2007 did not find any sign of old or current nesting by any marine turtle species (Miller and Abdulkadar 2009).

Qatar: Low-density nesting (1-10 individuals per annum) by hawksbill turtles occurs at Fuwairit, Halul, and Ras Laffan which are located on the northeastern portion of the Qatar peninsula (Figure 11.1) (Al-Ansi and Al-Khayat 2008; Tayab and Quiton 2003; Rees 2020).

United Arab Emirates: Nesting sites for hawksbill turtles occur on the offshore islands of Al Jarnain (11-50 individuals), Bu Tinah (11-50 individuals), Ghantoot (1-10 individuals), Sir Abu Nu'Ayr (11-100 individuals), Qarnain (Dayyinah Is.) (1-10 individuals), Arzannah (1-10 individuals), and Zirqu Islands (11-50 individuals), as well as numerous other islands (Figure 11.1) (Miller et al. 2004, 2009; Al-Ghais 2009; Natoli et al. 2017; Al Ameri et al. 2020). Nesting on the other islands in the UAE is low density (e.g.1-10 individuals at Siniya Island, Whelan et al. 2019) and may be intermittent at a few islands.

Oman: Hawksbill turtles nest in large numbers on Masirah Island at Omedu Beach (Ras Abu Ar Rasas) on the southern coast of the island and in low numbers at several other locations on the south and southwestern shores of the island (Ross 1981; Willson et al. 2020). It is believed that around 100 females per year breed at Masirah Island (Rees and Baker 2006). The nesting season occurs throughout winter and spring, overlapping to some extent (and at some locations) with the start of loggerhead turtle nesting at the end of April (Rees and Baker 2006).

On the Gulf of Oman coast, a large nesting aggregation (101-500 individuals) occurs on Daymaniyat Islands (Willson et al. 2020). The combined total for the islands may exceed 500 turtles per season (Mendonca et al. 2001). In 1999 and 2000, nesting activity was tracked twice monthly from March to May and once monthly for the other months of the year (Mendonca et al. 2001). The islands with larger beach areas hosted higher nesting activity, where the total number of tracks observed in the 1999 and 2000 seasons were 1,205 and 4,376, respectively (Mendonca et al. 2001). Assuming a nesting success of 60% and three clutches laid per turtle in a season, the annual nesting population could be between 250 and 750 females. In a study by Pilcher at al. (2014a), inter-nesting periods in Oman turtles were 11.1 days, with an average of three clutches per season. The nesting season extends from February/March to July/August each year, peaking in April/May (Mendonca et

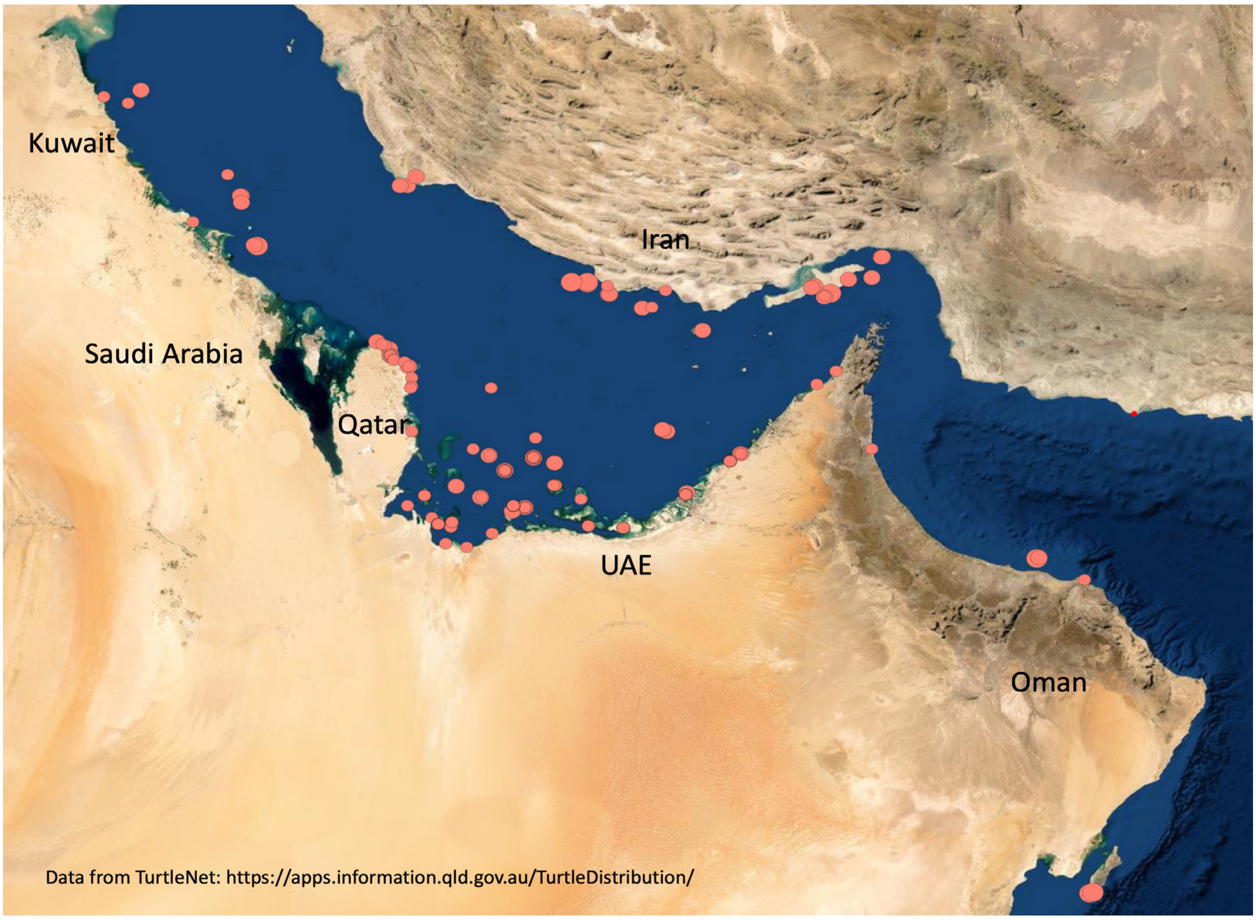


Figure 11.1 Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote unquantified nesting. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

al. 2001). Turtles in Oman were not shown to undertake summer migrations, nesting fewer times than Persian Gulf populations. The average size of the turtles (CCL) nesting on the Daymaniyat Islands in 1999 and 2000 was recorded as 80 cm. The Daymaniyat Islands Nature Reserve is considered to be one of the last sanctuaries for hawksbills in the region because of its protected status and the high pollution levels that exist in the Persian Gulf (Mendonca et al. 2001).

Iraq: There is no reported nesting by hawksbill turtles in Iraq, which consists of the Shatt al Arab River Delta (Phillott 2020).

Seventy-two hawksbill turtle nesting sites have been identified in the Persian Gulf, the Gulf of Oman, and the Arabian Sea (Table 11.1); none have been recorded in Iraq or Bahrain. There are no very large (>500 females per year) nesting aggregations in the Persian Gulf among the 72 identified nesting sites. Seven (6%) of the nesting sites host large (100-500) numbers of females annually, 27 (39%) sites are used by 11 to 100 nesting females annually, and 38 (55%) sites are used by fewer than 10 females annually.

Two of the sites located in the Gulf of Oman and in the Arabian Sea (Daymaniyat Islands and Masirah Island, respectively) host between 101 and 500 nesting hawksbill turtles annually (Mendonca et al. 2001). Numerous mainland sites in the Gulf of Oman along the coasts of Oman and Iran host additional, lower-density nesting.

Long-term monitoring and census data are needed to better define the number of nesting hawksbill turtles in the region. Research programmes that have been monitoring nesting should continue to record both clutches and the number of nesting females following standardised methods (Eckert et al. 1999; SWOT 2011; PERSGA/GEF 2019).

Table 11.1. Summary of size of annual hawksbill turtle nesting populations at 71 recorded nesting beaches in Persian Gulf and the Gulf of Oman/Arabian Sea management unit.

Estimated annual nesting population	Country	Number of beaches	Nesting beaches
501-1,000 females/ year	Iran	0	
	Kuwait	0	
	Oman	0	
	Qatar	0	
	Saudi Arabia	0	
	UAE	0	
101-500 females/year	Iran	3	Lavan Island (Jazireh-ye Sheykh Shoeyb), Shibdraz-Qeshm Island, Shitvar Island (Jazireh-ye Shotur)
	Kuwait	0	
	Oman	2	Daymaniyat Islands (Jazoor Daymaniyat), Masirah Island (Jazirat Masirah)
	Qatar	1	Ras Laffan, northeastern Qatar
	Saudi Arabia	1	Jana Island (Jazirat Jana)
	UAE	0	

Estimated annual nesting population	Country	Number of beaches	Nesting beaches
11-100 females/year	Iran	11	Faror Island, Hendorabi Island, Larak Island, Nakhiloo Island, Omolkaram Island, Queshm Islands, southeast of Hengam Island, southeast of Hormoz Island, south of Hendorabi Island, south of Kish Island, West of Qeshm Island
	Kuwait	0	
	Oman	1	Muscat (Bandar al Jissah, Bandar al Khiran to Quriyat)
	Qatar	3	Al Ghariya, Fuwairit, Ras Rakan
	Saudi Arabia	3	Juaryd Island (Jazirat Juaryd), Karan Island (Jazirat Karan), Kurayn Island (Jazirat Kurayn)
	UAE	8	Bu Tinah Island, Dalma Island, Al Jarnain Island, Saadiyat Island, Sir Bani Yas, Sir Bu Nu'air Island, Um Al Kurkum, Zirku Island
1-10 females/year	Iran	4	East of Gorzh, Hengam Islands, Karate coast, West of Charak
	Kuwait	3	Ras Al Zour (Beach D), Qaru Island (Beach A) Umm Al-Maradim Island (Beach C (North))
	Oman	3	Musandam, Ash Sharqiyah coast and Al Wusta coast
	Qatar	12	Al Dakerah, Al Huwaylah, Al Jassasiya, Al Khor, Al Mafjar, Al Maronah, Halul, Ras Marbakh (Ras Martbakh), Sharaawh Island, Umm Tays, Uraydah, Ras Laffan, northeastern Qatar
	Saudi Arabia	1	Ras Tanura
	UAE	15	Abu Al Abyad, Al Mubarraz, Al Rans Beach, Arzannah Island, Das Island, Dayyinah Island, Ghantoot (beach), Ghashshah (Ghasha) Island, Siniya Island, Muhaimat (Muhayimat) Island (northeast coast), Qarnein Island (southwest Coast), Um Al Hatab, Yasat Ali Island
Unquantified	Iran		Islands of the Persian Gulf and coastal areas of the Gulf of Oman/ Arabian Sea
	Kuwait		
	Oman		Islands of the southern side of the Strait of Hormoz; coastal areas and nearshore islands
	Qatar		
	Saudi Arabia		Harqus Island (Jazirat Harqus) [washed over]
	UAE		

Trends in nesting data

Iran: There are no trend data for hawksbill turtle rookeries in Iran. Based on published data from various sites, it is likely that between 200 and 300 females breed each year, in particular on Omolgorm and Nakiloo Islands (100 to 150 nesting females per year), Kish Island (10 to 15 nesting females per year), Sheedvar Island (20 to 25 nesting females per year), Lavan Island, Qeshan Island (30 nesting females per year), Hengam Island (30 nesting females per year), Hormuz Island (20 to 25 nesting females per year), and the Farour Islands (<10 nesting females per year). (Mobaraki and Elmi 2005; Mobaraki 2011, 2020; Zare et al. 2012; Hesni et al. 2016, 2019). See Groombridge and Luxmoore (1989) for earlier information.

Saudi Arabia: Initial surveys of nesting hawksbill turtles in Saudi Arabia occurred in 1986 and 1987 (Miller

1989). Monitoring was re-established in 1991 and continued until 1997 (Pilcher 1999; Al-Merghani et al. 2000). In 1991, surveys of three of the four rookeries (Jana, Karan, and Jurayd) were conducted from late May until early August to cover the entire nesting season. A total of 164 hawksbill turtles were tagged, 111 (68%) on Jana, 43 (26%) on Karan, and 10 (6%) on Jurayd. Hence, Jana is considered the most significant of the three rookeries for hawksbill turtles. From 1992 onwards, survey effort was reduced to ~3 weeks over the peak nesting period for hawksbill turtles at Jana based on Pilcher's (1999) estimate that sampling over this three-week period would allow 89% of nesting females to be encountered. No survey data after 2007 are available (Miller 2020a).

Qatar: Monitoring reports from 2010 to 2016 indicate an average of 32 clutches per year are laid at Fuwairit Beach (Table 11.2) and between 16 and 174 per year at several sites near Ras Laffan (64 in 2001, 174 in 2002; 16 in 2001, 65 in 2002). No monitoring records exist for Halul Island (Pilcher et al. 2014a; Chatting et al. 2018). No other recent data are available (Tayab and Quiton 2003; Rees 2020) (Figure 11.1).

The main nesting season for hawksbill turtles at these rookeries is May to July (end of spring into early summer) and is likely to be constrained by average air temperatures, which can increase by 13°C from the beginning to the end of the nesting season (Chatting et al. 2018).

Table 11.2. Hawksbill turtle clutches recorded per year at Fuwairit Island (cited in Chatting et al. 2018).

Year	Fuwairit Island (clutches per year)
2010	48
2011	21
2012	14
2013	15
2014	29
2015	31
2016	63

Table 11.3 Hawksbill turtle clutches recorded per year at Sir Abu Nu'Ayr and Jebel Ali by the Emirates Marine Environmental Group (Al Ameri et al. 2020).

Year	Sir Abu Nu'Ayr (clutches per year)	Jebel Ali (clutches per year)
2010	324	--
2011	376	--
2012	--	--
2013	--	--
2014	305	25
2015	260	37
2016	--	--
2017	--	--
2018	--	--
2019	351	51

United Arab Emirates: Al-Ghais (2009) reported 48 nests laid in a nesting season on Al Jarnain Island and 17 nests laid on Bu Tinah Island. Recent survey data collected between 2010 and 2019 by the Emirates Marine Environmental Group indicate an average of 30 and 323 clutches are laid per year at Jebel Ali and Sir Abu Nu'Ayr, respectively (Al Ameri et al. 2020). The trend is believed to be stable (Table 11.3).

Migration and distribution of foraging areas

Hawksbill turtle migration and habitat use was described for the Persian Gulf and the Gulf of Oman by Pilcher et al. (2014a, b, 2020). Pilcher et al. (2014a) reported on 3 years of satellite tracking data from 90 adult females tracked from nesting to foraging locations (including 25 tracked from Oman rookeries in the Gulf of Oman). All of the turtles tracked from Iran, UAE, and Qatar rookeries remained in the Persian Gulf. Migrations tended to be short in duration (10 days) and averaged 189 km in distance (13 to 660 km). Foraging home ranges were typically between 40 and 60 km^2 with a core use area of 3 to 5 km^2. One interesting feature of turtles from this management unit is that during the warmer summer months the turtles embarked on summer migration loops – typically moving in a northeast direction and spanning 650 km movements that, at their apex, had waters 2^{o}C cooler than their foraging area (Pilcher et al. 2014a, b).

The areas around Ras Al Hadd and between the southern tip of Masirah Island and Shannah on the mainland of Oman are important migratory pathways for hawksbill turtles (Pilcher et al. 2014a, 2020). Post-nesting turtles were tracked migrating southeast from the Daymaniyat Islands, past Ras al Hadd and southwest towards the waters off Shannah, Masirah Island, and Quwayrah (Pilcher et al. 2014a). Turtles from Masirah Island rarely travelled further than 50 to 80 km to coastal foraging sites off the Oman mainland coast (Pilcher et al. 2014a).

Migrations by turtles nesting at the Daymaniyat Islands were longer than those nesting at Masirah Island, averaging 672.6 km and requiring an average of 28.6 days to complete (Pilcher et al. 2014a). All turtles reached or passed Masirah Island with only one migrating north into the Persian Gulf. This is the first documented instance of a hawksbill migration into or out of the Persian Gulf. Migrations by turtles at Masirah Island were statistically shorter than those from Daymaniyat Islands. These turtles travelled an average of 80.5 km in an average of 3.95 days. During the same period, when most turtles were migrating along the coast of Oman (June to September), the Somali current travels in the opposite direction but does not seem to impede turtle migration. Migration distances for turtles departing the Daymaniyat Islands were more than twice the global average for adult hawksbills (Pilcher at al. 2014a).

Hawksbill turtles tracked from nesting sites in Kuwait (two from Umm Al Maradim Island, two from Qaruh Island; Rees et al. 2019) displayed migrations that tended to be short and in shallow nearshore waters to the north of Abu Ali Island in Saudi Arabia. From 2010 to 2012, 15 hawksbills were tracked by the Saudi Wildlife Authority from nesting sites on Jana Island, Saudi Arabia, to foraging areas located mostly offshore in the western area of the Persian Gulf between Ras as Saffaniyah and the border between Qatar and the UAE (Miller et al. 2019). Hawksbill turtles nesting in the southern Persian Gulf have been tracked to the northern side of Abu Ali Island, which has been identified as an important foraging area (Pilcher et al. 2014a). These data suggest that hawksbill turtles in the northern and southern parts of the Persian Gulf utilise foraging areas throughout the region.

In addition to defining foraging areas, other biological characteristics need to be determined (Table 11.4). For example, the size at which young turtles leave pelagic foraging areas and move to reef and nearshore areas requires investigation. Two other pieces of information are critical to understanding the responses of the population to environmental change. Growth rate and survivorship of members of the pre-reproductive and reproductive segments of the population need to be determined for the turtles of the Persian Gulf region. Collecting these data requires long term studies.

Threats to the population

Although several authors have provided lists of known and potential threats (e.g. Miller 1989; Gasperetti et al. 1993), few quantified data exist on threats to marine

Table 11.4. Biological data – Foraging- for hawksbill turtles of the Arabian Peninsula and the Gulf of Oman/Arabian Sea.

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging) (CCL)	~10 to 15 cm	Pilcher et al. (2015)
Growth rates	unknown	
Survivorship estimates	unknown	

turtles of the Persian Gulf (Table 11.5). Overall, in this region of the Indian Ocean, the deliberate take or retention of bycaught turtles for sale into illegal markets was considered to be very low (Riskas et al. 2018). Fisheries bycatch of hawksbill turtles is believed to occur at a low level. In a two-year study of stranded turtles in Bahrain, hawksbill turtles were caught in large wire traps but not commonly caught in trawl-based fisheries (Abdulqader and Miller 2012). In Oman, hawksbills (unlike green turtles) are not traditionally targeted for consumption. However, bycatch has been identified as the major conservation concern (Pilcher et al. 2014a), although the level of take of hawksbill turtles has not been assessed. In addition, a few countries report that a low level of consumption, use, or sale of turtle eggs occurs locally (IOSEA 2019a, b, c, d).

Other threats have been identified but not quantitatively documented. Issues of concern include: 1) habitat change resulting from coastal development (particularly the impact of changes in light horizon); 2) climate change (related to increased air temperatures and their likely influence on hatchling sex ratios); 3) sea level rise because most of the nesting locations are low-lying, coral-fringed islands; and 4) the ingestion of, or entanglement in, marine debris. Examination of the degree to which these threats may impact hawksbill turtles from the Persian Gulf management unit is required.

International shipping may pose a threat to marine turtles, particularly in narrow waterways such as the Strait of Hormuz. For example, Pilcher et al. (2014a) reported that 24 of the 25 tracked turtles travelled to foraging sites close to the Oman coast. A 20-km-wide zone off Ras Al Hadd, and along the shoreline between Daymaniyat, Muscat, and Masirah Island, constitutes an important migration pathway and bottleneck for hawksbill turtles (Pilcher et al. 2014a). The maritime traffic present in this bottleneck could pose a major concern for turtles in Oman. The Persian Gulf is one of the world's most important areas for oil and gas exploration, extraction/production, and shipping; indeed, Oman experiences some of the largest shipping densities in the world (Pilcher et al. 2014a). Combined with extensive artisanal and commercial fishing in the waters off Oman, activities present in this bottleneck constitute a substantial threat to local hawksbill populations.

Terrestrial organisms such as ghost crabs (Ocypode spp.) and birds are known egg and hatchling predators. Elsewhere in the world, the proportion of eggs lost to ghost crabs may be as high as 60% (Stancyk 1995). The threat of ghost crabs and other natural predators (birds) was assessed in 1999 and 2000 on the Daymaniyat Islands (Mendonca et al. 2001). Ghost crabs were identified as the only potential predators of turtle eggs. However, because their burrows were generally located closer to the water than turtle nests (9-17m above tide) they were deemed to be not a significant threat to turtle eggs. In addition, birds such as herons, ospreys, sooty falcons, house crows, and sooty gulls were identified as predators of turtle hatchlings. However, the effect of bird depredation can only be considered significant in the instance of daytime/full moon hatching, when birds are able to easily see their prey (Mendonca et al. 2001; Al Kiyumi et al. 2005). On the offshore islands of Saudi Arabia, Miller (1989) observed mice consuming unquantified numbers of eggs and hatchlings. Whether this was opportunistic or focused depredation was not determined.

Management and protection

The countries surrounding the Persian Gulf participate in many international and regional agreements to promote conservation in the region (Table 11.6). Of these, the Regional Organization for the Protection of the Marine Environment (ROPME) helps coordinate among states and links to other relevant national and international organizations, such as PERSGA (Red Sea region), the Council of Arab Ministers Responsible for the Environment (CAMRE), and the regional office of the United Nations Environment Programme (UNEP). Although the general focus of these agreements is toward preventing oil pollution, as well as industrial waste and sewage discharge, they also deal with protecting marine resources. Some of the agreements, such as CMS IOSEA Marine Turtle MOU provide guidance and context for state-level, regional-level, and international-level coordination and evaluation of conservation efforts. Others (e.g. CITES) help enforce international and regional regulations concerning trade in wildlife and derived products. Still others deal mainly with protecting marine and coastal environments. All these agreements and organisations directly or indirectly help improve the situation for marine turtles. However, because hawksbill turtles tend to nest on the offshore islands, local enforcement can be a problem. The countries bordering the Persian Gulf provide legal protection for marine turtles and have national laws that prohibit or regulate the use of eggs and turtles found on beaches, as well as those captured in foraging areas either directly or by accident. However, enforcement is an ongoing issue because of the lack of resources (IOSEA 2019 a,b,c,d).

Although most marine protected areas (MPAs) were not designated with the specific purpose of conserving habitat for marine turtles, but many coincide with turtle nesting and/or foraging areas, Multiple MPAs provide some protection to critical habitat used by hawksbill turtles (Table 11.7).

The hawksbill population of the Persian Gulf and the Oman Gulf/Arabian Sea would benefit from cooperative, coordinated, multinational research and conservation

Table 11.5. Summary of threats to the Persian Gulf management unit of hawksbill turtles. KEY: Known or likely location of impact: A=nesting beach, B=oceanic/high seas, C=coastal foraging areas. Quantified: 1=comprehensive documentation across population, 2=comprehensive documentation for some of the population, 3=non-published evidence only, 4=not quantified; Blank= unknown. See IOSEA 2019a,b,c,d; Phillott and Rees 2020 for details.

Country	Iran	Kuwait	KSA	Bahrain	Qatar	UAE	Oman
Consumption – nesting beach							
Egg collection	A, 4		A, 4				A, 4
Commercial use of turtles	4		4				4
Non-commercial use of turtles	A, 4		A, 4				A, 4
Predation of eggs by non-native fauna	4		4				4
Predation of eggs by native fauna	4		4				4
Consumption – foraging turtles							
Commercial use of turtles							
Non-commercial use of turtles	4	4	4	4	4	4	4
Climate change impacts							
Increasing beach temperature	4	4	4	4	4	4	4
Beach erosion	4	4	4	4	4	4	4
Sea level rise	4	4	4	4	4	4	4
Coastal development							
Habitat modification (urban)	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4
Habitat modification (industrial)	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4
Light horizon disorientation	4	4	4	4	4	4	4
Fisheries impacts							
Bycatch – trawl	4		4	4		4	
Bycatch – longline			4				
Bycatch – gillnet	4		4	4		4	
Impact to benthic ecology from fisheries	4		4	4		4	
IUU fishing							
Pollution							
Water quality	4	4	4	4	4	4	4
Entanglement in discarded fishing gear	4	4	4	4	4	4	4
Ingestion of marine debris	4	4	4	4	4	4	4
Noise pollution	4	4	4	4	4	4	4
Disease and pathogens	4	4	4	4	4	4	4

Table 11.6. Selected regional and international agreements adopted by countries in the Persian Gulf, Gulf of Oman, and Arabian Sea region. ✓ indicates adoption, ratification, or membership. See Phillott and Rees 2020.

	Iran	Iraq	Kuwait	Saudi Arabia	Bahrain	Qatar	UAE	Oman
Regional Organization for the Protection of the Marine Environment (1979) [ROPME]	✓	✓	✓	✓	✓	✓	✓	✓
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) [CITES]	✓	✓	✓	✓	✓	✓	✓	✓
Convention on Biological Diversity (1992) [CBD]	✓	✓	✓	✓	✓	✓	✓	✓
Convention on the Conservation of Migratory Species of Wild Animals (1979) [CMS]	✓	✓		✓	✓	✓	✓	
Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia [IOSEA]	✓			✓	✓		✓	✓
Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971) [RAMSAR]		✓	✓		✓		✓	✓
International Convention for the Prevention of Pollution from Ships (1973/78) [MARPOL]	✓	✓	✓	✓	✓	✓	✓	✓
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972)	✓	✓	✓	✓	✓	✓	✓	✓
United Nations Convention on the Law of the Sea (1982) [UNCLOS]		✓	✓	✓	✓	✓		✓
Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982)	✓	✓	✓	✓	✓	✓	✓	✓
Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1989)	✓	✓	✓	✓	✓	✓	✓	✓

efforts. Although the information base on marine turtles in the region has improved, especially in recent years, much remains to be learned. The use of standardised methods (Eckert et al. 1999; SWOT 2011; PERSGA/GEF 2019) would allow comparison of data among research projects. In addition, initiation of research to collect long-term datasets will enable better definition of the regional population characteristics that are essential for conservation management.

Biological data

During the decades since the initial studies on marine turtles in the Arabian region began, biological information concerning hawksbill turtles has been accumulating (Phillott and Rees 2020) (Table 11.8). Unfortunately, several important topics still have not been determined. For example, the pivotal temperature and the sex-determining range of temperature have not been discovered for any population. In the context of the rather extreme environmental conditions of the Persian Gulf (Sheppard et al. 2010; Chatting et al. 2018), defining the impact of increasing temperatures during incubation on hatchling sex ratios is important to conservation management of the region. In addition to impacting the sex ratio of hatchlings, environmental conditions may be affecting the growth and reproduction of turtles in the regional population. When compared graphically with data from turtle populations elsewhere, the mean carapace length and the mean number of eggs of hawksbill turtles from the Arabian Peninsula region form a loose group toward the lower end of the range (Miller 1989; Chatting et al. 2018). Suboptimal habitat (e.g. synergism among salinity, food quality and quantity, water temperature) may be impacting growth and reproduction. Although the smaller turtles of the Arabian region produce clutches that contain fewer eggs, the eggs are of similar mean diameter and mass when compared to those from other regions (Miller 1989).

Unfortunately, less is known about the habitats used by marine turtles. The recent use of satellite tracking has allowed identification of foraging areas and linkages to nesting areas (Pilcher et al. 2014), but more needs to be done. The development of a regional cooperative

Table 11.7. Designated and proposed Marine Protected Areas of the Persian Gulf. Sources: Marine Conservation Institute (2020), van Lavieren and Klaus (2012).

Site name	Index site Y/N	Relative importance to the population	Protection [Designated] (Country)
Faror Island	?	Minor	Faror Island Protected Area [1986] (Islamic Republic of Iran)
Hormuz Island	?	Very important	Other Area [Proposed] (Islamic Republic of Iran)
Karko island	N	Minor	Wildlife Refuge [1975] (Islamic Republic of Iran)
Nakhiloo Island	Y	Very important	Mond Protected Area [1975] (Islamic Republic of Iran)
Omolkaram Island	Y	Very important	Mond Protected Area [1975] (Islamic Republic of Iran)
Sheedvar Island*	Y	Very important	Wildlife Refuge [1975]; Sheedvar Island Ramsar Site, Wetland of International Importance [1999] (Islamic Republic of Iran)
North West Qaruh Island	?	Minor	North West Qaruh Island Coral Reef Area [Proposed] (Kuwait)
Umm Al Maradim Island	?	Minor	Natural Reserve [Proposed] (Kuwait)
Ras Al Zour		Minor	Al Zour Reef Area [Proposed] (Kuwait)
Al Daymaniyat Islands	Y	Extremely important	Al Daymaniyat Islands Nature Reserve [1996] (Oman)
Jana Island	Y	Very Important	Gulf Islands Special Nature Reserve [Proposed] (Saudi Arabia)
Karan Island	Y	Very important	Gulf Islands Special Nature Reserve [Proposed] (Saudi Arabia)
Harqus Island	N	Not important	Gulf Islands Special Nature Reserve [Proposed 1990] (Saudi Arabia)
Jana and Kurayn Islands	Y	Very important	Gulf Islands Special Nature Reserve [Proposed] (Saudi Arabia)
Ras Tanura	N	Minor	Jubail Marine Wildlife Sanctuary Reserve [Proposed] (Saudi Arabia)
Saadiyat Island	N	Minor	Al Saadyat Protected Area [2014] (United Arab Emirates)
Al Yasat Island	?	Minor	Protected Area [2009] (United Arab Emirates)
Al Mubarraz Island	?	Important	Marawah UNESCO-MAB Biosphere Reserve [2007] (United Arab Emirates)
Bu Tinah Island	Y	Important	Marawah UNESCO-MAB Biosphere Reserve [2007] (United Arab Emirates)

management plan in the next few years will improve the situation for the turtles and their habitats.

Red Sea (including the Gulf of Aden) management unit(s) (putative)

Mancini et al. (2015) and Phillott and Rees (2020) provide the most recent reviews of the literature concerning marine turtles of the Red Sea, including the distribution of major nesting sites and protective legislation. Prior to these reviews, Groombridge and Luxmoore (1989) reviewed the status of hawksbill turtles in each country bordering the Red Sea and Gasperetti et al. (1993) summarised the older records, including museum specimens. In addition, PERSGA/GEF (2004, 2007) has prepared conservation management plans for marine turtles in the Red Sea to facilitate local and multilateral research efforts using a standardised methodology (PERSGA/GEF 2019).

Table 11.8. Biological data – breeding – for hawksbill turtles of the Arabian Peninsula. See also Phillott and Rees (2020) for details.

Parameter	Value (Mean ± SD (n))	Reference(s)
Pivotal temperature	Unknown	
Remigration interval	4 to 5 yrs (3)	Pilcher 1999 (Saudi Arabia)
Clutches per season	2.2 ± 0.12 (42)	Pilcher 1999 (Saudi Arabia)
	3 (up to 6)	Pilcher et al. 2014a
	2+	Rees et al. 2019 (Kuwait)
Mean size of nesting adult (CCL)	71.2 ± 4.1 cm (240)	Pilcher 1999 (Saudi Arabia)
	71.6 ± 2.56, 64.2-75.6 cm (50)	Hesni et al. 2016 (Iran)
	70.8 ± 2.85, 60-80 cm (150)	Chatting et al. 2018 (Qatar)
	71.9 ± 2.4, cm (9)	Mobaraki 2004a (Iran)
	71.0 ± 3.1cm (23)	Mobaraki 2004b (Iran)
	71.2 ± 3.95 cm (313)	Al Merghani et al. 2000 (Saudí Arabia)
	70.8 ± 3.79,63.5-79.5 cm (38)	Pazira et al. 2016 (Iran)
	70.74 ± 3.56 cm (11)	Pilcher et al. 2014a (Iran)
	69.31 ± 2.19 cm (7)	Pilcher et al. 2014a (UAE)
	81.08 ± 3.62 cm (22)	Pilcher et al. 2014a (Oman)
	73.47 ± 5.52 cm (4)	Pilcher et al. 2014a (Qatar)
	70.22 ± 4.3 cm (122)	Razaghian et al. 2019a (Iran)
	67.43 ± 10.17 cm (60)	Aghanajefizadeh and Askzri 2020 (Iran)
	72.5 ± 5 cm	Dehghani et al. 2012 (Iran)
(*SCL ± SE)	70.25±3.75 (41)	Razaghian et al. 2019b (Iran)
	77.2 ± 5.25 cm (53)	Ross 1981 (Oman)
Age at maturity	Unknown	
Clutch size	79 (30-128)	Chatting et al. 2018 (Qatar)
	98.4 ± 15.8, 79-118	Mobaraki and Elmi 2005 (Iran)
	74±3.9 (41)	Razaghian et al. 2019b (Iran)
	73.25 ± 12.1	Pazira et al. 2016 (Iran)
	75.2	Hesni et al. 2016 (Iran)
Hatching success	46.4% (2.4-79.8%) (1991 season)	Pilcher 1999 (Saudi Arabia)
	70.9% (54.3-81.9%) (1991 season)	Pilcher 1999 (Saudi Arabia)
	71% (54-91%)	Al Merghani et al. 1996, 2000 (Saudi Arabia)
	52.45 ± 14.9	Razaghian et al. 2019b (Iran)
	84.3 ± 22.1 (24); 73.3 ± 11.1 (11)	Zare et al. 2012 (Iran)

Ecological range

The Red Sea is fringed by a shallow coastal shelf that varies in depth and width and includes numerous islands and reefs (Rasul et al. 2015). As a result of physical and biological characteristics of the shelves (Rasul et al. 2015), the Red Sea and the Gulf of Aden provide foraging habitat for hawksbill turtles. Nesting sites are distributed unevenly around the Red Sea. Islands located in the northern and southern portions host higher density nesting than the islands in the central areas. Because of this nesting distribution, more than one genetically-distinct management unit may exist for hawksbill turtles in the Red Sea. However, no studies on the genetic composition or relatedness of hawksbill nesting populations have been conducted for populations in the Red Sea (FitzSimmons and Limpus 2014).

Geographic spread of foraging sites

Within the long and relatively narrow geographic area of the Red Sea, the distribution of foraging by hawksbill turtles can be characterized as widespread, occurring essentially wherever suitable habitat occurs. No broad-scale surveys of the uniformity of foraging distribution have been conducted in recent years (PERSGA/GEF 2004, 2007).

Geographic spread of nesting

Each country bordering the Red Sea, except Jordan, hosts some nesting (Phillott and Rees 2020) (Figure 11.2). However, nesting is not uniformly distributed. Older data indicate that hawksbill turtles have nested at low densities on many of the offshore islands and at several nearshore and mainland locations (e.g. Saudi Arabia, Ormond et al. 1982; Egypt, Frazier and Salas 1984; other countries, Groombridge and Luxmoore 1989). Higher density nesting aggregations are located in the northern (i.e. Egypt) and southern (i.e. Eritrea, Saudi Arabia) portions, with low-density nesting elsewhere (Groombridge and Luxmoore 1989; Mancini et al. 2015; Phillott and Rees 2020). Recent work by Shimada et al. (2021) reinforces the need to conduct widescale surveys to assess the density and locations of nesting by hawksbill turtles. They confirmed nesting at several known locations and added several more previously unknown locations to the list.

An estimated 400 to 600 female hawksbill turtles breed each year on the beaches and islands of the nations that border the Red Sea (Mancini et al. 2015). Hatching success has been reported by very few studies. Post-hatchling dispersal for this management unit has not been described.

Trends in nesting data

Systematic long-term data sets concerning hawksbill turtle nesting do not exist for any country bordering the Red Sea, although information from the regional countries is improving (Phillott and Rees 2020). Confirmation is required concerning the species present, numbers of females nesting, and the timing of the nesting season for all known nesting locations. Determining long-term trends requires monitoring the number of turtles nesting at specific locations on a regular basis; the use of standardized methods (Eckert et al. 1999, SWOT 2011, PERSGA/GEF 2019) would facilitate comparison among reports. Some data on nesting turtles are based on counting individual turtles, while others report the number of tagged turtles, and still others report the number of body pits found at the site. Further, most studies record data during only part of the nesting season. Although there are good reasons (time and logistical constraints) for using each approach, the mixture of methods impacts the estimated number of nesting turtles (Whiting et al. 2020). For example, counting body pits is likely to overestimate the number of turtles nesting, even when adjusted by the mean number of nests produced, because (a) pits may be destroyed by other nesting turtles, (b) turtles may dig several body pits before beginning oviposition or abandoning the effort, and (c) pits from previous seasons do not necessarily degrade (Miller 1989).

Migration and distribution of foraging areas

There have been no studies investigating the post-nesting migrations of hawksbill turtles as they return to their foraging areas in the Red Sea. Given the habitats present on the fringing shelf of the Red Sea, and that hawksbill turtles reside on most of the coral reef-fringed islands and cays of the Red Sea, it is likely that a significant proportion of nesting hawksbill turtles migrate between foraging and nesting areas within the region or from the Gulf of Aden.

Egypt

The majority of hawksbill turtle nesting along the Egyptian coast, including the Sinai Peninsula, is considered low density (1-10 females per season) (Mancini et al. 2020). However, medium-density nesting (11-100 females) occurs on Giftun Kabir Island (Big Giftun) and Giftun el Sagheer Island (Little Giftun). Low-density nesting at multiple sites in Wadi El Gemal National Park, including Baruda Island and coastal nesting sites, aggregate to indicate this area hosts medium-density nesting (11-100 females) (Mancini et al. 2020). Additional medium-density nesting occurs in the Hamata Islands (50 females per year in the 1980s; Groombridge and Luxmoore 1986).

Hala'ib Triangle

Medium-density nesting (11-100 females) occurs at three locations in the Hala'ib Triangle between Egypt and

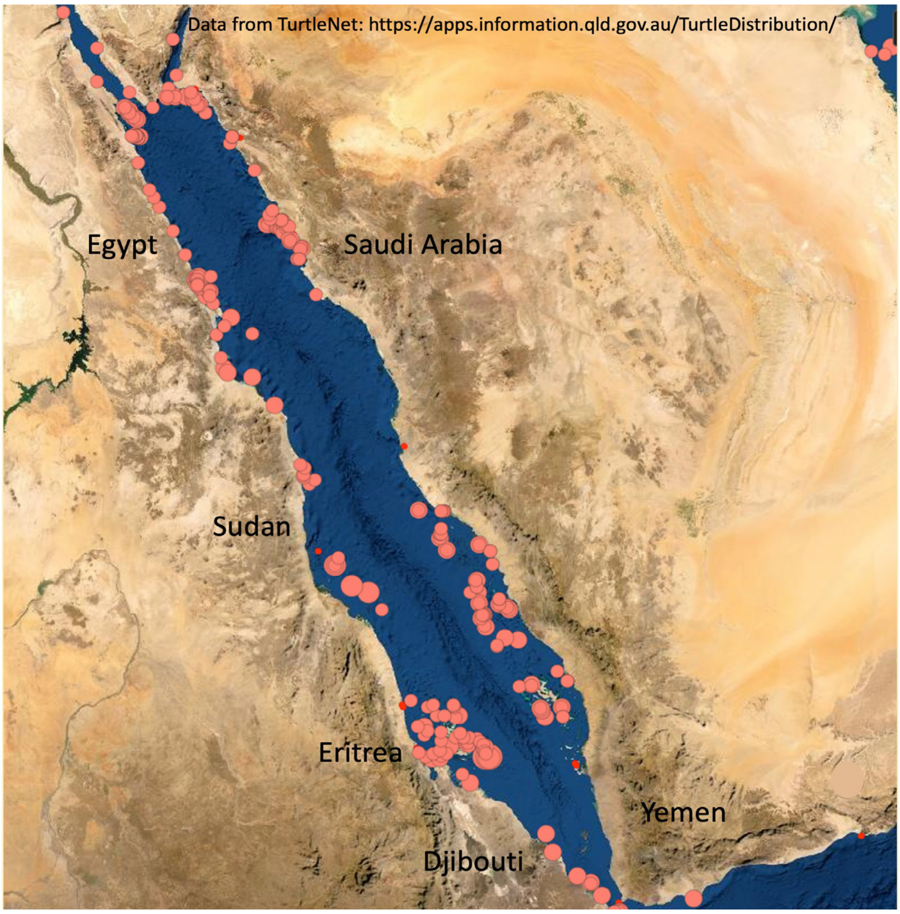


Figure 11.2 Pink dots denote rookeries with quantified nesting and the size of the dot reflects the relative abundance. Red dots denote unquantified nesting. Data source: https://apps.information.qld.gov.au/TurtleDistribution/

Sudan (Frazier and Salas 1984; Mancini et al. 2020).

Sudan

Low-density nesting (1-10 females) occurs at several sites in the Dungonab Bay Marine National Park area (Al-Mansi et al. 2003; PERSGA/GEF 2003, Rees et al. 2020). Higher-density nesting occurs on Mukkawar (Mesgarsam) Island, where 41 tracks were recorded in 2003 (Al-Mansi et al. 2003; PERSGA/GEF 2003; Rees et al. 2020).

In addition, low-density hawksbill turtle nesting (1-10 females) occurs on most of the islands of the Suakin Archipelago (Hirth and Abdel Latif, 1980; Al-Mansi et al. 2003), in particular, Talla Talla Saghir, Seil Ada Kebir, Barr Musa Kebir, Masamirit, Daraka, and Abu Isa (Rees et al. 2020). In 1976, it was estimated that 330 females per year nested on islands in the archipelago (Moore and Balzarotti 1977, cited in Groombridge and Luxmoore 1989). Al-Mansi et al. (2003) tagged 15 hawksbill turtles on Seil Ada Kebir in three nights. From 11 to 18 March in 1978, Hirth and Abdel Latif (1980) measured 42 individual (tagged 25) hawksbill turtles nesting on the same island. However, there is no current assessment of the distribution or density of hawksbill turtle nesting available for Sudan (Rees et al. 2020).

Eritrea

Eritrea hosts the highest number of nesting sites for hawksbill turtles in the Red Sea (Hillman and Geberemariam 1995). Nesting has been recorded at 110 islands and a few mainland locations (Teclemariam 2013), mostly at low densities (1-10 females) except in the southern part of the Dahlak Archipelago (Teclemariam et al. 2009). Aucan and Mojeidi Islands host between 101 and 500 nesting turtles as indicated by tagging studies (46 and 96 in 2006 and 2007, respectively), and counts of clutches and body pits (Teclemariam et al. 2009). During 2005 and 2006, more than 2,000 hawksbill nests (pits) were recorded on Mojeidi Island, with peak nesting occurring during February and March. During the same period, 1,500 hawksbill nests were recorded on Aucan Island (de Grissac and Negussie 2007). Other important island nesting sites hosting more than 11 nesting hawksbill turtles per year include Dissei, Dahret Sigala, Dhul-kuff, Dehil, Entaentor, Entaasnu, Fatuma Island, and Urukia (Urubia). In addition, low-density nesting occurs along the mainland coast at several sites including Berasole, Ras Tarma, Gahro, and Deleme (de Grissac and Negussie 2007; Teclemariam et al. 2009).

Djibouti

Two nesting aggregations are recognized in Djibouti: Ras Siyyan and Sept-Frères islands. Nesting occurs from March to June. These may be part of the nesting population that utilizes Perim Island (Yemen) located across the Bab al-Mandab Strait (Barker et al. 2002). Two islands, Horod le 'Ale (Île de l'Est) and Kadda Dabali (Grand Isle), accommodate nesting but the identification of species and numbers require clarification (Mancini et al. 2015; Phillott et al. 2020).

Yemen

In the Red Sea portion of Yemeni territory, hawksbill turtle nesting primarily occurs on Perim Island (in the 101-500 female range of nesting; Hirth 1968; Hirth and Carr 1970; Ross and Barwani 1982). Nesting has also been reported on Kamaran and Makran Islands (Mancini et al. 2015; Miller 2020b). Nesting occurs at the lower end of the 11 to 100 females range along the Yemeni Gulf of Aden coast, Khor Umaira, on Jabal Aziz Island (Jazirat Aziz), at Ras Imran, and on Azizi Island (PERSGA/GEF 2004). Low-density nesting (1-10 females) may occur infrequently along the Sharma-Jethmoun-Dhargham coast, Hadhramaut Province, eastward towards Oman (Nasher and Jumaily 2015). The distribution and density of nesting needs to be assessed (Miller 2020b).

Saudi Arabia (Red Sea)

Older data indicate that hawksbill turtles nest at low densities (1-10 females) on many of the offshore islands that are scattered along the full length of the Saudi Arabian coast (Ormond et al. 1984; Groombridge and Luxmoore 1989; Miller 2020a). The Farasan Islands in the southeastern Red Sea host 50 to 100 nesting females in the nesting season from February to May (PERSGA/GEF 2004). At least 22 of the offshore islands of the Umm al-Qamari Islands and four nearshore/onshore locations between the Farasan Islands and Jeddah host an additional 1 to 10 nesting hawksbill turtles each season. There is scattered, low density nesting in the area from just south of Jeddah northward to near the Weji Banks. The highest density of nesting occurs in the northern portion on Tiran, Sanafir, and Shusha Islands (near the Sinai Peninsula), where 11 to 100 turtles nest (Ormond et al. 1984; Groombridge and Luxmoore 1989; Miller 1989, 2020a). Shimada et al. (2021) confirmed nesting on many of the northern islands and added several to the list of known nesting sites. There are no long-term monitoring data available (Miller 2020a).

The majority of the known nesting sites used by hawksbill turtles in the Red Sea host fewer than 100 turtles per annum (Table 11.9). However, because of differences in methods used to count nesting turtles and because the majority of nesting sites have not been assessed in recent years, all sites should be resurveyed to accurately define the distribution of nesting and to determine the number of nesting turtles (Miller 2020a). The increasing use of drone technology to survey for indications of nesting (e.g. El Kafrawy et al. 2018) is likely to reduce the cost of surveying the myriad of islands in the region.

Threats to the population

Threats to hawksbill turtles in the Red Sea were reviewed by Phillott and Rees (2020), Mancini et al. (2015), Gasperetti et al. (1993), and Miller (1989). The key threats include (in ranked order): artisanal fishing, commercial fisheries, habitat destruction, oil industry, and dredging and/or land-filling (PERSGA 2006) (Table 11.10). There are no quantified data on these threats and their impact on the population(s) is likely to vary among countries and locations. For example, the major threat to turtles in Yemen was identified as artisanal fishing (including egg collection) (PERSGA/GE 2004), in contrast to Saudi Arabia, where the major threat is development on or near nesting beaches, including oil spills (PERSGA 2006). Coastal and island development, including tourism, pose clear threats to nesting and foraging areas. Older anecdotal information suggests that the threats to hawksbill turtles inhabiting the Red Sea are low to locally moderate (Miller 1989), but this may have changed.

Countries surrounding the Red Sea report no commercial use of adults and eggs (PERSGA/GE 2001; IOSEA 2019e, f, g, h, i), but some may occur. Any use of hawksbill turtles and/or their eggs appears to be artisanal. However, any artisanal consumption varies among areas because some local groups consider the meat to be poisonous (Miller 1989). The impact of fisheries (trawling, longline, gillnets) is widespread, but bycatch of turtles is unquantified throughout the region (PERSGA/GE 2001; IOSEA 2019e, f, g, h, i). The complexity of the habitat used by hawksbills may afford some protection to the species, but bycatch and damage to foraging habitat may be impacting the regional population, at least in local areas.

The projected impacts of climate change threaten most island and many coastal nesting sites in the Red Sea, but the potential impacts have not been assessed. Hawksbill turtles depend on coral reefs, foraging on sponges and other soft bodied organisms living in association with coral reefs and rocky outcroppings (Witzell 1983). Recently there has been extensive coral mortality on many reefs, including the southern Red Sea,

Table 11.9. Summary of size of annual hawksbill turtle nesting populations at nesting beaches in the Red Sea region

Estimated annual nesting population	Country	Number of beaches	Nesting beaches
501-1,000 females/ year	Djibouti	0	
	Egypt	0	
	Eritrea	1	Aucan Island
	Saudi Arabia	0	
	Sudan	0	
	Yemen	0	
101-500 females/year	Djibouti	0	
	Egypt	0	
	Eritrea	1	Mojeidi Island
	Saudi Arabia	0	
	Sudan	2	SD-01-07, Suakin Archipelago
	Yemen	2	Perim Island (Barim), Ras Imran and Azizi Island, Aden.
11-100 females/year	Djibouti	2	Horod le 'Ale (Île de l'Est), Kadda Dabali (Grand Isle)
	Egypt	17	Abu Ghoson North (Wadi Al-Gimal NP), Baruda Island (Wadi Gimal NP), Giftun (Jiftun) el Sagheer (Little Giftun Island), Giftun (Jiftun) Kabir (Big Giftun Island), Gobal Kobra, Gobal Soghra, Hamata Island, Ras Banas (Hertway), Ras Hankorab, Seiul Kobra, Shedwan Island, Umm Al-Karsh, Umm El-Abas, El Hasa, Marsa Soma, Robala Island, Siyal Island (Jebel Elba).
	Eritrea	13	Dahret Bulke Island, Dahret Island, Dahret Segala Island, Delemi (Dilemmi), Dhul-kuff Island, Dissei Island, Entaasnu Island, Entaentor Island, Gahro, Ras Fatuma, Ras Terma, Selafi (Berasole), Urubia (Urukia) Island
	Saudi Arabia	29	Al Hala Island, Al Umm Island, Barqan Island E., Barqan Island S., Barton Island, Birema Island (Mashabih), Dahert Simer Island, Danak Island, Dhahrat Simer Island, Disan Island, Dohrab Island, Dorish Island, Hadara Island, Mafsubber/Sabiya Island, Maghabiya Island, Malathu Island, Marrak Island, Qadd Humais Island S, Qalib Island chain, Qutu Island, Sharbain Island (Sharbayn), Shusha Island E., Sinafir Island W., Sirrain (Sirrayn) Island, Tidhkar Island, Tiran Island, Towasela Island, Waqada Island, Wasaliyat Island S, Zuqaq Island (Zukak)
	Sudan	2	Mukawwar Island (Megarsam) (SD-04-11), Seil Ada Kebir
	Yemen	2	Kamaran Island, Makran [part of Kamaran Island],

Estimated annual nesting population	Country	Number of beaches	Nesting beaches
1-10 females/year	Djibouti	0	
	Egypt	26	Abu Mingar, Abu Rodeis, Al Ghardaqa, Amalawaya (Hamata Islands), Beremce, Foul Bay, Hamrawaya, Hertway (Wadi Al-Gimal NP), Mahabis Island (Hamata Island), Marsa Alum, Marsa Mubarak (Wadi Al-Gimal NP), Na'ama Bay, Nuweiba, Quseir, Ras Garra, Ras Mohammed, Ras Shartib, Safaga Is, Sharm Sabeha (Wadi Al-Gimal NP), Shawarit Island (Hamata Islands), Shelatin Island, Sherm Litu (Wadi Al-Gimal NP), Siyal Island (Hamata Islands), Wadi Al-Gimal National Park, Wadi el Dom, Zabarga Island (St. John's Island).
	Eritrea	34	Anber Siel, Assarca White Island, Auali Hutub Island, Auali Shaura Island, Auatib Kebir Island, Auatib Seghir Island, Baradu Island, Betta Seil, Bilha Island, Dergamman Sekhir Island, Derom Island, Dhu-l-Fidol Island, Difnein Island, Enteara Island, Erfan Island, Fatuma Island, Ghabbi-Hu Island, Gharib Island, Harat Island, Harmil Island, Hermil Seil, Hermil Island, Isratu Island, Madote Island, Marsa Mubarak, Martaban Island, Rijyuma Island, Salima Island, Sarad Island, Segala Island, Senach Island, Sheikh Said Island, Umm Ali Island, Zauber Island.
	Saudi Arabia	18	Abu Rukaba Island, Al Hasani Island S, Central Island, Dhi Dhayaha Island, Dohar Island, Fara fir Island, Firan Island, Jebel Sabaya Island, Maliha Island, Marmar Island, Muska Island, Pelican Island, Qishran Islet (3), Qishran Islet (1), Qishran Islet (2), Sharm Antar, Sila Island, Simer Island (Zamhar),
	Sudan	10	(Al) Seil Ada Kebir, Abington Reef (Island) (SD-04-13), Hindi Gidir Island, Masamirit Island (Masamarthu), Mayetib Kabir Island (Umm ar Dood) (SD-04005), Mishareif Island (SD-04-02), Sarawat Island (SD-02022), SD-02-12, SD-02-23, SD-20-20.
	Yemen	1	Sharma-Jethmoun-Dhargham coast
Unquantified	Djibouti	2	Horod le 'Ale (Île de l'Est), Kadda Dabali (Grand Isle)
	Egypt	?	Coastal
	Eritrea	?	Several islands in Dalak Archipelago likely host some nesting
	Saudi Arabia	?	Many islands of the Red Sea
	Sudan	?	Coastal areas
	Yemen	2	Zebejir, Zukur

the Socotra archipelago, and northeast Gulf of Aden (PERSGA/GEF 2004). Potentially, the reduction in coral density and diversity will impact communities of food sources on which hawksbill turtles forage. However, there has been no assessment of these impacts on hawksbill turtles in the region.

Management and protection

Coastal and marine protected areas are declared for a variety of reasons (Kelleher 1999; PERSGA 2016), including the protection of nesting and foraging habitats used by marine turtles and other species of concern or special interest. Of the 24 national and international coastal and marine protected areas in the Red Sea, 12 include hawksbill turtle nesting sites (Table 11.11). In addition, those areas that contain coral and rocky reefs also support foraging habitat. Unfortunately, most do not have published or completed management plans (MCI 2020). Although the remote nature of these coastal and marine protected areas assists in conserving both the nesting sites and foraging areas used by hawksbill turtles, several areas of importance to marine turtles are outside the designated boundaries.

The countries that border the Red Sea are members of

Table 11.10. Threats to hawksbill turtles in the Red Sea region. KEY: Known or likely location of impact: A=nesting beach, B=oceanic/high seas, C=coastal foraging areas. Quantified: 1=comprehensive documentation across population, 2=comprehensive documentation for some of the population, 3=non-published evidence only, 4=not quantified.

Sources: Frazier and Salas (1984); IOSEA (2019e, f, g, h, i); Miller (1989); PERSGA/GEF (2001, 2004, 2007); Phillott and Rees (2020).

Country	Egypt	Sudan	Eritrea	Djibouti	Yemen	Saudi Arabia	Jordan
Length of coast (km)	**1,805**	**750**	**2,234**	**370**	**800, 1,400***	**1840**	**27**
Consumption – nesting beach							
Egg collection	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, 4
Commercial use of turtles	4	4	4	A, C, 4	4	4	4
Non-commercial use of turtles	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, 4
Predation of eggs by non-native fauna	4	4	4	4	4	4	4
Predation of eggs by native fauna	4	4	4	4	4	4	4
Consumption – foraging turtles							
Commercial use of turtles	4	4	4	4	4	4	4
Non-commercial use of turtles	A, C, 4	4	A, C, 4	A, C, 4	A, C, 4	4	4
Climate change impacts							
Increasing beach temperature	4	4	4	4	4	4	4
Beach erosion	4	4	4	4	4	4	4
Sea level rise	4	4	4	4	4	4	4
Coastal development							
Habitat modification (urban)	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	4
Habitat modification (industrial)	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	4
Light horizon disorientation	4	4	4	4	4	4	4
Fisheries impacts							
Bycatch – trawl	A, C, 4	4	A, C, 4	4	A, C, 4	A, C, 4	4
Bycatch – longline	A, C, 4	4	A, C, 4	4	A, C, 4	4	4
Bycatch – gillnet	A, C, 4	4	A, C, 4	A, C, 4	A, C, 4	4	4
Impact to benthic ecology from fisheries	4	4	4	4	4	4	4
IUU fishing	4	4	4	4	4	4	4
Pollution							
Water quality	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	4

Country	Egypt	Sudan	Eritrea	Djibouti	Yemen	Saudi Arabia	Jordan
Length of coast (km)	**1,805**	**750**	**2,234**	**370**	**800, 1,400***	**1840**	**27**
Entanglement in discarded fishing gear	4	4	4	4	4	4	4
Ingestion of marine debris	4	4	4	4	4	4	4
Noise pollution	4	4	4	4	4	4	4
Disease and pathogens	4	4	4	4	4	4	4

*Yemen Red Sea coast ~800 km; Gulf of Aden coast ~ 1400km

many international agreements that directly or indirectly protect hawksbill turtles and/or their habitat (Table 11.12). Compliance is likely to vary among countries based on their resources and the information on which their conservation and management actions are based. Sudan is the only country that currently has RAMSAR sites that include habitat for marine turtles (i.e. Dongonab Bay-Marsa Waiai and Suakin-Gulf of Agig) (Fretey and Triplet 2020).

In addition, the countries of the Red Sea region have national laws that prohibit or regulate the use of eggs and turtles found on beaches as well as those captured in foraging areas either directly or by accident (Mancini 2015). However, enforcement is an ongoing issue due to the lack of resources (IOSEA 2019e, f, g, h, i).

PERSGA/GEF (2004, 2007) has identified regional issues that impact marine turtles and their habitats in the Red Sea region. In addition, PERSGA/GEF (2019) has developed a standardised methodology (in Arabic and English) for studying marine turtles and other marine organisms and habitats. These provide the context and actions necessary for the conservation and management of marine turtles and their habitats of the Red Sea and provide a standard against which progress can be measured.

Biological data – breeding and foraging

Biological data for nesting hawksbill turtles are unavailable for the majority of the breeding population in the Red Sea region (Table 11.13). Previously recorded nesting sites need to be assessed for current use throughout the Red Sea region (Mancini et al. 2015; Phillott and Rees 2020). At present, hawksbill turtles in the Red Sea appear to have a somewhat shorter curved carapace length than those occurring elsewhere (Witzell 1983; Chatting et al. 2018), but larger sample sizes and better representation of nesting aggregations in the data are needed. The reasons for the apparent size difference remain unknown. Long-term monitoring at multiple sites using standardized methods (see PERSGA/GEF 2019) is needed.

Characteristics of the foraging population (e.g. growth rate and survivorship of different size and age classes) are more difficult to obtain, but are necessary for conservation management of the turtles in the region (Table 11.14). Determining the distribution of foraging habitat, as well as the extent of threatening processes, will aid the development of management in areas important to hawksbill turtles. Data collection from turtle and habitat monitoring at multiple sites using standardized methods (PERSGA/GEF 2019) is required to fill in the missing data. Widespread mapping of the marine environment of the marginal shelf of the Red Sea (e.g. Bruckner et al. 2012) would aid in defining habitats used by marine turtles and provide guidance for coastal environmental management throughout the region.

Maldives

Geographic spread of foraging sites

The Maldives is comprised of 26 atolls and nearly 1,200 low-lying coral reef islands, providing substantial foraging and refuge areas for hawksbill turtles. Stomach contents of an immature hawksbill from Dhigali, Baa Atoll, were composed entirely of soft-bodied sessile invertebrates, primarily sponges, as expected for this species (Frazier et al. 1984, 2000). A 2015 survey conducted in-water SCUBA surveys on eight coral reefs and found that hawksbill turtles were sighted at rates of 0.5 to 2.5 per 60-minute survey, making them the most commonly-seen marine turtle species. Most sightings were of sub-adult size classes (Ali and Shimal 2016). In the last five to ten years, several resort operations have begun citizen science projects to encourage divers and dive companies to record sightings of marine megafauna, such as hawksbill turtles, that occur around dive sites, and to rehabilitate sick and injured turtles. The growth of these citizen science initiatives across the nation could benefit species and habitat protection.

Table 11.11. Designated and proposed protected areas that include hawksbill turtle nesting areas in the Red Sea region. Based on PERSGA/GEF (2004, 2007); Mancini (2015); Phillott and Rees (2020); MCI (2020)

Country	Name	Designation	Type	Status	Comment
Djibouti	Îles Musha et Maskhali	Marine protected landscape	National	Proposed	Nesting occurs at Iles Musha et Maskhali
Djibouti	Îles des Sept Frères, Ras Syan, Khor Angar, and the forest of Godoria	Marine protected landscape	National	Proposed	Nesting occurs at Ras Siyyan
Egypt	Ras Mohammed	National Park	National	Designated	Only minor nesting occurs within park; major nesting occurs on Tiran Island [co-claimed by Saudi Arabia]
Egypt	Abu Gallum	Multiple Use Management Area	National	Designated	Only minor nesting occurs within park
Egypt	Wadi El-Gemal – Hamata	National Park	National	Designated	Park hosts important nesting on coast and islands; adjacent mainland to the north hosts minor to moderate nesting (Hamata area)
Egypt	Elba	Multiple Use Management Area	National	Designated	Minor coastal nesting
Egypt	Red Sea Islands	Developing Resources Protected Area	National	Designated	Only minor nesting occurs within park; major nesting occurs on islands to the south of the park
Saudi Arabia	Farasan Islands	Resource Use Reserve	National	Designated	Nesting on Disan Island, Dhi Dhayaha Island, and is probable on other islands in low numbers as well as on islands (Marrak Island, Dohrab Island, Towasela Island, Simer Island to the south and on islands to the west of the park)
Saudi Arabia	Ra's Suwayhil / Ra's al-Qasbah	Resource Use Reserve	National	Proposed	These islands are co-claimed by Egypt and host major nesting at Tiran Island and Barqan Island
Saudi Arabia	Al-Wajh Bank	Resource Use Reserve	National	Proposed	Major nesting occurs on Waqada Island and the Qalib Island chain. Several minor nesting sites also occur within the designated area
Saudi Arabia	Ra's Kishran / Jazirat Sharifah	Reserve	National	Proposed	Qishran Islands host minor nesting. Nearby Qadd Humais Island hosts moderate nesting but is not with the designated area
Sudan	Suakin Archipelago	National Park	National	Proposed	
Sudan	Sanganeb Marine National Park and Dungonab Bay - Mukkawar Island Marine National Park	World Heritage Site (natural or mixed)	International	Inscribed	Nesting occurs on Mukawwar Island

Table 11.12. Accession of PERSGA States to international legal instruments relevant to turtle conservation. PERSGA/GEF 2007 Regional Action Plan for the Conservation of Marine Turtles, and International Environmental Agreements (IEA) Database Project, 2002-2019. ✓indicates adoption, ratification, or membership.

	Djibouti	Egypt	Eritrea	Jordan	Saudi Arabia	Somalia	Sudan	Yemen
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) [CITES]	✓	✓	✓	✓	✓	✓	✓	✓
Convention on Biological Diversity (1992) [CBD]	✓	✓	✓	✓	✓	✓	✓	✓
Convention on the Conservation of Migratory Species of Wild Animals (1979) [CMS]	✓	✓	✓	✓	✓	✓		✓
Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971) [RAMSAR]	✓	✓		✓			✓	✓
Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia [IOSEA]		✓	✓	✓	✓		✓	✓
Regional Organisation for the Conservation of the Red Sea and Gulf of Aden Environment (1982) [PERSGA]	✓	✓		✓	✓	✓	✓	✓
International Convention for the Prevention of Pollution from Ships (1973/78) [MARPOL]	✓	✓	✓	✓	✓	✓	✓	✓
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972)	✓	✓	✓	✓	✓	✓	✓	✓
United Nations Convention on the Law of the Sea (1982) [UNCLOS]	✓	✓		✓	✓	✓	✓	✓
Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982)	✓	✓	✓	✓	✓	✓	✓	✓

Geographic spread of nesting

Nesting sites were reported by Frazier et al. (1984, 2000), Groombridge and Luxmoore (1989), Zahir (2000), and more recently by Ali et al. (2016) and Hudgins et al. (2017). Data indicate that nesting occurs on most of the nation's uninhabited islands, in particular Baa Atoll, North Malé, and South Malé. A survey in 2015 using local citizen science found North Malé had the only two confirmed hawksbill nests recorded during the surveys of three atolls (also surveyed were Baa and Noonu). However, both nests were recorded in the first week of April, making it possible that two females used the island during this sampling period. Importantly, the peak of nesting is thought to run through March and April and there were no surveys between late February and early April (Hudgins et al. 2017). However, an earlier survey found a recently emerged nest on 30 December, and there were indications that nesting occurred year-round (Frazier et al. 1984, 2000). It is likely that the abundance of nesting hawksbill turtles in the Maldives has declined significantly over the past half century.

Trends in nesting data

There have been no studies to identify trends in the hawksbill turtles nesting at rookeries in the Maldives.

Migration and distribution of foraging sites

There have been no studies on the migration of hawksbill turtles from rookeries in the Maldives.

Threats to the population

The Maldives was the main source of hawksbill turtle shell for the artisanal carving industry in Sri Lanka, as documented by Arab explorers no later than the 12th century (Frazier et al. 1984, 2000). Between 1970 and 1981, a total of 36,447 kg of hawksbill shell was exported from the Maldives, with at least 9,221 kg imported into Japan (Figure 11.3a, with data from Table 136 of Groombridge and Luxmoore 1989). Earlier, Milliken and Tokunaga (1987) reported that Japanese imports of turtle shell from Maldives between 1970 and 1986 totalled 9,661 kg. From 1973 to 1983, the annual figures were fairly regular and modest, but in 1985 and 1986, the annual Maldivian exports to

Japan jumped to 2,225 and 1,956 kg, respectively – well above the previous annual high of 1,266 kg for 1979 (Figure 11.3b). It was suggested that turtle shell exports from the Maldives to Japan may have included re-exports (i.e. items sent from the Maldives but originating elsewhere) to take advantage of the Maldives not being a Party to CITES, thus facilitating the international trafficking of turtle shell that would otherwise be banned.

An experienced bekko dealer in Japan estimated that the average weight of shell from a Maldivian hawksbill was 0.80 kg. This would indicate that more than 12,000 hawksbills had been killed to produce the amount of shell that was exported to Japan during just 15 years (from 1972 to 1986) (Milliken and Tokunaga 1987).

It has been assumed that most of the turtles caught for trade came from nesting beaches, and that consumptive use almost certainly depleted the local populations. Opportunistic retention of hawksbill turtles caught in fishing gear also occurs and contributes to domestic use (Riskas et al. 2018). The export of whole turtle shells (either greens or hawksbills), which had become rampant after the beginning of organised tourism in 1972, was banned in the late 1980s, and another regulation banned the catching, sale, or display for sale of hawksbills with shells less than 60 cm in length (Frazier et al. 1984, 2000).

Biological data on nesting and foraging

There have been no studies on the biology of nesting and foraging of hawksbill turtles in the Maldives.

Table 11.13. Biological data – Breeding – for hawksbill turtles in the Red Sea region. See Phillott and Rees (2020) for further details.

Parameter	Value (n)	Reference(s) (Country)
Pivotal temperature	unknown	
Remigration interval	unknown	
Clutches per season	unknown	
Mean size of nesting adult (CCL)	59.5 cm	PERSGA 2006 (Djibouti)
	72 cm	Frazier and Salas 1984 (Egypt)
	66-71.9 cm	PERSGA 2006 (Sudan)
	71.9 ± 2.96 cm, 67.5-78 cm (17)	Al-Mansi et al. 2003 (Sudan)
	69.2 ± 5.36 cm (25)	Hirth and Abdel Latif 1980 (Sudan)
Age at maturity	unknown	
Clutch size	74 ± 17.73, 34-95 (13)	Hanafy 2012 (Egypt)
	112.7, 96-134 (3)	Frazier and Salas 1984 (Egypt)
	100.8, 34-148 (26)	Hirth and Abdel Latif 1980 (Somalia)
Hatching success	66.5 ± 13.13, 53.4-96.3 (13) (11)	Hanafy 2012 (Egypt)

Table 11.14. Biological data – Foraging – for hawksbill turtles in the Red Sea region.

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

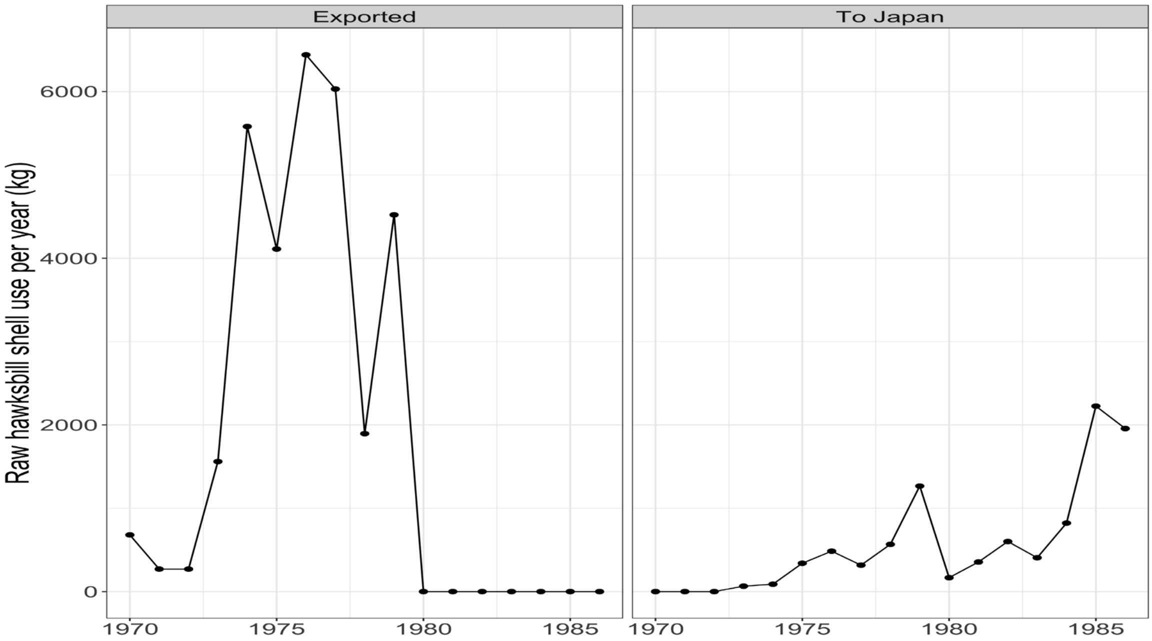


Figure 11.3. Unworked hawksbill turtle shell a) exported annually from the Maldives and b) imported annually into Japan from the Maldives (from Groombridge and Luxmoore 1989).

12. Northeast Indian Ocean

Hawksbill turtles nest in Myanmar, Bangladesh, India, Sri Lanka, and Thailand (Indian Ocean coast). There have been no genetic-based studies to identify management units in this region.

Myanmar

Geographic spread of foraging sites

Hawksbill turtles are known to reside in Myanmar, but there are no data on their distribution or abundance. Two areas with foraging hawksbill turtles have been recognised: Longlone Bok Island and Maung Ma Gan Bok Island (Thant and Maung Maung Lwin 2012).

Geographic spread of nesting

Nesting sites are described by Maxwell (1911), Groombridge and Luxmoore (1989), and more recently by Thorbjarnarson et al. (2000). At Thameehla (Diamond) Island, hundreds of hawksbill turtles nested annually in the 1890s, but in response to long-term excessive egg collection, no hawksbill turtle nesting has been recorded on the island in recent decades (Maxwell 1911; Thorbjarnarson et al. 2000; Limpus 2012). Thorbjarnarson et al. (2000) report hawksbill turtles to be extremely rare in Myanmar. There is low-density nesting reported from Cocokyan within the Andaman Sea in 2007, and unquantified nesting at Hteik kwet galay (Gadongalay) Island in 2010 and Mail Kyan in 2011; Maungmakan Bok Kyan in 2011 and Nant Thar Kyan in 2011; Shimmaw Kyan in 2011; Tin Pamm Kyan in 2007; Ye Kyun in 2011; Kyun Me Gyi Kyan in 2011 (Myanmar report to IOSEA).

Trends in nesting data

There have been no studies to identify trends in the hawksbill turtles nesting at rookeries in Myanmar.

Migration and distribution of foraging sites

There have been no studies on the migration of hawksbill turtles from rookeries in Myanmar.

Threats to the population

The near-total harvest of eggs throughout the 20th century has almost certainly caused significant declines in the nesting and foraging populations. In 1975 and 1977, 300 kg and 500 kg respectively of unworked turtle shell, presumably hawksbill and presumably caught in Myanmar, was exported from Myanmar to South Korea (Groombridge and Luxmoore 1989). During awareness campaigns for fishers between 2008 and 2010, the Myanmar Department of Fisheries received reports of 12 hawksbill turtles caught by gillnets at Longlone Bok Island; eleven of them were released alive (Thant and Maung Maung Lwin 2012). Opportunistic retention of hawksbill turtles caught in fishing gear also occurs and contributes to domestic use (Riskas et al. 2018).

Biological data on nesting and foraging

The have been no studies on the biology of nesting and foraging of hawksbill turtles in Myanmar.

Bangladesh

Geographic spread of foraging sites

There are no data on foraging turtles in Bangladesh.

Geographic spread of nesting

Nesting by hawksbill turtles has been occasionally recorded from St Martin's Island. Surveys between 1996 and 2001 reported 3 female hawksbill turtles nesting in 1998 and none in the other years (Islam 2002). There are no recent data.

Migration and distribution of foraging sites

There have been no hawksbill turtles tracked from nesting beaches in Bangladesh.

Threats to the population

Based on impacts to other marine turtle species nesting in Bangladesh, it is likely that hawksbill populations have been impacted by the harvest of eggs, which has almost certainly caused significant declines in the nesting populations. Stuffed hawksbill turtles and ornaments were reported being sold in stores in Cox's Bazar in 2010, but it is not known if these were from local sources (Islam 2001). Opportunistic retention of hawksbill turtles caught in fishing gear also occurs and contributes to domestic use (Riskas et al. 2018).

Biological data on nesting and foraging

The have been no studies on the biology of nesting and foraging of hawksbill turtles in Bangladesh.

India and western Thailand

India

Geographic spread of foraging sites

There are no published accounts of surveys or research on foraging hawksbill turtles in India. Nevertheless, it is likely that hawksbill turtles are found throughout the Indian EEZ, especially in association with the coral or rocky reef habitats found on India's coastlines. In particular, the coastline of the three island groups (Lakshadweep, Andaman, and Nicobar) includes extensive fringing coral reef habitats (Kumar 1997), which support foraging of juvenile, sub-adult, and adult hawksbill turtles throughout the year (Andrews et al. 2000; Tripathy et al. 2006; John et al. 2010). Mortality records of juvenile and sub-adult hawksbill turtles as bycatch on the mainland coast of India indicate the presence of small foraging turtles.

Geographic spread of nesting sites

Hawksbill turtles are found in India's three island groups: the Lakshadweep, Andaman, and Nicobar Islands. While there are sporadic records of nesting in the Lakshadweep Islands, hawksbill turtle nesting primarily occurs in the Andaman and Nicobar Islands (Bhaskar 1993). The distribution of marine turtle nesting within the Andaman and Nicobar Islands was initially surveyed by Satish Bhaskar from 1978 to 1995. A compilation of Bhaskar's marine turtle surveys and data from the Andaman and Nicobar Islands are found in Namboothri et al. (2012), and other summaries of nesting hawksbill turtles include Murugan (2004) and Andrews et al. (2006). Among the Andaman and Nicobar Islands, hawksbill turtles have been recorded nesting in at least 41 sites: 30 in the Andaman Islands and 11 in the Nicobar group (Andrews et al. 2006). The nesting season runs from July to November and peaks in September through October (Namboothri et al. 2012).

Lakshadweep Islands: Hawksbill nests have been reported from the Agatti and Kalpitti Islands in the Lakshadweep group of islands (Tripathy et al. 2006; Kumar and Choudhury 2008).

Andaman Islands: Hawksbill turtle nesting occurs on islands off the east and west coasts, with the most important hawksbill nesting sites at North and South Brother Islands and South Reef Island (Bhaskar 1993).

Nicobar Islands: Hawksbill turtle nesting occurs on Great Nicobar Island and Little Nicobar Island.

Based on the available information, Andrews et al. (2006) estimated 205 females nesting annually on the Andaman Islands and 45 females nesting on islands in the Nicobar group. A summary of data collected from the monitoring camps conducted by Bhaskar in 1992 and 1995 indicate that hawksbill turtles on South Reef Island averaged 77 cm in CCL and 69 cm in CCW, and that they laid around three clutches per season (114 eggs per clutch) at approximately 14-day intervals (Bhaskar 1996; Namboothri et al. 2012). The Andaman and Nicobar Islands have been recorded as having the best nesting locations for hawksbills in India, as the turtles favour small, isolated island beaches (Bhaskar 1993).

Migration and distribution of foraging sites

There have been no hawksbill turtles tracked from nesting beaches in India.

Threats to the population

Although not comprehensively quantified, hawksbill turtles have been reported as bycatch in coastal fisheries in mainland India (WWF 2013; Sulochanan et al. 2016). Within the Andaman and Nicobar Islands, many of the marine turtle nesting sites are remote, far from areas of human settlement, and officially listed as wildlife sanctuaries. The main threats recorded within the islands include hunting for meat and eggs, incidental capture in coastal fisheries (e.g. shark fisheries), and the predation of eggs by native and introduced species such as feral dogs (Andrews 2000; Namboothri et al. 2012).

Western Thailand

Low numbers of hawksbill turtles nest along the islands of the west coast of Thailand, in particular the Surin and Similan Islands (Chantrapornsyl 1996).

Threats to the population

Based on impacts to other marine turtle species nesting in the region, it is likely that hawksbill populations have been impacted by the harvest of eggs, which has almost certainly caused significant declines in the nesting populations. Opportunistic retention of hawksbill turtles caught in fishing gear also occurs and contributes to domestic use (Riskas et al. 2018).

Sri Lanka

Geographic spread of foraging sites

There are no data on foraging hawksbill turtles in the Sri Lanka region.

Geographic spread of nesting

Hawksbill turtle nesting in Sri Lanka is sparse and scattered along the eastern and southern coastline between Batticaloa and Kosgoda, in particular Amaduwa. Between 1986 and 1988, it was reported that between three and 33 hawksbill clutches were laid each year on the 5 km stretch of beaches between Induruwa to Ahungalla (Hewavisenthi 1990). Between 1996 and 2000, three hawksbill turtles (representing 0.36% of all nesting turtles) were reported to nest in the vicinity of the Rekawa marine turtle monitoring area (Ekanayake et al. 2002). In 2014, Jayathilaka et al. (2016) reported eight individual hawksbills nesting on four beaches (0.5% of clutches laid) between Mount Lavania and Koggala in Southwest Sri Lanka: Mount Lavania (2 turtles), Kosgoda (3), Ahungalla (2), and Kahawa (1). A summary of hawksbill nesting dates for Sri Lanka suggests that nesting occurs year round (Witzell 1983).

Migration and distribution of foraging sites

There have been no hawksbill turtles tracked from nesting beaches in Sri Lanka.

Threats to the population

The harvest of turtles for export and domestic use throughout the 19th and 20th century has almost certainly caused significant declines in the nesting and foraging populations. More recently, opportunistic retention of hawksbill turtles caught in fishing gear also occurs and contributes to domestic use (Rajakaruna et al. 2009; Riskas et al. 2018). In general, there has been significant progress made in reducing the use and sale of hawksbill shell products so that it may no longer be considered a key threat to hawksbill turtles in Sri Lanka (Rajakaruna et al. 2012).

Biological data on nesting and foraging

The have been no studies on the biology of nesting and foraging of hawksbill turtles in Sri Lanka.

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CMS Secretariat
IOSEA Marine Turtle MOU
UN Campus
Platz der Vereinten Nationen 1
53113 Bonn

Tel: (+49) 228 815 24 91
E-mail: iosea@un.org
www.cms.int/iosea-turtles