



**MEMORANDUM OF UNDERSTANDING
ON THE CONSERVATION AND
MANAGEMENT OF MARINE TURTLES
AND THEIR HABITATS OF THE INDIAN
OCEAN AND SOUTH-EAST ASIA**

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Agenda Item 7.3

**DRAFT ASSESSMENT
OF THE CONSERVATION STATUS OF THE HAWKSBILL TURTLE
IN THE INDIAN OCEAN AND SOUTH EAST ASIA**

(Prepared by the Advisory Committee)

Action requested:

- Take note of the report
- Provide comments and feedback

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

IOSEA Species Assessment: Volume 3

DRAFT REPORT Oct 2019 – prepared for the IOSEA Advisory Committee
and Signatory States for Comment and review

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Preface

The *Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia* (IOSEA Marine Turtle MoU) is a non-binding framework under the Convention on Migratory Species through which States of the Indian Ocean and South-East Asia region are working together to conserve and replenish depleted marine turtle populations for which they share responsibility. The IOSEA Marine Turtle MoU took effect in September 2001 and has 35 Signatory States (as of May 2014). Supported by an Advisory Committee of eminent scientists and complemented by the efforts of numerous nongovernmental and intergovernmental organisations, Signatory States are working towards the implementation of a comprehensive Conservation and Management Plan.

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

Accordingly, in 2006 the IOSEA Secretariat published the first-ever *Assessment of the conservation status of the leatherback turtle in the Indian Ocean and South-East Asia*, which covered legislative provisions as well as aspects of conservation related to both nesting and foraging populations. This was followed in 2013 with the release of the *Assessment of the conservation status of the loggerhead turtle in the Indian Ocean and South-East Asia*. Importantly, both assessments also included detailed recommendations and proposals for dealing with deficiencies that had been identified. The Leatherback Assessment was comprehensively reviewed and updated in 2012 to reflect new information and developments. All three assessments are published online and remain available for download from the IOSEA website.

The IOSEA Advisory Committee determined that the hawksbill turtle should be the next species to benefit from a comprehensive assessment. Similar to the loggerhead turtle assessment we review the status of hawksbill turtles with regard to their distinct management units. To obtain information we sought published material, reports from Signatory States to the IOSEA and experts within each of the regions. The following hawksbill assessment presents a synopsis of the current state of knowledge for the species in the IOSEA region.

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Hawksbill turtle synthesis

Summary – nesting

Hawksbill turtles currently nest in 30 nations within the Indian Ocean and Southeast Asia region. All except Japan are Signatory States of the Indian Ocean and South-East Asia Marine Turtle Memorandum of Understanding (IOSEA). There are no recent records to indicate whether hawksbill turtle still nest in Somalia, and it is no longer believed that hawksbill turtles nest in Cambodia, Viet Nam, Bangladesh, and Myanmar. 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. A summary of the nesting status for each of the management units and other nesting regions is in Table 1.

Table 1. Summary of the estimated size range of the annual breeding female population in the Indian Ocean and southeast Asian region.

Management Unit or Country	Estimated size range of the annual nesting population	Description of trend
North-east Australia	1000-5000	Decreasing trend over past two decades.
Northeast Arnhem Land	101-500	No data to infer trend
Eastern Indian Ocean	1000-5000	No data to infer trend, believed to be stable
Sulu Sea	101-500	Variable trend since 1980s
Gulf of Thailand	11-100	Decline since the 1980s, likely stable at low numbers at Pulau Redang, no recent data from Ko Kram
Western Peninsula Malaysia	101-500	Increase since 1980s from <100 to ~400 nests laid per year
Arabian/Persian Gulf	501-1000	No data to infer trend, believed to be stable
Western/Central Indian Ocean	501-1000	Variable rates of recovery since 1980s, believed to still be at lower levels than pre-bekko trade.
Indonesia (Java Sea)	501-1000	Variable rates of recovery since 1980s, believed to still be at lower levels than pre-bekko trade.
Red Sea	501-1000	No recent data, believed to be stable
Southwest Indian Ocean	101-500	No data to infer trend
Oman and Yemen	501-1000	No recent data for Yemen, data Oman from 2001

Summary – foraging

Data from capture-mark-recapture studies, tag recoveries, satellite telemetry (end points), and fisheries bycatch indicate that hawksbill turtles have been recorded within the Exclusive Economic Zones of most of the IOSEA Signatory States (including their Territories). In addition, hawksbill turtles have been recorded in the waters of all non-signatory range states.

Population and biological studies on foraging turtles have been conducted in Australia the Arabian/Persian Gulf region and Indonesia.

Summary – population identification

There are at least eight distinct populations/management units (MU) of hawksbill turtles within the IOSEA region, and one adjacent (Solomon Islands) (see Figure 1 adapted from FitzSimmons and Limpus 2014 and Vargas et al. 2016). These have been classified as distinct based on a combination of genetic and biological data. While the nesting sites are distinct, individuals from more than one population may inhabit particular foraging areas. It is possible that there is more than one genetically distinct management unit in the Persian Gulf. There has been no genetic-based research done with turtles from rookeries in Maldives, Sri Lanka, Thailand (Indian Ocean), India, Indonesia, Philippines, South and West Indian Ocean nations (except Seychelles and Chagos), Oman, Egypt, Saudi Arabia (Red Sea), Yemen, Djibouti, Eritrea or Sudan so it is likely that additional management units exist.

Larger, Regional Management Units, and the conservation status for hawksbill turtles were also defined as part of the Burning Issues initiative of the Marine Turtle Specialist Group (Wallace et al. 2010; 2011). They describe 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 that include IOSEA signatory states. However, the genetic basis for these designations was based on limited sample size and statistical power.

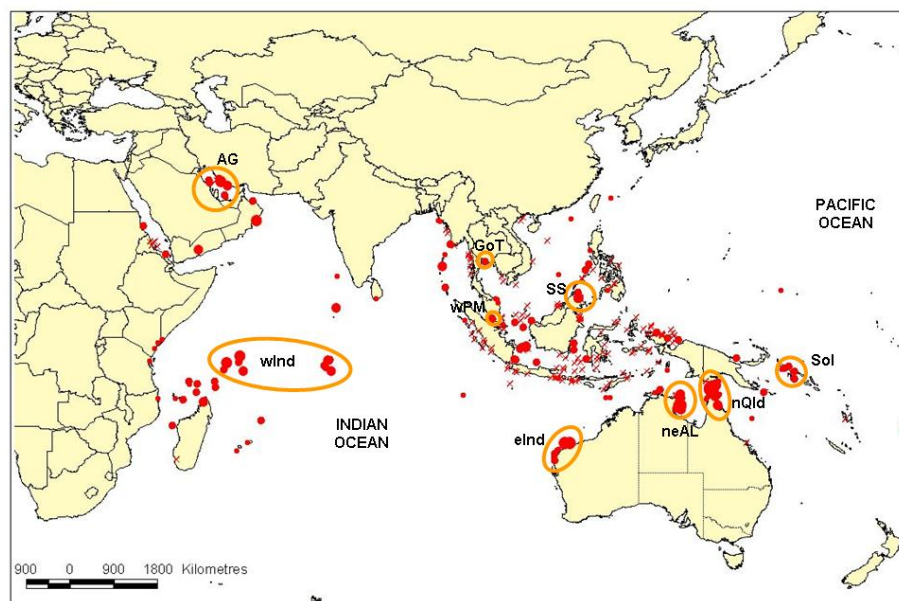


Figure 1. Distribution of hawksbill turtle (*Eretmochelys imbricata*) nesting within the Indian Ocean – Southeast Asian region (after FitzSimmons and Limpus, 2014, using data with the Queensland Department of Environment and Science Turtle Conservation Data Base). Genetic stocks identified by the nesting beaches are enclosed in orange lines. “x” denotes beaches where hawksbill turtle nesting has been recorded but not quantified.

Gaps in the basic biological information

Population structure

There is a key need for genetic based research to be done on rookeries in Myanmar, India, Sri Lanka, Maldives, Indonesia, Philippines, South and West Indian Ocean nations (except Seychelles and Chagos), Oman, Yemen and from rookeries throughout the Red Sea to identify a complete suite of genetic based management units for hawksbill turtles in the IOSEA region. Such research would provide a foundation for future status assessments and conservation activities.

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 by referring to each population section of this report. Data on life history attributes are necessary for the development of accurate population models and implementing effective management. It is preferential that life history parameters be collected from at least one rookery per management unit. The gaps in life history attributes evident in most management units include:

- Lack of genetic mtDNA profiles for several rookeries/management units
- Annual census data at representative nesting beaches are required to quantify the number of females nesting, the number of clutches laid or the number of beachings by nesting turtles
- Quantifying mortality from human related sources across all life history stages
- Quantifying key demographic parameters:
 - the number of clutches laid per female per year/nesting season
 - the number of years between breeding seasons
 - the rate of recruitment into the breeding population
 - survivorship of adult females
 - incubation success and hatchling recruitment
- Determination of the temperature profile and hatchling sex ratios of nesting populations
- Understand patterns of inter-nesting areas and habitat use

B. Non-nesting beach aspects

Within the IOSEA region there are substantial gaps in our knowledge of hawksbill turtle foraging areas, habitat use (oceanic and coastal), inter-nesting area habitats, diet, growth, age and survivorship. Additionally, while there have been substantial tracking and foraging area studies in the Australian, Solomon Islands and Arabian/Persian Gulf populations, few data on migration and home range exist for the other populations.

Gaps in management

Reporting gaps

Similar to the findings of the loggerhead assessment it was evident during the writing of this assessment that much of the threat, mortality and management information contained within the IOSEA website and the Signatory States reports is not species specific. It could be that

“species” level information is not collected, or that it is not reported on. In terms of threats such as bycatch it is most likely the former. Improving species-specific data collection about threats and mortality will improve management.

Bycatch and fisheries-associated mortality

From examining the literature there is a clear need to improve the quantification of hawksbill turtle bycatch in coastal fisheries, and couple bycatch monitoring with sampling from the turtles so that genetic-based stock assessments are possible. Understanding the cumulative impacts of multiple fisheries, or fisheries types in different spatial areas is also necessary.

Clutch loss to predators and human take and loss via erosion and flooding.

There is a paucity of nesting beach monitoring for numbers of clutches laid and the number of clutches that fail to hatch (i.e. monitoring clutch loss). It is recommended as a generalised management goal, that at least 70% of clutches laid should survive to successful hatching.

Human use of turtles

Across most of the region there is excessive loss of eggs and turtles through human use. Collectively, the trade is of high magnitude, involves several nations, and threatens the recovery of depleted hawksbill turtle populations. There is a need to understand the social and economic drivers underpinning the illegal use and trade, such as social dimensions of social ecological systems, in particular, the incentives individuals and groups have to be involved in the illegal use, their resilience to change, and opportunities for affected people to develop incentives towards alternatives. There is a demonstrable need to strengthen Monitoring, Control, and Surveillance and employ regional coordination to help build capacity in less-developed nations. There is a recognised need to improve the understanding of hawksbill products seized by customs agencies, such as the collection and analysis of samples collected from scutes.

Climate change

There is a need for systematic collection of sand temperature data from nesting beaches for each stock, ideally sampling would cover a range of microhabitats and locations. Elevation profiles could also be collected from important nesting locations to examine the potential vulnerability to sea level rise.

Standard monitoring

There is a need to develop or maintain standardised monitoring projects for each of the nesting stocks and foraging aggregations for each management unit. Doing this will enable the recovery of the management units to be track over time. There is a need for the collection of genetic material from unsampled locations to aid in the refinement of management unit boundaries, and DNA sampling from turtles caught in bycatch or illegal operations so that threats can be better assigned to management units.

The turtle shell trade – a summary

The information and status of hawksbill turtles summarised in this report needs to be considered in the context of large scale – geographic and temporal – commercial trade in hawksbill shell projects that occurred for several centuries but predominantly the 20th century (Figure 2a). For the most part the trade occurred before CITES, and the signing of CITES by individual nations. The historic tortoiseshell trade out of Australia and Seychelles prior to World War II illustrate the scale of this past trade, mostly into Europe (Figure 2b,c).

Groombridge and Luxmoore (1989) also note international and domestic trade of hawksbill turtles and/or their eggs going back to the late 18th century – for example, data on the trade of hawksbill turtle shell from the Seychelles between 1884 and 1982 indicate an annual trade of around 1079 kg per year (Figure 2b). The more recent trade was well summarised by Groombridge and Luxmoore (1989); in particular, between 1950 and 1986, 310598 kg (mean 8394 per year) of raw hawksbill (Bekko) shell was exported from countries within the IOSEA region into Japan. There are various weights cited in the literature to convert kg of shell to the number of turtles. Using the conversions of 0.92 kg and 1.5 kg as equivalents for one turtle, between 207,000 (5596 per year) and 295,000 (7974) hawksbill turtles were killed in the IOSEA region for the trade of raw turtle shell into Japan between 1950 and 1992. Contributions to this trade came from at least 20 countries, predominantly Indonesia, Tanzania and the Philippines. Trade into Hong Kong, Korea, Sri Lanka, Taiwan, Europe and the USA from IOSEA nations also occurred (Figure 2a). Plus, in addition to the raw shell trade there was considerable trade of other hawksbill turtle products (eggs, skin and processed shell).

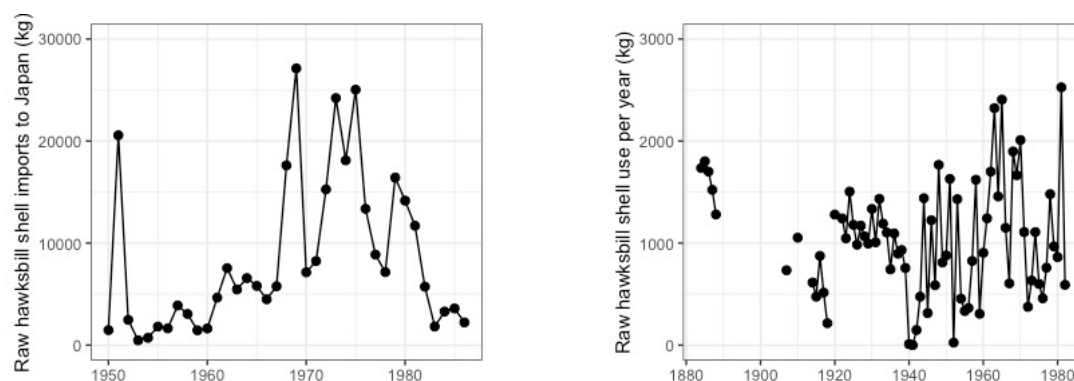


Figure 2. (a) Kilograms of raw hawksbill shell imported into Japan from IOSEA nations per year between 1950 and 1986 and (b). Kilograms of raw hawksbill shell use per year from the Seychelles. Data extracted from Groombridge and Luxmoore (1989) tables 102 and 177 respectively.

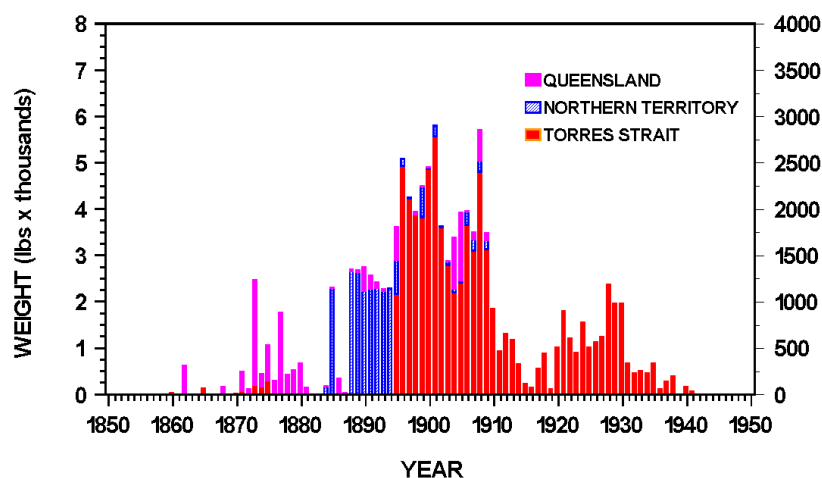


Figure 2c. Export of tortoiseshell from Australia documented by Australian/Colonial Customs statistics. Export via Northern Territory prior to 1888 and Torres Strait prior to

1896 was undocumented or incompletely documented. The trade prior to World War II was directed mostly into Europe.

Additional issues for hawksbill turtles in the IOSEA region

Bycatch in legal fisheries

Incidental bycatch in legal fisheries is recognised across the world as a significant threat to populations of marine turtles (Lewison et al. 2004, Bourjea et al. 2008, Wallace et al. 2010). In general, the three types of fisheries believed to have the highest impact on marine turtles are gill nets, bottom trawling and long-lines. However, for most fisheries, especially artisanal fisheries there are no quantitative data from which to understand the severity of the threat. In the Indian Ocean and southeast Asian region of the Pacific Ocean bycatch in legal fisheries is also considered to be a key threat to sea turtles, however quantitative data are not common (Bourjea et al. 2008, Williams et al. 2019). The Governments of several nations and fisheries regulatory bodies have implemented bycatch reduction and/or observer programs aimed at mitigating the issues or understanding the scale of impact. Management includes a suite of operation controls (e.g. turtle excluder devices, limits to trawl length set times, set depths, setting restrictions, bait and hook type) and spatial closures. However, the effectiveness of mitigation is rarely evaluated, and where bycatch records are collected they are usually examined at fisheries scales making cumulative impacts hard to understand (Riskas et al. 2016). In the past 10 years we found 15 science-based publications of bycatch of marine turtles in the Indian Ocean and southeast Asian region. Eleven of these described bycatch in fisheries operating in the southwest Indian Ocean, two for southeast Asia and two for the northern Indian Ocean. Collectively the papers indicate the bycatch of hawksbill turtles from long-line and purse seine fisheries is very low (n=8), bycatch from gill nets and coastal artisanal fisheries are likely have the highest impacts (n=7) and bycatch is spatially and temporally variable and usually low in magnitude making statistical inference challenging. Two of the key challenges are to quantify the bycatch in coastal fisheries, and couple bycatch monitoring with sampling from the turtles so that genetic-based stock assessments are possible.

- Bourjea, J., Nel, R., Jiddawi, N. S., Koonjul, M. S., & Bianchi, G. (2008). Sea turtle bycatch in the West Indian Ocean: review, recommendations and research priorities. *Western Indian Ocean Journal of Marine Science*, 7(2), 137-150.
- Lewison, R. L., Crowder, L. B., Read, A. J., & Freeman, S. A. (2004). Understanding impacts of fisheries bycatch on marine megafauna. *Trends in ecology & evolution*, 19(11), 598-604.
- Riskas, K. A., Fuentes, M. M., & Hamann, M. (2016). Justifying the need for collaborative management of fisheries bycatch: a lesson from marine turtles in Australia. *Biological Conservation*, 196, 40-47.
- Wallace, B. P., Lewison, R. L., McDonald, S. L., McDonald, R. K., Kot, C. Y., Kelez, S., ... & Crowder, L. B. (2010). Global patterns of marine turtle bycatch. *Conservation letters*, 3(3), 131-142.
- Williams, J. L., Pierce, S. J., Hamann, M., & Fuentes, M. M. (2019). Using expert opinion to identify and determine the relative impact of threats to sea turtles in Mozambique. *Aquatic Conservation: Marine and Freshwater Ecosystems*.

Illegal use, Illegal Unregulated and Unreported Fishing

In response to increasing concern about the illegal use and sale of hawksbill turtles and the role on IUU fisheries in the trade the CITES facilitated a study on the legal and illegal international trade in marine turtles (CITES 2019). The CITES study included case studies in

Mozambique, Madagascar, Indonesia, Malaysia and Viet Nam (CITES 2019). In addition, Riskas et al. (2018) conducted a survey of experts in marine turtle conservation and fisheries management in the Indian Ocean and southeast Asian Region to examine the threat of IUU on marine turtles and the barriers and opportunities for mitigating the threat of IUU, Williams et al. (2019) examined the illegal capture and commercial use of marine turtles in Mozambique and Vuto et al. (2019) conducted similar work in the Solomon Islands. Importantly, all studies reach complementary conclusions.

1. IUU fishing is likely to have potentially significant impacts on sea turtle populations in IOSEA through targeted exploitation and international wildlife trafficking.
2. The motivations for use differ across the region. In the southwest Indian Ocean illegal use is predominantly for local domestic consumption, or domestic trade. In southeast Asia the illegal use supplies both local and international markets. The production of handicrafts and sale of stuffed turtles is more common. CITES seizure records also support the finding that trade occurs between countries of the southeast Asia sub-region.
3. An organised domestic trade network was found in Madagascar, allowing the movement of turtles from coastal to inland areas. In southeast Asia there was increased evidence of turtles being caught, stored in pens, and then traded when enough turtles had been caught.
4. Individual fishers generally understood that the capture/retention and selling of turtles was not legal, but believed that the benefits of doing so were perceived to outweigh the risk of getting caught.
5. Enforcement of legislation was a universal issue across the region that requires attention and improvement.
6. Increased attention on the trade, especially the international trade, has largely caused the trade to be driven underground, and in Indonesia and Malaysia, online.
7. There is likely to be considerable collection of eggs in Sabah and Sarawak for trade into markets in Peninsula Malaysia.
8. The illegal trade in *E. imbricata* particularly via China and Viet Nam provides an incentive for continuing illegal trade of *E. imbricata* or their scutes from the developing countries in the neighbourhood of Queensland (see also Vuto et al. 2019).
9. Collectively, the trade is of high magnitude, involves several nations, and threatens the recovery of depleted hawksbill turtle populations.
10. There are considerable social and economic drivers underpinning the illegal use and trade, they cross several governance and social structures and they are not well understood.
11. There is a demonstrable need to strengthen Monitoring, Control, and Surveillance and employ regional coordination to help build capacity in less-developed nations.
12. There is a demonstrable need to better understand the social dimensions of social ecological systems, in particular, the incentives individuals and groups have to be involved in the illegal use, their resilience to change, and opportunities for affected people to develop incentives towards alternatives.

CITES (2019). Status, scope and trends of the legal and illegal international trade in marine turtles, its conservation impacts, management options and mitigation priorities. Eighteenth (18th) meeting of the CITES Conference of the Parties (Geneva, August 2019), Document CoP18 Inf. 18.

- Riskas, K. A., Tobin, R. C., Fuentes, M. M., & Hamann, M. (2018). Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. *Biological Conservation*, 217, 232-239.
- Vuto, S., Hamilton, R., Brown, C., Waldie, P., Pita, J., Peterson, N., ... & Limpus, C. (2019). A report on turtle harvest and trade in Solomon Islands. The Nature Conservancy, Solomon Islands 34p.
- Williams, J. L., Pierce, S. J., Hamann, M., & Fuentes, M. M. (2019). Using expert opinion to identify and determine the relative impact of threats to sea turtles in Mozambique. *Aquatic Conservation: Marine and Freshwater Ecosystems*.

Climate change

Climate change is a ubiquitous issue throughout the world. While marine turtles have coped with changing climates over past millennia, the rate of current and predicted change, coupled with additional and cumulative threats and pressures (e.g. coastal development, pollution, fisheries), is unprecedented. While it may be a ubiquitous issue, the degree to which various species or populations of marine turtle are exposed, and how they are able to adapt, will vary considerably (Hamann et al. 2013). In our review of the recent literature (2009 to 2019) we found four publications focussed on aspects of climate change related to hawksbill turtles in the Indian Ocean and Southeast Asia region. Three of these research papers focussed on beach/sand temperatures or sea level rise (Butt et al. 2016, Eseban et al. 2016, Tanabe 2018) and one focussed on in-water behaviour (Pilcher et al. 2014).

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 become unsuitable for nesting, either through increased sand temperatures or sea level rise. From the perspective of temperature, there are potential nesting habitat to the south of existing sites which could be used, or turtles could begin nesting earlier/later in the season to avoid the warmest temperatures.

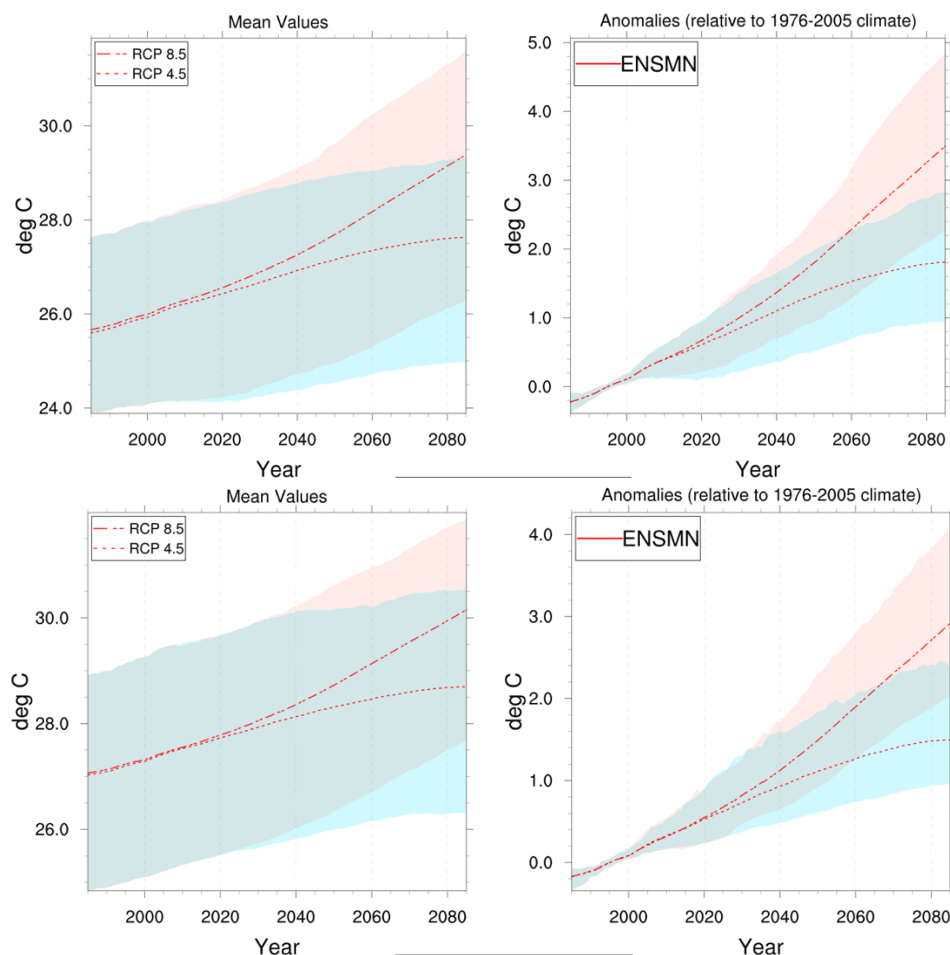
Esteban et al. (2016) examined sex ratios of green and hawksbill clutches on the islands of the Chagos Archipelago. They found that sand temperatures collected at the same depth of hawksbill turtle clutches varied throughout the year, the peak nesting season, on beaches in relation to season and shade profile. Consequently, this spatial and temporal variation in sand temperature led to a balanced sex ratio for hawksbill clutches. Long-term studies such as this are required for all management units in the region.

Tanabe (2018), conducted post-graduate thesis research on the 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 29C and during late July to mid-September they are above 33C. Although this study spanned five months in a single year, it highlights a need to continue similar monitoring to understand the situation and implications.

Pilcher et al. (2014) used a large satellite telemetry dataset of hawksbill turtles in the Persian/Arabian gulf. In the Gulf, surface water temperatures during summer averaged 33C and peaked at 34C. During the summer months the turtles made temporary movements into deeper cooler waters where the surface water temperatures was around 2C cooler. They

them moved back once the 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 Indian Ocean and Southeast Asian region will be ecologically, socially and economically vulnerable to increased air and sea-surface temperatures and sea level rise. There are several published accounts of existing changes in the regions 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 (United States) Earth Systems Research Laboratory (<https://www.esrl.noaa.gov/psd/>) indicate that between 2019 and 2100 air temperatures across the Indian Ocean and Southeast Asian region can be expected to rise by 0.9 to 2.2°C (RCP4.5) or 2.0 to 4.2°C (RCP8.5) by 2100 (Figure 3). Sea levels are also expected to rise by 0.3 to 0.47 m (RCP4.5) or 0.3 to 0.63 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.



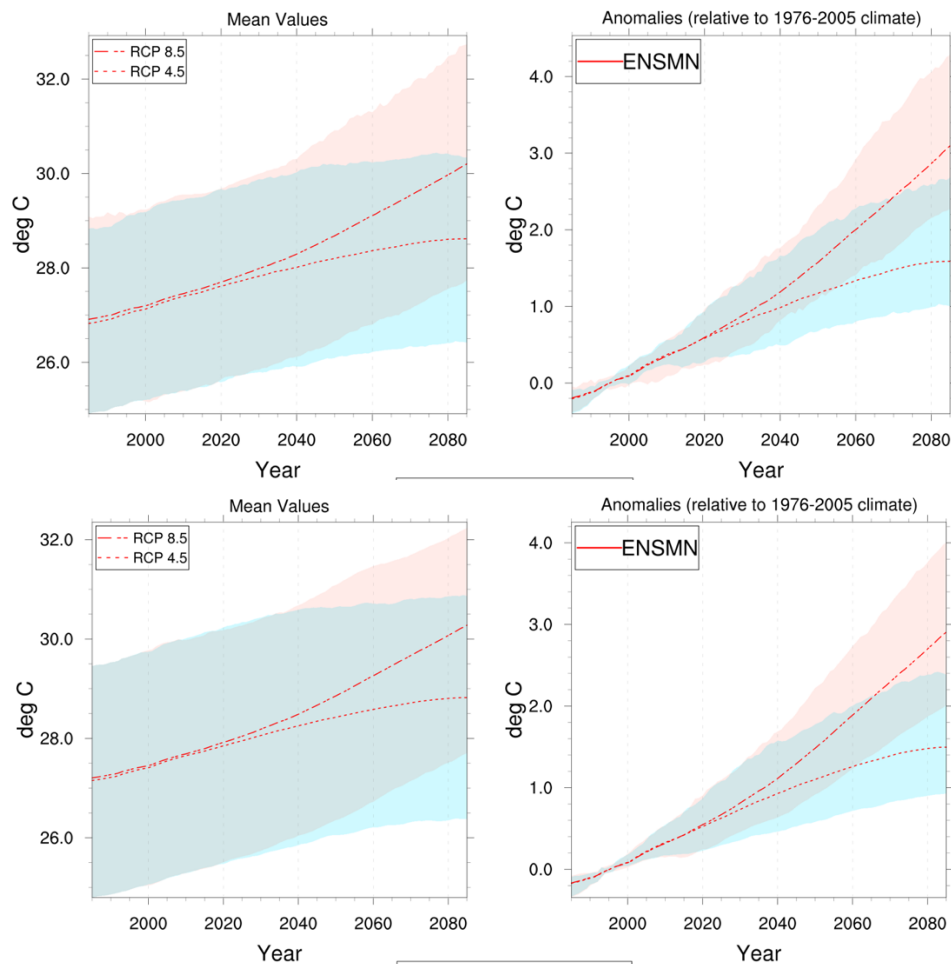


Figure 3. Predicted change to air temperatures over the next 80 years in four regions of the IOSEA region, data are derived from the average of CMIP5 climate model outputs https://www.esrl.noaa.gov/psd/ipcc/ocn/timeseries_lens.html. Panel (a) Arabian/Persian Gulf, (b) Sulu/Cerebes Seas, (c) northern Australia and (d) Central Indonesia. RCP4.5 assumes that global annual GHG emissions peak around 2040 and then decline and RCP8.5 assumes the GHG emissions continue to rise throughout the 21st century.

Currently there are no foraging area studies to examine future change in the sex ratio of hawksbill turtles and how they may change over time. While there have been some published studies of beach related impacts such as increased incubation temperatures and sea level rise, a structure approach is required for each stock so the situation can be monitored over coming decades. A useful starting point would be standardised collection of sand and air temperatures and baseline elevation mapping of nesting habitats.

- Al-Rashidi, T. B., El-Gamily, H. I., Amos, C. L., & Rakha, K. A. (2009). Sea surface temperature trends in Kuwait Bay, Arabian Gulf. *Natural Hazards*, 50(1), 73-82.
- Ben-Hasan, A., & Christensen, V. (2019). Vulnerability of the marine ecosystem to climate change impacts in the Arabian Gulf—an urgent need for more research. *Global Ecology and Conservation*, 17, e00556.
- Bryndum-Buchholz, A., Tittensor, D. P., Blanchard, J. L., Cheung, W. W., Coll, M., Galbraith, E. D., ... & Lotze, H. K. (2019). Twenty-first-century climate change impacts on marine animal biomass and ecosystem structure across ocean basins. *Global change biology*, 25(2), 459-472.
- Butt, N., Whiting, S., & Dethmers, K. (2016). Identifying future sea turtle conservation areas under climate change. *Biological Conservation*, 204, 189-196.

- Descombes, P., Wisz, M. S., Leprieur, F., Parravicini, V., Heine, C., Olsen, S. M., ... & Pellissier, L. (2015). Forecasted coral reef decline in marine biodiversity hotspots under climate change. *Global Change Biology*, 21(7), 2479-2487.
- Esteban, N., Laloë, J. O., Mortimer, J. A., Guzman, A. N., & Hays, G. C. (2016). Male hatchling production in sea turtles from one of the world's largest marine protected areas, the Chagos Archipelago. *Scientific reports*, 6, 20339.
- Kubicek, A., Breckling, B., Hoegh-Guldberg, O., & Reuter, H. (2019). Climate change drives trait-shifts in coral reef communities. *Scientific reports*, 9(1), 3721.
- McGregor, J. L., Nguyen, K. C., Kirono, D. G., & Katzfey, J. J. (2016). High-resolution climate projections for the islands of Lombok and Sumbawa, Nusa Tenggara Barat Province, Indonesia: Challenges and implications. *Climate Risk Management*, 12, 32-44.
- Shirvani, A., Nazemosadat, S. M. J., & Kahya, E. (2015). Analyses of the Persian Gulf sea surface temperature: prediction and detection of climate change signals. *Arabian Journal of Geosciences*, 8(4), 2121-2130.
- Tanabe, L. K. (2018). *Sand temperature profiles at turtle nesting sites in the Red Sea: implications for hatchling sex ratios* (Doctoral dissertation).
- Wabnitz, C. C., Lam, V. W., Reygondeau, G., Teh, L. C., Al-Abdulrazzak, D., Khalfallah, M., ... & Cheung, W. W. (2018). Climate change impacts on marine biodiversity, fisheries and society in the Arabian Gulf. *PloS one*, 13(5), e0194537.

Marine debris and plastic pollution

Marine debris, in particular plastic pollution, is emerging as an important and widespread threat to marine turtle populations globally (Schuyler et al. 2014, 2016, Wilcox et al. 2013, Duncan et al. 2019). Although most of the published accounts of impacts on sea turtles come from the Pacific and Atlantic oceans, it is becoming clear that the South-East Asian and Indian Ocean regions contain substantial levels of plastic pollution (e.g. Hoarau et al. 2014, Stelfox et al. 2015, Schuyler et al. 2016, Imhof et al. 2017). The main threats that plastics pose to turtles occur when turtles ingest plastic fragments, become entangled in discarded nets (ghost nets), or have their nesting habitats impacted by them. Key research gaps include quantification of the impact across populations and life stages, the oceanographic features that disperse the pollution, understanding the social and economic drivers behind the pollution, and the barriers and opportunities for management (see Vegter et al. 2014, Nelms et al. 2015, Duncan et al. 2017).

- Duncan, E. M., Botterell, Z. L., Broderick, A. C., Galloway, T. S., Lindeque, P. K., Nuno, A., & Godley, B. J. (2017). A global review of marine turtle entanglement in anthropogenic debris: a baseline for further action. *Endangered Species Research*, 34, 431-448.
- Duncan, E. M., Broderick, A. C., Fuller, W. J., Galloway, T. S., Godfrey, M. H., Hamann, M., ... & Santillo, D. (2019). Microplastic ingestion ubiquitous in marine turtles. *Global change biology*, 25(2), 744-752.
- Hoarau, L., Ainley, L., Jean, C., & Ciccione, S. (2014). Ingestion and defecation of marine debris by loggerhead sea turtles, *Caretta caretta*, from by-catches in the South-West Indian Ocean. *Marine Pollution Bulletin*, 84(1-2), 90-96.
- Imhof, H. K., Sigl, R., Brauer, E., Feyl, S., Giesemann, P., Klink, S., ... & Muszynski, S. (2017). Spatial and temporal variation of macro-, meso- and microplastic abundance on a remote coral island of the Maldives, Indian Ocean. *Marine pollution bulletin*, 116(1-2), 340-347.
- Nelms, S. E., Duncan, E. M., Broderick, A. C., Galloway, T. S., Godfrey, M. H., Hamann, M., ... & Godley, B. J. (2015). Plastic and marine turtles: a review and call for research. *ICES Journal of Marine Science*, 73(2), 165-181.
- Schuyler, Q., Hardesty, B. D., Wilcox, C., & Townsend, K. (2014). Global analysis of anthropogenic debris ingestion by sea turtles. *Conservation biology*, 28(1), 129-139.
- Schuyler, Q. A., Wilcox, C., Townsend, K. A., Wedemeyer-Strombel, K. R., Balazs, G., van Sebille, E., & Hardesty, B. D. (2016). Risk analysis reveals global hotspots for marine debris ingestion by sea turtles. *Global Change Biology*, 22(2), 567-576.
- Stelfox, M. R., Hudgins, J. A., Ali, K., & Anderson, R. C. (2015). High mortality of Olive Ridley Turtles (*Lepidochelys olivacea*) in ghost nets in the central Indian Ocean. *BOBLME-2015-Ecology-14*, 1-23.

- Vegter, A. C., Barletta, M., Beck, C., Borrero, J., Burton, H., Campbell, M. L., ... & Gilardi, K. V. (2014). Global research priorities to mitigate plastic pollution impacts on marine wildlife. *Endangered Species Research*, 25(3), 225-247.
- Wilcox, C., Hardesty, B. D., Sharples, R., Griffin, D. A., Lawson, T. J., & Gunn, R. (2013). Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia. *Conservation Letters*, 6(4), 247-254.

Recommendations for hawksbill turtle conservation

Gap	Project context/relevance	Expected outcomes	Nations/agencies targeted

Introduction

The hawksbill turtle (*Eretmochelys imbricata*) occurs in all of the world's tropical and temperate oceans. Hawksbill turtle nesting is wide spread, and in some areas, abundant within the IOSEA region. As a widely distributed and long-lived marine species, a challenge has been the determination of hawksbill turtle conservation status at scales appropriate for management (Meyland and Donnelly 1999; Wallace et al. 2011; FitzSimmons and Limpus 2014). Similar to other marine turtle species, the hawksbill turtle consists of numerous populations, which possess separate nesting locations 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, global status assessments using the IUCN Red List framework have proven challenging and sometimes controversial (Godfrey and Godley 2008). However, for conservation strategies to be effective, it is crucial that the relationships between the geographic areas used by each population are identified, to permit impacts from anthropogenic sources to be determined at the population level (FitzSimmons and Limpus 2014) and implement effective management.

There have been several attempts to categorise marine turtles into independent population units below the species level, but above the nesting population level. The first initiatives used population genetics to determine genetically distinct populations, and then classed these populations as stocks or management units (as per Moritz et al. 2002). At least eight (plus one adjacent) management units for hawksbill turtles in the IOSEA region where subsequently documented by FitzSimmons and Limpus (2014) and Vargas et al. (2016). In addition, FitzSimmons and Limpus (2014) provide locations in the region where no genetic data have been collected. Given the knowledge gaps in genetic structure exist for many regions of the world, and in an attempt to address the challenges of data poor areas, Wallace et al. (2010) described regional management units (RMU) for all seven species of marine turtle. They describe six RMUs for hawksbill turtles in the IOSEA – although six of them were scored as

putative and may require modification as data become available. Together these approaches identify the most appropriate management units (MUs) for hawksbill turtles (Table 2).

Table 2. Outputs from the Wallace et al. (2011) burning issues initiative for hawksbill turtle populations in the IOSEA region and the management unit designation by FitzSimmons and Limpus (2014), * indicate putative RMUs and + indicates an RMU scored as a critical data need (Wallace et al. 2011).

Regional Management Unit	IOSEA Countries with hawksbill turtle nesting	Genetic stocks included (FitzSimmons and Limpus 2014)
Northwest Indian Ocean*	Iran, Saudi Arabia, Kuwait, Qatar, UAE, Oman, Yemen, India (Lakshadweep Islands), Maldives	Arabian/Persian Gulf (only Iran and Saudi Arabia were assessed). Sites in India, Maldives, Oman, and Yemen are out of the Gulf
Southwest Indian Ocean	Seychelles, Chagos (BIOT), Madagascar, Mozambique, Tanzania, Kenya, Comoros, Mauritius, Mayotte	Western/central Indian Ocean (only Seychelles and Chagos were assessed)
Northeast Indian Ocean*	Sri Lanka, India (Nicobar and Andaman Islands), Myanmar, Thailand	Data deficient
Southeast Indian Ocean*	Timor Leste, Australia (west)	One management unit identified (eastern Indian Ocean, Western Australia)
Southeast Asia*	Japan, China, Vietnam, Thailand, east coast Peninsula Malaysia, Singapore, Indonesia, Philippines	Sulu Sea (Malaysia), Gulf of Thailand (Kho Kram) and western Peninsula Malaysia (Maluka) populations have been assessed. Rookeries in Indonesia, Singapore, Vietnam, China, Japan and Philippines have not been assessed.
Pacific west central*	Indonesia (West Papua)	Data deficient
Pacific southwest	Australia (Northern Territory and Queensland), Papua New Guinea and Solomon Islands	Three management units identified: North Queensland, northeast Arnhem Land and Solomon Islands

With regard to identifying status of marine turtle species there has been considerable debate about the most effective scale to undertake the review. One aim of the approach used by Wallace et al. (2011) was to assess each of the RMUs in terms of population risk level (population size, recent trend, long-term trend, rookery vulnerability and genetic diversity) and existing threats (fisheries bycatch, take, coastal development, pollution and pathogens, and climate change). In doing so they identified RMUs which could be considered 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 high risk and high threat were within the IOSEA region (1) the Northeast Indian Ocean which comprises stocks in the Persian Gulf but would also include rookeries in the Red Sea and (2) the Pacific West/Southeast Asia which includes stocks in Timor Leste, Indonesia, Malaysia, Singapore, Philippines Thailand, Cambodia, Vietnam, China and Japan.

In compiling our assessment on hawksbill turtles in the IOSEA region we used the genetic stocks approach as per the loggerhead assessment (Hamann et al. 2013). We used the genetic

stocks identified by FitzSimmons and Limpus (2014). Then for each of the recognised stocks we (1) collated data from published literature, reports prepared by the Signatory States and expert opinion to summarise the status of eight hawksbill stocks in the Indian and Pacific oceans. In addition, we summarise published information and reports for rookeries/countries for which biological data are available but have not been assigned to a genetic stock.

References

- Bell, I. & M. P. Jensen (2018). Multinational genetic connectivity identified in western Pacific hawksbill turtles, *Eretmochelys imbricata*. *Wildlife Research* 45(4): 307-315.
- Hamann, M., Kamrowski, R. L., & Bodine, T. (2013). Assessment of the conservation status of the loggerhead turtle in the Indian Ocean and South-East Asia. *IOSEA Species Assessment*, 2, 56.
- FitzSimmons, N. N., & Limpus, C. J. (2014). Marine turtle genetic stocks of the Indo-Pacific: identifying boundaries and knowledge gaps. *Indian Ocean Turtle Newsletter*, 20(July), 2-18.
- Meylan, A. B., & Donnelly, M. (1999). Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 IUCN Red List of Threatened Animals. *Chelonian conservation and Biology*, 3(2), 200-224.
- Vargas, S. M., Jensen, M. P., Ho, S. Y., Mobaraki, A., Broderick, D., Mortimer, J. A., ... & Hoenner, X. (2015). Phylogeography, genetic diversity, and management units of hawksbill turtles in the Indo-Pacific. *Journal of Heredity*, 107(3), 199-213.
- Wallace, B. P., DiMatteo, A. D., Hurley, B. J., Finkbeiner, E. M., Bolten, A. B., Chaloupka, M. Y., ... & Bourjea, J. (2010). Regional management units for marine turtles: a novel framework for prioritizing conservation and research across multiple scales. *Plos one*, 5(12), e15465.
- Wallace, B. P., DiMatteo, A. D., Bolten, A. B., Chaloupka, M. Y., Hutchinson, B. J., Abreu-Grobois, F. A., ... & Bourjea, J. (2011). Global conservation priorities for marine turtles. *PloS one*, 6(9), e24510.
- Godfrey, M. H., & Godley, B. J. (2008). Seeing past the red: flawed IUCN global listings for sea turtles. *Endangered Species Research*, 6(2), 155-159.

North Queensland management unit

The North Queensland management unit was assessed using IUCN red-listing criteria by the Threatened Species Technical Advisory Group, Queensland Department of Environment and Science (DES). This management unit is listed now as *Endangered* under the Queensland Nature Conservation Act. Limpus (2009) and Limpus and Miller (2008) provide a review of the biology of this management unit.

Ecological range

The nesting distribution of this Queensland endemic management unit and the neighbouring management unit in NE Arnhem Land has been mapped (Limpus et al. 2008a). Genetic-based research has been conducted on rookeries across northern Australia. Although the mtDNA profiles of hawksbill turtles are similar in turtles sampled from rookeries within north Queensland and northeast Arnhem Land, turtles in north Queensland and northeast Arnhem Land 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

These hawksbill turtles have been recorded foraging on a wide range of habitats: coral reefs, rooky reefs, sea grass flats and inter-reef habitats over the continental shelf (Limpus, 1993; Limpus et al. 2008b). Migration data obtained from satellite tracking and flipper tag returns indicates that turtles from the north Queensland management unit occur throughout the Gulf of Carpentaria, southern Indonesia, Torres Strait, Papua New Guinea, the northern Great Barrier Reef (Figure 4) (DES Turtle Conservation Database; Limpus and Miller, 2008; Limpus, 2009). A recent genetic-based study conducted on a foraging aggregation of hawksbill turtles on the Howick Reefs of the northern Great Barrier Reef found that 70 to 92% (mean 83%) of hawksbill turtles sampled were from rookeries in the Bismark-Solomon Sea region and only 15% were from the north Queensland management unit (Bell and Jensen 2018).

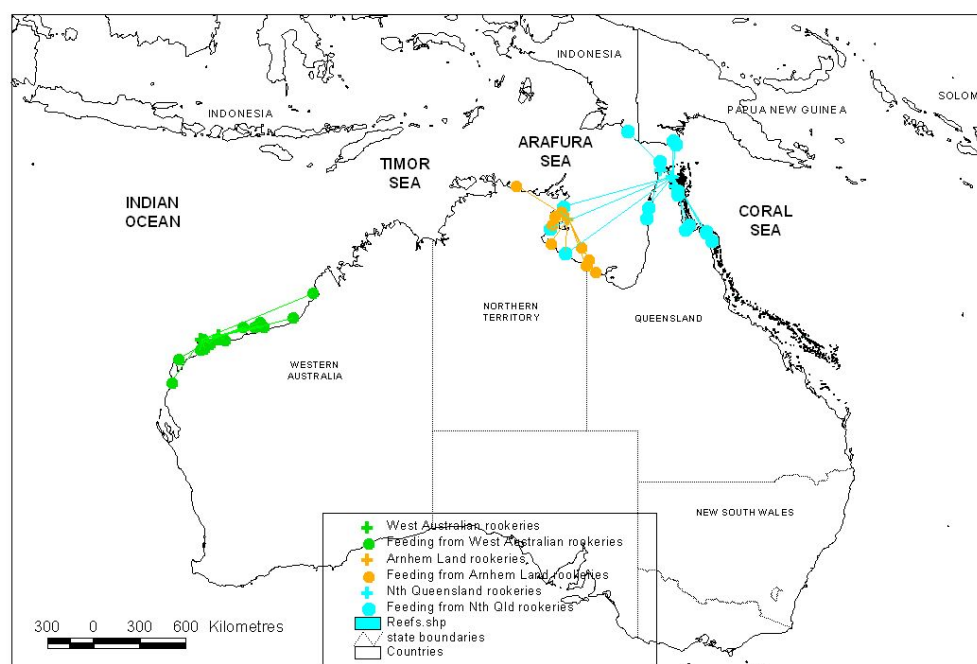


Figure 4. Foraging areas linked to Australian management units, based on satellite telemetry tracking and flipper tag recovers: blue denotes north Queensland management unit, orange denotes Northeast Arnhem Land management unit, green denotes eastern Indian Ocean management unit; crosses denote nesting sites, dots denote foraging sites.

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

Geographic spread of nesting

Nesting by this North Queensland management unit occurs within the eastern Arafura Sea – eastern Gulf of Carpentaria (Torres Strait and western Cape York Peninsula) and the northern Great Barrier Reef within the Coral Sea (Limpus et al. 2008a) (Figure 5).

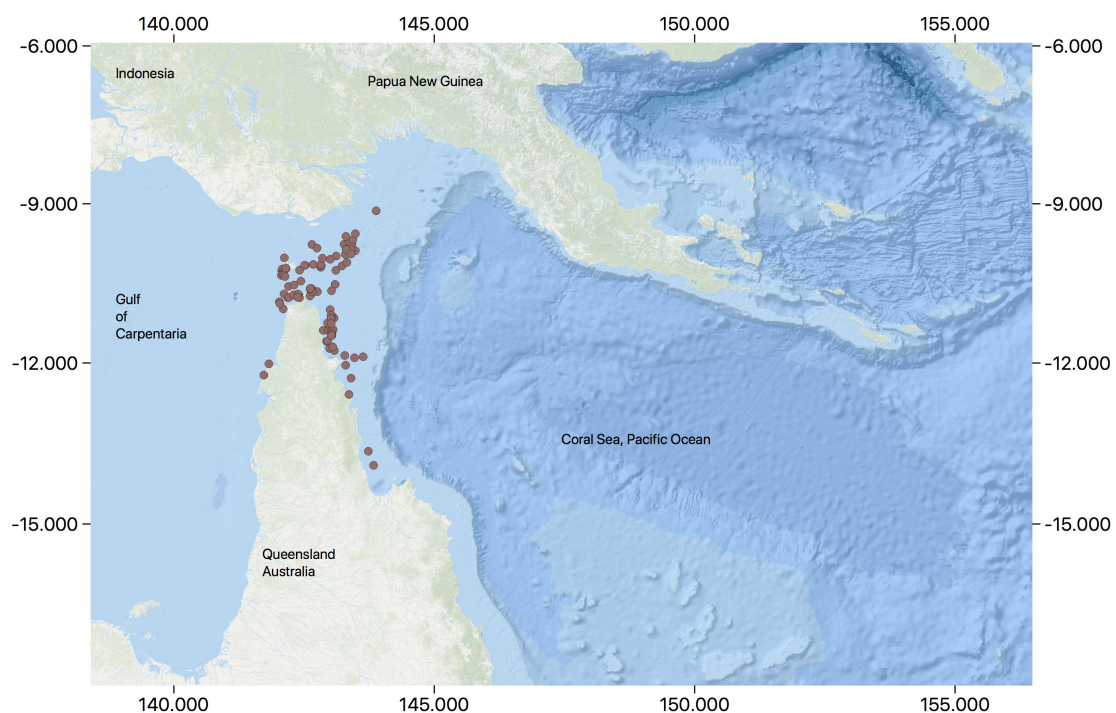


Figure 5. Distribution of *Eretmochelys imbricata* nesting beaches for the north Queensland management unit. The relative size of the annual nesting population is represented by the dots of different sizes as defined in Table 3. Crosses denote that the size of the annual nesting population has not been quantified.

Table 3. Summary of size of annual hawksbill turtle nesting populations at 103 recorded nesting beaches in Queensland, mostly based 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
501-1000 females/year	1	Sassie (Long Island)
101-500 females /year	19	Hawksbury, Dayman, 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)

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 across a quarter of a century, commencing in the 1990-1991 breeding season. This nesting population has undergone a significant decline in the size of the annual nesting populations recent years (Figure 6). This decline is occurring even though this rookery and its surrounding waters are within the most highly protected areas for marine turtles globally: Milman Island National Park Scientific, the Great Barrier Reef Marine Park and the associated World Heritage Area.

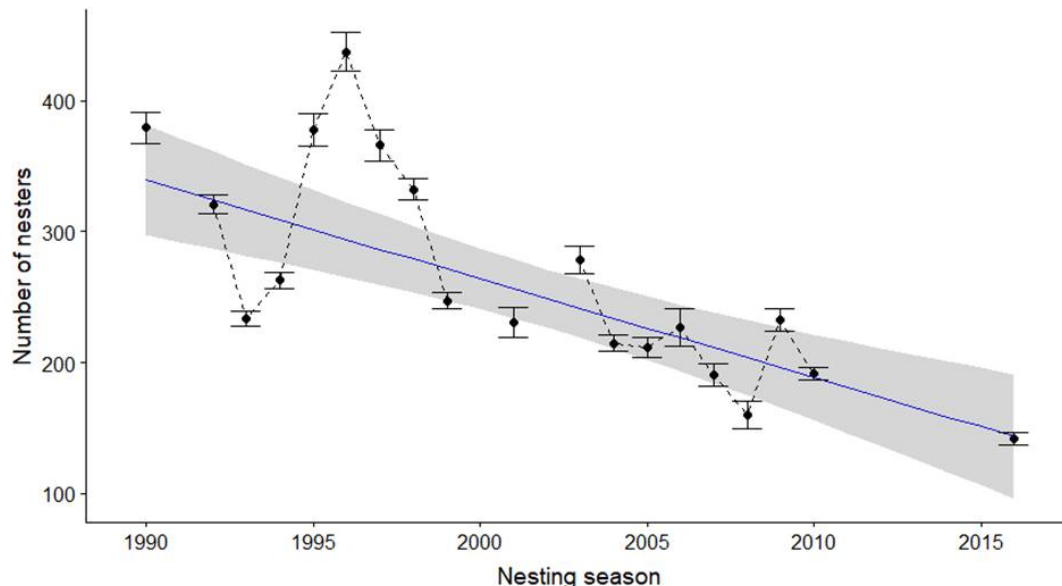


Figure 6. Trend analysis of *Eretmochelys imbricata* nesting census data from Milman Island across 27 breeding seasons, 1990-91 to 2015-16 (unpublished data, DES Aquatic Threatened Species Program): Note: The multistate open robust design model (MSORD) was used to analyse the abundance and survival of the nesting population of hawksbill turtles at Milman Is on the northern GBR. 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 & Bjorkland 2001). The primary sampling consisted of 27 annual austral summer nesting seasons, and secondary sampling occasions consisted of 12 successive sampling periods, each 14 d 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 \pm 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. Nesting seasons with no data were excluded.

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 is considered. Two very high-risk threats were identified – entanglement in marine debris and international take (outside of Australia’s jurisdiction). 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 and indigenous take are all moderate level risks.

In addition, the largely unquantified cumulative loss of turtles and eggs via multiple significant impacts on the north Queensland *Eretmochelys imbricata* management were summarised in the DES Hawksbill turtle Threatened Species assessment (Table 4). There are currently no clear indications of when or how they can be resolved and therefore, these are sound reasons for accepting that the current trends in negative impacts on the habitats and ecology of *E. imbricata* in Queensland from cumulative loss of turtles and eggs will continue.

Table 4 Summary of key issues related to the cumulative loss of turtles and eggs from the north Queensland management unit of hawksbill turtles (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	The legal take of <i>E. imbricata</i> in foraging areas by Indigenous communities in the Northern Territory, Indonesian New Guinea and PNG
4	The substantial loss of post-hatchling <i>E. imbricata</i> in ghost nets, particularly in the Arafura Sea region
5	The presumed substantial but unquantified mortality of foraging <i>E. imbricata</i> in the commercial fisheries of eastern Indonesia (Arafura Sea) and southern PNG (Gulf of Papua).
6	The failure of CITES signatory States to enforce CITES regulations banning the export of Appendix 1 listed species such as <i>E. imbricate</i> (see also Vuto et al. 2019)
7	The illegal trade in <i>E. imbricata</i> particularly via China and Vietnam provides an incentive for continuing illegal trade of <i>E. imbricata</i> or their scutes from the developing countries in the neighbourhood of Queensland (see also Vuto et al. 2019).

Given that almost all of these impacts have already been operational and not controlled for extended periods and that many lie outside the direct legislative control of Queensland, the prospect of a timely reversal of the significant decline in the north Queensland management unit of *E. imbricate* population is extremely poor.

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 evidence only 4=not quantified
Consumption – nesting beach		
Egg collection for food	1	4
Commercial use of turtles	0	2
Non-commercial use of turtles	0	2
Predation eggs by non-native fauna	1	2
Predation 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	4
Coastal development		
Habitat modification (urban)	0	2
Habitat modification (industrial)	0	4
Light horizon disorientation	0	2
Fisheries impacts		
Bycatch – trawl	0	2
Bycatch – long line	2	2
Bycatch – gill net	3	3
Impact to benthic ecology from fisheries	3	4
IUU impacts	3	3
Pollution		
Water-quality related impacts	3	4
Entanglement in discarded fishing gear	2,3	2
Ingestion of marine debris	2,3	3
Noise pollution	3	4
Disease and pathogen	3	4

Management status and governance

Nesting rookeries for the north Queensland management unit are located within a single state of Australia - Queensland. The management unit listed as Endangered under Queensland's Nature Conservation Act, and the species is listed as Vulnerable under the Australian

Government's Environmental 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. The foraging habitats of the waters of the Great Barrier Reef are protected under the Great Barrier Reef Marine Park Act 1975. Rookeries and waters within the Torres Strait region, while outside of protected areas, fall under ownership of Indigenous groups. However, under the Torres Strait Treaty, Papua New Guineans can take turtles in a large proportion of the waters of Torres Strait.

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Milman Island and numerous nesting islands of nGBR	Nesting beach	Y	Very-high	<ul style="list-style-type: none"> Queensland Nature Conservation Act 1992
Great Barrier Reef Marine Park	Nesting and foraging	y	Very-high	<ul style="list-style-type: none"> GBRMP Act 1975

Biological data – breeding

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

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging)	~35 cm CCL	Limpus 2009
Growth rates	Max 2.2 cm/year at 60 cm CCL	Limpus 2009
Sex ratio – in foraging populations		Limpus et al. 2000
adults	71% female	
pubescent immature	74% female	
large pre-pubescent immature	74% female	
small pre-pubescent immature	73% female	

References & new publications – 2010 to 2019

Australian Government (2017) Recover plan for marine turtles in Australia. Australian Department of Environment and Energy. 108p <https://www.environment.gov.au/marine/publications/recovery-plan-marine-turtles-australia-2017>

- Bell, I. & Pike, D. A. (2012). Somatic growth rates of hawksbill turtles *Eretmochelys imbricata* in a northern Great Barrier Reef foraging area. *Marine Ecology Progress Series* 446, 275-283.
- Broderick, D., Moritz, C., Miller, J. D., Guinea, M., Prince, R. I. T., & Limpus, C. J. (1994). Genetic studies of the hawksbill turtle *Eretmochelys imbricata*: evidence for multiple stocks in Australian waters. *Pacific Conservation Biology* 1, 123-131.
- Dobbs, K. A., Miller, J. D., Limpus, C., & Landry, A. M. (2010). Hawksbill turtle hatchling sex ratios and incubation and pivotal temperatures from Milman Island, Great Barrier Reef. *Marine Turtle Newsletter* 128, 12-16.
- FitzSimmons, N. N., & Limpus, C. J. (2014). Marine turtle genetic stocks of the Indo-Pacific: identifying boundaries and knowledge gaps. *Indian Ocean Turtle Newsletter*, 20(July), 2-18.
- Limpus, C. J. (1992). The hawksbill turtle, *Eretmochelys imbricata*, in Queensland: population structure within a southern Great Barrier Reef feeding area. *Wildlife Research* 19, 489-506.
- Limpus, C. J. (2009). A biological review of Australian marine turtles. 3. Hawksbill turtle *Eretmochelys imbricata* (Linnaeus). (Queensland Environmental Protection Agency: Brisbane.)
- Limpus, C. J. & Miller, J. D. (2008). Australian Hawksbill Turtle Population Dynamics Project. (Queensland Environmental Protection Agency: Brisbane.)
- Limpus, C. J., Miller, J. D., Bell, I. P., & Limpus, D. J. (2008a). *Eretmochelys imbricata* foraging populations in eastern Australia. Limpus, C. J. and Miller, J. D. Australian hawksbill turtle population dynamics project. 107-115. Queensland Environment Protection Agency: Brisbane.
- Limpus, C. J., Miller, J. D., & Chatto, R. (2008b). Distribution and abundance of marine turtle nesting in northern and eastern Australia. Limpus, C. J. and Miller, J. D. Australian hawksbill turtle population dynamics project. 19-39. 2008. Queensland Environment Protection Agency: Brisbane.
- Vuto, S., Hamilton, R., Brown, C., Waldie, P., Pita, J., Peterson, N., ... & Limpus, C. (2019). A report on turtle harvest and trade in Solomon Islands. The Nature Conservancy, Solomon Islands 34p.

Northeast Arnhem Land management unit

Ecological range

Genetic-based research has been conducted on rookeries across northern Australia. Although the mtDNA profiles of hawksbill turtles are similar in turtles sampled from rookeries within north Queensland and northeast Arnhem Land, turtles in north Queensland and northeast Arnhem Land breed at different times of the year and are thus considered to be separate management units. The ecological range for the management unit has not been well studied. Aside from Australia, turtles from this management unit may occur in southern Indonesia or Timor Leste.

Geographic spread of foraging sites

Based on GPS satellite telemetry tracking (Hoenner et al. 2016), known foraging sites occur within the Gulf of Carpentaria of Queensland and Northern Territory and coastal waters of Arnhem Land, Northern Territory (Figure 7). 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 hence international connections are possible.

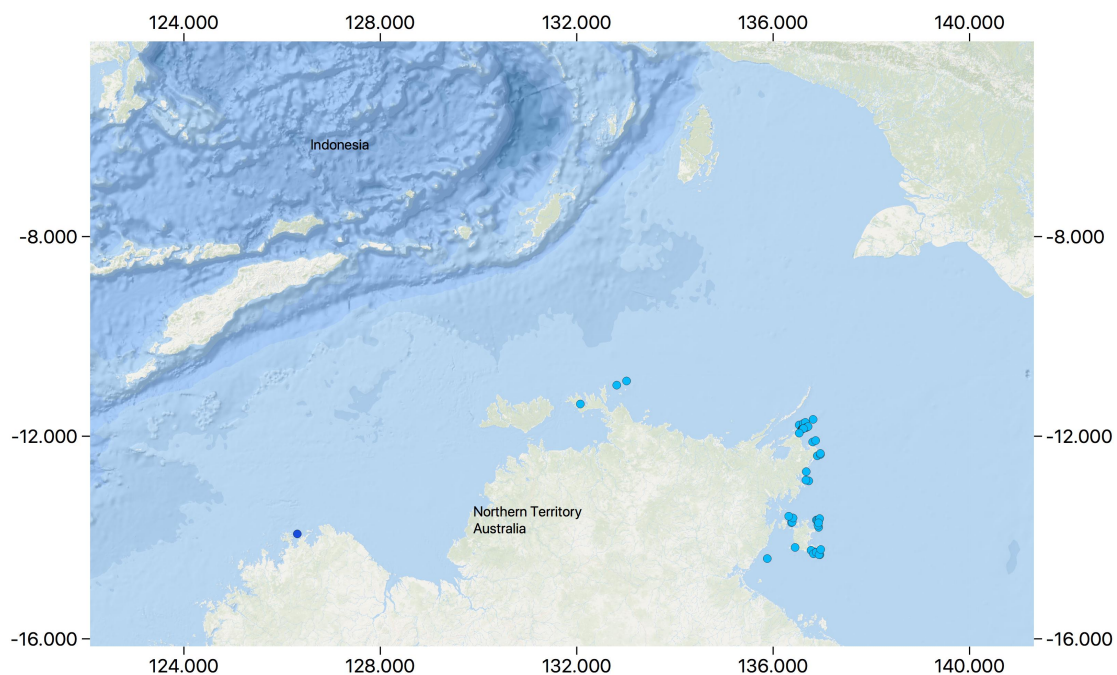


Figure 7. Distribution of *Eretmochelys imbricata* nesting beaches for the northeast Arnhem Land management unit.

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. They occur predominantly on islands from the north-east 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 north-eastern coast of Groote Eylandt (Chatto and Baker 2008; Limpus et al. 2008a). Scattered, low density nesting has been reported from as far west as the Coburg Peninsula and as far east as the Sir Edward Pellow Islands.

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

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 north-east Arnhem Land to the southern coast of the Gulf of Carpentaria (Hoenner et al. 2016). Lagrangian particle modelling conducted on virtual hatchling dispersal from North East Island indicates that hatchlings would disperse throughout the north-western 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 is considered. Two very high-risk threats were identified – entanglement in marine debris and international take (outside of Australia's jurisdiction. However, for the later, we have no evidence of any international migration for 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 are all moderate level risks. It is likely that the issues related to the cumulative loss of turtles and eggs from the north Queensland management unit (Table X) are also relevant to the northeast Arnhem Land management unit. However, quantitative data on these threats do not exist.

Management status and governance

Nesting rookeries for the north-east 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 Environmental 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.

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 evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	1	4
Commercial use of turtles	0	2
Non-commercial use of turtles	0	2
Predation eggs by non-native fauna	1	4
Predation 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)	0	2
Habitat modification (industrial)	0	2
Light horizon disorientation	0	2
Fisheries impacts		
Bycatch –trawl	0	2
Bycatch – long line	2	2
Bycatch – gill net	3	3
Impact to benthic ecology from fisheries	3	4
IUU impacts	3	3
Pollution		
Water-quality related impacts	3	4
Entanglement in discarded fishing gear	2,3	2
Ingestion of marine debris	2,3	3
Noise pollution	3	4
Disease and pathogen	3	4

Management and protection

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

Biological data – breeding

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

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging)	na	
Growth rates	na	
Sex ratio – adults in foraging	na	

References & new publications – 2010 to 2019

- Australian Government (2017) Recover plan for marine turtles in Australia. Australian Department of Environment and Energy. 108p <https://www.environment.gov.au/marine/publications/recovery-plan-marine-turtles-australia-2017>
- Chatto R, Baker B (2008) The distribution and status of marine turtle nesting in the Northern Territory. Technical Report 77. Northern Territory Parks and Wildlife Service https://dtsc.nt.gov.au/_data/assets/pdf_file/0006/279915/marine_turtle_nesting.pdf
- Hoenner, X.; Whiting, S. D.; Hamann, M.; Limpus, C. J.; Hindel, M. A., & McMahon, C. R. (2015). High-resolution movements of critically endangered hawksbill turtles help elucidate conservation requirements in northern Australia. *Marine and Freshwater Research*. doi.org/10.1071/MF15013.
- Hoenner, X., Whiting, S. D., Enever, G., Lambert, K., Hindell, M. A., & McMahon, C. R. (2016). Nesting ecology of hawksbill turtles at a rookery of international significance in Australia's Northern Territory. *Wildlife research*, 43(6), 461–473.
- Limpus, C. J., Miller, J. D., and Chatto, R. (2008a). Distribution and abundance of marine turtle nesting in northern and eastern Australia. Limpus, C. J. and Miller, J. D. Australian hawksbill turtle population dynamics project. 19-39. Brisbane, Queensland Environment Protection Agency.

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). There are rookeries in close proximity which remain to be sampled, for example in southern Philippines and the Indonesian Islands within 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 no genetic-based research on foraging turtles in the region. Based on flipper tag recoveries and three satellite telemetry tracks from nesting hawksbill turtles tagged in Sabah, foraging turtles from this management unit are spread through Sabah (Malaysia), Sulu Sea area of Philippines and widely along the east coast of Kalimantan (Indonesia).

Geographic spread of nesting

Hawksbill turtles in the Sulu Sea genetic stock primarily nest on the nine beaches of the Turtle Islands Heritage Protected area (Figure 8) – including Palau Gulisaan (~90% of clutches), Palau Selingan (~8% of clutches) and Palau Bakkungan (~5% of clutches) in Malaysia. Nesting occurs all year with a peak between March and August. Lower-level regular or aperiodic nesting occurs on many of the islands in the Semporna region of Sabah, and the Sulu and Celebes Seas in Malaysia, Philippines and Indonesia.

Index nesting beaches: Malaysia, Sabah, Palau Gulisaan

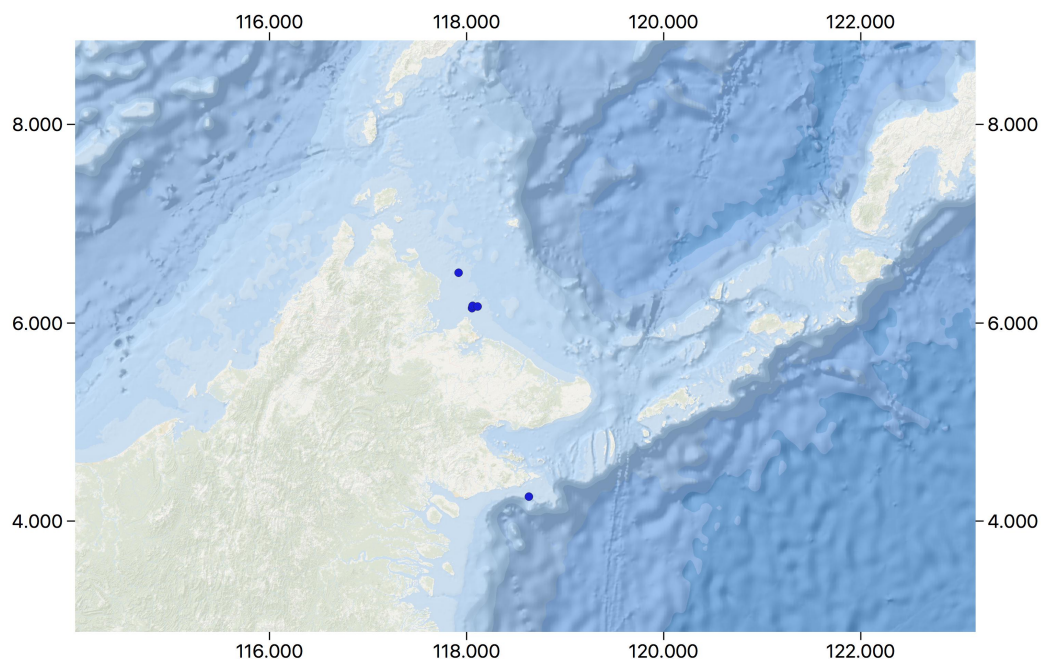


Figure 8 Main nesting sites for the Sulu Sea Management unit of hawksbill turtles

Trends in nesting data

The hawksbill turtles of the Turtle Islands have been monitored since the 1970s (de Silva 1986), however early efforts were impacted by poor tag retention. Chan et al. (1999) summarised the monitoring data from 1979 to 1996. They report a declining trend from 1979 to 1986 followed by a reversal in trend from 1986 to 1994 (Figure 9), with the number of clutches being reported in the last five years of available data being around 400 clutches per year, nearly double the levels of the mid 1980s – however it appears to be declining and more recent data are required to better understand the status. Data from 1999 to 2018 are available from a minor rookery (Pulau Lankayan) which shows a stable trend of around 50 clutches per year. Data from 2006 to 2010 from the islands of the Semporna region indicate – 10 clutches a year at Pulau Mataking, Pulau Pom Pom, and Pulau Pandanan (Jolis and Kassem 2011) and less than 10 clutches per year laid on Sipidan Islands.

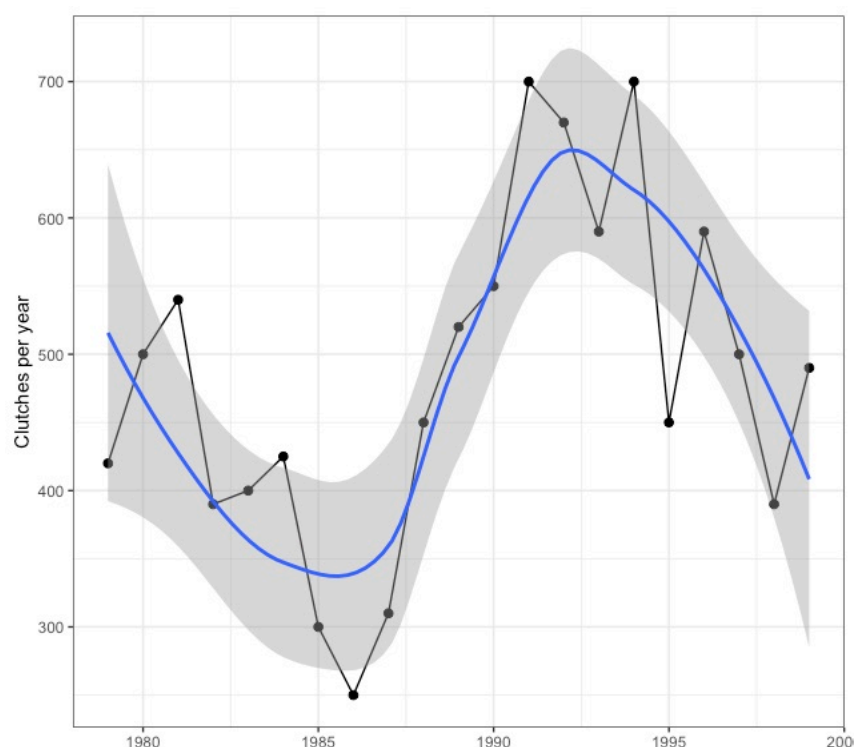


Figure 9. Number of hawksbill clutches recorded per year between 1979 and 1998 at Palau Gulisaan, Sabah, Malaysia. Data extrapolated from Chan (2007) and Basintal (2001).

Migration and distribution of foraging areas

Tag returns from hawksbill turtles tagged while nesting in the Turtle Islands have been recovered locally in Sabah, and also 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 report on three females tracked after nesting in the Turtle Islands. One moved northwards along the Sabah coastline and remained in Sabah's waters and two moved southwards along the Sabah and Indonesia (Kalimantan) coastline and remained in Indonesia. It is likely that foraging sites for this stock occur in Indonesia, Philippines and Malaysia.

Threats to the population

The threats to the Sulu Sea management unit for hawksbill turtles 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, sea level rise because most of the nesting locations are low lying coral-reef atolls and the ingestion of, or entanglement in marine debris. Examination of the degree to which these threats may impact hawksbill turtles from the Sulu Sea management unit are required.

Although not recently quantified, the cumulative loss of turtles and eggs via multiple significant impacts on the Sulu Sea management unit are of primary concern (e.g. Table 5). There are currently no clear indications of when or how they can be resolved and therefore, these are sound reasons for accepting that there will continue be negative impacts on the habitats and ecology of *E. imbricata* in the Sulu Sea.

Table 5 Summary of key issues related to the cumulative loss of turtles and eggs from the Sulu Sea management unit of hawksbill turtles

1	Illegal harvest of eggs by people living or visiting islands for consumption or sale
2	The potential loss of post-hatchling, or immature, <i>E. imbricata</i> in ghost nets
3	The presumed substantial but unquantified mortality of foraging <i>E. imbricata</i> in the commercial fisheries of Indonesia, Philippines and Malaysia
4	The direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale
5	The failure of CITES signatory States to enforce CITES regulations banning the export of Appendix 1 listed species such as <i>E. imbricate</i> (CITES, Vuto et al. 2019)
6	The illegal trade in <i>E. imbricata</i> particularly via China and Vietnam provides an incentive for continuing the illegal trade of <i>E. imbricata</i> or their scutes from countries in southeast Asia (e.g. CITES, Riskas et al. 2018)

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

Type of threat	Known or likely location of impact	Quantified
	1=nesting beach	1=comprehensive documentation across population
	2=Oceanic/high seas	2= comprehensive documentation for some of the population
	3=Coastal foraging areas	3=non-published 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 eggs by non-native fauna	1	4
Predation eggs by native fauna	1	4

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	?	4
Sea level rise	?	4
Coastal development		
Habitat modification (urban)	1,3	4
Habitat modification (industrial)	?	4
Light horizon disorientation	1	4
Fisheries impacts		
Bycatch – trawl	3	3
Bycatch – long line	3	4
Bycatch – gill net	3	3
Impact to benthic ecology from fisheries	?	4
IUU impacts	3	3
Pollution		
Water-quality related impacts	?	4
Entanglement in discarded fishing gear	3	3
Ingestion of marine debris	3	3
Noise pollution	?	4
Disease and pathogen	?	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Palau Gulisaan	Island	Yes	Very high	THIP area
Palau Selingan	Island	No	High	THIP area
Palau Bakkungan	Island	No	High	THIP area

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	na	
Remigration interval	1.8 years	Pilcher and Ali 1999
Clutches per season	2.7	Pilcher and Ali 1999
Clutch size	120.4	Chan et al. 1996
Mean size of nesting adult	76.3 cm	Chan et al. 1996
Age at maturity	na	

Biological data – foraging

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

References & new publications – 2010 to 2019

- Chan, E. H., Joseph, J., & Liew, H. C. (1999). A study on the hawksbill turtles (*Eretmochelys imbricata*) of Pulau Gulisaan, Turtle Islands Park, Sabah Malaysia. *Sabah Parks Nature Journal*, 2, 11-22.
- Chan, E. H. (2006). Marine turtles in Malaysia: On the verge of extinction? *Aquatic Ecosystem Health & Management*, 9(2), 175-184.
- FitzSimmons, N. N., & Limpus, C. J. (2014). Marine turtle genetic stocks of the Indo-Pacific: identifying boundaries and knowledge gaps. *Indian Ocean Turtle Newsletter*, 20(July), 2-18.
- Jolis, G. & Kassem, K (2011) Marine Turtle Status in Northeast Semporna Priority Conservation Area. Kota Kinabalu, Malaysia: WWF-Malaysia.
- Pilcher, N. J. & Ali, L. (1999). Reproductive biology of the hawksbill turtles, *Eretmochelys imbricata*, in Sabah Malaysia. *Chelonian Conservation Biology*, 3, 330-336.
- Riskas, K. A., Tobin, R. C., Fuentes, M. M., & Hamann, M. (2018). Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. *Biological Conservation*, 217, 232-239.
- Vuto, S., Hamilton, R., Brown, C., Waldie, P., Pita, J., Peterson, N., ... & Limpus, C. (2019). A report on turtle harvest and trade in Solomon Islands. The Nature Conservancy, Solomon Islands 34p.

Western Peninsula Malaysia management unit

Ecological range

The samples used to identify the Western Peninsula Malaysia management unit were collected from rookeries in Malaka (FitzSimmons and Limpus, 2014). There are rookeries in close proximity which remain to be sampled, for example in islands of Singapore, the Java Sea and southern Kalimantan (Indonesia), eastern Peninsula Malaysia (including Malaysian Islands) and the Riau Islands. 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 2008 and 2013 WWF Malaysia and the Department of Fisheries Malaka tracked 15 hawksbill turtles from Malaccan 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 of Indonesia. It is likely that turtles from the Western Peninsula Malaysia management unit migrate to foraging areas in Indonesia, Singapore, elsewhere in Malaysia and possibly Thailand (Indian Ocean coast).

Geographic spread of nesting

Hawksbill turtles from the Western Peninsula Malaysia management unit primarily nest on mainland and island beaches of the state of Malaka (Figure 10). Nesting on the beaches of Malaka occurs all year, with a peak between June and August. Nesting is distributed along 20 beaches in Malaka, with approximately 20% occurring at Padang Kemunting, 12% at Kem Terendak and 10% at each of Balik Batu, Palau 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 10). There are also several rookeries in the Java Sea region of Indonesia and it is yet to be determined which management unit they belong to (see section on Indonesia).

Index nesting beaches: Malacca beaches

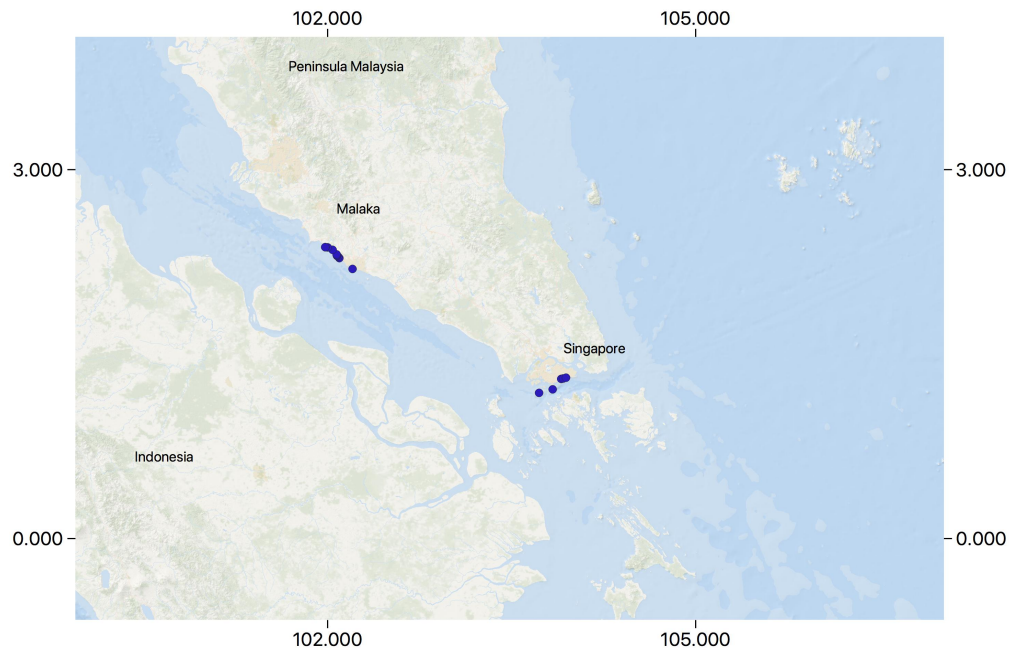


Figure 10. Distribution of nesting sites for the Western Peninsula Malaysia Management unit of hawksbill turtles.

Trends in nesting data

In 1991 the abundance of hawksbill clutches laid on beaches of Malaka was estimated at 330 clutches (Mortimer et al. 1993) and in 2013 and 2014 it was estimated at 481 and 463 clutches respectively (Salleh et al. 2018). Hawksbill turtle monitoring in Malaka is coordinated by the Department of Fisheries Malaka. Annual data from the beaches indicate that approximately 245 clutches were laid per year between 1991 and 2004. Since 2004 there has been an average of 419 clutches laid per year (Figure 11), representing a 4% annual increase in the number of clutches being laid per season on the beaches of Melaka (Figure 11). The power to detect a statistically significant trend based on these data (alpha 0.01) is 90%.

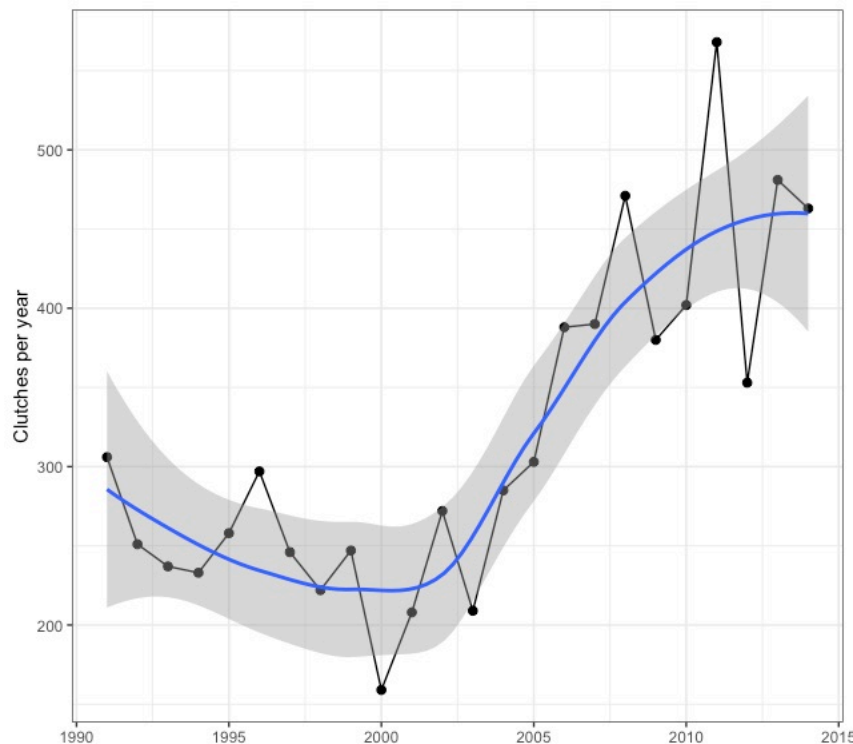


Figure 11. Number of hawksbill clutches recorded per year at Malaka in Peninsula Malaysia. Data from Department of Fisheries Malaka and Salleh et al. (2018)

Threats to the population

The threats to the western Peninsula Malaysia management unit for hawksbill turtles have not been comprehensively assessed. Issues of concern include habitat change and habitat development because most of the beaches are developed, or are adjacent to developed areas, exposure to light pollution, climate change related to increased air temperatures and their likely influence on hatchling sex ratios, sea level rise because most of the nesting locations are bordered with developed areas and thus there is little space for which nesting beaches can shift, and the ingestion of, or entanglement in marine debris. Examination of the degree to which these threats may impact hawksbill turtles from the western Peninsula Malaysia management unit are required.

Although not recently quantified, the cumulative loss of turtles via multiple significant impacts on the western Peninsula Malaysia management unit are of primary concern (e.g. Table 6). There are currently no clear indications of when or how they can be resolved and therefore, these are sound reasons for accepting that there will continue be negative impacts on the recovery of *E. imbricata* in the western Peninsula Malaysia.

Table 6 Summary of key issues related to the cumulative loss of turtles and eggs from the Sulu Sea 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)
2	The potential loss of post-hatchling, or immature, <i>E. imbricata</i> in ghost nets

3	The presumed substantial but unquantified mortality of foraging <i>E. imbricata</i> in the commercial fisheries of Indonesia and Malaysia
4	The direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale
5	The failure of CITES signatory States to enforce CITES regulations banning the export of Appendix 1 listed species such as <i>E. imbricata</i> (CITES, Vuto et al. 2019)
6	The illegal trade in <i>E. imbricata</i> particularly via China and Vietnam provides an incentive for continuing the illegal trade of <i>E. imbricata</i> or their scutes from countries in southeast Asia (e.g. CITES, Riskas et al. 2018)

Summary of threats to the Western Peninsula 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 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 eggs by non-native fauna	?	4
Predation 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	4
Fisheries impacts		
Bycatch - trawl	3	4
Bycatch – long line	3	4
Bycatch – gill net	3	4
Impact to benthic ecology from fisheries	3	4
IUU impacts	3	4

Pollution		
Water-quality related impacts	3	4
Entanglement in discarded fishing gear	3	4
Ingestion of marine debris	3	4
Noise pollution	3	4
Disease and pathogen	3	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Padang Kemunting	mainland	Y	Very high	
Kem Terendak	mainland	Y	High	
Balik Batu	mainland	Y	High	
Palau Upeh	island	Y	High	
Meriam Patah	mainland	Y	High	

Biological data – breeding

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

Biological data – foraging

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

References & new publications – 2010 to 2019

- Mortimer, J. A., Ahmad, Z., & Kaslan, S. (1993). Green Turtle *Chelonia mydas* of Melaka and Negeri. *Malayan Nature Journal*, 46, 243-253.
- Salleh, S. M., Nishizawa, H., Sah, S. A. M., & Safri, M. F. (2017). Spatiotemporal preferences in nesting of the hawksbill turtle (*Eretmochelys imbricata*) in Melaka, Malaysia. *Journal of the Marine Biological Association of the United Kingdom*, 1-8.
- Riskas, K. A., Tobin, R. C., Fuentes, M. M., & Hamann, M. (2018). Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. *Biological Conservation*, 217, 232-239.
- Vuto, S., Hamilton, R., Brown, C., Waldie, P., Pita, J., Peterson, N., ... & Limpus, C. (2019). A report on turtle harvest and trade in Solomon Islands. The Nature Conservancy, Solomon Islands 34p.

Gulf of Thailand (possible) management unit

Ecological range

There are records of hawksbill turtle nesting along the islands off the east coast of Peninsula Malaysia, Thailand and Cambodia (summarised in Meylan and Donnelly 1999). Collectively, these rookeries are believed to constitute a management unit FitzSimmons and Limpus (2014) and Nishizawa et al. (2016), however this remains to be confirmed by genetic-based research.

Geographic spread of foraging sites

The limited satellite telemetry tracking from this management unit indicates a population with a restricted foraging range within Thailand (Monanunsap et al. 2002). However, it is possible they occur across throughout the Gulf of Thailand, 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. 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 offshore of Terengganu, in particular Pulau Redang, and the islands of Johor (Figure 12). The nesting season occurs primarily from May to October.

Index nesting beaches:

Ko Khram, Thailand

Pulau Redang (Chagar Hutang), Malaysia

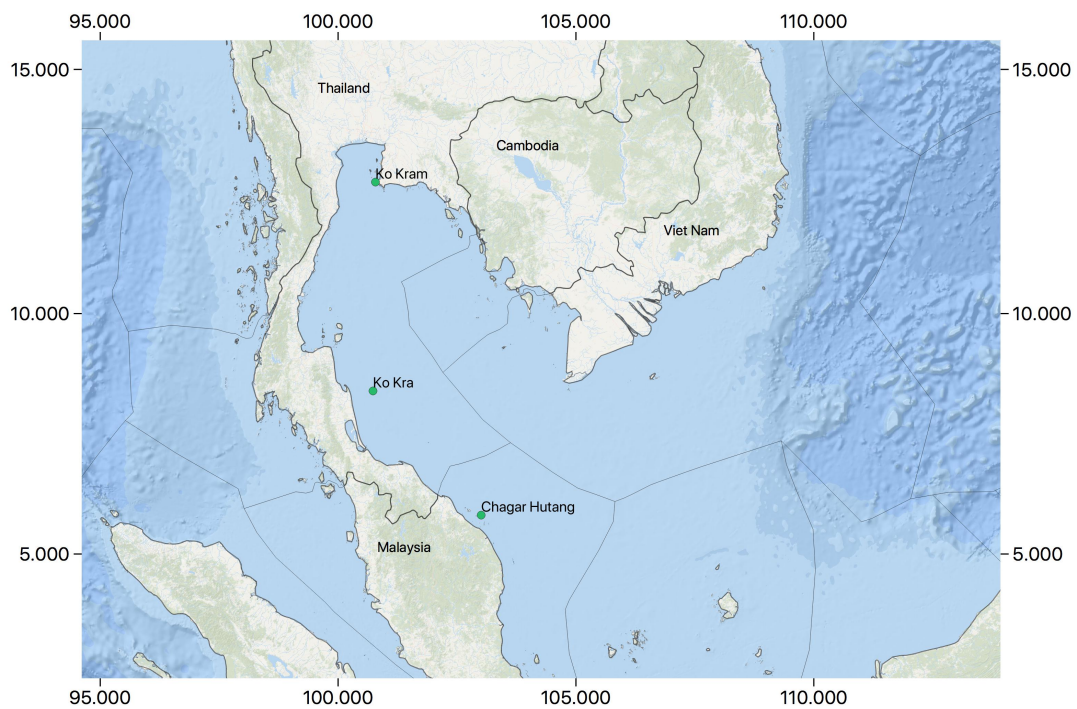


Figure 12 Main nesting sites for the possible Gulf of Thailand management unit of hawksbill turtles, faint lines are the EEZ boundaries of adjacent nations.

Trends in nesting data

In Thailand, data from the egg collection and trade in the 1950s and nest counts indicated that around 100 female hawksbill turtles nested on Ko Kram each year, and then between 1973 and 1995, these levels declined to around 11 to 18 females (around 55 clutches laid per year) and then stabilised (Monanunsap 1997 - summarised in Meylan and Donnelly 1999) (Figure 13). The most recent data from Malaysia's Chagar Hutang (Pulau Redang) show a small stable nesting population (Figure 14)

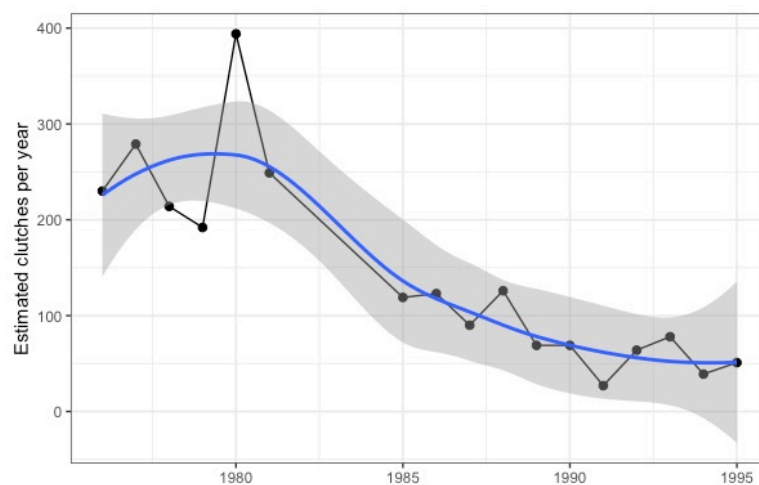


Figure 13. Number of hawksbill clutches recorded per year at Ko Kram, Thailand. Data from 1976 to 1981 is estimated from Table 201 in Groombridge and Luxmoore (1989) and data from 1985 to 1995 is from Chantrapornsyl (1996).

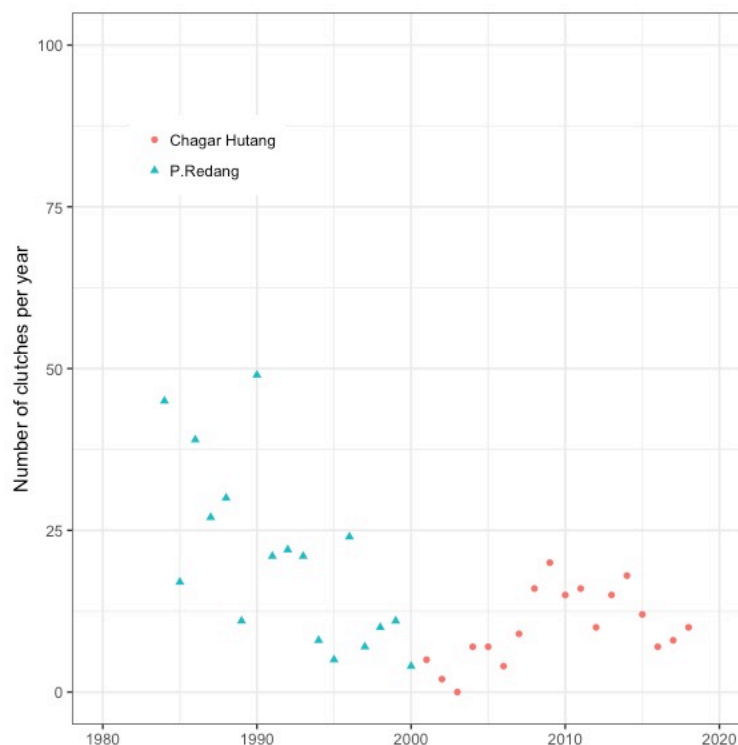


Figure 14. Number of hawksbill clutches recorded per year at Pulau Redang and Chagar Hutang (single beach on Pulau Redang), in Peninsula Malaysia. Data from Chan (2007) and unpublished data from SEATRU (2008 to 2018).

Migration and distribution of foraging areas

Five female hawksbill turtles from Ko Ira and Ko Charn (Thailand) were tracked using satellite tags throughout their nesting season and up to six months after the nesting season. All 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 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 are required.

Although not recently quantified, the cumulative loss of turtles and eggs via multiple significant impacts on the Gulf of Thailand management unit have been and continue to be of primary concern (e.g. Table 7). There are currently no clear indications of when or how they

can be resolved and therefore, these are sound reasons for accepting that there will continue be negative impacts on the recovery of *E. imbricata* in the Gulf of Thailand.

Table 7 Summary of key issues related to the cumulative loss of turtles and eggs from the Sulu Sea 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 from on the beaches of southern Viet Nam and Cambodia between the 1940s and 1980s are believed to have been collected and used to supply the hawksbill turtle farms at Ha Tien (Viet Nam) (Hamann et al. (2006)
2	The potential loss of post-hatchling, or immature, <i>E. imbricata</i> in ghost nets or through ingestion of marine debris
3	The presumed substantial but unquantified mortality of foraging <i>E. imbricata</i> in the commercial fisheries of Thailand, Viet Nam, Cambodia and Malaysia
4	The 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 1 listed species such as <i>E. imbricata</i> (CITES, Vuto et al. 2019)
6	The illegal trade in <i>E. imbricata</i> provides an incentive for continuing the illegal trade of <i>E. imbricata</i> or their scutes from countries in southeast Asia (e.g. CITES, Riskas et al. 2018)

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 evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	1	4
Commercial use of turtles	0	2
Non-commercial use of turtles	0	2
Predation eggs by non-native fauna	1	4
Predation 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)	0	2
Habitat modification (industrial)	0	2
Light horizon disorientation	0	2
Fisheries impacts		
Bycatch – trawl	0	2
Bycatch – long line	2	2
Bycatch – gill net	3	3
Impact to benthic ecology from fisheries	3	4
IUU impacts	3	3
Pollution		
Water-quality related impacts	3	4
Entanglement in discarded fishing gear	2,3	2
Ingestion of marine debris	2,3	3
Noise pollution	3	4
Disease and pathogen	3	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Ko Kram (Thailand)	Island	Yes	Very high	Protected and access restricted
Chagar Hutang (Malaysia)	Island	Yes	Very high	Protected

Biological data – breeding

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

Biological data – foraging

There has been no research or monitoring studies on foraging hawksbill turtles known to be from the Gulf of Thailand management unit although foraging hawksbills are known to occur

in most of the island systems in the Gulf of Thailand, eastern Peninsula Malaysia and the South China Sea.

References & new publications – 2010 to 2019

- Chan, E. H., & Liew, H. C. (1999). Hawksbill turtles, *Eretmochelys imbricata*, nesting on Redang Island, Terengganu, Malaysia, from 1993 to 1997. *Chelonian Conservation and Biology*, 3(2), 326-329.
- Chantrapornsy S (1996) Status of marine turtles in Thailand. Proceedings of the first SEAFDEC workshop. Malaysia 1996
http://seaturtle.org/library/ChantrapornsyS_1996_InProceedingsoftheFirstSEAFDECWorksho_p77-92.pdf
- Hamann, M., Hong, N. D., Thuoc, P., & Thu hien, B. T. (2006). Distribution and abundance of marine turtles in the Socialist Republic of Viet Nam. *Biodiversity & Conservation*, 15(11), 3703-3720.
- Meylan, A. B., & Donnelly, M. (1999). Status justification for listing the hawksbill turtle (*Eretmochelys imbricata*) as critically endangered on the 1996 IUCN Red List of Threatened Animals. *Chelonian conservation and Biology*, 3(2), 200-224.
- Monanunsap, S., Charucinda, M. & Kenichi, T. (2002) Satellite tracking of nesting hawksbill turtles, *Eretmochelys imbricata* in the Gulf of Thailand, SEASTAR 2002. 22-25.
- Nishizawa, H., J. Joseph and Y. K. Chong (2016). "Spatio-temporal patterns of mitochondrial DNA variation in hawksbill turtles (*Eretmochelys imbricata*) in Southeast Asia." *Journal of Experimental Marine Biology and Ecology* 474: 164-170.
- Riskas, K. A., Tobin, R. C., Fuentes, M. M., & Hamann, M. (2018). Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. *Biological Conservation*, 217, 232-239.

Eastern Indian Ocean management unit (Western Australia)

Ecological range

Genetic-based research has been conducted on rookeries across northern Australia (Fitzsimmons and Limpus, 2014). The rookeries located along the Western Australian coast form the eastern Indian Ocean management unit (Figure 15). Although all existing data indicate the management unit is contained within Western Australia, it remains possible that the management unit spreads into Timor Leste and southern Indonesia.

Geographic spread of foraging sites

To date all tag returns from turtles originally tagged at a Western Australia nesting beach and satellite telemetry data from post-breeding female turtles indicates that foraging for the stock could be constrained to the Western Australian coastline (i.e. Figure 4). However, continued genetic-based research is required, especially from Timor Leste and southern Indonesian foraging areas to confirm.

Geographic spread of nesting

The distribution of breeding sites in the southern extent of the management unit's range have 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 breeding numbers of hawksbill turtles in the Indian Ocean (Limpus 2009, Pendoley et al. 2016). Pendoley et al. (2016) report on 20 years of beach surveys and found 45 nesting sites (Table 7). There are also scattered hawksbill nesting on the Ningaloo coastline (unpublished data) and recent records of hawksbill turtles breeding at low density on the islands of the Kimberley coast (Whiting et al. 2018). Although these Kimberley rookeries have not yet been quantified or analysed for genetic similarity. There are records of occasional nesting of hawksbill turtles at Ashmore Reef, however genetic-based analysis has not been conducted to determine if they are aligned to the eastern Indian Ocean management unit or a management unit from southern Indonesia (Limpus 2009).

Table 7. Summary of size of annual hawksbill Turtle nesting populations at 45 recorded 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 Group, Enderby Island
1-10 tracks / night	23	
Unquantified nesting	17	

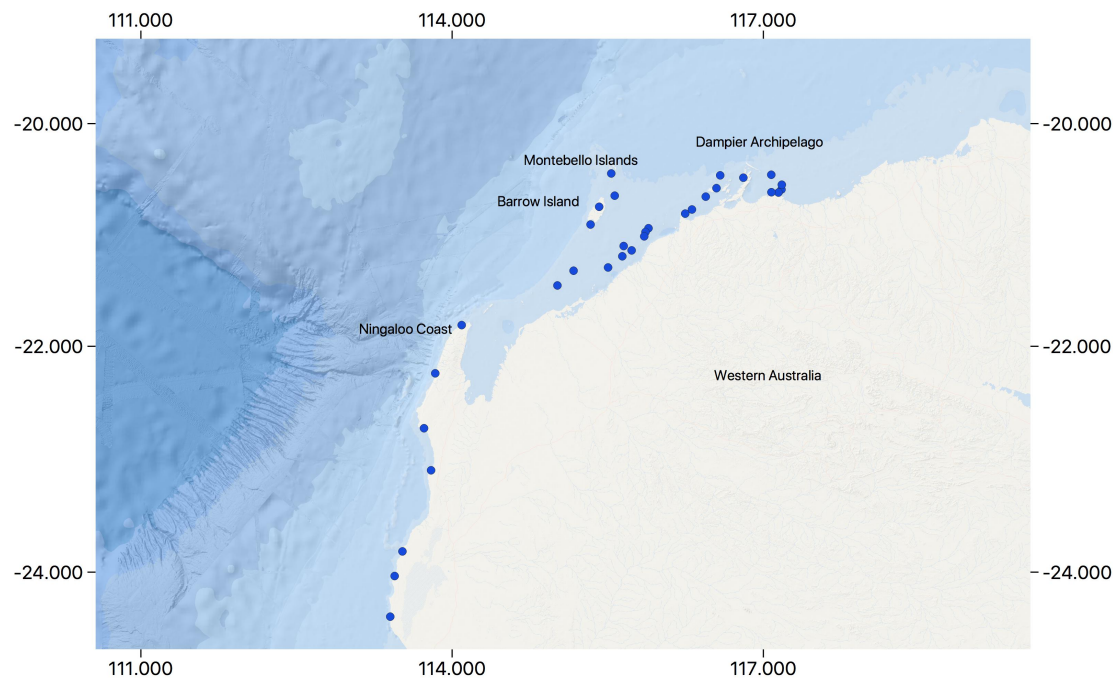


Figure 15. Distribution of *Eretmochelys imbricata* nesting beaches for the eastern Indian Ocean management unit.

Trends in nesting data

An analysis of capture-mark recapture data at Rosemary suggests that this large nesting population has been approximately stable over recent decades (Prince and Chaloupka 2012). A stable trend was shown for hawksbill turtle nesting at Varanus Island, a low-density rookery, derived from 20 years of flipper tagging data (Prince and Chaloupka 2012). Collectively, monitoring data for the eastern Indian Ocean management unit collected over three decades indicates a very large and stable population.

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 is considered. One very high-risk threat was identified – international take (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 are all moderate level risks.

Summary of threats to the East 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 evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	0	3
Commercial use of turtles	0	2
Non-commercial use of turtles	0	2
Predation eggs by non-native fauna	0	3
Predation eggs by native fauna	1	4
Consumption – foraging turtles		
Commercial use of turtles	Not known	4
Non-commercial use of turtles	Not known	4
Climate change impacts		
Increasing beach temperature	Likely	4
Beach erosion	Not known	4
Sea level rise	Not known	4
Coastal development		
Habitat modification (urban)	0	2
Habitat modification (industrial)	1	2
Light horizon disorientation	1	2
Fisheries impacts		
Bycatch - trawl	Not known	4
Bycatch – long line	Not known	4
Bycatch – gill net	?	4
Impact to benthic ecology from fisheries	3	4
IUU impacts	Not known	4
Pollution		
Water-quality related impacts	3	4
Entanglement in discarded fishing gear	2,3	2
Ingestion of marine debris	2,3	3
Noise pollution	3	4
Disease and pathogen	3	4

Management status 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, and the species is listed as Vulnerable under the

Australian Governments Environmental 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	Y	Very important	Yes, Nature Reserve
Montebello Islands	Islands	N	Very important	Yes, Nature Reserve

Biological data – breeding

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

Biological data – foraging

Parameter	Value	Reference(s)
Mean size at recruitment (to inshore foraging)	na	
Growth rates	na	
Survivorship estimates	na	Prince and Chaloupka (2012)

References & new publications – 2010 to 2019

- Limpus, C. J. (2009). *A biological review of Australian marine turtles; the hawksbill turtle* (p. 324). Queensland Environmental Protection Agency.
- Pendoley, K. L., Whittock, P. A., Vitenbergs, A., & Bell, C. (2016). Twenty years of turtle tracks: marine turtle nesting activity at remote locations in the Pilbara, Western Australia. *Australian Journal of Zoology*, 64(3), 217-226.
- Prince, R. I., & Chaloupka, M. (2012). Estimating demographic parameters for a critically endangered marine species with frequent reproductive omission: hawksbill turtles nesting at Varanus Island, Western Australia. *Marine Biology*, 159(2), 355-363.

Western/central Indian Ocean management unit

Ecological range

The samples used to identify the western central Indian Ocean management unit were collected from rookeries in Seychelles and Chagos. There are several rookeries in the southwest Indian Ocean which remain to be sampled, for example rookeries in Madagascar, Mozambique, Tanzania, Kenya and other French and British Indian Ocean Territories. 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 in Chagos and Seychelles waters are derived from nesting in Chagos or Seychelles.

Geographic spread of nesting

In the Seychelles, hawksbill turtle nesting occurs on many of the granitic islands and sandy cays, especially those in the northern atolls (summarised in Groombridge and Luxmoore (1989). In Chagos, hawksbill turtles have been reported nesting on each of the five atolls, especially Diego Garcia, which is the largest island in the group (Sheppard et al. 2012). Hawksbill nesting has been known to occur in most of the countries and territories in the south-west Indian Ocean, but it is not yet known whether these rookeries are part of the same management unit, for example rookeries in Kenya, Tanzania, Mozambique, Madagascar, Mauritius, Comoros, Mayotte, Reunion, Tromelin and Europa (Figure 16).

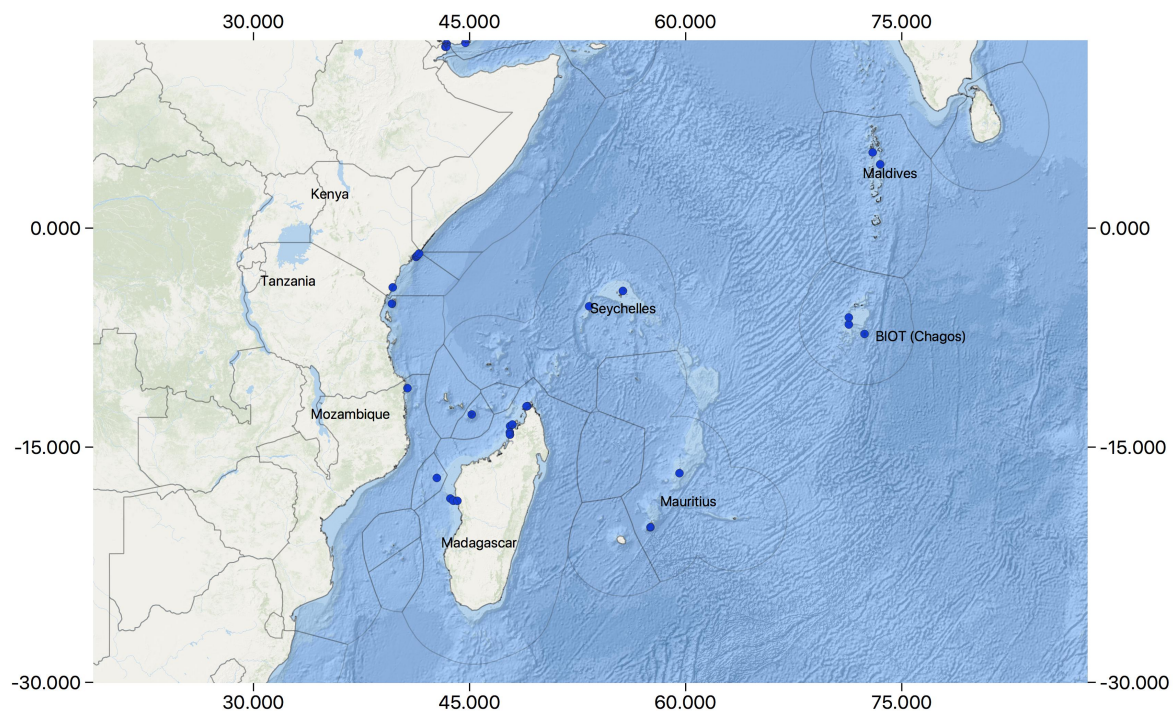


Figure 16. Distribution of *Eretmochelys imbricata* nesting beaches for the western Indian Ocean management unit, plus unsampled rookeries within the region.

Index nesting beaches:

Cousine Island (Seychelles) – data from early 1970s, and published as recently as 2008

Trends in nesting data

In the 1980s an estimated 1230 to 1740 female hawksbill turtles bred each year in the Seychelles (Mortimer 1984), however near complete harvest of nesting turtles across 30 years severely impacted the status of the population and an estimated 47 to 71% of the estimated annual nesting population was killed between 1980 and 1982 (Meylan and Donnelly 1999). An exception was the small rookery of Cousine Island which in the 1980s supported between 2 to 7% the nesting hawksbill turtles of the Seychelles (Mortimer 1984). Monitoring of this rookery has continued and although there have been changes to monitoring effort and tagging protocols it serves as an index site for the population. The number of turtles breeding at Cousine between 1973 and 1998 averaged 32 females per year and, in response to closure of the local tortoiseshell trade in 1993, this has increased to an average of 160 turtles per year between 1999 and 2008 (Figure 17). At D'Arros Island, in the Amirantes Group of the Seychelles, year-round surveys of nesting turtles between 2004 and 2009 indicate a relatively stable trend of around 300 clutches (range 277 to 318) per year which is likely to be around 60 females (Mortimer et al. 2011). Summarising data from the Seychelles, Mortimer (2006) highlights the value of beach-based protection. Data collected across the inner islands of the Seychelles between 1981 and 2003, indicate that the number of females nesting each year declined from an estimated 820 (early 1980s) to 625 (early 2000s). However, at the two well protected islands the number of nesting turtles increased by 490%, and at the seven intermediately protected islands, and the 13 non-protected islands the size of the nesting population declined by 21% and 31% respectively. Highlighting the value of site-based protection of nesting habitats.

At Chagos, the nesting population was substantially impacted by the direct killing of nesting turtles to supply the global trade in turtle shell, indeed Mortimer (2009 – cited in (Sheppard et al. 2012)) report that between 1900 and 1946 an average of 222 kg of hawksbill turtle shell were exported from Chagos each year (equivalent to ~ 111 adult sized hawksbill turtles per year). Mortimer and Day (1999) estimated the annual nesting population to be between 300 and 700 in the 1990s and Mortimer (2007) reports little change in the numbers of hawksbill turtles nesting between 1996 to 2006 in four atolls and a slight increase at Diego Garcia.

While there are positive signs regarding current status, the nesting population in Chagos and Seychelles is not likely to have recovered to pre-1900 baseline levels.

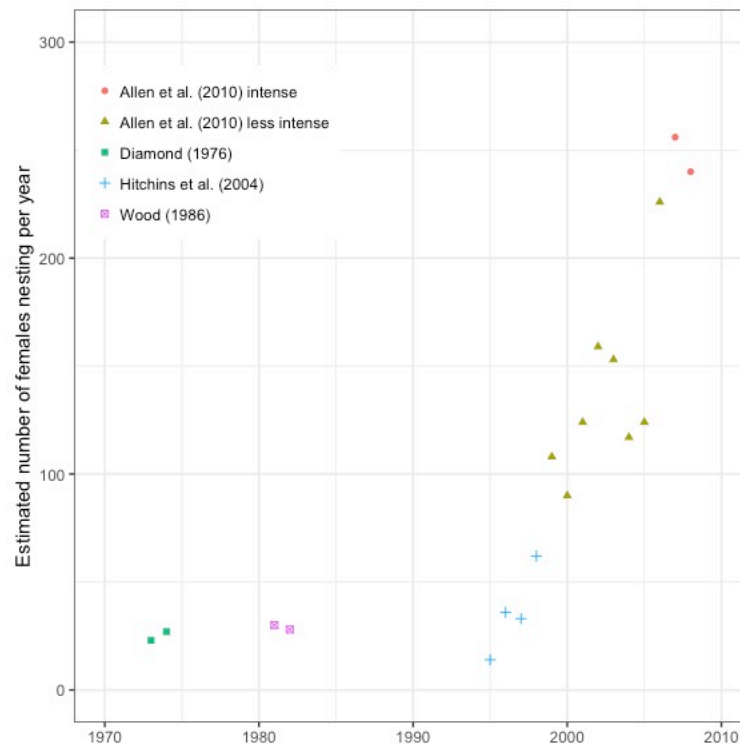


Figure 17. Number of females nesting per year at Cousine Island, Seychelles.

Migration and distribution of foraging areas

There have been no published accounts of hawksbill turtles being tracked from nesting beaches in the southwest Indian Ocean rookeries. There are records of tag recoveries from turtles tagged in the Seychelles in other areas of the southwest Indian Ocean. There are also examples of 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's Atoll in 2013 and last recorded at St Joseph's atoll in 2014, was recaptured 11 months later in Kenya, and two immature turtles tagged at Aldabra Atoll were later recaptured ~1000 km away as adult-sized animals, representing a possible developmental migration (Mortimer et al. 2010, Von Brandis et al. 2017). In the absence of genetic-based research these movements indicate connectivity between rookeries of Seychelles and the broader southwest Indian Ocean.

Threats to the population

The wide-scale systematic harvest of hawksbill turtles for shell has essentially been managed by the Seychelles Government. However, not all nesting beaches are protected small levels of harvest are believed to occur. Similarly, there is believed to be localised and small-scale use of turtle eggs.

Although the threats to the western/central Indian Ocean management unit for hawksbill turtles are known, 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 the ingestion of, or entanglement in marine debris. Examination of the degree to which these threats may impact hawksbill turtles from the western/central Indian Ocean management unit are required.

Although not recently quantified, the cumulative loss of turtles and eggs via multiple significant impacts and occurring throughout the probable range of the hawksbill turtles from the western/central Indian Ocean management unit are of concern (e.g. Table 8). There are currently no clear indications of when or how they can be resolved and therefore, these are sound reasons for accepting that there will continue be negative impacts on the recovery of *E. imbricata* in the western/central Indian Ocean management.

Table 8. Summary of key issues related to the cumulative loss of turtles and eggs from the Sulu Sea management unit of hawksbill turtles

1	Illegal harvest of eggs by people living or visiting non-protected islands for consumption or sale
2	The potential loss of post-hatchling, or immature, <i>E. imbricata</i> in ghost nets
3	The presumed substantial but unquantified mortality of foraging <i>E. imbricata</i> in the commercial fisheries of the southwest Indian Ocean and eastern Africa
4	The direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale, in particular Madagascar and Mozambique (REF)
5	The failure of CITES signatory States to enforce CITES regulations banning the export of Appendix 1 listed species such as <i>E. imbricate</i> (CITES)
6	The illegal trade in <i>E. imbricata</i> particularly via China and Vietnam provides an incentive for continuing the illegal trade of <i>E. imbricata</i> or their scutes from countries in southeast Asia (e.g. CITES, Riskas et al. 2018)

Summary of threats to the West-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 evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	1	3
Commercial use of turtles	-	3
Non-commercial use of turtles	-	3
Predation eggs by non-native fauna	?	4
Predation eggs by native fauna	?	4
Consumption – foraging turtles		
Commercial use of turtles	-	4
Non-commercial use of turtles	-	4
Climate change impacts		
Increasing beach temperature	?	4
Beach erosion	?	4
Sea level rise	?	4

Coastal development		
Habitat modification (urban)	1	3
Habitat modification (industrial)	1	3
Light horizon disorientation	1	3
Fisheries impacts		
Bycatch – trawl	3	3
Bycatch – long line	3	3
Bycatch – gill net	3	3
Impact to benthic ecology from fisheries	?	4
IUU impacts	?	4
Pollution		
Water-quality related impacts	?	4
Entanglement in discarded fishing gear	?	4
Ingestion of marine debris	?	4
Noise pollution	?	4
Disease and pathogen	?	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Cousin Island	Island	Yes	Very high	Protected Area

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	na	
Remigration interval	2 to 3 years	Mortimer and Bresson 1999
Clutches per season	3.6	
Mean size of nesting adult	81.2	Hitchins et al. 2004
Age at maturity	na	

Biological data – foraging

Parameter	Value	Reference(s)
Smallest size of foraging turtles	32.6 cm CCL	Mortimer et al. (2003)
Growth rates (Seychelles) CCL		Mortimer et al. (2003)
30-40	1.5 cm/yr	
40-50	2.7 cm/yr	
50-60	3.2 cm/yr	
60-70	3.7 cm/yr	
70-80	1.6 cm/yr	
Chagos CCL	0.7 to 2.7 cm/yr	Mortimer et al. (2002)
Survivorship estimates	na	

References & new publications – 2010 to 2019

- Diamond, A. W. (1976). Breeding biology and conservation of hawksbill turtles, *Eretmochelys imbricata* L., on Cousin Island, Seychelles. *Biological Conservation*, 9(3), 199-215.
- Hitchins, P. M., Bourquin, O., Hitchins, S., & Piper, S. E. (2004). Biometric data on hawksbill turtles (*Eretmochelys imbricata*) nesting at Cousine Island, Seychelles. *Journal of Zoology*, 264(4), 371-381.
- Mortimer, J.A. 2006. Simple, yet effective: protection at the nesting beach. SWOT Report 1:8.
- Mortimer, J. A., Day, M., & Broderick, D. (2002). Sea turtle populations of the Chagos Archipelago, British Indian Ocean Territory. In *Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation* (pp. 47-49).
- Mortimer, J. A., Collie, J., Jupiter, T., Chapman, R., Liljevik, A., & Betsy, B. (2003). Growth rates of immature hawksbills (*Eretmochelys imbricata*) at Aldabra Atoll, Seychelles (Western Indian Ocean). In *Seminoff JA (compiler) Proceedings of the twenty-second annual symposium on sea turtle biology and conservation. NOAA Technical Memorandum NMFS-SEFSC-503* (pp. 247-248).
- Mortimer, J. A., Gerlach, J., & Summerton, P. (2010). Long distance migrations of hawksbills tagged as juveniles at Aldabra Atoll: confirmation from digital photography. *Mar. Turt. Newsl*, 129, 11-13.
- Mortimer, J. A., Camille, J. C., & Boniface, N. (2011). Seasonality and status of nesting hawksbill (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) at D'Arros Island, Amirantes Group, Seychelles. *Chelonian Conservation and Biology*, 10(1), 26-33.
- Phillips KP, Jorgensen TH, Jolliffe KG, Jolliffe SM, Henwood J, & Richardson DS. (2013). Reconstructing paternal genotypes to infer patterns of sperm storage and sexual selection in the hawksbill turtle. *Molecular Ecology*. 22:2301–2312.
- Phillips KP, Mortimer JA, Jolliffe KG, Jorgensen TH, & Richardson DS. (2014). Molecular techniques reveal cryptic life history and demographic processes of a critically endangered marine turtle. *Journal of Experimental Marine Biology and Ecology*. 455:29–37.
- Sheppard, C. R., Ateweberhan, M., Bowen, B. W., Carr, P., Chen, C. A., Clubbe, C., ... & Gaither, M. R. (2012). Reefs and islands of the Chagos Archipelago, Indian Ocean: why it is the world's largest no-take marine protected area. *Aquatic Conservation: marine and freshwater ecosystems*, 22(2), 232-261.
- Riskas, K. A., Tobin, R. C., Fuentes, M. M., & Hamann, M. (2018). Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. *Biological Conservation*, 217, 232-239.
- von Brandis, R. G., Mortimer, J. A., van de Geer, C., & Lea, J. S. (2017). A Long Migratory Record for a Small Post-Pelagic Hawksbill. *Marine Turtle Newsletter*, 152, 13-15.

Arabian / Persian Gulf management unit

Ecological range

Despite the close geographic proximity there could be more than one management unit of hawksbill turtles in the Arabian/Persian Gulf. Three nesting areas in the Persian Gulf have been sampled – 2 in Iran and 1 in Saudi Arabia – the two rookeries sampled in Iran are genetically distinct but both are not distinct from Saudi Arabia (FitzSimmons and Limpus 2014; Tabib et al. 2014; Nishizawa et al. 2016).

Geographic spread of foraging sites

Foraging sites are known to occur in the coastal waters of UAE, Saudi Arabia, Qatar, Bahrain and Kuwait (Pilcher et al. 2014b). No studies have been conducted to determine the extent of hatchling and post-hatchling dispersal for this management unit. However, it is believed that most of the coral-reef fringed islands in the Gulf would support foraging of hawksbill turtles.

Geographic spread of nesting

Iran: Nesting sites for hawksbill turtles in Iran predominantly occur in offshore islands, Ommolkaram, Nakhiloo, Hengam, Faror, Shidvar, Lavan, Nakhiloo, Tahmadon, Omolgorm, Khark, Hendourabi, Kish, and Islands in the Gulf and Qeshm, Larak and Hormuz Island. (Mobaraki 2004, Nabavi et al. 2012, Hensi et al 2016) (Figure 18).

Saudi Arabia: Nesting sites for hawksbill turtles occur on four islands Karan, Kurayn, Jana, and Jurayd (Figure 18).

United Arab Emirates: Nesting sites for hawksbill turtles occur on Jarnain, Bu Tinah, Ghantoot, Sir Bu Nair, Quernain, and Zirqu Islands (Figure 18).

Qatar: Nesting sites for hawksbill turtles occur on Fuwairit, Halul, and Ras Laffan (Figure 18).

Kuwait: Scattered, low density nesting of hawksbill turtles has been reported (Rees et al. 2013) (Figure 18).

Index nesting beaches: There is annual monitoring of turtles at Shidvar Island in Iran

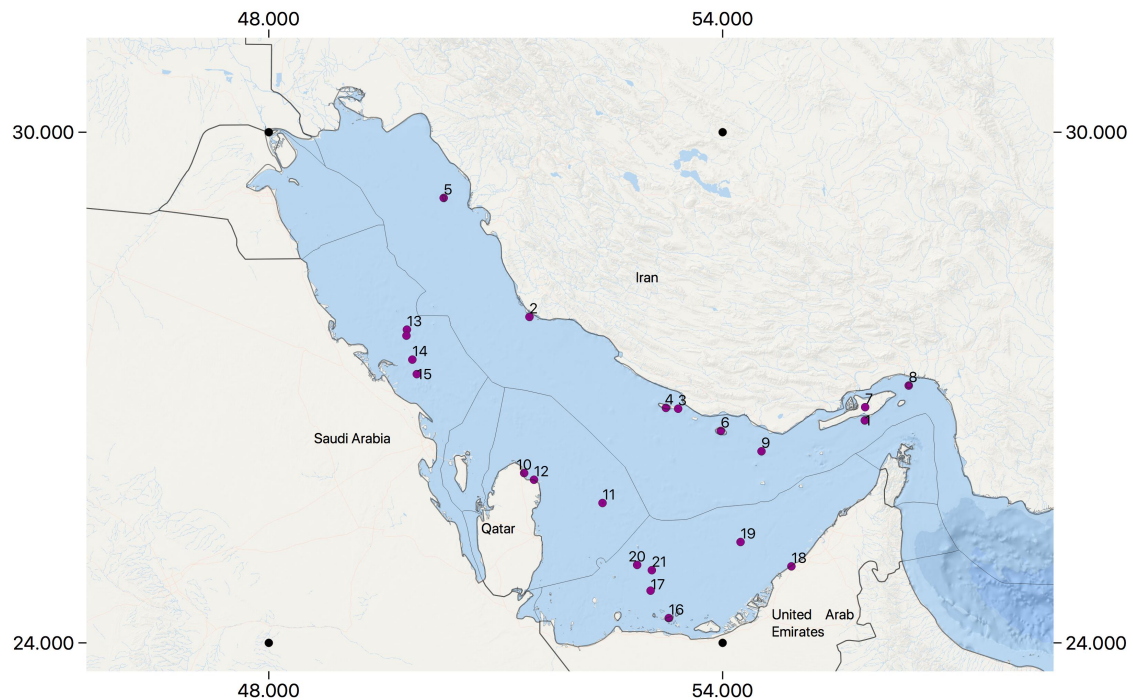


Figure 18. Distribution of nesting sites for hawksbill turtles in the Persian / Arabian Gulf

Trends in nesting data

Saudi Arabia: Surveys of nesting hawksbill turtles were conducted by Pilcher (1999) at three of the four rookeries and in two breeding seasons (1991 and 1992). At Jana Island 111 females were tagged during 1991 and 120 in 1992. At Karan Island 42 females were tagged in 1991 and 7 in 1992). Pilcher et al. (2014a) estimate the number of hawksbill turtles nesting each year on Jana as 500.

Iran: There are no long-term trend data for rookeries in Iran. Based on published data it is likely that around 1000 females breed each year, in particular on Kish, Shidvar, Lavan, Qeshan, Hormuz and Farour Islands.

United Arab Emirates: In 2009 Al-Ghais report 48 nests laid in a nesting season on Jarnain and 17 nests laid on Bu Tinah.

Qatar: Records indicate 100 to 200 females breed each year across Fuwairit, Ras Laffan and Halul Islands (Pilcher et al. 2014, Chatting et al. 2018)

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 13°C from the start to end of the nesting season (Chatting et al. 2018).

Migration and distribution of foraging areas

The migration and habitat use of hawksbill turtles from the Arabian / Persian Gulf management unit is well described by Pilcher et al. (2014). They report 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 Gulf and most migrated to the southern Gulf coast. 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 km² with a core use area of 3 to 5 km². 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 north-east direct and spanning 650 km movements that, at their apex, had waters 2°C cooler than their foraging area (Pilcher et al. 2014a,b).

Studies on foraging hawksbill turtles have been conducted in Qatar. In Qatar's shallow coastal water areas 31 hawksbill turtles were caught between 2013 and 2015. All were juvenile, the sex ration was 4M:1F and it is believed to be a transient or developing foraging aggregation. The genetic composition and home range use for these juvenile turtles remains to be investigated (Pilcher et al. 2015).

Threats to the population

Few quantified data exist on threats. Several authors have indicated that the consumption or sale of turtle eggs occurs on islands in the Arabian/Persian Gulf region. Fisheries bycatch is believed to occur, in a two-year study of stranding turtles in Bahrain, hawksbill turtles were reported to have been caught in large wire traps, and not commonly caught in trawl-based fisheries (Abdulqader and Miller 2012). In this region of the Indian Ocean the deliberate take, or retention of bycatch for sale into IUU markets was considered to be very low (Riskas et al. 2018).

Other threats have been identified but not 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, sea level rise because most of the nesting locations are low lying coral-fringed islands and the ingestion of, or entanglement in marine debris. Examination of the degree to which these threats may impact hawksbill turtles from the Arabian/Persian Gulf management unit are required.

Summary of threats to the Arabian/Persian Gulf 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 evidence only 4=not quantified
Consumption – nesting beach		
Egg collection	1	4

Commercial use of turtles	-	4
Non-commercial use of turtles	-	4
Predation eggs by non-native fauna	?	4
Predation eggs by native fauna	?	4
Consumption – foraging turtles		
Commercial use of turtles	-	4
Non-commercial use of turtles	-	4
Climate change impacts		
Increasing beach temperature	1	2
Beach erosion	1	2
Sea level rise	1	2
Coastal development		
Habitat modification (urban)	1,2,3	2
Habitat modification (industrial)	1,2,3	2
Light horizon disorientation	1	2
Fisheries impacts		
Bycatch – trawl	3	2
Bycatch – long line	3	2
Bycatch – gill net	3	2
Impact to benthic ecology from fisheries	?	4
IUU impacts	-	3
Pollution		
Water-quality related impacts	3	4
Entanglement in discarded fishing gear	3	4
Ingestion of marine debris	3	4
Noise pollution	?	4
Disease and pathogen	?	4

Management and protection

Site name	Type	Index site Y/N	Relative importance (to the population)	Protection
Shidvar Island	Island	Y	Very high	Protected as a wildlife refuge

Biological data – breeding

Parameter	Value	Reference(s)
Pivotal temperature	na	
Remigration interval	na	
Clutches per season	3 (up to 6)	Pilcher et al. (2014a)
Mean size of nesting adult	65.8	Pilcher (1999) Saudi Arabia
	71.6	Hesni et al. (2016) Iran
	70.8	Chatting et al. (2018) Qatar
Age at maturity	na	
Clutch size	79 eggs	Chatting et al. (2018) Qatar

Biological data – foraging

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

References & new publications – 2010 to 2019

- Abdulqader, E. A., & Miller, J. (2012). Marine turtle mortalities in Bahrain territorial waters. *Chelonian Conservation and Biology*, 11(1), 133-138.
- Chatting, M., Smyth, D., Al-Maslamani, I., Obbard, J., Al-Ansi, M., Hamza, S., ... & Marshall, C. D. (2018). Nesting ecology of hawksbill turtles, *Eretmochelys imbricata*, in an extreme environmental setting. *PloS one*, 13(9), e0203257.
- Hesni, M. A., Tabib, M., & Ramaki, A. H. (2016). Nesting ecology and reproductive biology of the Hawksbill Turtle, *Eretmochelys imbricata*, at Kish Island, Persian Gulf. *Journal of the Marine Biological Association of the United Kingdom*, 96(7), 1373-1378.
- Loghmani, M., Savari, A., Mobaraki, A. and Sadegi, P. (2011) Hawksbill turtle (*Eretmochelys imbricata*) nesting in Hormoz Island coasts. *Iranian Journal of Biology* 23, 884–892. [In Farsi, English Abstract].
- Mobaraki, A. (2004). Marine turtles in Iran: results from 2002. *Marine Turtle Newsletter* 104, 13.
- Nabavi, S. M. B., Zare, R., & Vaghefi, M. E. (2012). Nesting activity and conservation status of the hawksbill turtle (*Eretmochelys imbricata*) in Persian Gulf. *Journal of Life Sciences*, 6(1).
- Pilcher, N. J (1999) The hawksbill turtle. *Eretmochelys imbricata*, in the Arabian Gulf. *Chelonian Conservation Biology* 3: 312-318.
- Pilcher, N. J., Antonopoulou, M., Perry, L., Abdel-Moati, M. A., Al Abdessalaam, T. Z., Albeldawi, M., ... & Chikhi, A. (2014a). Identification of important sea turtle areas (ITAs) for hawksbill turtles in the Arabian region. *Journal of experimental marine biology and ecology*, 460, 89-99.
- Pilcher, N. J., Perry, L., Antonopoulou, M., Abdel-Moati, M. A., Al Abdessalaam, T. Z., Albeldawi, M., ... & Das, H. S. (2014b). Short-term behavioural responses to thermal stress by hawksbill turtles in the Arabian region. *Journal of experimental marine biology and ecology*, 457, 190-198.
- Pilcher, N. J., Al-Maslamani, I., Williams, J., Gasang, R., & Chikhi, A. (2015). Population structure of marine turtles in coastal waters of Qatar. *Endangered Species Research*, 28(2), 163-174.
- Rees, A. F., Hafez, A. A., Lloyd, J. R., Papathansopoulou, N., & Godley, B. J. (2013). Green turtles, *Chelonia mydas*, in Kuwait: nesting and movements. *Chelonian Conservation and Biology*, 12(1), 157-163.
- Riskas, K. A., Tobin, R. C., Fuentes, M. M., & Hamann, M. (2018). Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. *Biological Conservation*, 217, 232-239.
- Tabib, M., F. Frootan and M. & Hesni (2014). Genetic diversity and phylogeography of hawksbill turtle in the Persian Gulf. *J Biodivers Environ Sci* 4: 51-57.
- Zare, R., Vaghefi, M. E., & Kamel, S. J. (2012). Nest location and clutch success of the hawksbill sea turtle (*Eretmochelys imbricata*) at Shidvar Island, Iran. *Chelonian Conservation and Biology*, 11(2), 229-234.

Known nesting areas currently unassigned to a management unit

Indonesia

Hawksbill turtles have been reported nesting across the breadth of the nation, mostly in the Java sea region (Figure 19).

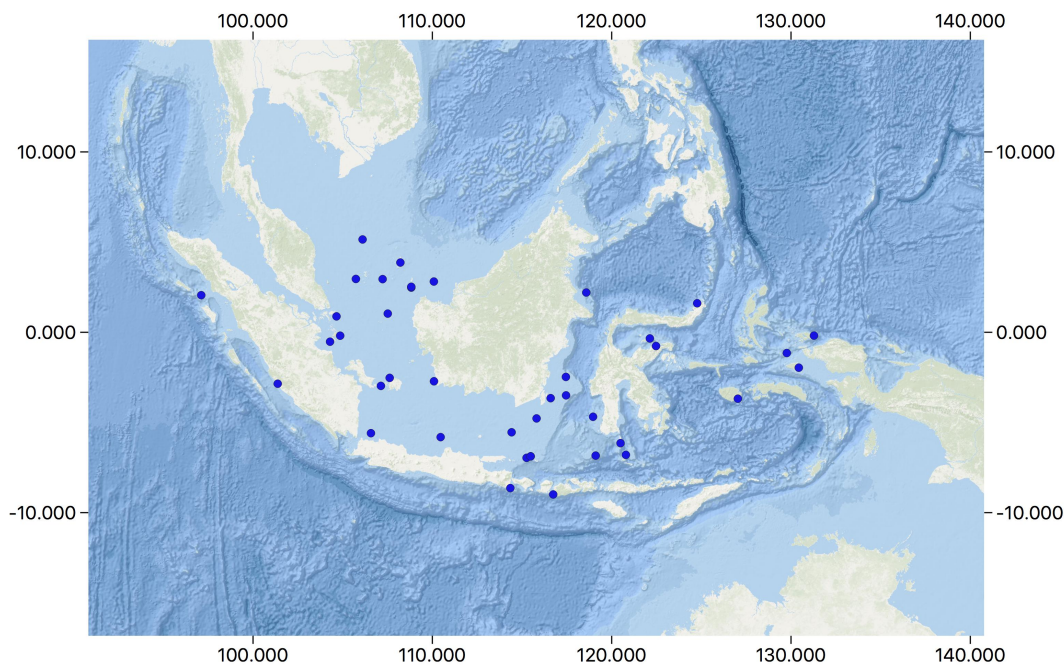


Figure 19. Distribution of nesting sites for hawksbill turtles in Indonesia

Indonesia – East Kalimantan, Celebes Sea regions.

Nesting

Low level nesting was reported on the Berau Islands – estimated 50 nests per year in the 1980s (Groombridge and Luxmoore 1989). Recent data from the monitoring programs focussed on green turtles indicates <10 nests per year are currently laid (Maulida et al. 2017).

Foraging

Maulida et al. (2017) conducted a survey of hawksbill turtle foraging and health in Bakungan Kecil (2°12'N, 118°35'E). 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 –South China Sea, Java Sea, West and South Sulawesi

There are eight Provinces in this region of Indonesia that 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 9). Throughout this region there is a long, and variously quantified, history of egg collection and supply of turtles for the turtle shell trade (Groombridge and Luxmoore 1989). In more recent years, Sukanuma et al. (1999) and Tanaka et al. (2010) conducted surveys on 15 of the 30 known hawksbill turtle nesting rookeries. Although several sites are protected, the illegal use of eggs persists in the region.

Riau, Riau Islands, South Sumatra, Bangka Belitung, 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 of nesting activity, nesting effort was examined in seven of the 10 rookeries in the late 1990s (Gresik, South Natuna and Tambelan) or early 2000s (Bintang, 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 9). 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) - Momperang (including Momperang and Pesemut), Penambun and Kimar (Table 9; Figure 20).

Lampung and Jakarta Provinces

The islands of the Kepulauan Seribu Islands National Park in Jakarta Bay are important for hawksbill turtle nesting, in particular, in the early 1990s it was estimated that around 500 females bred 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 community and NGOs (Table 9; Figure 20).

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 19) (Groombridge and Luxmoore 1989). In South Kalimantan ELNA conducted interview surveys of island residents between 2006 and 2010 on Pulau Sambergelap and 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.

Table 9. Estimated number clutches laid per year for hawksbill turtles in South China Sea, Java Sea, West and South Sulawesi

Location	Clutches laid per year		
	1980 estimates (Table 88 of Groombridge and Luxmoore 1989)	2008/2009 estimate (Tanaka et al. 2010 Sukanuma et al. 1999) * body pits counted	Most recent estimate (year) ELNA pers communication

Riau and Riau Island Provinces

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Senayang	400		
Natuna Besar	200		
Natuna Selatan	620	285 (2009)*	
Anambas	800	na	na
Tambelan	800	42 (1995)	241 (2009)*
Riau and Lingga	150	94 (2009) (Lingga)*	na
Bintang	na	192 (2009)*	na
Singkep	na	27 (2009)*	na
<hr/>			
<u>South Sumatra and</u>			
<u>Bangka Belitung</u>			
<u>Provinces</u>			
Momperang/Peserat	400	357 (2009)	915 (2016-18)
Gresik		219 (1996)	203 (2008)
Kimar	na	290 (2009)	666 (2016-18)
Momperak and	1250	na	
Pesambung			
Tengah and	800	na	
Sembilan			
Other islands (P.	1100	na	
Manggar, P.			
Plemah, P.Seliu, P			
Lima, P.Panjang, P.			
Lengkuas, Belitung			
<hr/>			
<u>Lampung and</u>			
<u>Jakarta Provinces</u>			
Seribu Islands NP	500	50 (1994)*	
Segama	na	463 (2009)	1347 (2016-18)
<hr/>			
<u>South Kalimantan</u>			
<u>Province</u>			
Sambergelap area	na	672 (2009)	na
<hr/>			
<u>West Kalimantan</u>			
<u>Province</u>			
Paloh region	300	na	na
Kendawangan	na	165 (2009)*	112 (2015-18)
region			(Penambun)
<hr/>			
<u>South Sulawesi</u>			
<u>Province</u>			
Islands in Makassar	3000 to 4000	na	na
and P. Kayadi,			
Islands south of			
South Suluwesi			
<hr/>			

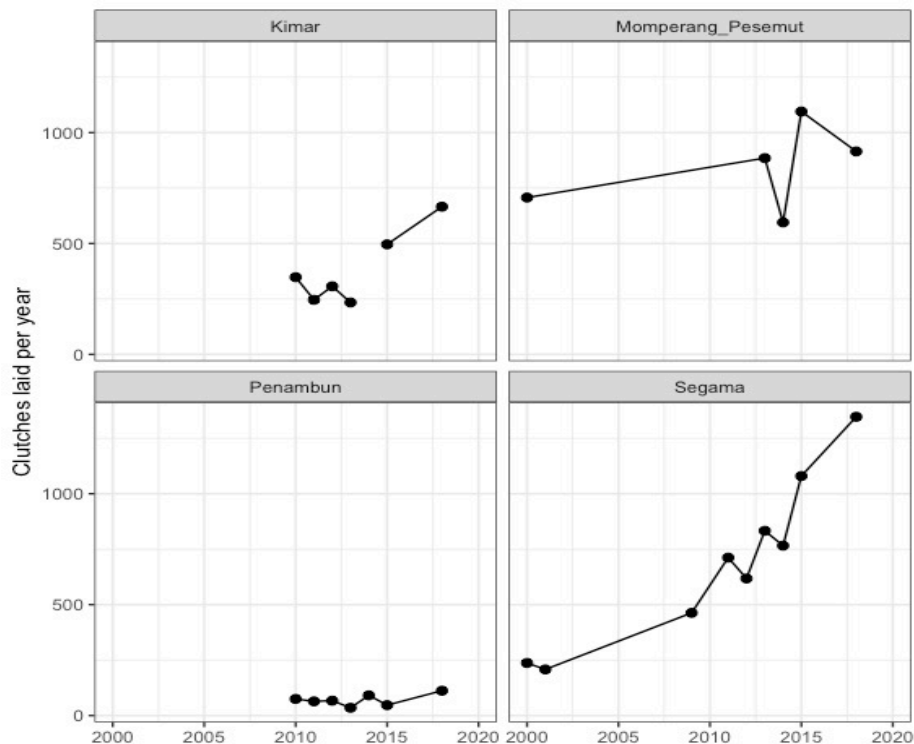


Figure 20. Results of monitoring in four locations in the Indonesian, Java Sea by the the NGO Everlasting Nature of Asia. Data up until 2010 (Tanaka et al. 2010) and data between 2010 and 2018 are unpublished and supplied by ELNA. The value for 2018 represents an average of 2016 to 2018.

Nesting

In this region of Indonesia hawksbill turtles nest year-round with the peak of the nesting varying slightly between island groups (Table 10). At Pesemut, Momperang, Kimar and Segama Besar monitoring is coordinated by the ELNA and Yayasan Penyu Laut Indonesia (YPLI).

Table 10 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)

Foraging

There are no data on foraging turtles in the region. However, there are 1000s 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 Malaka in Malaysia have migrated into the Java Sea.

Indonesia – Aceh, West Sumatra, Bengkulu, East Java, West Java, 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 have not been quantified since first surveyed in the 1980s (see Table 88 of Groombridge and Luxmoore 1989). More recent surveys show considerable declines are likely to have occurred.

Foraging

There are no data on foraging turtles in the region. However, there are 1000s 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 – 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 area have not been quantified since first surveyed in the 1980s (see Table 88 of Groombridge and Luxmoore 1989).

Foraging

There are no data on foraging turtles in the region. However, there are 1000s 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 – Southeast Suluwesi, Maluka, North Maluka, West Papua, Papua Provinces

Nesting

Surveys in the 1980s highlighted these Provinces as important areas for hawksbill turtle nesting, however the number of turtles using the area have not been quantified since first surveyed in the 1980s (see Table 88 of Groombridge and Luxmoore 1989). More recent surveys show considerable declines are likely to have occurred.

Bird's Head Peninsula, Cendrawasih Bay and Raja Ampat

Low numbers of hawksbill turtles nest on the beaches/islands of the Bird's Head Peninsula region. In particular, Putrawidjaja (2000) report 13 clutches being laid on Baturumah and Warmamedia Beaches between May and October 1999, these beaches are primarily used by leatherback turtles. In addition, Putrawidjaja (2000) report hawksbill turtle nesting on five islands in Cendrawasih Bay (Nusambier, Iwari, Kuwom, Matas, and in particular, Wairundi). A survey in this region by Setyadi (1997; cited in Putrawidjaja (2000)) found hawksbill turtle nests on 16 nests on 6 of 8 beaches surveyed (Iwari, Matas, Rorebo, Tridacna Atoll, Kabau, Nutabari). Hitipeuw (2003) report nesting on three islands in Raja Ampat, Waigeo (around 5

nests per year), Kofiau (two beaches and around five nests per year), and in particular Misool (six beaches and around 30 nests per year).

Maluku North Maluku and Southeast Suluwesi

There are no updates on the nesting sites, or the numbers using this region to breed.

Foraging

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

Migration

No migration records exist for hawksbill turtles in this region

Threats to the turtles of Indonesia

It is likely, based on the extent of harvest in other areas of Indonesia that the harvest of hawksbill turtle eggs throughout the 20th century was significant and could have contributed to declines in the nesting and foraging populations. Egg collection, incidental bycatch, opportunistic retention of bycatch and deliberate take of turtles for the sale of shell are still considered to be threats to the hawksbill turtles of Indonesia. However, there are no quantifiable data to indicate the magnitude of the threat. Several authors, over the past 10 to 20 years have indicated that the collection of eggs for sale or non-commercial consumption continues to occur on most non-protected islands, and on some protected islands (Putrawidjaja 2000, Hitipeuw 2003, Tapilatu et al. 2017). Levels of take are unquantified, yet they are believed to occur across most of the regions in Indonesia. Similarly, there are no quantitative data on the incidental, or deliberate, capture of hawksbill turtles and the sale of hawksbill turtle products (Table 11), it is however, generally considered to be substantial in the context of local and regional population sizes. There are currently no clear indications of when or how they can be resolved and therefore, these are sound reasons for accepting that there will continue be negative impacts on the recovery of *E. imbricata* in Indonesia.

Table 11. Summary of key issues related to the cumulative loss of turtles and eggs from the Sulu Sea management unit of hawksbill turtles

1	Illegal harvest of eggs by people living or visiting islands for consumption or sale
2	The potential loss of post-hatchling, or immature, <i>E. imbricata</i> in ghost nets
3	The presumed substantial but unquantified mortality of foraging <i>E. imbricata</i> in the commercial fisheries of Indonesia, Timor Leste, Papua New Guinea and Malaysia
4	The direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale (see CITES)
5	The failure of CITES signatory States to enforce CITES regulations banning the export of Appendix 1 listed species such as <i>E. imbricate</i> (CITES, Vuto et al. 2019)
6	The illegal trade in <i>E. imbricata</i> particularly via China and Vietnam provides an incentive for continuing the illegal trade of <i>E. imbricata</i> or their scutes from countries in southeast Asia (e.g. CITES, Riskas et al. 2018)

Publications/weblinks for Indonesia

- Hitipeuw (2003) Status of sea turtle populations in the Raja Ampat Islands. Chapter 5 in Report on a rapid ecological assessment of the Raja Ampat Islands, Papua, Eastern Indonesia, held October 30 – November 22, 2002.
- Maulida, F. F., Imron, M. A., & Reischig, T. (2017). Geometry Morphometry and Health Status of Hawksbill Turtle (*Eretmochelys imbricata* Linnaeus, 1766) in Maratua Island, East Kalimantan-Indonesia. *KnE Life Sciences*, 100-110.
- Putrawidjaja M. 2000. Marine turtles in Irian Jaya, Indonesia. *Marine Turtle Newsletter* 90: 8-10.
- Tapilatu, R. F., Wona, H., & Batubara, P. P. (2017). Status of sea turtle populations and its conservation at Birds Head Seascape, Western Papua, Indonesia. *Biodiversitas Journal of Biological Diversity*, 18(1).

Philippines

Nesting

Hawksbill turtles have been documented to nest on Panikian Island (Sagun 2002) and the Calamiane Islands (Poonian et al. 2016) and less than five hawksbill turtles were reported to nest per year in the Philippine Turtle Islands in 2002 (Cruz 2002). In the Calamiane Islands the most important beaches are located on the islands to the west of Busuanga and Culion, particularly 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, Guimaras).

Based on data from Panikan Island the peak of the nesting season occurs between April-June (Cruz 2002).

Foraging

The Calamian Islands also provide important foraging grounds for marine turtles due to their diversity in habitats including coral reefs, beaches, and seagrass beds, and provide a range of habitats 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). Lagunoy 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

Hawksbills found foraging on reefs between 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 have there been any genetic-based research to identify the spread of foraging habitats.

Work has begun to reclassify the Balabac Strait in Palawan an MPA. 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 Biodiversity Management Bureau 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 to be jointly managed

(e.g. the Turtle Islands Heritage Protected Area (TIHPA). The TIHPA is comprised of three islands of the Turtle Islands Park of Sabah, Malaysia and six islands of the Turtle Islands Wildlife Sanctuary of TawiTawi Province, Philippines (Sagun 2002, DENR Biodiversity Management Bureau 2019); Boan, Lihiman, Langaan, Great Bakkungan, Taganak, and Baguan (Philippines National Commission for UNESCO 2015).

Threats

Populations of Turtles 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 tracks domestic trade of turtle by-products (Trono 1991). In the Philippines a large amount of the educational campaigns around turtle conservation have focused on local fishers - and fishers are often encouraged to record bycatch data, such as history of capture, take photos and measure turtles before re-release (Sagun 2002). In 2011 an album comprising photographs of 68 turtles and the threats they face was published by 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, education and economic resources. Local governments, and organisations such as PCP have had great success at reducing threats to turtle populations by educating and mobilising local residents, by providing health services, education and alternative livelihoods to directly tackle reliance on egg harvesting and turtle hunting as a source of income. Similarly, in 1996 WWF Philippines aimed to understand socio-economic, socio-cultural and political drivers of island communities (Poonian et al. 2016) in conjunction with a biological, social, and community assessment to formulate a long-term integrated conservation plan to end unsustainable use of marine resources and to relieve pressure on hawksbill turtle populations (Palma et al. 2000). However, the success or failure of these projects is rarely examined or documented.

Closing commercial and export trade requires more effective enforcement of laws (Poonian, Ramilo and Lopez 2016). Since 2002 the DENR have stopped issuing permits to collect marine turtle eggs in the Turtle Islands, Tawi-tawi (Marine Wildlife Watch of the Philippines 2014). Data from the PCP showed that between 1979-1991, ~266 businesses were engaged in the trade of marine turtle by-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 1989-1991, 171 stuffed turtles and 20 turtle carapace guitars were confiscated, 20% were Hawksbill turtle origin (Trono 1991). Hunting and egg collection is still very prevalent and remains a major threat to marine turtles in the Calamianes (Poonian et al. 2016). However anecdotal evidence from local communities mentioned that *E.imbricata* 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). Bantay Pawikan (formed in 2000) is a people’s organisation in Bataan, comprised of previous licensed egg collectors, that now serve to protect egg clutches and nesting, whose livelihoods is provided by their provincial government (Sagun 2002).

Philippine turtle populations are also under threat from local and international illegal use and fisheries. Direct catches and bycatch numbers 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 Vietnam (Bagarinao 2011).

Gill nets, long lines, skimming nets, beach seines and bamboo fish corrals operate around Panay and Guimaras almost daily, and as a consequence hawksbills are caught by various gear sporadically over the year in these cases sea turtles are 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 sea turtles were captured by fisheries or stranded around Panay and Guimaras Islands (and reported to FishWorld), 15 of these were hawksbill turtles.

Publications/weblinks

- Bagarinao. (2011). The sea turtles captured by coastal Fisheries in the northeastern Sulu sea, Philippines: Documentation, care, and release. *Herpetological Conservation and Biology* 6.
- Cruz. R (2002). Marine Turtle Distribution in the Philippines. *Proceedings of the Western Pacific Sea Turtle Cooperative Research and Management Workshop*. February 5–8, 2002:57-65.
- Department of Environment and Natural Resources. 2019. A Sea of Safe Havens, Establishing the Marine Turtle Protected Area Network in the Philippines. Brochure:
http://www.coraltriangleinitiative.org/sites/default/files/resources/Safehaven_MarineTurtle%20Network_brochure.pdf Visited: 04/10/2019.
- Fabinyi. (2012). *Fishing for Fairness: Poverty, Morality and Marine Resource Regulation in the Philippines*. ANU E Press. The Australian National University, Canberra ACT 0200, Australia.
- Marine Wildlife Watch of the Philippines. 2014. *Philippine Aquatic Wildlife Rescue and Response Manual Series: Marine Turtles*. Marine Wild Fauna Watch of the Philippines, Inc. 86 pages.
- Trono, P.R. (2000). Approaches for an Integrated Conservation and Development Program in the Philippine Turtle Islands. *Proceedings of the Twentieth Annual Symposium on Sea Turtle Biology and Conservation* 20: 15-17.
- Poonian, R.L (2016). Diversity, habitat distribution, and indigenous hunting of marine turtles in the Calamian Islands, Palawan, Republic of the Philippines. *Journal of Asia-Pacific Biodiversity* 9: 69-73.
- Ramirez de Veyra. (1994). Foreign Tag Recoveries from the Philippines. *Marine Turtle Newsletter* 64:6-9.
- Sagun. (2002). Updates on Marine Turtle Conservation in the Philippines. *Proceedings of the 3rd Workshop on SEASTAR2000* 2002. 87-93.
- Trono. R (1991). Philippine Marine Turtle Conservation Program. *Marine Turtle Newsletter* 53:5-7.
- WWF. (2005). Protecting the turtles of the Turtle Islands. Weblink: <http://wwf.panda.org/?23610/Protecting-the-turtles-of-the-Turtle-Islands> Visited: 04/10/2019.
- WWF. (2008). Foreign poachers cost Philippines another 100 turtles. Weblink: http://wwf.panda.org/wwf_news/?144741/Foreign-poachers-cost-Philippines-another-100-turtles Visited: 04/10/2019.

Myanmar

Nesting

Nesting sites are described by Maxwell (1911), Groombridge and Luxmoore (1989) and more recently by Thorbjarnarson et al. (2000). At Thameehla Island 100s of hawksbill turtles nesting annually in the 1890s but, in response to long term excessive egg collection in the past, no hawksbill turtle nesting has been recorded on the island in recent decades (Maxwell, 1911; Thorbjarnarson et al. 2000; Limpus, 2012. Figure 21). Thorbjarnarson et al. (2000) report hawksbill turtles to be extremely rare in Myanmar.

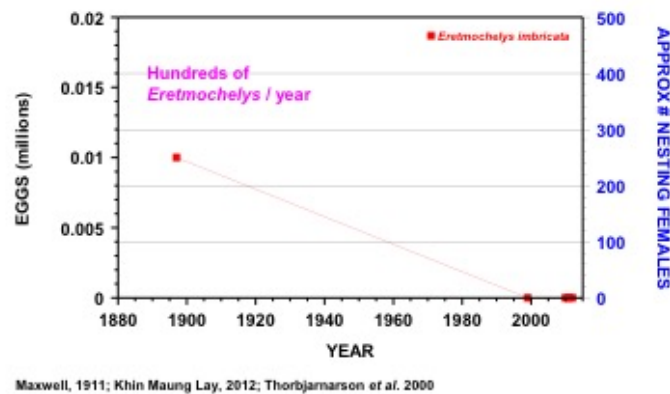


Figure 21. Long term changes in hawksbill turtle nesting at Thameehla Island, Myanmar, after Limpus (2012).

Foraging

There are no data on foraging turtles in the Myanmar region. Two areas with foraging hawksbill turtles have been recognised, Longlone Bok Island and Maung Ma Gan Bok Island (Thant and Maung Maung Lwin 2012).

Migration

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

Threats

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 of unworked turtle shell, presumably hawksbill and presumably caught in Myanmar was exported from Myanmar to South Korea (Groombridge and Luxmoore 1989). Between 2008 and 2010 the Myanmar Department of Fisheries received reports of 12 hawksbill turtles caught by gill nets at Longlonebok Island during awareness campaigns for fishers. 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).

Publications/weblinks

Limpus, C. J. (2012). Assessment of the turtle conservation actions at Thameehla Island, Myanmar, within the framework of the IOSEA Technical Support/Capacity-building Programme. Myanmar: Department of Fisheries. Thant S and Maung Maung Lwin 2012 Distribution of hawksbill turtles (*Eretmochelys imbricata*) in Longlonebok Island and its adjacent area in Myanmar. Proceedings of the 7th SEASTAR2000 Kyoto University 2012. <http://hdl.handle.net/2433/154049> Thorbjarnarson, J. B., Platt, S. G., & Khaing, S. T. (2000). Sea turtles in Myanmar: past and present. *Marine Turtle Newsletter*, 88, 10-11.

Bangladesh

Nesting

Occasional nesting by hawksbill turtles has been recorded on St Martin's Island. Surveys between 1996 and 2001 reported 3 hawksbill females nesting in 1998 and none in the other years (Mohammad Zahirul Islam 2002).

Foraging

There are no data on foraging turtles in Bangladesh.

Migration

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

Threats

It is likely, based on impacts to other sea turtle species nesting in Bangladesh that hawksbill populations have been impacted by the harvest of eggs and this 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, however, it is not known if these were from local sources (Mohammad Zahirul Islam 2001). Opportunistic retention of hawksbill turtles caught in fishing gear also occurs and contributes to domestic use (Riskas et al. 2018).

Publications

Mohammad Zahirul Islam (2001) Notes on the trade in marine turtle products in Bangladesh. *Marine Turtle Newsletter* 94: 10.

Mohammad Zahirul Islam (2002) Marine turtle nesting at St Martin's Island, Bangladesh. *Marine Turtle Newsletter* 96: 19-21.

India (Nicobar and Andaman Islands), Western Thailand

Nesting

India: In the Nicobar and Andaman Islands, hawksbill turtles have been recorded nesting at 12 sites in the Nicobar group and 3 sites in Little Andaman. The nesting season peaks in September through October.

Andaman Islands: the most important hawksbill nesting sites include North Brother and Snake Islands in the South Andaman (Bhaskar, 1993).

Nicobar Islands: Pulo Milo, Terassa and Katchal Islands. Meroe, Trak and Treis Islands. In Pulo Milo, only hawksbill nesting has been reported. Lower density nesting has also been reported from Pulo Kiyang, Bahuva and Tauhiyol and Muhincohn Islands

Great Nicobar - Saphed Balu Island

Overall, Andrews et al. (2006) estimate that 205 females nest annually on Andaman Islands and 45 on Nicobar, however it is not clear how the values were derived.

Thailand: Low numbers of hawksbill turtles nest along the islands of the west coast of Thailand – in particular the Surin or Similan Islands.

Threats

It is likely, based on impacts to other sea turtle species nesting in the region that hawksbill populations have been impacted by the harvest of eggs and turtles, and this has almost certainly caused 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).

Publications/weblinks

- Andrews, H. V., Tripathy, A., Aghue, S., Glen, S., John, S., & Naveen, K. (2006). The status of sea turtle populations in the Andaman and Nicobar Islands of India. *Towards an integrated and collaborative sea turtle conservation programme in India: a UNEP/CMS-IOSEA Project Report*, 71-82.
- Chantrapornsy S (1996) Status of marine turtles in Thailand. Proceedings of the first SEAFDEC workshop. Malaysia 1996
http://seaturtle.org/library/ChantrapornsyS_1996_InProceedingsoftheFirstSEAFDECWorksho_p77-92.pdf

Sri Lanka

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 3 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 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) report eight individuals hawksbills nesting on four beaches (0.5% of clutches laid) between Mount Lavana and Koggala in Southwest Sri Lanka (Mount Lavana (2), Kosgoda (3), Ahungalla (2) and Kahawa (1).

Foraging

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

Migration

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

Threats

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 in reducing the use and sale of hawksbill turtle shell products and it may not be considered as a key threat to hawksbill turtles (Rajakaruna et al. 2012).

Publications/weblinks

- Ekanayake, E. L., Ranawana, K. B., Kapurusinghe, T., Premakumara, M. G. C., & Saman, M. M. (2002). Marine turtle conservation in Rekawa turtle rookery in southern Sri Lanka. *Ceylon Journal of Science (Biological Science)*, 30, 79-88.
- Hewavisenthi, S. (1990). Exploitation of marine turtles in Sri Lanka: historic background and the present status. *Marine Turtle Newsletter*, 48, 14-19.

- Jayathilaka, R.A.M. Maldeniya, R., Kumara, M.D.I.C. A study on temporal and spatial distribution of sea turtle nesting on the south west coast of Sri Lanka. National Aquatic Resources Research and Development Agency (NARA), Scientific Sessions 2016
- Rajakaruna, R. S., Dissanayake, D. M. N. J., Ekanayake, E. L., & Ranawana, K. B. (2009). Sea turtle conservation in Sri Lanka: assessment of knowledge, attitude and prevalence of consumptive use of turtle products among coastal communities. *Indian Ocean Turtle newsletter*, 10, 1.
- Rajakaruna, R. S et al. (2012) Tortoiseshell trade in Sri Lanka: Is centuries old trade now history? *Marine Turtle Newsletter*. 134: 9-11.
- Riskas, K. A., Tobin, R. C., Fuentes, M. M., & Hamann, M. (2018). Evaluating the threat of IUU fishing to sea turtles in the Indian Ocean and Southeast Asia using expert elicitation. *Biological Conservation*, 217, 232-239.

Maldives

Nesting

Nesting sites are described by Groombridge and Luxmoore (1989) and more recently by Ali et al. (2016) and Hudgins et al. (2017). Data indicate that nesting is scattered along most of the uninhabited islands of the nation, in particular, Baa Atoll, North Male and South Male. A survey in 2015 using local citizen science found North Male had the only two true 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 runs through March and April and there were no surveys between late Feb and early April (Hudgins et al. 2017).

Foraging

The Maldives is comprised of 1200 coral reef islands and atolls, therefore providing substantial foraging area for hawksbill turtles. A 2015 survey to review the status of marine turtles in the Maldives 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 et al. 2016).

Migration

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

Threats

Maldives was one of the main sources of hawksbill turtle shell for the artisan carving industry in Sri Lanka. Between 1970 and 1981 36447 kg of hawksbill shell was exported from the Maldives, at least 9221 was imported into Japan (Figure 22, from Table 136; Groombridge and Luxmoore 1989), this use has almost certainly impacted the local populations. Opportunistic retention of hawksbill turtles caught in fishing gear also occurs and contributes to domestic use (Riskas et al. 2018).

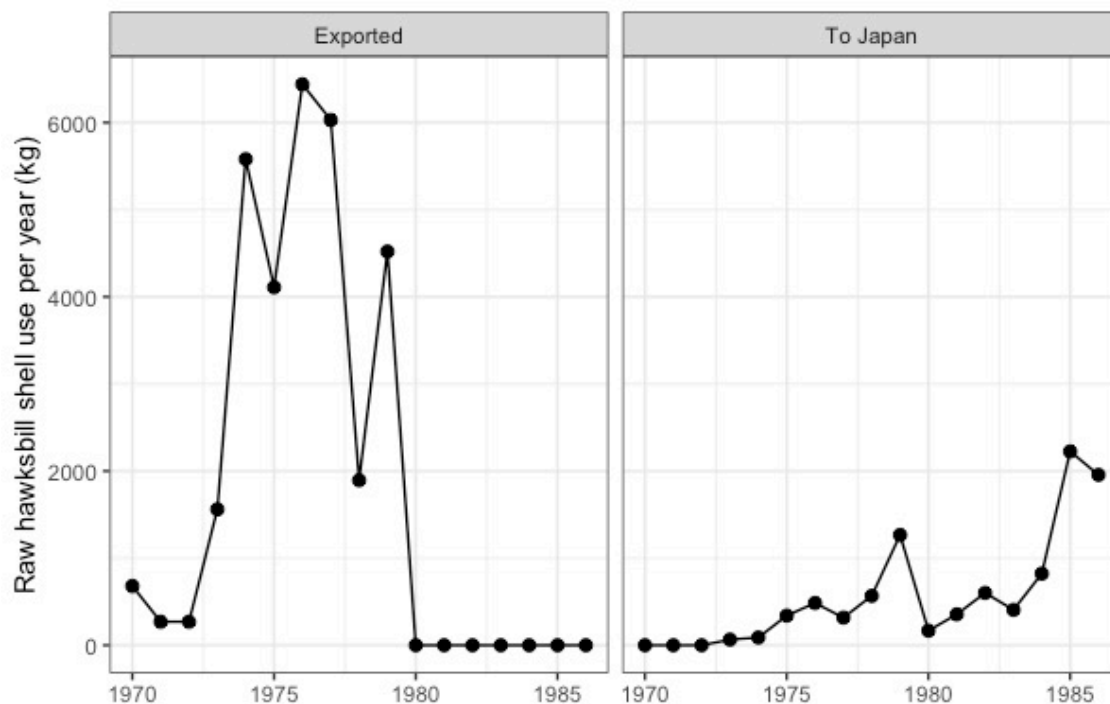


Figure 22. Raw hawksbill turtle shell exported from the Maldives and imported into Japan

Publications/weblinks

- Ali, K., Shimal, M. 2016. Review of the status of marine turtles in the Maldives. Marine Research Centre, Ministry of Fisheries and Agriculture, Malé, Rep. of Maldives, 27pp.
- Hudgins, J. A., Hudgins, E. J., Ali, K., & Mancini, A. (2017). Citizen science surveys elucidate key foraging and nesting habitat for two endangered marine turtle species within the Republic of Maldives. *Herpetology Notes*, 10, 473-475.

Oman and Yemen

Nesting

The Dimaniyat Island in the Gulf of Oman boasts one of the densest populations of hawksbills Turtles in the northwest Indian Ocean (Mendonca et al. 2001). The Dimaniyat Islands were proclaimed a Nature Reserve in 1996 and lie about 16–18 km from the coast of Oman. The archipelago of nine uninhabited islands is surrounded by more than 20,000 ha of sea, seabed and coral reefs, and provides good feeding and nesting grounds for hawksbills (Mendonca et al. 2001). The Dimaniyat Islands have been considered as one of the last sanctuaries to hawksbills in the region, due to the protected status of the islands and the high pollution levels that exist in the Persian Gulf (Mendonca et al. 2001). It is believed that 200 to 300 females nest per year at Demaniyat.

Marisah Island is 70km long and 4-10km wide, and is 8km from the Oman mainland coast. The beaches are remote and challenging to survey, however the roads towards the Masirah nesting beaches are becoming increasingly paved, opening up the area for increased access. It is believed that around 100 females per year breed at Masirah. The nesting season occurs throughout winter and spring (the opposite time of the year to loggerhead turtle nesting at the same site) (Rees and Baker 2006).

Al Hallaniyat archipelago, in the Arabian sea, consists of four islands: Al Hasikiyat, As Sawda, Al Hallaniyat and Al Qibliyat. All islands are uninhabited apart from Al Hallaniyat, with a population of ~300 people (Mendonca et al. 2005). Some of the beaches may provide suitable nesting areas for hawksbill turtles but they have not been confirmed.

In a study by Pilcher et al. (2014) nesting periods for Oman turtles was 11.1 days, with an average of three clutches per season. The nesting season is from February/March to July/August each year, peaking April/May (Mendonca et al. 2001). Omani turtles were not shown to undertake summer migration loops, nesting fewer times than Arabian Gulf populations. The average size of the turtles (CCL) nesting on Damaniyat Islands in 1999 and 2000 was recorded at 80 cm.

In 1999 and 2000 nesting activity was tracked twice monthly from March-May and once monthly for the other months of the year (Mendonca et al. 2001). The Islands with larger beach areas experienced higher nesting activity and the total number of tracks observed in the 1999 and 2000 seasons were 1205 and 4376 respectively (Mendonca et al 2001). Assuming a nesting success of 60% and three clutches a season, the annual nesting population could be between 250 and 750 females.

Yemen: Hawksbill turtle nesting primarily occurs on Perim Island and Jabal Aziz Island. Along the Yemeni Red Sea coast, nesting has been reported on the Kamaran Islands, Makran, and Perim Island (Mancini et al. 2015), at Jabal Aziz (PERSGA/GE 2004), Socotra, Abdal Kuri, and at low coral islands 3-30 km offshore. The most recent available (from the 1960 and 1970s) (Ross and Barwani 1982), estimates the annual nesting population of hawksbills turtles in Yemen at ~ 500. Along the Yemeni Red Sea coast, nesting has been reported on the Kamaran Islands, Makran, and Perim Island (Mancini et al. 2015), at Jabal Aziz (PERSGA/GE 2004), Socotra, Abd al Kuri, and at low coral islands 3-30 km offshore.

Foraging

Oman:

In Oman foraging habitats are spread along 500 km of coastline, and are restricted to a narrow coastal belt (Pilcher et al. 2014). Although there are few coral reefs in the area there are corals covering the rocky substrate and biomass of benthic invertebrates are suitable for hawksbill foraging (Ross 1981). Pilcher et al. (2014) identified two main foraging areas, Shannah and Quwayrah. Both were small in size and turtles using them had core areas focused on shallow patches of coral-reef habitats around 3km², and home range areas of 40-60km².

Yemen:

In Yemen the fringing reefs in the Gulf of Aden have been identified as key foraging sites for Yemeni Hawksbill turtles (PERSGA/GE 2004). Unusually, in a study into the environmental status of the coasts of Yemen, the Gulf of Aden coast was shown to have lower prevalence and abundance of coastal flora and corals than the Red Sea, but to have higher total number of turtles (specific species numbers were not recorded) (Wilson et al. 2003).

Migration

Oman:

The areas around the Ras Al Hadd and between the southern tip of Masirah island and Shannah on the mainland are important migratory pathways for hawksbill turtles (Pilcher et al 2014). In the Picher et al. (2014) study, Post-nesting turtles were tracked migrating southeast from Daymaniyat islands, rounding Ras al Hadd and heading southwest towards the waters off Shannah and Marisah island and Quwayrah. Turtles from Masirah rarely travelled further than 50–80 km to coastal foraging sites off the Oman mainland coast (Pilcher et al 2014). Migrations from the Daymaniyat islands were longer than those from Marisah, averaging 672.6 km and taking an average of 28.6 days to complete (Pilcher et al. 2014). All turtles reached or passed Masirah island with only one migrating north into the Gulf. This is the first documented instance of a hawksbill migration in or out of the Gulf. Migrations by turtles at Masirah islands were statistically shorter than those from Daymaniyat islands, averaged 80.5 km and lasted an average of 3.95 days. At the same time that most turtles are migrating south along the coast of Oman (June to September), the Somali current is travelling in the opposite direction - but does not seem to impede turtle migration. Migration distances for turtles departing the Daymaniyat islands were shown to be more than twice the global average for adult hawksbills (Pilcher et al. 2014).

Yemen:

There have been no studies on the migration of hawksbill turtles from Yemen.

Threats

All but one of the 25 turtles tracked in the Pilcher study 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 constitutes an important migration pathway and bottleneck for hawksbill sea turtles (Pilcher et al 2014). This bottleneck could pose a major concern for Oman turtles. The Gulf is one of the world's most important areas for oil and gas, exploration and shipping, and Oman experiences some of the largest shipping densities in the world (Pilcher et al 2014). This paired with extensive artisanal and commercial fishing in the waters off Oman constitutes a substantial threat to Omani hawksbill populations.

Hawksbill turtles depend on coral reefs for foraging on sponges. There has recently been extensive coral mortality on many reefs due to climate change, including the southern Red Sea, the Socotra archipelago and north east Gulf of Aden. A number of Red Sea sites that had healthy coral cover in the 1980s, experienced near total mortality from bleaching (PERSGA/GE. 2004). Reduction in coral density and diversity will potentially have a marked impact on Hawksbill foraging.

In Oman hawksbills (unlike green turtles) are not traditionally targeted for consumption and bycatch has been identified as the major conservation concern (Pilcher et al 2014).

The major threat to turtles in Yemen was identified as artisanal fishing (including egg collection) (PERSGA/GE. 2004). Terrestrial predators such as ghost crabs (*Ocypode* spp.) and birds are known egg and hatchling predators, with eggs lost to ghost crabs estimated between 0-60% (Stancyk 1995). The threat of Ghost crabs and other natural predators (birds) were assessed in 1999 and 2000 on the Damaniyat Islands (Mendonca et al. 2001). Ghost crabs were identified as the only potential predators to turtle eggs. However, as their burrows were generally placed below turtle nests (9-17m above tide) they were deemed to be not a significant threat to turtle eggs. Birds such as herons, osprey, sooty falcons, house crows and sooty gulls, were identified as predators of turtle hatchlings, along with ghost crabs. The effect of bird predation can only be considered significant in the instance of day time/full

moon hatching, when they are able to easily see their prey (Al Kiyumi et al. 2005, Mendonca et al. 2001).

- Al Kiyumi, A., Al Saady, S.M., Mendonca, V.M., Grobler, H.J., Erzini, K.A., (2005). Natural predation on eggs and hatchlings of hawksbill turtles *Eretmochelys imbricata* on Al Dimaniyat Islands, Gulf of Oman. Proc 21st International Symposium Sea Turtle Biology Conservation. Philadelphia, USA, 2001. NOAA Tech Memo NMFS-SEFSC 528:90-91.
- Mancini, A., Elsadek, I., & El-Alwany, M. A. (2015). Marine turtles of the Red Sea. In *The Red Sea* (pp. 551-565). Springer, Berlin, Heidelberg.
- Mendonça, V. M., Al-Kiyumi, A. A., Al-Saady, S. M., Grobler, H. J., & Erzini, K. (2001). Environment of the Densest Known Nesting Grounds of the Critically Endangered Hawksbill Turtle *Eretmochelys imbricata* on the Dimaniyat Islands, Gulf of Oman. In *Proc. International Conference on Fisheries, Aquaculture and Environment in the NW Indian Ocean, Sultan Qaboos University, Muscat, Sultanate of Oman* (pp. 160-168).
- Mendonca, V.M., Al Kiyumi, A., Al Saady, S.M., Rasbiy, A.A., Bait-Said, A.S. Amriy, S.A., Grobler, H.J., Erzini, K.A., (2005) Sea turtle populations on Al Hallaniyat Islands. International Symposium Sea Turtle Biology Conservation. Philadelphia, USA, 2001. NOAA Tech Memo NMFS-SEFSC 528:90-91.
- PERSGA/GE. 2004. Regional Action Plan for the Conservation of Marine Turtles and their Habitats in the Red Sea and Gulf of Aden. PERSGA, Jeddah.
- Pilcher, N. J., Antonopoulou, M., Perry, L., Abdel-Moati, M. A., Al Abdessalaam, T. Z., Albeldawi, M., ... & Chikhi, A. (2014). Identification of important sea turtle areas (ITAs) for hawksbill turtles in the Arabian region. *Journal of experimental marine biology and ecology*, 460, 89-99.
- Rees, A. F., & Baker, S. L. (2006). Hawksbill and olive ridley nesting on Masirah Island, Sultanate of Oman: an update. *Marine Turtle Newsletter*, 113, 2-5.
- Ross, J. P. (1981). Hawksbill turtle *Eretmochelys imbricata* in the sultanate of Oman. *Biological Conservation*, 19(2): 99-106
- Ross, J. P., & Barwani, A. M. (1982). Review of Sea Turtles in the Arabian Sea' Biology and Conservation of Sea Turtles.
- Salm, R.V. (1991). Turtles in Oman: Status, Threats and Management Options. Scientific Results of the IUCN Coastal Zone Management Project. IUCN/Ministry of Commerce and Industry, Muscat, Oman. 32
- Stancyck, S.E. (1995). Non-human predators of sea turtles and their control. In: *Biology and Conservation of Sea Turtles*. K.A. Bjorndal Ed.). Revised Edition. Smithsonian Institution Press, Washington DC, USA.
- Wilson, G., Price, A. R. G., Huntington, T., & Wilson, S. C. (2003). Environmental status of Yemen's Gulf of Aden coast determined from rapid field assessment and satellite imagery. *Aquatic Ecosystem Health & Management*, 6(2), 119-129.

Red sea: Egypt, Saudi Arabia (Red Sea), Eritrea, Djibouti, Sudan, Yemen

Nesting: It has been estimated that in the Red Sea region there are between 400 and 600 female hawksbill turtles breeding per year on the beaches and islands of five nations (Mancini et al. 2015) (Figure 23).

Saudi Arabia: Along the Red Sea coastline an estimated 100 to 200 female hawksbill turtles nest annually across the islands and beaches around Tiran Island (Sinafir, Shusha and Barqan) and the islands of the Farasan Banks. February to May - Farasan ~ 50 females per year (PERSGA 2004). There are no published data updates.

Egypt: hawksbill turtle nesting has been recorded from many of the islands along Egypt's Red Sea coastline, in particular Giftun Kebir and neighbouring islands (estimated 100 females a year in 1980s), Baruda and Hamata islands (estimated 50 females per year in the 1980s) (Groombridge and Luxmoore 1986). There are no published data updates.

Eritrea: The hawksbill turtle is the most common species of marine turtle found nesting in Eritrea. Surveys have reported hawksbill nesting on at least 110 islands and coastal sites in the country. The main nesting sites include Mojeidi, Dissei, Aucan and the surrounding islands (Teclemariam et al. 2009). There are no published data updates.

Djibouti: Hawksbill turtle nesting has been reported from Ras Siyyan and Sept Frères Island (March to June) – no population size estimates

Sudan: Hawksbill turtle nesting occurs on most of the islands of the Suakin Archipelago, in particular, Talla Talla Saghir, Seil Ada Kebir, Barn Musa Kebir, Masamirit, Daraka and Abu Isa. 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). There are no published data updates.

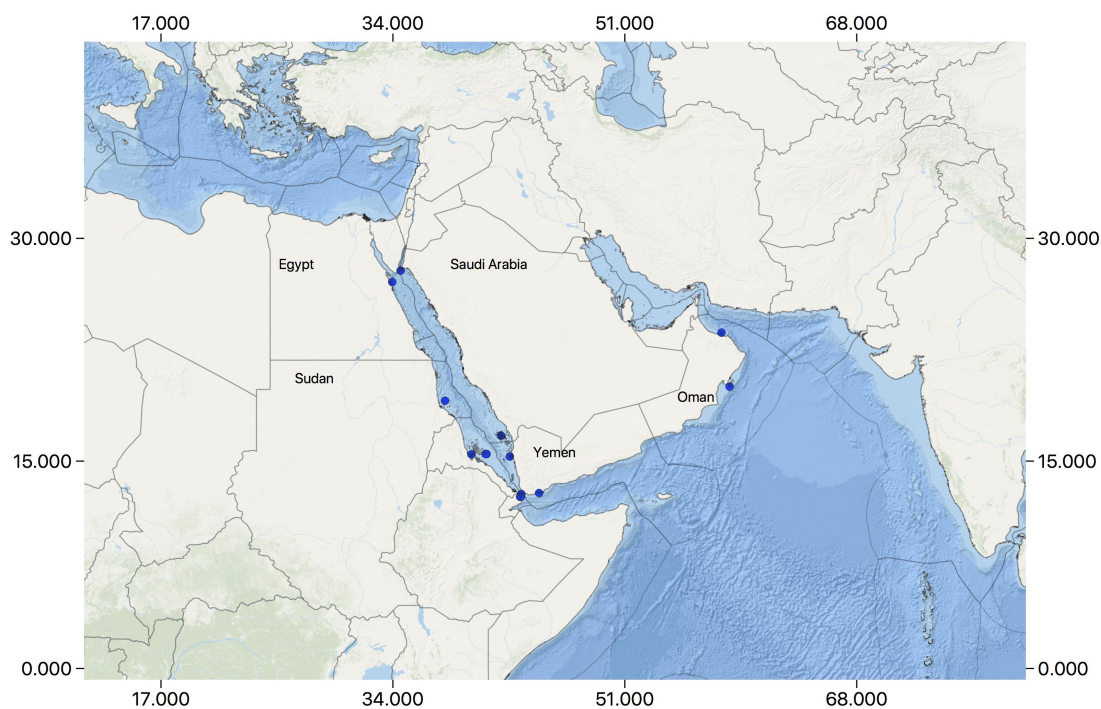


Figure 23. Distribution of hawksbill turtle nesting sites in the Red Sea, Oman and Yemen

Foraging and Migration

There have been no studies on the foraging turtles of the Red Sea, or tracking studies investigating foraging locations for post-breeding turtles. It is likely that hawksbill turtles reside on most of the coral-reef fringed islands and cays of the Red Sea.

Threats

Threats to hawksbill turtles in the Red Sea have been reviewed by Mancini et al. (2015). The key threats are direct harvest, bycatch in legal fisheries, habitat change such as dredging and light pollution, and pollution/marine debris. There are no quantified data on these threats.

Qualitative data indicates that bycatch in legal fisheries throughout the region is considered to be the threat having the greatest impact on hawksbill turtles in the Red Sea.

Publications/weblinks

- Teclmariam, Y., Giotom, M., Mengstu, T., Abraha, H., & Mahmud, S. (2009). An update on marine turtles in Eritrea, Red Sea. *Indian ocean turtle Newsletter*, 9.
- Mancini, A., Elsadek, I., & El-Alwany, M. A. (2015). Marine turtles of the Red Sea. In *The Red Sea* (pp. 551-565). Springer, Berlin, Heidelberg.
- El Kafrawy, S. B., Said, R. E., Saber, S. A., Soliman, M. A., & Al Attar, N. M. (2018). Using remote sensing and geographic information system to assess the status of the nesting habitat of hawksbill turtles (*Eretmochelys imbricata*): At Big Giftun Island, Red Sea, Egypt. *The Egyptian Journal of Remote Sensing and Space Science*.

French Territories of the South-west Indian Ocean, Madagascar, Mozambique, Tanzania, and Kenya

Anastácio and Pereira (2017) sampled 57 turtles from the Vamizi nesting rookery in Mozambique and report 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 is thus likely to reveal important genetic population structure.

Nesting

Nesting sites in the region include (and see Figure 16):

Mozambique: Vamizi Island in the Quirimbas Archipelago supports around 10 nesting females per year, key beaches are Comisette and Farol (Anastácio et al. 2017). On Vamizi, both Comisette and Farol were monitored between 2002 and 2010 during the peak months of the nesting season (December and January), the number of clutches laid each year ranged from zero (in 2006 and 2010) up to 34 clutches in 2003, the average clutch size is 128 eggs and the average incubation period (from 35 clutches) is 60.9 days. Interestingly, the clutches laid on the north facing Comisette beach have a shorter incubation period (56.9) than clutches laid on the south facing Farol beach (62.7 days) (Anastácio et al. 2017). Lower level, scattered nesting is also likely to occur on the islands in the Quirimbas National Park (Humber et al. 2017).

Comoros and Mayotte: The islands of Comoros, and the broader Comoros Archipelago (including Mayotte) are likely to support small numbers of nesting turtles – Comoros (25 to 50 females per year and Mayotte 10 to 50 females per year) (Ben Mohadji 1996) (Project Biodiversity 2000).

Eparses Islands (Juan de Nova) which reportedly supports around 50 nesting females per year (Lauret-Stepler et al. 2010). Hawksbill turtles nest all year, with a distinct summer (December and January) peak.

Mauritius: The islands of Mauritius, including St Brandons, support low numbers (<50 females per year) of nesting hawksbill turtles.

Madagascar: Nosy Iranja Kely, an island in the North West of Madagascar was surveyed between 200 and 204 and 67 hawksbill nests were found (~17 per year) and thus it is likely to support <10 females per year (Bourjea et al. 2006). Hawksbill turtle nesting has also been

recently surveyed in the the Barren Isles, in particular, Nosy Abohazo, Nosy Andrano and Nosy Dondosy. Collectively these islands support around 10 females per year (Humber et al. 2017). Metcalf et al. (2007) report hawksbill nesting occurs in the Nosy Hara region (between 101 and 500 clutches per year) and the Redama Islands (<50 clutches per year). Unquantified, but likely to be low level nesting has also been reported at Beheloka-Besambay Islands, Anakao, and Antsotsomoroy (Andavadoaka) (Humber et al. 2017). Collectively, it is possible that around 100 females per year breed on the beaches of Madagascar.

Tanzania: hawksbill turtles nest on the island of Misali (Pemba region of Zanzibar). Giorno and Herrmann (2016) analysed turtle monitoring data from 2002 until 2014. Over the 12 years there is a low, but seemingly stable nesting population of hawksbill turtles. The number of clutches laid per year averaged 5 per year and ranged from zero (2010) to 10 in 2012.

Kenya: hawksbill turtle nesting has been recorded in the Lamu Archipelago, the Mombasa region and the Kiunga region however, nesting activity is low, and aperiodic (Okemwa et al. 2004, Olendo et al. 2017). For example, in 10 years of surveys between 2002 and 2012 only 31 nests were recorded – primarily on the beaches of Kiwayu, Mkokoni, and Rubu (Olendo et al. 2017).

Foraging

Each of the countries in the southwest Indian ocean have a considerable number of coral-reef or rock-reef habitats which offer the type habitat for hawksbill turtles. They are often caught deliberately in shallow coastal waters by spears or nets, hence they probably occur in most of the coral-reef fringed habitats throughout the region (Chassagneux et al. 2013, Bourjea et al. 2008, Williams et al. 2015).

Migration

In 2008 a single adult female hawksbill turtle was tracked using a satellite tag from Kiungu region of Kenya by a local NGO. She migrated south, along the coastline to a coastal foraging area adjacent to the Kenya/Tanzania border – a distance of around 450 km.

Threats

At Vamizi Island Anastácio et al. (2017) indicate that 104 juvenile hawksbill turtles (average size of 42 cm SCL) were caught by hand or accidentally in nets between 2004 and 2009. Similarly, analysis of the data from market and fisheries in Madagascar indicates that most of the 24 hawksbill turtles caught and retained by fisher are immature (mean size of 50.6, range 31 to 89). Around half of the turtles in the Madagascar sample were caught using spears or harpoons and 30% caught by nets designed to catch turtles and elasmobranchs (Humber et al. 2011).

Publications/weblinks

- Anastácio, R., & Pereira, M. J. (2017). A Piece of a Puzzle of Haplotypes for the Indian Ocean Hawksbill Turtle. *Natural Resources*, 8(08), 548.
- Anastácio, R., Lopes, C., Ferrão, J., & Pereira, M. J. (2017). *Eretmochelys imbricata*: Lessons to Learn from a Monitoring Program in the North of Mozambique. *Natural Resources*, 8(05), 382.
- Bourjea, J., Ciccione, S., & Ratsimbazafy, R. (2006). Marine turtle surveys in Nosy Iranja Kely, north-western Madagascar. *Western Indian Ocean Journal of Marine Science*, 5(2), 209-212.
- Bourjea, J., Nel, R., Jiddawi, N. S., Koonjul, M. S., & Bianchi, G. (2008). Sea turtle bycatch in the West Indian Ocean: review, recommendations and research priorities. *Western Indian Ocean Journal of Marine Science*, 7(2), 137-150.

- Chassagneux, A., Jean, C., Bourjea, J., & Ciccione, S. (2013). Unravelling behavioural patterns of foraging hawksbill and green turtles using photo-identification. *Marine Turtle Newsletter*, (137), 1.
- Giorno, T., & Herrmann, M. (2016). Nesting trends of the Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) turtles on Misali Island, Pemba.
- Humber, F., Godley, B. J., Ramahery, V., & Broderick, A. C. (2011). Using community members to assess artisanal fisheries: the marine turtle fishery in Madagascar. *Animal conservation*, 14(2), 175-185.
- Humber, F., Godley, B. J., Nicolas, T., Raynaud, O., Pichon, F., & Broderick, A. (2017). Placing Madagascar's marine turtle populations in a regional context using community-based monitoring. *Oryx*, 51(3), 542-553.
- Lauret-Stepler, M., Ciccione, S., & Bourjea, J. (2010). Monitoring of marine turtle reproductive activities in Juan de Nova, Eparses Islands, South Western Indian Ocean, based on tracks count and width. *Indian ocean turtle Newsletter*, 11, 18-24.
- Metcalf, J., Hampson, K., Andrimizava, A., Andrianirina, R., Ramiarisoa, C., Sondotra, H. (2007) The importance of north-west Madagascar for marine turtle conservation. *Oryx*, 41, 232–238.
- Olendo, M. I., Okemwa, G. M., Munga, C. N., Mulupi, L. K., Mwasi, L. D., Mohamed, H. B., ... & Ong'anda, H. O. (2017). The value of long-term, community-based monitoring of marine turtle nesting: a study in the Lamu archipelago, Kenya. *Oryx*, 1-10.
- Okemwa, G. M., Nzuki, S., & Mueni, E. M. (2004). The status and conservation of sea turtles in Kenya. *Marine Turtle Newsletter*, 105, 1-6.
- Project Biodiversity 2000. Conservation action plan for marine turtles in the Federal Islamic Republic of the Comoros. Projet Conservation de la Biodiversite et Developement Durable (PNUD/FEM). 1-20 p
- Williams, J. L., Pierce, S. J., Fuentes, M. M., & Hamann, M. (2015). Effectiveness of recreational divers for monitoring sea turtle populations. *Endangered Species Research*, 26(3), 209-219.

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 wide spread commercial harvest of hawksbill eggs and turtles occurred for many decades. This coupled with widespread use of wildlife as food options during the years of conflict has severely impacted local populations (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 each of the adult turtles were taken for food or sale (Hamann et al. 2006). Recent surveys in these same areas have not found any evidence of hawksbill turtle nesting.

In terms of use, throughout the 1970s and 1980s (and possibly prior to that) there was a dedicated fishing and collection of wild turtles from inshore waters for sale into local or international markets. Indeed, between 1982 and 1985, an average of 17000 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 the presence of hawksbill turtles on near shore reefs considered rare, however, they 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, and the role of Viet Nam in international trade. The Vietnamese Government became a signatory to CITES in 1994, and prohibition of domestic use of marine turtles was established in 2002 (Decree 48/2002/ND-CP). The Vietnamese Government and key NGO agencies have also implemented several large-scale awareness and education campaigns to enhance awareness among the public, strengthened the monitoring and

compliance capacity of regional fisheries staff and instigated projects to restore habitat condition and protect hawksbill turtles from capture.

Bourret R. 1941. Les tortues de l'Indochine. Institut Oceanographique de l'Indochine, Station Maritime de Cauda, Nha Trang.

Hamann, M., Chu The, C. Hong, N. D., Thuoc, P., & Thu Hien, B. T. (2006). Distribution and abundance of marine turtles in the Socialist Republic of Viet Nam. *Biodiversity & Conservation*, 15(11), 3703-3720.

TRAFFIC Southeast Asia-Indochina 2004. The trade in marine turtle products in Viet Nam. Report to the marine turtle conservation and management team, Viet Nam, TRAFFIC Southeast Asia-Hanoi, Viet Nam

Singapore

Singapore National Parks have recently commenced the monitoring of turtle nesting in Singapore. In 2018 there were 65 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 (Figure 24). Data to date indicates that tens of hawksbill turtles breed annually in Singapore. The nesting locations of Singapore are located almost equidistant between rookeries in Malaka, Malaysia and Indonesian rookeries of the western Java Sea. Genetic-based research will be needed to assign these rookeries to a management unit.

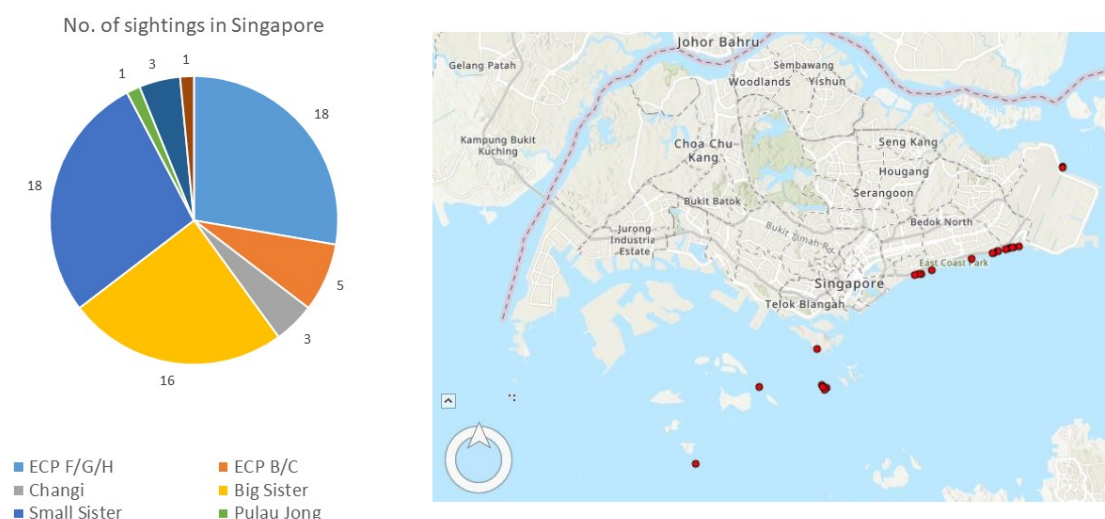


Figure 24. Distribution of 65 hawksbill turtle nesting events recorded in Singapore during 2018 (unpublished data, Singapore National Parks)

The nesting in Singapore occurs on artificial beaches which have been created from dredging spoil (C. Limpus, pers. comm.). There have not been any other studies on hawksbill turtles in Singapore, however, Parks Singapore are beginning to collect data on nesting parameters, sand temperatures and genetics.

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. There are unverified reports of hawksbill turtle nesting, however it is likely to be low density and aperiodic. No surveys of marine turtles have been conducted in Timor Leste.