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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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9TH MEETING OF THE ADVISORY COMMITTEE
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Agenda Item 4

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

(Prepared by AC Members)

Action Requested:

- Discuss what is needed to get the assessment finished and develop a concrete plan how to proceed

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

IOSEA Species Assessment: Volume 3

<u>DRAFT REPORT Nov2020 – prepared for the review</u>

Compilers
Mark Hamann, Colin Limpus, Jeff Miller, Freya Flavell (to be finalised)

IOSEA Marine Turtle MoU Secretariat

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We are thankful for the contributions of Kartik Shanker, Naveen, Adhith, Muralidharan Manoharakrishnan, Jarina

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.

Tasks remaining (March 2021)

Update maps
Correct all table and figure numbers
Incorporate reviewer comments
Correct and/or finalise statements in "yellow"
Complete the recommendation section (~page 17)
Compile table of contents
Whole document edit and proof read

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Hawksbill turtle synthesis

The hawksbill turtle has a global distribution and occurs in at least 97 countries, 45 of them within the IOSEA region and 35 of them are Signatory States to the IOSEA MoU. The species was assessed at a global level as Critically Endangered in 1996 and 2008, and Meylan and Donnelly (1999) and Mortimer and Donnelly (2008) provide the supporting information for the 1996 and 2008 assessments respectively.

Summary – nesting

Hawksbill turtles currently nest in at least 32 nations within the Indian Ocean and Southeast Asia region. All except Japan, Singapore, Qatar and Kuwait 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 turtles still nest in Somalia or Timor Leste, and it is no longer believed that hawksbill turtles nest in 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. UPDATE BASED ON REVIEWS AND NEW DATA

Management Unit or Country	Estimated size range of the annual nesting population	Description of trend
North-east Australia	?	Decreasing trend over past two decades.
Northeast Arnhem Land	?	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, slight annual increase in nesting at Ko Kram – believed to still be at lower levels than prior to the CITES restrictions on trade
Western Peninsula Malaysia	101-500	Increase since 1990s from <100 to ~400 clutches laid per year
Arabian/Persian Gulf	501-1000	No data to infer trend, believed to be stable
Western/Central Indian Ocean	1000-5000	Generally positive rates of recovery since 1980s, Several key sites show a positive trend but believed to still be at lower levels than prior to protection from trade.
Indonesia (Java Sea)	501-1000	Variable rates of recovery since 1980s, believed to still be at lower levels than prior to the CITES restrictions on trade
Red Sea	501-1000	No recent data, believed to be stable

Southwest Indian Ocean	101-500	No data to infer trend, believed to still be at lower levels than prior to the CITES restrictions on trade
Oman and Yemen	501-1000	No recent data for Yemen, data in Oman are 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; 2020). 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 likely there two genetically distinct management units in the Persian Gulf (Vargas et al. 2020). 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 rookeries in 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..

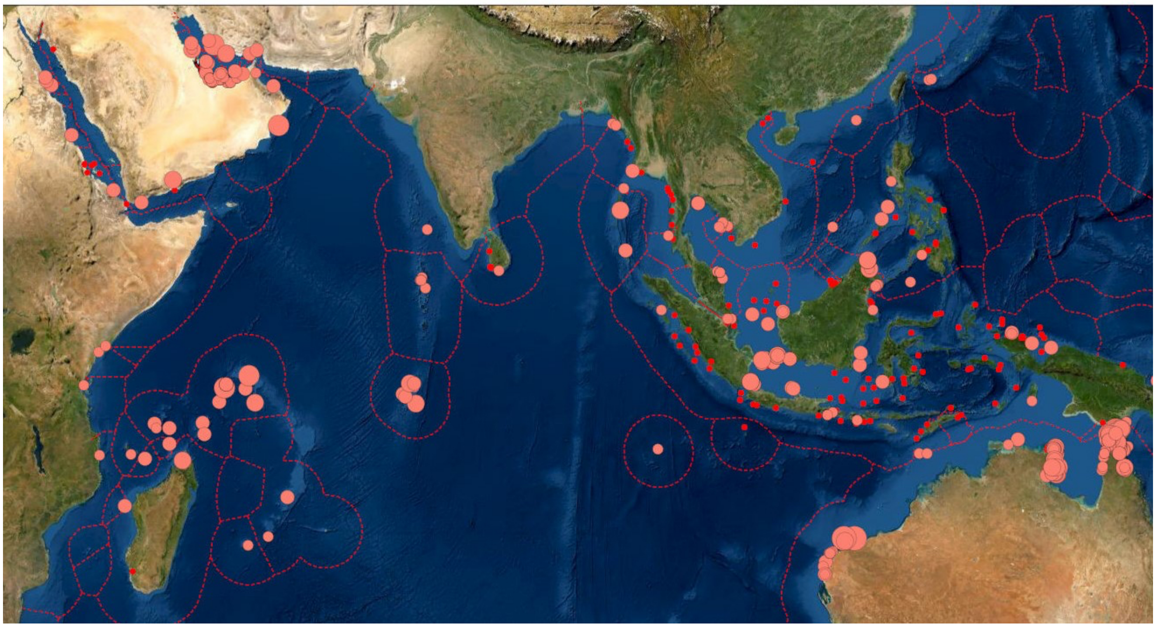


Figure 1. Distribution of hawksbill turtle (*Eretmochelys imbricata*) nesting within the Indian Ocean – Southeast Asian region (after FitzSimmons and Limpus, 2014, using data with the Queensland Department of Environment and Science Turtle Conservation Data Base). UPDATE TO SAME FORMAT

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, or limited sampling for genetic mtDNA profiles in 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 tracks (nesting attempts) 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 leatherback and 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 strong 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 tracked 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 in the Indian Ocean region for around 2000 years but predominantly since the 18th century. The trade and its impact on hawksbill turtle populations across the globe has been well summarised by Milliken and Tokunaga (1987); Groombridge and Luxmoore (1989); Meylan and Donnelly (1999) and Mortimer and Donnelly (2008). While it is recognised that the international and domestic commercial trade of hawksbill turtles and/or their eggs dates back to the 9th century demand for turtle shell and turtle shell products rapidly expanded in the 17th century – for example, data on the trade of hawksbill turtle shell from the Seychelles between 1884 and 1982 indicate an annual trade of around 1079 kg per year (Figure 2a). In the 20th century the use of hawksbill turtle shell became an established industry and although it was largely centred on Japan it occurred in most civilised nations (Mortimer and Donnelly 2008). The 20th century trade was well documented in the latter half of the century in national trade records and these records were summarised by Groombridge and Luxmoore (1989). The global trade of large-sized hawksbill turtles into Japan between 1950 and 1992 was around 1.3 million and 310598 kg (8394 per year) of raw hawksbill (Bekko) shell was exported from countries within the IOSEA region into Japan (Figure 2b). There are various weights cited in the literature to convert a kilogram of hawksbill turtle 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 per year) 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. Plus, in addition to the raw shell trade, there was considerable trade of other hawksbill turtle products (eggs, skin, stuffed turtles and processed shell). The hawksbill turtle was included on Appendix I of the Convention on International Trade in Endangered Species (CITES) in 1977. By 1990 Japan, under international pressure, began to reduce its imports, and by 1992 had stopped importing hawksbill turtle shell.

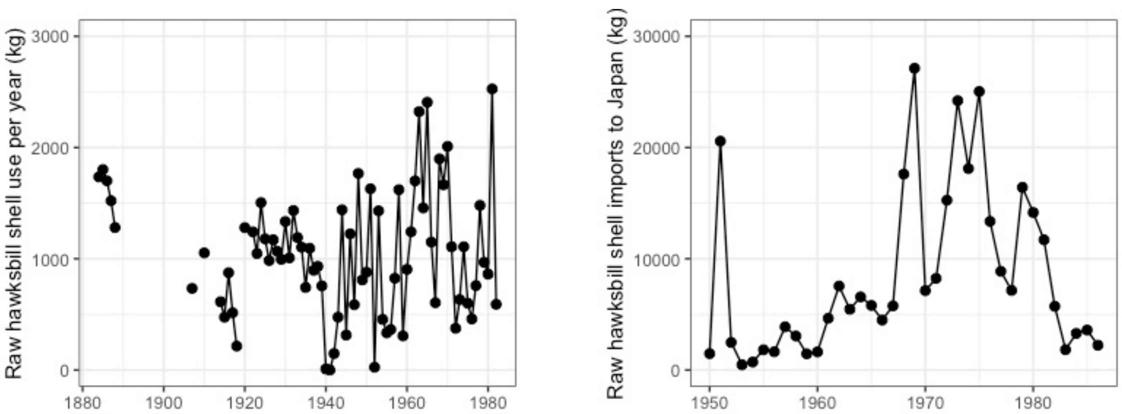


Figure 2. (a) Kilograms of raw hawksbill shell imported into Japan from IOSEA nations per year between 1950 and 1986 and (b). Kilograms of raw hawksbill shell use per year exported from the Seychelles. Data extracted from Groombridge and Luxmoore (1989) tables 102 and 177 respectively.

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 12 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 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).

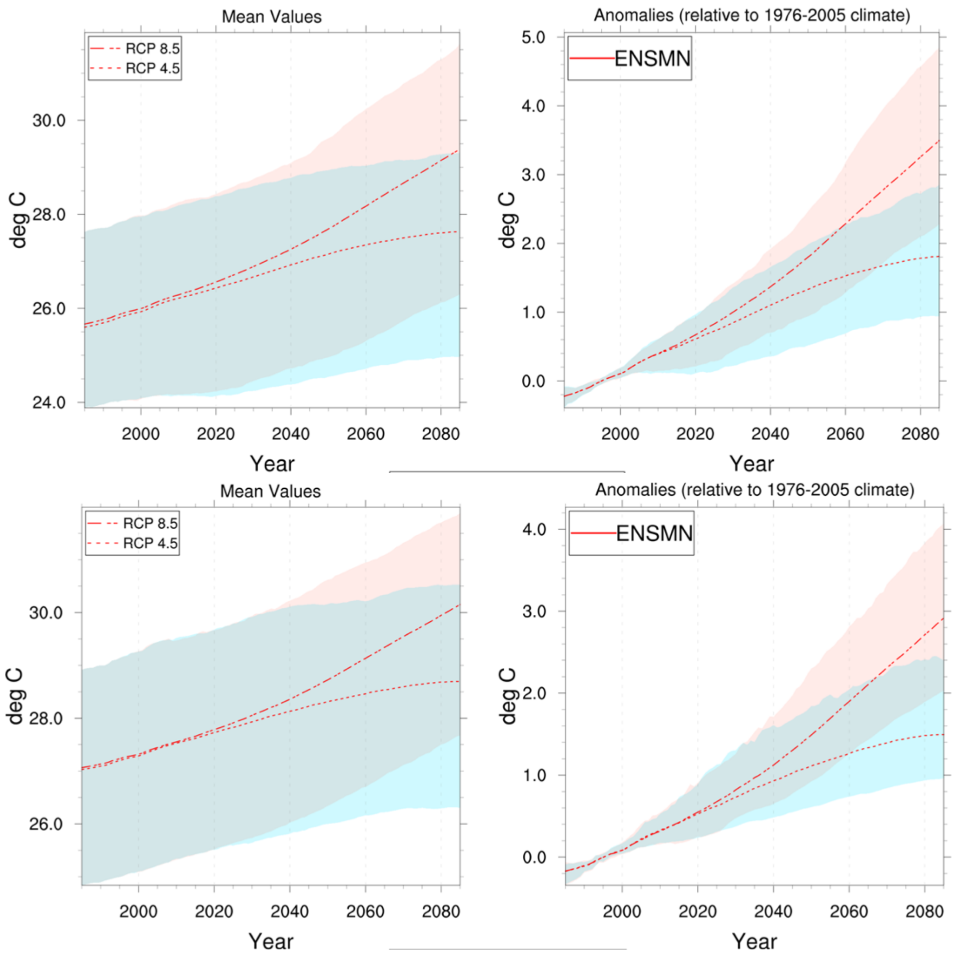
Butt et al. (2016) used predictive climate models to examine the effects of increased air temperature and sea level rise on hawksbill turtle nesting sites in Australia. They found that by 2100 some of the current nesting habitats in Western Australia, Northern Territory and Queensland are likely to be 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 should be developed 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 (turtle nesting season) they are above 33C. Although this study spanned five months in a single year, it highlights a need to continue similar monitoring over longer time frames 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 then 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^{o}C (RCP4.5) or 2.0 to 4.2^{0}C (RCP4.5) by 2100 (Figure 3). Sea levels are also expected to rise by 0.3 to 0.47 m (RPC4.5) 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 without using locally-derived weather data..



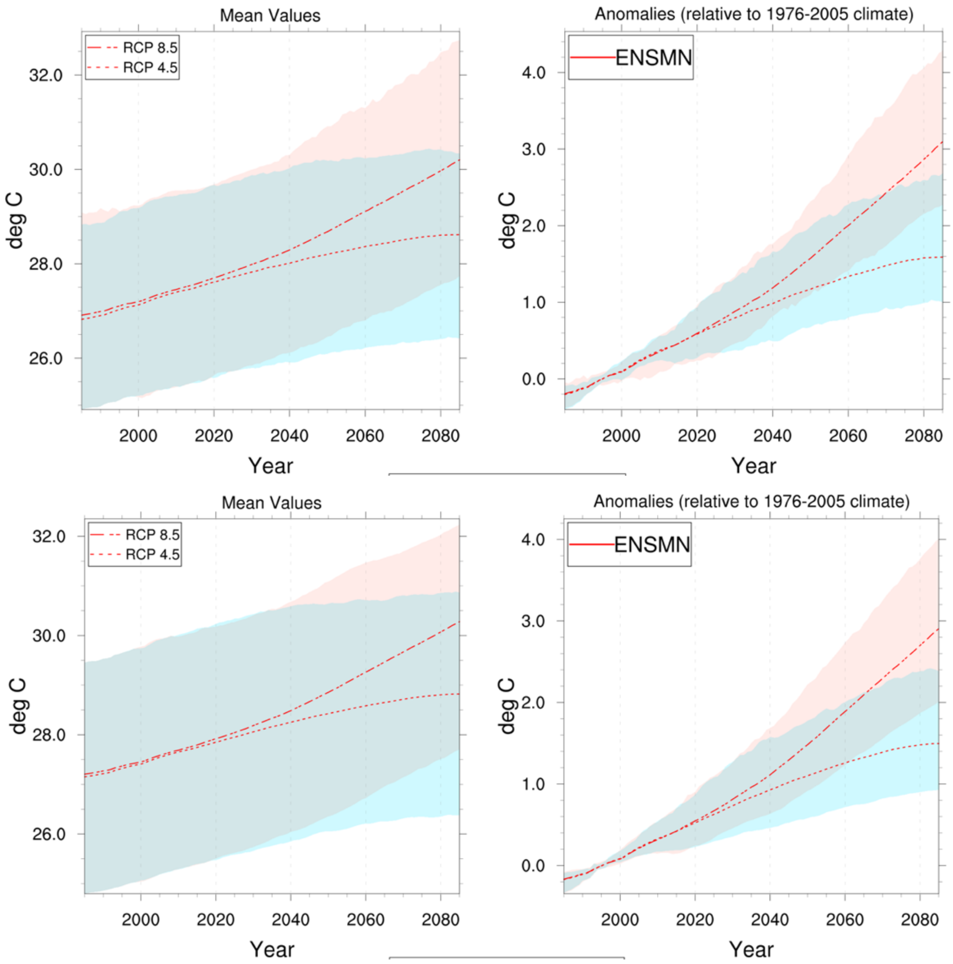


Figure 3. Predicted change to air temperatures over the next 80 years in four regions of the IOSEA region, data are derived from the average of CMIP5 climate model outputs https://www.esrl.noaa.gov/psd/ipcc/ocn/timeseries_lens.html. Panel (a) Arabian/Persian Gulf, (b) Sulu/Cerebes Seas, (c) northern 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 collecting data from which we can examine 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.

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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).

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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 (Meylan and Donnelly 1999; Mortimer and Donnelly 2008; Wallace et al. 2011; FitzSimmons and Limpus 2014). Similar to other marine turtle species, the hawksbill turtle 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. (2010) burning issues initiative for hawksbill turtle populations in the IOSEA region and the management unit designation by FitzSimmons and Limpus (2014),

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	Of the turtle rookeries in Arabian/Persian Gulf only Iran and Saudi Arabia rookeries have been sampled for genetics. Turtles from rookeries in India, Maldives, Oman, and Yemen are yet to be sampled.
Southwest Indian Ocean*	Seychelles, Chagos (BIOT), Madagascar, Mozambique, Tanzania, Kenya, Comoros, Mauritius, French Indian Ocean Territories	Only rookeries in the Seychelles and Chagos were sampled for genetic-population structure.
Northeast Indian Ocean*+	Sri Lanka, India (Nicobar and Andaman Islands), Thailand	No sampling for genetic-population structure
Southeast Indian Ocean*	Australia (Western Australia)	One management unit identified (eastern Indian Ocean, Western Australia)
Southeast Asia*	Japan, China, 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 genetic-population structure.
Pacific west central*+	Indonesia (West Papua)	No sampling for genetic-population structure
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. No sampling for genetic-population structure has occurred in Papua New Guinea

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 asses 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.

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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). Limpus and Miller (2008) provide a comprehensive review of the biology of this management unit and a recent analysis of the populations status is provided by Bell et al. 2020).

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 the north Queensland management unit, based on satellite telemetry tracking and flipper tag recoveries

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).

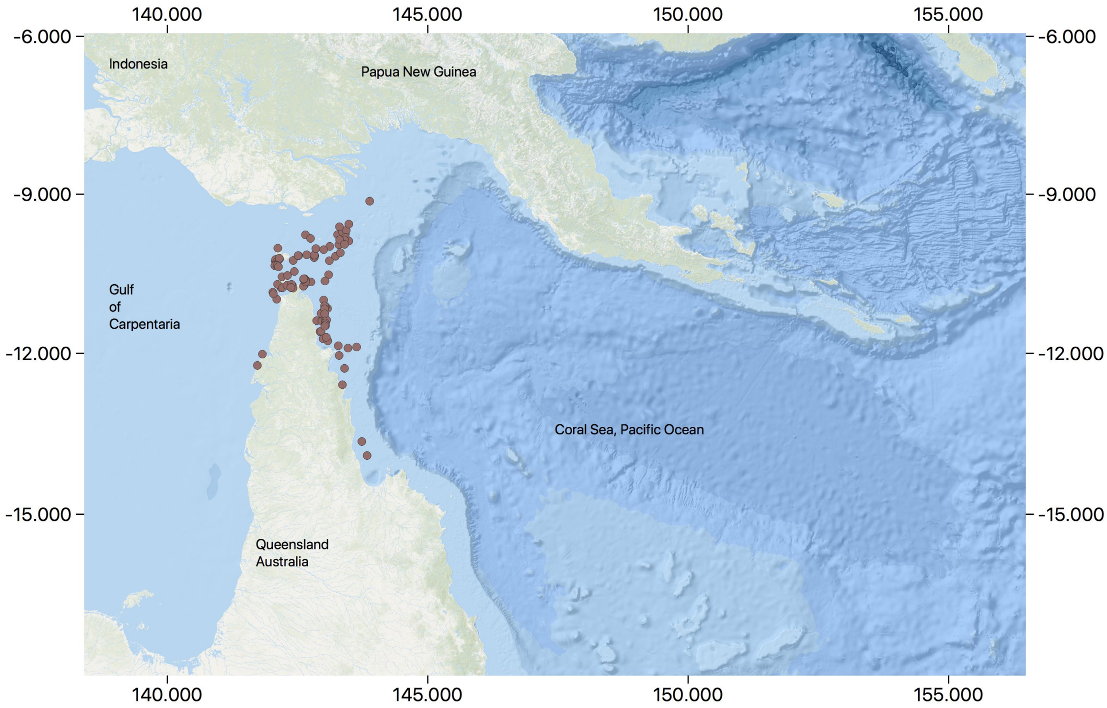

Figure 5. Distribution of *Eretmochelys imbricata* nesting beaches for the north Queensland management unit.

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) (Bell et al. 2020)

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 and data has been published as most recently as the 2016/2017 breeding season. In the absence of data from a second index site it is presumed that this nesting population has undergone a significant decline in 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.

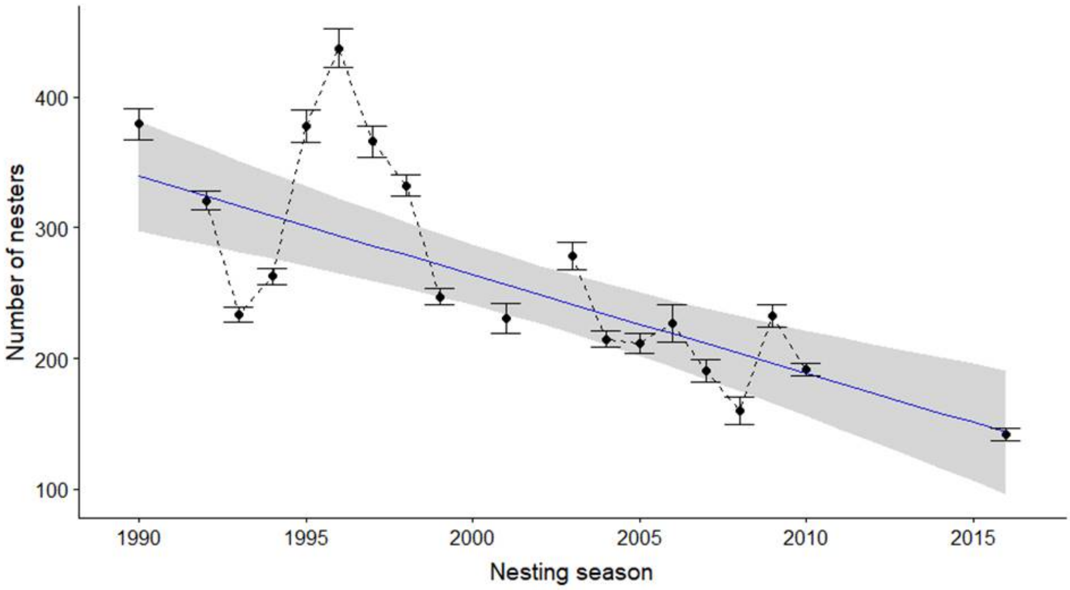

Figure 6. Trend analysis of *Eretmochelys imbricata* nesting census data from Milman Island across 27 breeding seasons, 1990-91 to 2015-16 (unpublished data, DES Aquatic Threatened Species Program): Note: The multistate open robust design model (MSORD) was used to analyse the abundance and survival of 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 ± 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 or 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 *E. imbricata* in foraging areas by Indigenous communities in the Northern Territory, Indonesian New Guinea and PNG
4	The substantial loss of post-hatchling *E. imbricata* in ghost nets, particularly in the Arafura Sea region
5	The presumed substantial but unquantified mortality of foraging *E. imbricata* 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 *E. imbricate* (see also Vuto et al. 2019
7	The illegal trade in *E. imbricata* particularly via China and Vietnam 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).

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 Environment Protection and Biodiversity Conservation Act 1999, classifying it as a Matter of National Environmental Significance. The index site for the management unit (Milman Island) and many other nesting islands within the Great Barrier Reef are National Parks and managed by the Queensland Parks and Wildlife Service. 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 beach	Y	Very-high	• Queensland Nature Conservation Act 1992

nesting islands of nGBR				
Great Barrier Reef Marine Park	Nesting and foraging	y	Very-high	• 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	

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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 (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). It is also likely that hawksbill turtles foraging along most of the coral and rocky reef habitats of the Northern Territory (e.g. Fog Bay near Darwin Whiting and Guinea 1997a). No tag recoveries from this management unit have been reported from overseas. However, hawksbill turtles reside in the coastal waters of Timor Leste, Indonesia and Papua New Guinea and hence international connections are possible.

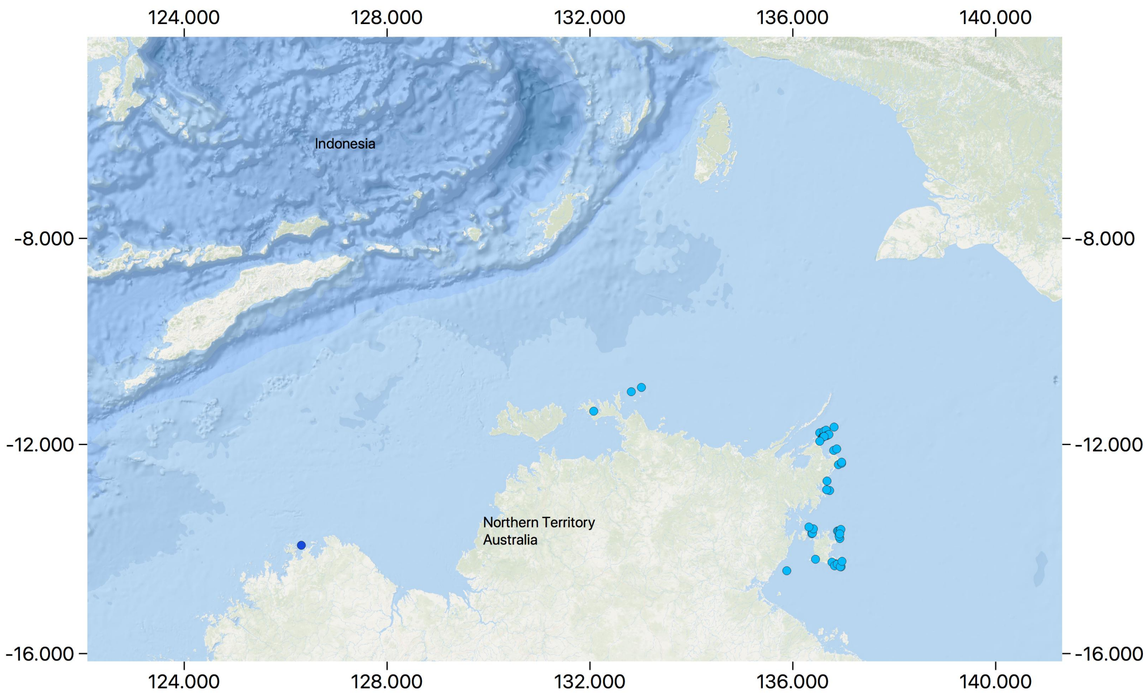

Figure 7. Distribution of *Eretmochelys imbricata* nesting beaches for the northeast Arnhem Land management unit.

Geographic spread of nesting

Nesting locations for the management unit have been reasonably well surveys, 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.

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

Estimated size of annual nesting population	Number of beaches	Nesting beaches
501-1000 females/year	0	
101-500 females /year	1	North East Island
11-100 females /year	11	e.g. Truant Island, Hawk Island, Bromby Islands
1-10 females / year	19	
Unquantified nesting	8	

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

Trends in nesting data

The status and trend of the management unit has not been determined

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 or 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 Governments 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 hawksbill turtles were caught in the Fog Bay region, near Darwin in the Northern Territory. The aggregation was predominantly comprised of sub-adult age classes (average size 49 cm CCL) – (Whiting and Guinea 1997b), and adult-sized animals were believed to have moved into adjacent deeper water habitats.

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

References & new publications – 2010 to 2019

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Whiting, S. D., & Guinea, M. L. (1997b). A large population of slow growing hawksbills: preliminary results from a wild foraging population in Fog Bay, Northern Territory. In *ANNUAL SEA TURTLE SYMPOSIUM* (p. 110).

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

Geographic spread of nesting

Hawksbill turtles in the Sulu Sea genetic stock primarily nest on the 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 (Table X). 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 (Joseph 2017).

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

Estimated size of annual nesting population	Number of beaches	Nesting beaches
501-1000 females/year	0	
101-500 females /year	1	P. Gulisaan
11-100 females /year	1	P. Lankayan
1-10 females / year	6	P. Selingan, P. Bakkangan, P. Mataking, P. Pom Pom, P. Pandanan, P. Sipidan
Unquantified nesting	0	

Index nesting beaches: Malaysia, Sabah, Palau Gulisaan

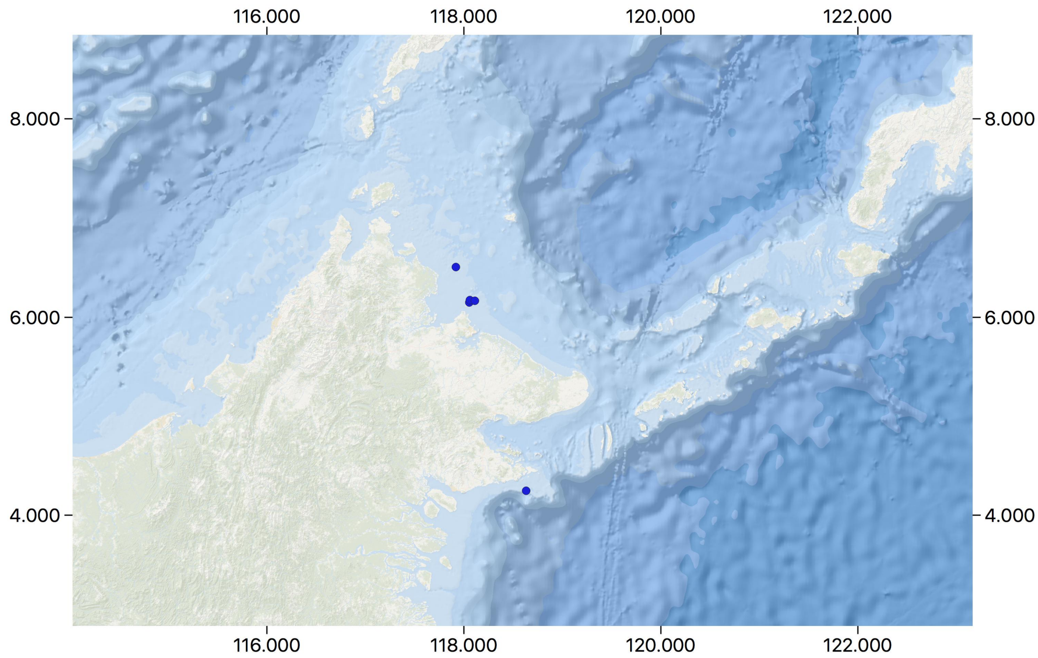

Figure 8 Main nesting sites for the Sulu Sea Management unit of hawksbill turtles

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 and differences in survey effort. Chan et al. (1999) summarised the monitoring data from 1979 to 1996 and Joseph (2017) reported data from 1979 to 2016). Across the three beaches in the TIPA the number of clutches recorded varied from 243 to 713 in a year (Figures X and X). They report a cyclical but overall declining trend from 1979 to 2016 (Figure 9). With the number of clutches reported in the most recent five years of available data (2012 to 2016) being lower (~275) clutches per year), than the levels recorded between 1979 and 1983) (Figure X). The nesting trend and nesting biology data has been summarised in more detail by Joseph (2017). Data from 1999 to 2018 are available from a minor rookery (Pulau Lankayan) and this data shows a stable trend of around 50 clutches 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.

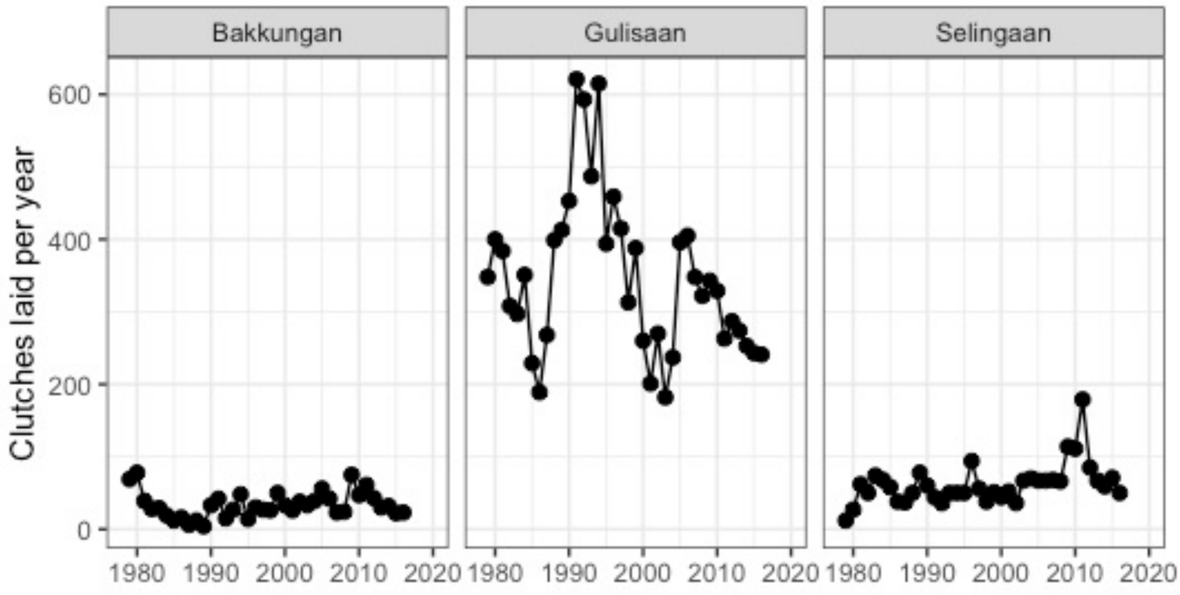

Figure X. Number of hawksbill clutches recorded per year between 1979 and 2016 at the three islands within the Turtle Islands Protected Area, Sabah, Malaysia. Data from Joseph (2017).

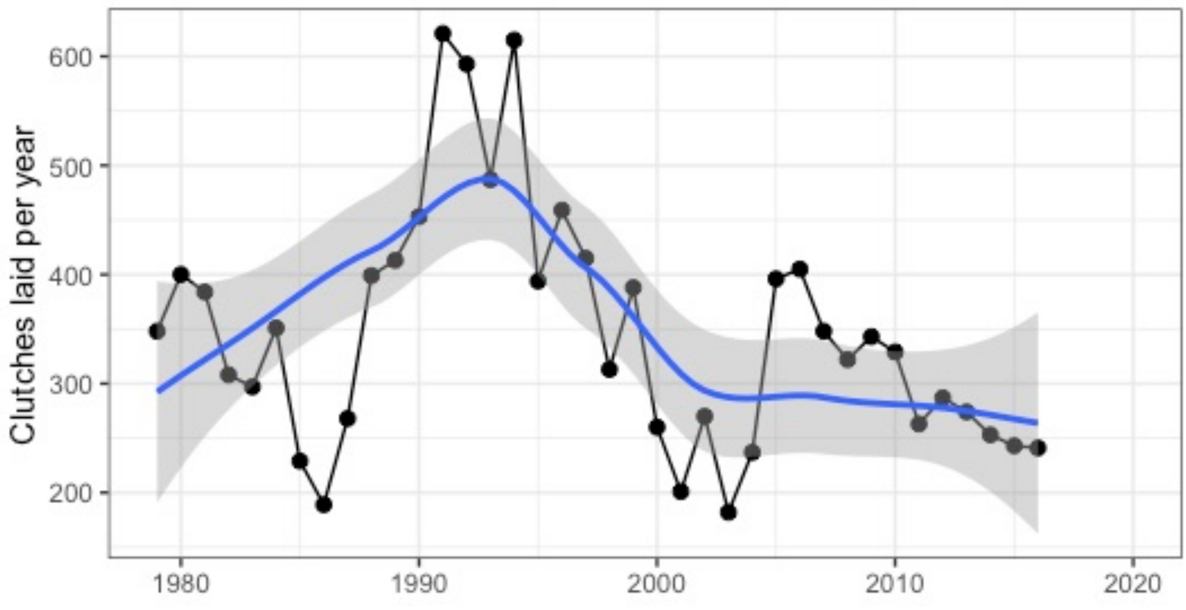

Figure X. Number of hawksbill clutches recorded per year between 1979 and 2016 at Palau Gulisaan, Sabah, Malaysia. Data from Joseph (2017).

Migration and distribution of foraging areas

Since 2000 around 4000 nesting turtles have been double flipper tagged (Joseph et al. 2017). 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 management unit 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 each of these threats individually or collectively may impact hawksbill turtles from the Sulu Sea management unit are required. There is anecdotal and local expert knowledge to suggest that coastal erosion is impacting the quality of nesting habitat on Pulau Guilisaan (Joseph 2017).

Nearly all clutches for this management unit are moved to protected hatcheries and the average emergence success of clutches is low (67%, range 50 to 85%). It is unknown why the success is low and variable across years, or what impact this may have on population recovery. According to Joseph (2017) because of recent concerns about the stability of Pulau Gulisaan, since 2015 all clutches laid on Pulau Gulisaan are now transferred to hatcheries on Pulau Selingaan during the morning following laying which involves a boat ride of 5-10 minutes. This process is likely reduce the success of eggs, and although it us current best practice on the TIP area increased research on the processes involved could help identify the specific issues and allow corrective action to be taken to increase emergence success to consistently be > 80%.

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
	Low and variable emergence success of clutches transferred to protective hatcheries
3	The potential loss of post-hatchling, or immature, *E. imbricata* in ghost nets
4	The presumed substantial but unquantified mortality of foraging *E. imbricata* in the commercial fisheries of Indonesia, Philippines and Malaysia
5	The direct capture, or retention of bycatch, of hawksbill turtles for consumption or sale

6	The failure of CITES signatory States to enforce CITES regulations banning the export of Appendix 1 listed species such as *E. imbricate* (CITES, Vuto et al. 2019)
7	The illegal trade in *E. imbricata* particularly via China and Viet Nam provides an incentive for continuing the illegal trade of *E. imbricata* 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** 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	2,3
Commercial use of turtles	1	3
Non-commercial use of turtles	1	3
Predation eggs by non-native fauna	1	2
Predation eggs by native fauna	1	2
Consumption – foraging turtles		
Commercial use of turtles	3	3
Non-commercial use of turtles	3	2,3
Climate change impacts		
Increasing beach temperature	1	4
Beach erosion	?	3
Sea level rise	?	3
Coastal development		
Habitat modification (urban)	1,3	4
Habitat modification (industrial)	?	4
Light horizon disorientation	1	4
Fisheries impacts		
Bycatch – trawl	3	3
Bycatch – 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
Hatchery management (& egg collection)	1	2

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

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

Parameter	Value	Reference(s)
Pivotal temperature	na	
Remigration interval	1.8 years	Pilcher and Ali 1999
	1.8 years	Joseph 2017
Clutches per season	2.7	Pilcher and Ali 1999
	1.9	Joseph 2017
Clutch size	120.4	Chan et al. 1996
	119.5	Joseph 2017
Mean size of nesting adult	76.3 cm	Chan et al. 1996
	79.8 cm	Joseph 2017
Emergence success of clutches	67% (50 to 83%)	Joseph 2017
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

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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 rookeries of West Peninsula Malaysia were first identified and surveys in the early 1990s (Mortimer et al. 1993). 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, Table X)). 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).

Table X. Summary of size of annual hawksbill turtle nesting populations at XX recorded nesting beaches in Western Peninsula Malaysia

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

Index nesting beaches: Malacca beaches

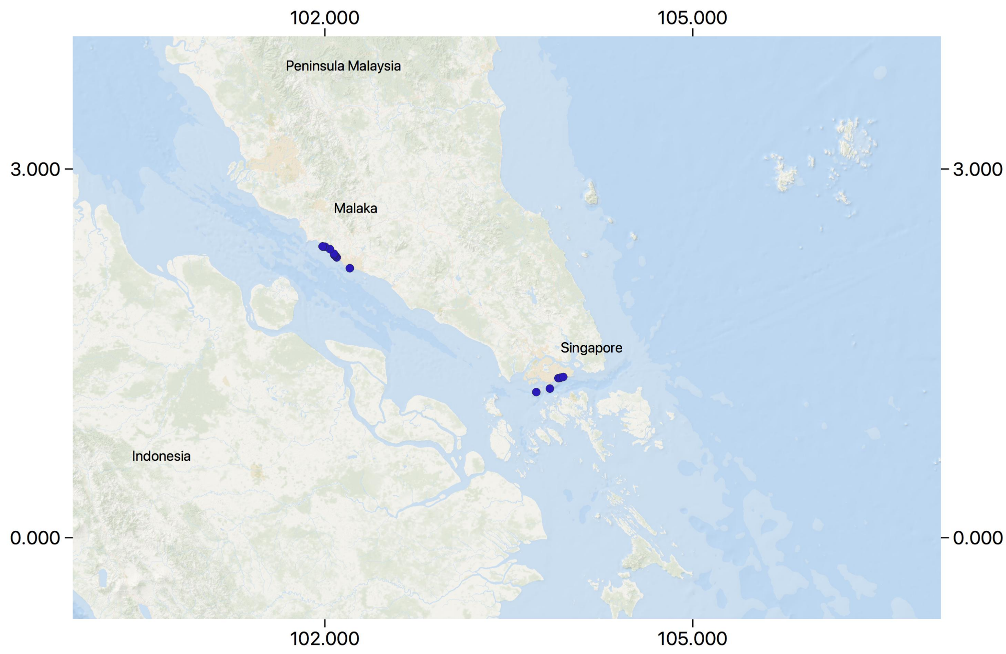

Figure 10. Distribution of nesting sites for the Western Peninsula Malaysia Management unit of hawksbill turtles.

Trends in nesting data

The first surveys for the Management Unit in 1991 revealed the abundance of hawksbill clutches laid on beaches of Malaka to be around 330 (Mortimer et al. 1993), and the most recent published data from 2013 and 2014 estimated 481 and 463 clutches per year respectively (Salleh et al. 2018). Hawksbill turtle monitoring in Malaka is coordinated by the Department of Fisheries Malaka. In terms of a trend annual data from the beaches indicate that approximately 245 clutches were laid per year between 1991 and 2004 and from 2004 onwards 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 Malaka (Figure 11). The power to detect a statistically significant trend based on these data (alpha 0.01) is 90%. However, it should be acknowledged that the nesting turtles and eggs were likely highly impacted by commercial use prior to the first surveys, thus the current abundance is still likely to be below the pre-harvest baselines.

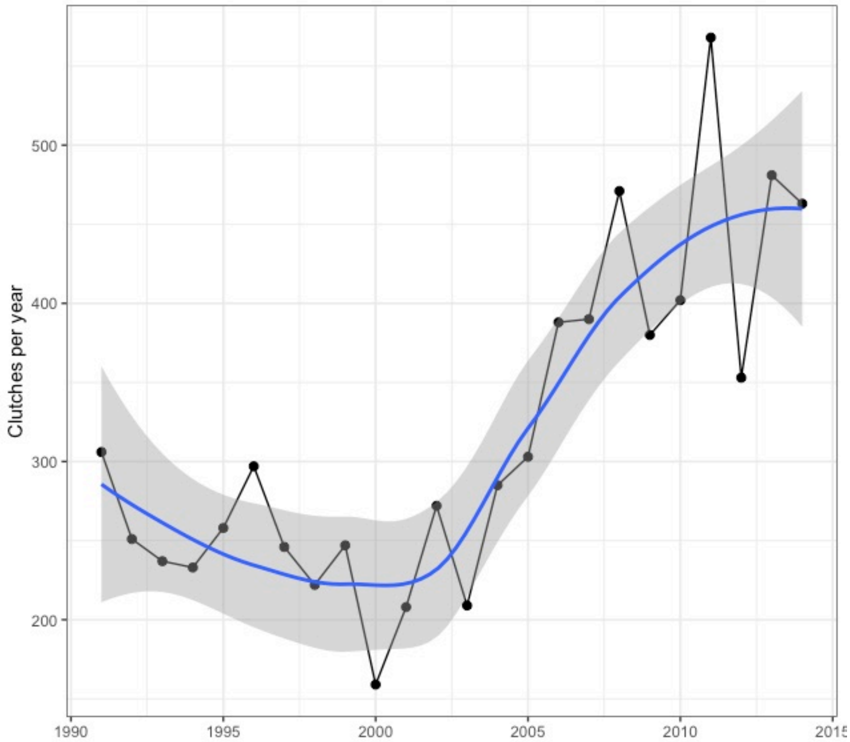

Figure 11. Number of hawksbill clutches recorded per year at Malaka in Peninsula Malaysia. Data from Department of Fisheries Malaka and Salleh et al. (2018)

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. Most of the beaches are developed, are adjacent to developed areas, or are close to planned development zones, most beaches are exposed 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, *E. imbricata* in ghost nets

3	The presumed substantial but unquantified mortality of foraging *E. imbricata* 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 *E. imbricate* (CITES, Vuto et al. 2019)
6	The illegal trade in *E. imbricata* particularly via China and Vietnam provides an incentive for continuing the illegal trade of *E. imbricata* 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

In Malaysia, marine turtles are managed and protected by State and National legislation. The collection and sale of eggs from Malaka beaches is prohibited by law, although transfer of eggs from other states into Malaka is permitted (REF). Palau Upeh is a protected site, and all turtle clutches are protected from predation or human influence. In Singapore hawksbill turtles are protected by National legislation which prohibits the use of turtles or their eggs. Nesting sites are managed and monitored by National Parks Board staff. Each clutch of eggs are recorded and monitored.

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.

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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 units

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, sampling has been constrained by low levels of nesting and low sample sizes for the genetic-based research has impeded the description of population genetics (Arshaad and Kadir, 2009; Nishizawa et al. 2016). Recent research by Nishizawa et al. (2016) indicate that the hawksbill turtles nesting at Pulau Redang in eastern Peninsula Malaysia are genetically distinct than those nesting in Sabah and Malaka in western Peninsula Malaysia. Based on a small sample size they also indicate that the hawksbill turtles nesting in Johor, situated in southeaster Peninsula Malaysia could also be genetically different to those in Malaka. However, the small sample size from Johor also revealed a haplotype common to Ko Khram in Thailand (Arshaad and Kadir, 2009). Thus it is not clear whether there are more than one stock in the Gulf of Thailand. In this section we treat all of the rookeries in the Gulf of Thailand as a possible genetic stock.

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 the states of Terengganu, Pahang and Johor, in particular Pulau Redang, Pulau Tioman and the islands of Johor (Figure 12). The nesting season occurs primarily from May to October.

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

Estimated size of annual nesting population	Number of beaches	Nesting beaches
501-1000 females/year	0	
101-500 females /year	0	
11-100 females /year	1	Ko Khram (Thailand)
1-10 females / year	4	Ko Kra (Thailand), Palau Redang, Pulau Tioman, Johor Islands (Malaysia)
Unquantified nesting	At least 4	Koh Tang, Koh Pring, Koh Kong, Koh Rong (Cambodia)

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

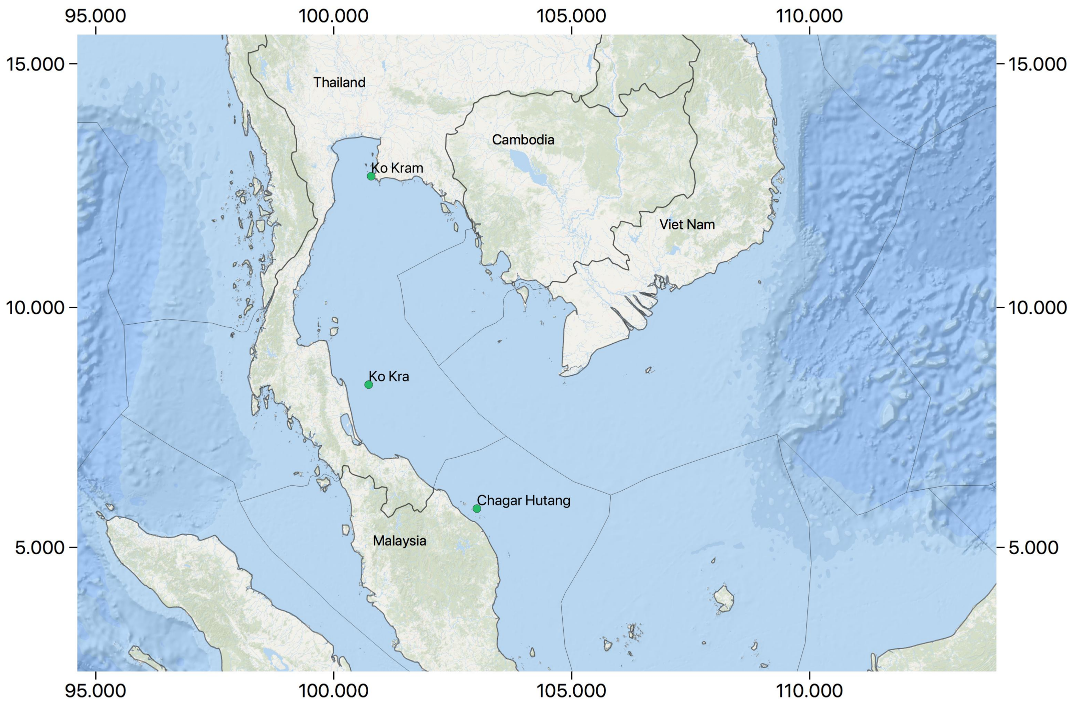

Figure 12 Main nesting sites for the possible Gulf of Thailand management unit of hawksbill turtles, faint lines are the EEZ boundaries of adjacent nations. ADD TIOMAN

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) and in recent years have increased to between 100 to 150 clutches per year (Figure 13). The most recent data from monitoring at Malaysia's Chagar Hutang (Pulau Redang) show a small stable nesting population of around 10 clutches per year (Figure 14). At Pulau Tioman in the state of Pahang, monitoring by the Juara Turtle Project has occurred since 2006 and they report relatively stable numbers of nesting turtles of around 5 to 20 clutches per year (Horcajo-Berna et al. 2018).

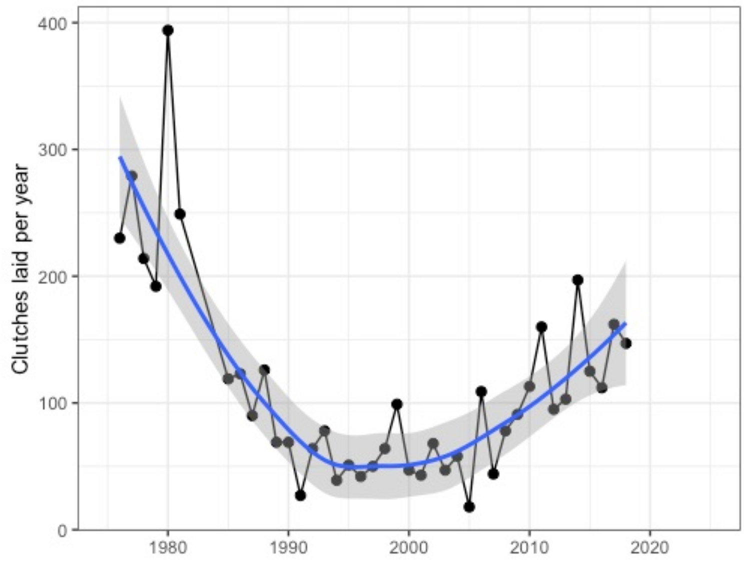

Figure 13. Number of hawksbill clutches recorded per year at Ko Kram, Thailand. Data from 1976 to 1981 is estimated from Table 201 in Groombridge and Luxmoore (1989), data from 1985 to 1995 is from Chantrapornsyl (1996) and unpublished data from 1995 to 2018 was provided by the Thailand Government.

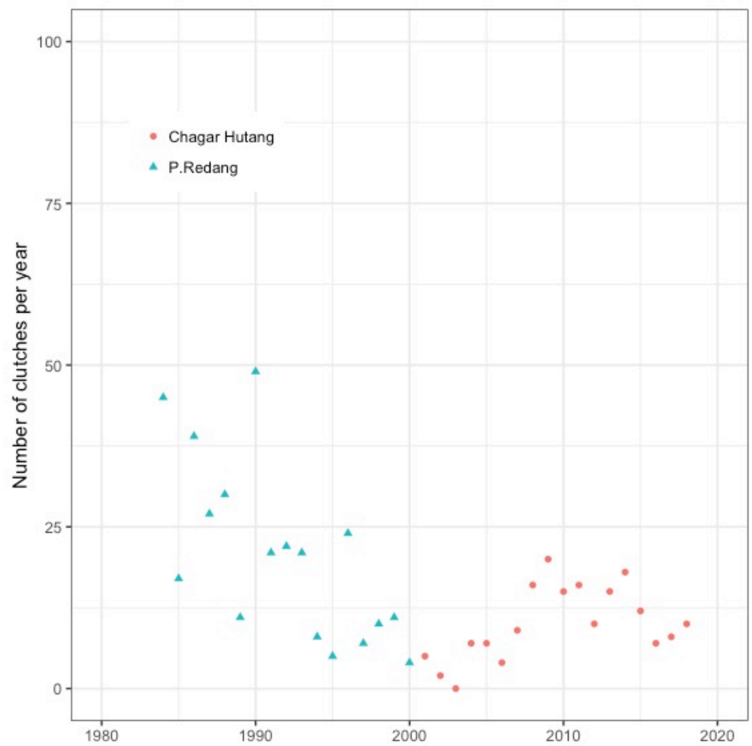

Figure 14. Number of hawksbill clutches recorded per year at Pulau Redang and Chagar Hutang (single beach on Pulau Redang), in Peninsula Malaysia. Data from Chan (2007) and unpublished data from SEATRU (2008 to 2018).

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, *E. imbricata* in ghost nets or through ingestion of marine debris
3	The presumed substantial but unquantified mortality of foraging *E. imbricata* 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 *E. imbricate* (CITES, Vuto et al. 2019)
6	The illegal trade in *E. imbricata* provides an incentive for continuing the illegal trade of *E. imbricata* 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	Quantified

	1=nesting beach 2=Oceanic/high seas 3=Coastal foraging areas	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

Pulau Redang - Chagar Hutang beach (Malaysia)	Island	Yes	Very high	Protected
Pulaua Tioman (Malaysia)	Island	Yes	Very high	Not protected but access to some beaches is restricted

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.

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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	

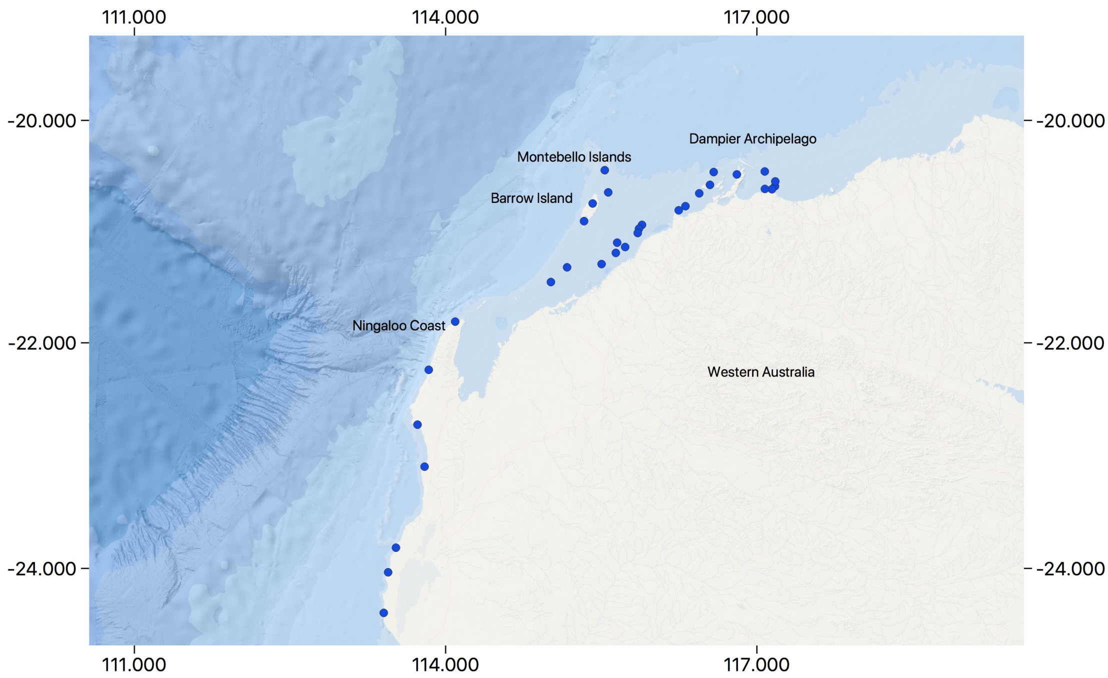

Figure 15. Distribution of *Eretmochelys imbricata* nesting beaches for the eastern Indian Ocean management unit.

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.

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Western/central Indian Ocean management unit

Ecological range

The samples used by researchers to identify the western central Indian Ocean management unit were collected from rookeries in Seychelles and Chagos (Vargas et al. 2016; Arantes et al. 2020). Most rookeries in the southwest Indian Ocean remain to be sampled, for example there are hawksbill turtle rookeries in Madagascar, Mozambique, Tanzania, Kenya and other French and British Indian Ocean Territories (see section XX- LINKTO SW INDIAN OCEAN). Thus, it is possible that more than one management unit exists in the south-western Indian ocean. It is likely that turtles from this management unit reside and forage at sites throughout the southwest Indian Ocean.

Geographic spread of foraging sites

Genetic-based studies indicate that most of the turtles foraging in Chagos and Seychelles waters are derived from nesting in Chagos or Seychelles (Mortimer and Broderick 1999).

Geographic spread of nesting

In the Seychelles, hawksbill turtle nesting distribution and abundance has been documented since the 1970s (Frazier 1975; Mortimer 1984). Nesting occurs at least 22 islands in the Inner Islands group, and on Outer Islands, in particular the Amirantes Group (Mortimer 1984; Groombridge and Luxmoore 1989; Mortimer and Day 1999). In Chagos, hawksbill nesting occurs across most of the atolls with suitable nesting habitat, however 90% of hawksbill nesting in the Chagos Archipelago occurs on Diego Garcia and Peros Banhos atolls, (Sheppard et al. 2012; Mortimer et al. 2020). 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).

INSERT MAP
Figure 16. Distribution of *Eretmochelys imbricata* nesting beaches for the western/central Indian Ocean management unit and additional hawksbill turtle rookeries of the South and West Indian Ocean

Index nesting beaches:
Seychelles: There are more than 20 sites (>11 islands in the Granitic group; >9 islands in the outer islands) that have been implementing long term year-round projects that monitor nesting hawksbills (and green turtles) and most of these projects have been ongoing for 10 to 40 years, among them are Cousin Island, Cousine Island, Curieuse Island, Aride, and D'Arros. New sites are regularly being added.
Chagos: Diego Garcia – published from 1995 to 2017 in Mortimer et al. 2020)

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 rookery of Cousin Island which supported 20 to 30 females per year in the early 1980s and afforded some protection for nesting hawksbill turtles (Mortimer 1984). Monitoring of the hawksbill turtles at the Cousin Island 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 Cousin in the 1970s and 1980s averaged 32 females per year (Mortimer 1984; Allen et al. 2010) and, in response to closure of the local tortoiseshell trade in 1993, this increased to an average of 248 turtles (714 clutches) per year between 2007 and 2008 (Allen et al. 2010). Annual monitoring continues at Cousin Island. On nearby Cousine Island hawksbill monitoring began in the mid 1990s and monitoring indicated that around 64 clutches (from around 30 females) are were laid per year (range 21 to 103) between 1995 and 1998 (Hitchins et al. 2004a,b), 104 clutches per year (range 60 to 230) between 2004 and 2013 (Gane et al. 2020) and 150 clutches per year in 2018 and 2019. On Curieuse Island monitoring was stardardised in 2010 and data collected from 2010 to 2015 indicate around 55 females nesting per year, which is an increase of 50 to 100% over numbers recorded in the mid 1980s (Burt et al. 2015). On Aride Island hawksbill turtles have been monitored since 1976 and with consistent methods since 1992. The annual number of clutches recorded on the monitored beaches of Aride Island between 1976 and 2000 was 11 (range 2 to 25). 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 and Donnelly (2008) highlights the value of protection. They report on data collected across the 22 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 389%, and at the seven intermediately protected islands, and the 13 non-protected islands the size of the nesting population declined by 21% and 59% respectively. Highlighting both the value of site-based protection of beach habitats and turtles, and the lengthy temporal delays between initiation of conservation interventions and population recovery. Current monitoring of hawksbill turtle nesting sites occurs and is managed through several Government, NGO, tourist industry, and community partnerships across around 20 islands.

In the Chagos Archipelago, the nesting population was substantially impacted by the direct killing of nesting turtles to supply the global trade in turtle shell, indeed 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, Mortimer (2007) reported little change in the numbers of hawksbill turtles nesting between 1996 to 2006 in four atolls and a slight increase at Diego Garcia and Mortimer et al. (2020) report an estimate of 6308 clutches a year being laid between 2011 and 2018, an increase of 2 to 5 times above the 1995 nesting abundance. Mortimer et al. (2020) estimate that the Chagos Archipelago accounts for 39 to 51% of hawksbill turtle in the south west Indian Ocean.

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

Migration and distribution of foraging areas

To date all hawksbill turtles tracked from nesting beaches in the southwest Indian Ocean rookeries have remained in the southwest Indian Ocean. There are records of tag recoveries from turtles tagged in the Seychelles in other areas of the southwest Indian Ocean. Satellite tracking of nesting turtles has revealed that all have stayed within the southwest Indian Ocean (Mortimer and Balazs 1999). 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 in the Seychelles and Chagos Archipelagos (Allen et al. 2010; Mortimer et al. 2020).

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

While protection and management of hawksbill turtles within the Seychelles and Chagos Archipelagos is sound, the long-term security of the management unit could be affected by the cumulative loss of turtles and/or eggs across the probable range of the western/central Indian Ocean management (e.g. Table 8). There are currently no clear indications of when or how many of these threats can be resolved and therefore continued conservation and monitoring attention is warranted.

Table 8. Summary of key issues related to the cumulative loss of turtles and eggs from the west central management unit of hawksbill turtles (not ranked)

1	Illegal harvest of eggs by people living or visiting non-protected islands for consumption or sale, or loss of eggs from predation from native or introduced species across the range of the management unit

2	The potential loss of post-hatchling, or immature, *E. imbricata* in ghost nets or other discarded fishing gears
3	The presumed substantial but unquantified mortality of foraging *E. imbricata* 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 (CITES 2019)
5	The presumed substantial but unquantified mortality arising from ingestion of plastic marine debris

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	-	-
Commercial use of turtles	-	-
Non-commercial use of turtles	-	-
Predation eggs by non-native fauna	1	4
Predation eggs by native fauna	?	4
Consumption – foraging turtles		
Commercial use of turtles	-	-
Non-commercial use of turtles	-	-
Climate change impacts		
Increasing beach temperature	?	4
Beach erosion	1	3
Sea level rise	1	3
Coastal development		
Habitat modification (urban)	1	3
Habitat modification (industrial)	-	-
Light horizon disorientation	1	3
Fisheries impacts		
Bycatch – trawl	3	3
Bycatch – long line	2,3	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

Hawksbill turtles and their nesting habitats are protected by domestic legislation in the Seychelles and Chagos Archipelagos. For the Seychelles marine turtles are protected under legislation the prevents the disturbance, harvest, collection, sale or use (Mortimer and Donnelly 2008) and there are plans to extend the no-take MPA system to cover 30% of their waters. In Chagos, the islands have been unoccupied since the early 1970s, and since 2010 the Chagos islands been included in a very large and successful no-take marine protected area (British Indian Ocean Territory (BIOTMPA) (see Mortimer et al. 2020 and Hays et al. 2020) protecting turtles from human use and managing other pressures. However, as turtles from this stock move out to foraging areas outside of Seychelles and the BIOT MPA levels of protection vary on a country basis and legal protection from use, or enforcement of legislation, is not always afforded.

Biological data – breeding

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

Parameter	Value	Reference(s)
Pivotal temperature	na	
Remigration interval	2 to 3 years	Mortimer and Bresson 1999
	3.7 years (n=9)	Dugdale 2001
Clutches per season (mean/median/mode)	3.6/4/5*	Mortimer and Bresson 1999
	3 to 5	Hitchins et al. 2004
Mean size of nesting adult (SCL)	81.2	Hitchins et al. 2004
Clutch size	176 eggs	Hitchins et al. 2004
Incubation period (days)		
1995 to 1999	58.1 (50 to 69)	Hitchins et al. 2006
2004 to 2013 clutches in full sun	57.8 (54 to 61)	Gane et al. 2020
2004 to 2013 clutches in partial sun	59.2 (57 to 68)	Gane et al. 2020
2004 to 2013 clutches in full shade	59.8 (57 to 66)	Gane et al. 2020

Hatching success of (natural nests)	61%	Hitchins et al. 2006
Emergence success (natural nests)	57%	Hitchins et al. 2006
	60%	Gane et al. 2020
Predation of eggs by crabs (natural nests)	19.3%	Hitchins et al. 2006
	7% (0.4 to 25)	Gane et al. 2020
Age at maturity	na	

*as acknowledged by the authors, this value is likely to be an underestimate because of within season tag loss, turtles non recorded because of movement between islands/ beaches, or nesting outside of the surveyed months, or mortality of nesting turtles

Biological data – foraging

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

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	
Mixed size classes	1.14 cm/yr	von Brandis (2010a)
Chagos CCL	0.7 to 2.7 cm/yr	Mortimer et al. (2002)
Survivorship estimates	na	

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Arabian (Persian) Gulf management unit

Groombridge and Luxmore (1986) reviewed the status of hawksbill turtles in each country boarding the Arabian (Persian) Gulf and the Gulf of Arabia. Gasperetti et al. (1993) summarized the older records, including museum specimens. Miller (1989) and Pilcher (1999) conducted the initial biological studies of hawksbill turtles in the Arabian (Persian) Gulf.

Ecological Range: Within the relatively small geographic area of the Arabian (Persian) Gulf and the Gulf of Arabia there could be more than one management unit of hawksbill turtles. Three nesting areas in the Persian Gulf have been sampled for genetic composition– 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; Vargas et al. 2015; Nishizawa et al. 2016). More sampling is required to define the genetic relationships in this region. No studies have been conducted to determine the extent of hatchling and post-hatchling dispersal for this management area.

Foraging [Geographical Spread]: In the Arabian (Persian) Gulf foraging areas occur in the coastal and off shore waters of UAE, Saudi Arabia, Qatar, Bahrain, and Kuwait (Pilcher et al. 2014b), and wherever suitable habitat occurs, including the coral-reef fringed islands and submerged rocky reef areas of Iran (Groombridge and Luxmoore 1989).
In the Gulf of Arabia, foraging habitats are spread along 500 km of coastline of Oman, and are restricted to a narrow coastal belt (Pilcher et al. 2014a). Although there are few coral reefs in the area, there are corals growing on the rocky substrate and the biomass of benthic organisms seems suitable for hawksbill foraging (Ross 1981). Pilcher et al. (2014a) identified two main foraging areas, Shannah and Quwayrah. Both were small in size and turtles using them had core areas focused on shallow patches of coral-reef habitats (around $3km^2$) and home range areas of $40\text{-}60km^2$. Along the Iranian coast of the Gulf of Arabia foraging is distributed along the coastal reef and rocky areas where suitable food occurs.

Nesting [Geographical Spread]: Low density nesting occurs in all except two countries (i.e., Iraq, Bahrain) that boarder the Arabian (Persian) Gulf. Although most nesting is low density (1-10 females per year), Iran, Saudi Arabia, Qatar, and UAE have at least one site where medium density (11-100 females per year) nesting occurs. Although the majority of nesting locations host low density nesting, the aggregation of the sites translates to medium nesting and means the general area is very important to the regional population.

<u>Iran:</u> In the Persian Gulf, nesting sites for hawksbill turtles in Iran predominantly occur in offshore islands of Ommolkaram, Nakhiloo, Hengam, Faror, Shidvar, Lavan, Nakhiloo, Tahmadon, Omolgorm, Khark, Hendourabi, and Kish Islands in the Gulf and Qeshm, Larak and Hormuz Islands in the Strait of Hormuz (Mobaraki 2004, Nabavi et al. 2012, Hensi et al. 2016) (Figure 18). Infrequent nesting may occur along the mainland, especially in areas adjacent to islands where nesting occurs on a regular basis. Low density hawksbill nesting has been reported from the Karate (mainland) coast of the Arabian Sea (Fadakar 2008) but infrequent nesting may occur elsewhere along the coast.

<u>Kuwait:</u> Scattered, low density nesting of hawksbill turtles has been reported at three locations (four beaches) (Rees et al. 2013) (Figure 18).

Saudi Arabia: Nesting sites for hawksbill turtles occur on four off-shore islands: Jana, Karan, Kurayn, and Jurayd (Figure 18) (Miller 1989, 2019; Pilcher 1999; Al-Merghani et al. 2000). Recently, hawksbill nesting has been recorded at Ras Tannurah on the mainland (Miller & Manja UnPub); nesting in this area occurred in the early 1950s (Gasperetti, pers. comm.) and was noted in 1987 (Miller 1989). No other areas of nesting on the mainland have been recorded. Neither Harqus nor Arabiyah Islands support nesting. Harqus Island is a low lying sand cay that is subject to tidal wash-over and Arabiyah Is. is ringed by rocky cliffs with only a few small crescent beaches.

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

Qatar: Low density (1-10) nesting sites for hawksbill turtles occur at Fuwairit, Halul, and Ras Laffan which are located on the North-eastern portion of the Qatar peninsula (Figure 18) (Al-Ansi and Al-Khayat 2008; Tayab and Quiton 2003).

United Arab Emirates: Nesting sites for hawksbill turtles occur on the off-shore islands of Jarnain (11-50), Bu Tinah (11-50), Ghantoot (1-10), Sir Bu Nair (11-100), Qarnain (Dayyinah Is.) (1-10), Arzannah (1-10), and Zirqu Islands (11-50), as well as numerous other islands (Figure 18) (Al-Ghais 2009; Natoli et al. 2017; Miller et al. 2004, 2009). Nesting on the other islands in UAE is low density (1-10) and may be intermittent at a few.

Oman: Hawksbill turtles nest in large numbers on Masirah Island at Omedu Beach (Ras abu Rasas) and in low numbers at several other locations on the island (Ross 1981). It is believed that around 100 females per year breed at Masirah (Rees and Baker 2006). 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).

On the Oman side of the Gulf of Arabia, a large nesting aggregation (101-500) occurs on Daminiyat Islands (= Jazirat Daminiyat), the combined total for the islands may exceed 500 turtles per season (Mendonca et al. 2001). In 1999 and 2000, nesting activity was tracked twice monthly from March-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. In a study by Pilcher at al. (2014a), inter-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. The Dimaniyat Islands are considered to be one of the last sanctuaries to hawksbills in the region, because of its protected status of the islands and the high pollution levels that exist in the Persian Gulf (Mendonca et al. 2001).

Al Hallaniyat Archipelago, in the Arabian Sea, consists of four islands: Al Hasikiyat, As Sawda, Al Hallaniyat and Al Qibliyat. Three of the islands are uninhabited; Al Hallaniyat has a population of ~300 people (Mendonca et al. 2005). Some of the beaches may provide suitable nesting areas for hawksbill turtles but nesting has not been confirmed.

<u>Iraq :</u> There is no reported nesting by hawksbill turtles for Iraq (which has only a short coastline).

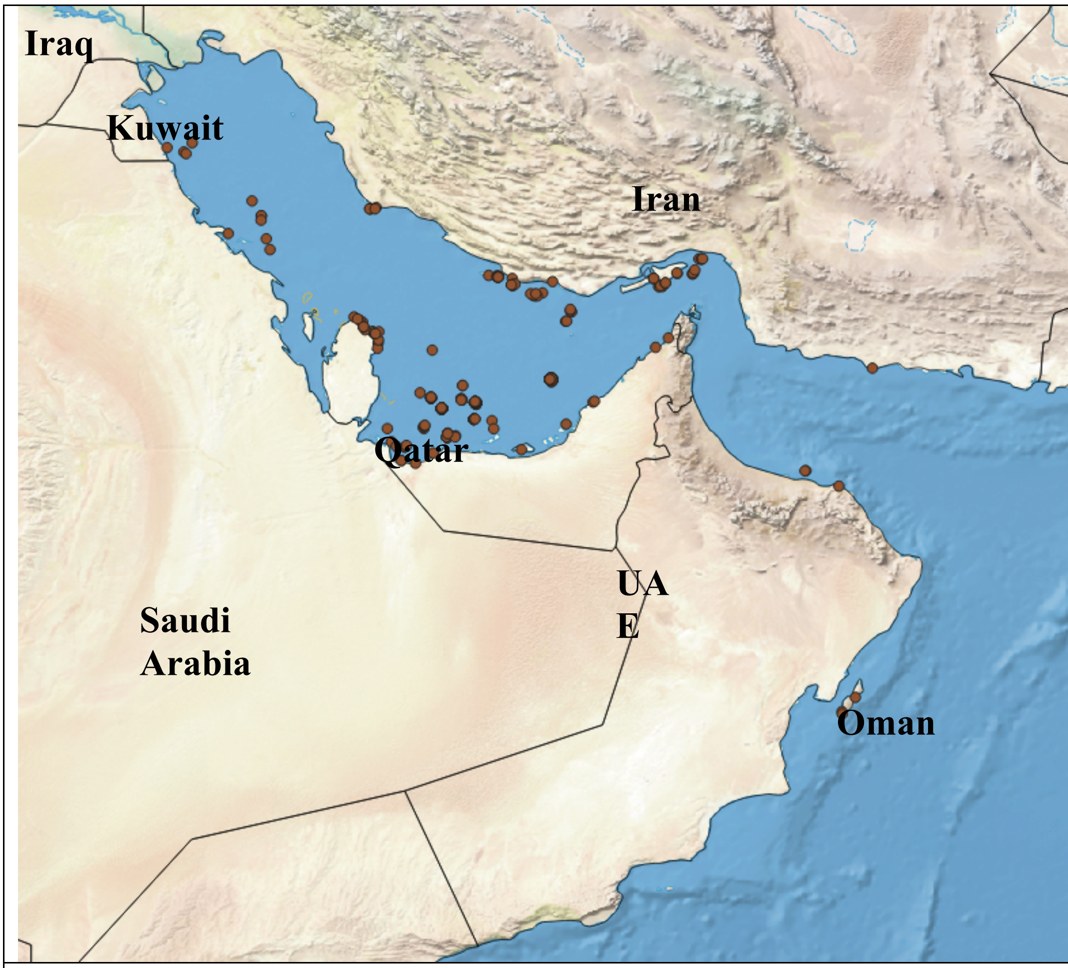

Figure 18. Distribution of nesting sites for hawksbill turtles in the Persian / Arabian Gulf UPDATE TO SAME FORMAT

Seventy-one hawksbill turtle nesting sites have been identified in Arabian (Persian) Gulf and Gulf of Arabia (**Table XX**); none have been recorded in Iraq and Bahrain. In the Arabian (Persian) Gulf, there are no very large (>500 females per year) nesting aggregations in the Gulf among the 69 identified nesting sites. Of these, only four (5.8%) of the nesting sites host large (>100, <500) numbers of females annually. Twenty-seven (39.1%) of the sites are utilised by between 11 and 100 nesting females annually. Thirty-eight (55.1%) of sites around the Gulf are used by fewer than 10 females annually.

Two sites located in the Gulf of Arabia in Oman (Daminiyat Islands, Masirah Island) host between 101 and 500 nesting hawksbill turtles annually. Other undefined sites in the Gulf of Arabia along the coast of Oman and the coast of Iran may host some very low density nesting.

Long-term monitoring and census data are needed to better define the number of nesting hawksbill turtles in the region. Research programs that have been monitoring nesting should continue to record both clutches and the number of females following standardized methodology (SWOT PERSGA 2019)

Table X. Summary of size of annual hawksbill turtle nesting populations at XX recorded nesting beaches in Arabian/Persian Gulf management unit.

Estimated Annual Nesting Population	Country	Number of Beaches	Nesting beaches
501-1000 females/year	Iran	0	
	Kuwait	0	
	Oman	0	
	Qatar	0	
	Saudi Arabia	0	
	UAE	0	
101-500 females/year	Iran	3	Lavan Island (= Jazireh-ye Sheykh Shoeyb), Shibdraz-Qeshm island, Shitvar Island (Jazireh-ye Shotur)
	Kuwait	0	
	Oman	2	Daminiyat Islands (= Jazirat Daminiyat), Masirah Island (= Jazirat Masirah)
	Qatar	1	Ras Laffan, north-eastern Qatar
	Saudi Arabia	1	Jana Island (= Jazirat Jana)
	UAE	0	
11-100 females/year	Iran		Faror island, Hendourabi Island, Larak island, Nakhiloo Island, Ommolkaram Island, Queshm Islands, South east of Hengam island, South east of Hormoz island, South of Hendourabi Island, South of Kish island, West of Qeshm island,
	Kuwait	0	
	Oman	0	
	Qatar	3	Al Ghariya, Fuwairit, Ras Rakan
	Saudi Arabia	3	Juaryd Island (=Jazirat Juaryd), Karan Island (=Jazirat Karan), Kurayn Island (= Jazirat Kurayn),
	UAE	10	Arzannah Is., Bu Tinah Is., Dalma Is., Dayyinah Is., Jarnain Island, Saadiyat Island, Sir Bani Yas, Sir Bu Nu'air Is., Um Al Kurkum, Zirku Is.
1-10 females/year	Iran	4	East of Gorzh, Hengam Islands, Karate coast, West of Charak
	Kuwait	3	Ras Al Zour -beach d, Qaru Island - Beach A Umm Al-Maradim Island- Beach C (North)
	Oman	3	Zarbarjad (= Insel St John's), Muscat, Omedu Beach (Ras abu Rasas)
	Qatar	12	Al Dakerah, Al Huwaylah, Al Jassasiya, Al Khor, Al Mafjar, Al Maronah, Halul,

			Ras Marbakh (Ras Martbakh), Sharaawh Island, Umm Tays, Uraydah, Ras Laffan, north-eastern Qatar
	Saudi Arabia	1	Ras Tannurah
	UAE	14	Abu Al Abyad, Al Mubarraz, Al Rans Beach, Arzannah Is., Bu Tinah Is., Das Is., Dayyinah Is., Ghantoot (beach), Ghashshah (Ghasha) Is., Muhaimat (Muhayimat) Island, N E Coast, Qarnein Is., S W Coast, Um Al Hatab, Yasat Ali Is
Unquantified	Iran		Islands of the Persian Gulf and Coastal areas of the Gulf of Arabia
	Kuwait		
	Oman		Coastal areas and near shore Islands
	Qatar		
	Saudi Arabia		Harqus Island (= Jazirat Harqus) [washed over]
	UAE		Islands of the Straits of Hormoz

Trends in Nesting Data:
Iran: There are no trend data for rookeries in Iran. Based on published data from various site records, it is likely that between 200 and 300 females breed each year, in particular on Omolgorm /Nakiloo Islands (100 to 150 females nest per year), Kish Island (10 to 15 females nest per year), Sheedvar Island (20 to 25 females nest per year), Lavan Island, Qeshan Island (30 females nest per year), Hengam Island (30 females nest per year), Hormuz Island (20 to 25 females nest per year), and the Farour Islands (<10 females nest per year). (Hesni et al. 2016, 2019; Zare et al. 2012; Mobaraki 2011; Mobaraki and Elmi 2005).

Saudi Arabia: Initial surveys of nesting hawksbill turtles in Saudi Arabia occurred in 1986 and 1987 (Miller 1989). In 1991 surveys were re-established and continued until 1997 (Al-Merghani et al. 2000; Pilcher 1999). In 1991 surveys of three of the four rookeries (Jana, Karan and Jurayd) were conducted from late May until early August to cover the entire nesting season. A total of 164 hawksbill turtles were tagged, 111 (68%) on Jana, 43 (26%) on Karan and 10 (6%) on Jurayd. Hence, Jana is considered the most significant of the three rookeries for hawksbill turtles. From 1992 onwards survey effort was reduced to ~3 weeks over the peak nesting period for hawksbill turtles at Jana based on Pilcher's (1999) estimate that sampling over this 3-week period will allow 89% of nesting females to be encountered. No survey data after 2007 are available.

Qatar: : Monitoring reports indicate an average of 32 (data from 2010 to 2016) clutches per year are laid at Fuwairit (**Table X**) and 160 per year at several sites near Ras Laffan (64 in 2001, 174 in 2002; 16 in 2001, 65 in 2002), and no monitoring records exist for the Halul Islands (Pilcher et al. 2014, Chatting et al. 2018). No recent data are available (Tayab and Quiton 2003; Figure 18).

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 ºC from the start to end of the nesting season (Chatting et al. 2018).

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

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

United Arab Emirates: In 2009 Al-Ghais (2009) report 48 nests laid in a nesting season on Jarnain and 17 nests laid on Bu Tinah. Recent survey data collected between 2010 and 2019 by the Emirates Marine Environmental Group indicate an average of 30 and 323 clutches are laid per year at Jebel Ali and Sir Bu Na'ir, respectively (Sir Bu Na'ir significant site report 2019). The trend is believed to be stable (Table X).

Table X Hawksbill turtle clutches recorded per year at Sir Bu Na'ir and Jebel Ali by the Emirates Marine Environmental Group (cited in the Sir Bu Na'ir Significant Site Report to IOSEA 2019).

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

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

Unfortunately, less is known about the habitats used by marine turtles. The use of satellite tracking is providing identification of foraging areas and linkage to nesting areas (Pilcher et al. 2014) but more needs to be done. The development of a regional, cooperative management plan in the next few years will improve the situation for the turtles and their habitats.

Table XX. Biological data – Breeding – for hawksbill turtles of the Arabian Peninsula.

Parameter	**Value** (Mean±Sd (n)	**Reference(s)**
Pivotal temperature	na	
Remigration interval	4 to 5 yrs (3)	Pilcher 1999 (Saudi Arabia)
Clutches per season	2.2 ± 0.12 (42) 3 (up to 6) 2^+	Pilcher 1999 (Saudi Arabia) Pilcher et al. 2014a Rees et al. 2019
Mean size of nesting adult	71.2±4.1 (240)	Pilcher 1999 (Saudi Arabia)
	71.6	Hesni et al. 2016 (Iran)
	70.8±2.85 (150)	Chatting et al. 2018 (Qatar)
	72.2	Mobaraki & Elmi 2005 (Iran)
	71.2±3.95 (313)	Al Merghani et al. 2000 (Saudi Arabia)
	71.3±3.41 (33)	Pazira et al. 2010 (Iran)
	70.74±3,56 (11)	Pilcher et al 2014 (Iran)
	69.31±2.19 (7)	Pilcher et al 2014 (UAE)
	81.08±3.62 (22)	Pilcher et al 2014 (Oman)
	73.47±5.52 (4)	Pilcher et al 2014 (Qatar)
	70.22±4.3 (122)	Razaqhian et al. 2019 (Iran)
	67.43±10.17 (60)	Aghanajefizadeh & Askzri 2018 (Iran)
	72.5±	Hadi et al. 2012 (Iran)
(*SCL ± SE)	73.3±1.6* (48)	Ross & Barwani 1982
	77.2±5.25 (53)	Ross 1980 (Oman)
Age at maturity	na	
Clutch size	79± eggs	Chatting et al. 2018 (Qatar)
	82.2±	Mobaraki & Elmi 2005 (Iran)
	73.25±12.1	Pazira et al. 2010 (Iran)
	75.2	Hesni et al. 2016 (Iran)
Hatching Success	46.4% (2.4-79.8%) (1991)	Pilcher 1999 (Saudi Arabia)
	70.9% (54.3-81.9%) (1991)	Pilcher 1999 (Saudi Arabia)
	71% (54-91%)	Pilcher & Al Merghani 1994 (Saudi Arabia)

Migration [Geographical Spread and Distribution of Foraging Areas]:

Hawksbill turtle migration and habitat use of was described for the southern basin and the Gulf of Oman 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 km^2 with a core use area of 3 to $5km^2$. One interesting feature of turtles from this management unit is that during the warmer summer months the turtles embarked on summer migration loops – typically moving in a north-east direction and spanning 650 km movements that, at their apex, had waters 2^oC cooler than their foraging area (Pilcher et al. 2014a,b).

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). Post-nesting turtles were tracked migrating southeast from Daymaniyat islands, past Ras al Hadd and southwest-ward towards the waters off Shannah and Marisah Island and Quwayrah (Pilcher et al. 2014). Turtles from Masirah Island rarely travelled further than 50–80 km to coastal foraging sites off the Oman mainland coast (Pilcher et al. 2014).

Migrations by turtles nesting at the Daymaniyat islands were longer than by those nesting at Marisah, averaging 672.6 km and required 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 to or out of the Gulf. Migrations by turtles at Masirah Island were statistically shorter than those from Daymaniyat islands, averaged 80.5 km and lasted an average of 3.95 days. During the same period when most turtles were migrating along the coast of Oman (June to September), the Somali current travels in the opposite direction but does not seem to impede turtle migration. Migration distances for turtles departing the Daymaniyat islands were shown to be more than twice the global average for adult hawksbills (Pilcher at al. 2014).

Few satellite tracking studies have been conducted in the northern basin of the Gulf. Hawksbill turtles tracked from nesting sites in Kuwait (2 from Umm Al Maradim Island; 2 from Qaru Island, Rees et al. 2019) tended to be short and near shore in shallow water situated to the north of Abu Ali Island in Saudi Arabia. Hawksbill turtles nesting in the southern basin have been tracked to the northern side of Abu Ali Island, which has been identified as an important foraging area (Pilcher et al. 2014a). These data suggest that hawksbill turtles in the northern Gulf utilize foraging areas that contain dispersed rocky/reefal habitat.

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

Table XX. Biological data – Foraging- for hawksbill turtles of the Arabian Peninsula.

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	

Threats to the Population: Arabian (Persian) Gulf

Although several authors have provided lists of potential and real threats (e.g., Miller 1989, Gasperetti et al. 1993), few quantified data exist on threats to sea turtles of the Arabian (Persian) Gulf. Overall 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). For example, fisheries bycatch of hawksbill turtles is believed to occur at a low level. In a two-year study of stranded turtles in Bahrain, hawksbill turtles were caught in large wire traps but not commonly caught in trawl-based fisheries (Abdulqader and Miller 2012). In Oman hawksbills (unlike green turtles) are not traditionally targeted for consumption and bycatch has been identified as the major conservation concern (Pilcher et al. 2014), although the level of take of hawksbill turtles has not been assessed. In addition, a few countries report that a low level of consumption or sale of turtle eggs occurs at a local use level (IOSEA 2019 National reports).

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

International shipping may pose a threat to marine turtles, particularly in narrow waterways such as the Strait of Hormuz. For example, Pilcher et al. (2014) reported that 24 of the 25 tracked turtles travelled to foraging sites close to the Oman coast. A 20 km wide zone off Ras Al Hadd, and along the shoreline between Daymaniyat, Muscat and Masirah 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, extraction/production, 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.

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

Table xx. Summary of threats to the Arabian/Persian Gulf management unit of hawksbill turtles. KEY: Known or likely location of impact: A=Nesting beach, B=Oceanic/high seas, C=Coastal foraging areas. Quantified: 1=comprehensive documentation across population, 2= comprehensive documentation for some of the population, 3=non-published evidence only, 4=not quantified; Blank= Unknown

Country	**Iran**	**Kuwait**	**KSA AG**	**Bahrain**	**Qatar**	**UAE**	**Oman**
Consumption – nesting beach							
Egg collection	A, 4		A, 4				A, 4
Commercial use of turtles	4		4				4
Non-commercial use of turtles	A, 4		A, 4				A, 4
Predation eggs by non-native fauna	4		4				4
Predation eggs by native fauna	4		4				4
Consumption – foraging turtles							
Commercial use of turtles							
Non-commercial use of turtles	4	4	4	4	4	4	4
Climate change impacts							
Increasing beach temperature	4	4	4	4	4	4	4
Beach erosion	4	4	4	4	4	4	4
Sea level rise	4	4	4	4	4	4	4
Coastal development							
Habitat modification (urban)	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4
Habitat modification (industrial)	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4
Light horizon disorientation	4	4	4	4	4	4	4
Fisheries impacts							
Bycatch – trawl	4		4	4		4	
Bycatch – long line			4				
Bycatch – gill net	4		4	4		4	

Impact to benthic ecology from fisheries	4		4	4		4	
IUU impacts							
Pollution							
Water-quality related impacts	4	4	4	4	4	4	4
Entanglement in discarded fishing gear	4	4	4	4	4	4	4
Ingestion of marine debris	4	4	4	4	4	4	4
Noise pollution	4	4	4	4	4	4	4
Disease and pathogen	4	4	4	4	4	4	4

Management and Protection

The countries surrounding the Gulf participate in many international and regional agreements to promote conservation in the region (**Table XX)**. Of these, ROPME helps coordinate among the regional states and links to other relevant national and international organizations, such as PERSGA (Red Sea region), the Council of Arab Ministers Responsible for the Environment (CARMRE), and the regional Office of UNEP. Although the general focus of these agreements is toward preventing oil pollution, as well as industrial waste and sewage discharge, they also deal with protecting marine resources. Some of the agreements, such as CMS, provide guidance and context for state-level, regional- level, and international level coordination and evaluation of conservation efforts. Others (e.g., CITES) help enforce international and regional regulations concerning trade in wildlife and derived products. Still others deal mainly with protecting the marine and coastal environments. All help improve the situation for marine turtles, either directly or indirectly. However, because marine turtles tend to nest off-shore islands, local enforcement can be a problem.

Table XX. Selected regional and international agreements adopted by the Gulf States.

	Iran	**Iraq**	**Kuwait**	**Saudi Arabia**	**Bahrain**	**Qatar**	**UAE**	**Oman**
Regional Organization for the Protection of the Marine Environment (1979) [ROPME]	X	X	X	X	X	X	X	X
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) [CITES]	X	X	X	X	X	X	X	X
Convention on Biological Diversity (1992) [CBD]	X	X	X	X	X	X	X	X
Convention on the Conservation of Migratory Species of Wild Animals (1979) [CMS]	X	X	O	X	X	X	X	O
Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia [IOSEA]	X	O	O	X	X	O	X	X
Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971) [RAMSAR]	O	X	X	O	X	O	X	X

International Convention for the Prevention of Pollution from Ships (1973/78)	X	X	X	X	X	X	X	X
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972)	X	X	X	X	X	X	X	X
United Nations Convention on the Law of the Sea (1982) [UNCLOS]	O	X	X	X	X	X	O	X
Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982)	X	X	X	X	X	X	X	X
Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1989)	X	X	X	X	X	X	X	X

The countries of the bordering the Arabian (Persian) Gulf provide legal protection for marine turtles and have national laws that prohibit or regulate the use of eggs and turtles found on beaches as well as those captured in foraging areas either directly or by accident. However, enforcement is an on-going issue because of the lack of resources (IOSEA 2019 a, b, c, d). Although most Marine Protected Areas in the Gulf were not designated with the specific purpose of conserving habitat for marine turtles, because many coincide with turtle nesting and/or foraging areas, MPAs provide some protection to critical habitat used by hawksbill turtles **(Table XX).**

Table XX. Designated and proposed Marine Protected Areas of the Arabian (Persian) Gulf. Source: Marine Conservation Institute. (2020), Lavieren et al. 2001.

Site Name	**Index site Y/N**	**Relative importance to the Population**	**Protection [Designated] (Country)**
Faror island	?	Minor	Faror island Protected Area [1986] (Islamic Republic of Iran)
Hormoz Island	?	Very Important	Other Area [Proposed] (Islamic Republic of Iran)
Karko island	N	Minor	Wildlife Refuge [1975] (Islamic Republic of Iran)
Nakhiloo Island	Y	Very Important	Mond Protected Area [1975] (Islamic Republic of Iran)
Ommolkaram Island	Y	Very Important	Mond Protected Area [1975] (Islamic Republic of Iran)
Sheedvar Island*	Y	Very Important	Wildlife Refuge [1975]; Sheedvar Island Ramsar Site, Wetland of International Importance [1999] (Islamic Republic of Iran)
North West Qaruh Island	?	Minor	North West Qaruh Island Coral Reef Area [Proposed] (Kuwait)
Umm Al Maradim Island	?	Minor	Natural Reserve [Proposed] (Kuwait)
Ras Al Zour		Minor	Al Zour Reef Area [Proposed] (Kuwait)

Al Diymaniyat Islands	Y	Extremely Important	Al Diymaniyat Islands Nature Reserve [1996] (Oman)
Jana Island	Y	Very Important	Gulf Islands Special Nature Reserve [Proposed] (Saudi Arabia)
Karan Island	Y	Very Important	Gulf Islands Special Nature Reserve [Proposed] (Saudi Arabia)
Harqus Island	N	Not Important	Gulf Islands Special Nature Reserve [Proposed 1990] (Saudi Arabia)
Jana & Kurayn Islands	Y	Very Important	Gulf Islands Special Nature Reserve [Proposed] (Saudi Arabia)
Ras Tannurah	N	Minor	Jubail Marine Wildlife Sanctuary Reserve [Proposed] (Saudi Arabia)
Saadiyat Island	N	Minor	Al Saadyat Protected Area [2014] (United Arab Emirates)
Al Yasat Island	?	Minor	Protected Area [2009] (United Arab Emirates)
Al Mubarraz Island	?	Important	Marawah UNESCO-MAB Biosphere Reserve [2007] (United Arab Emirates)
Bu Tinah Island	Y	Important	Marawah UNESCO-MAB Biosphere Reserve [2007] (United Arab Emirates)

The hawksbill population of the Arabian (Persian) Gulf and the Gulf of Arabia would benefit from cooperative, coordinated, multinational research and conservation efforts. Although the information-base on marine turtles in the region has improved, especially in recent years, much remains to be learned. The use of standardized methods would allow comparison of data among research projects. In addition, initiation of research to collect long-term data sets will aid better definition of characteristics of the regional population that are essential to conservation management in the region.

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

Mancini et al. (2015) provide the most recent review of the literature concerning the marine turtles of the Red Sea, including the distribution of major nesting and protective legislation. Prior to the 2015 review, Groombridge and Luxmore (1989) reviewed the status of hawksbill turtles in each country boarding the Red Sea. Gasperitti et al. (1993) summarized the older records, including museum specimens. PERSGA/GEF (2004, 2007) prepared conservation management plans for marine turtles in the Red Sea to facilitate within and among country research efforts using a standardized methodology (PERSGA 2019).

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

Foraging [Geographical Spread]
Within the long and relatively narrow geographic area of the Red Sea the distribution of foraging by hawksbill turtles can be characterized as being widespread, essentially wherever suitable habitat occurs. No broad-scale surveys of the uniformity of foraging distribution have been conducted (PERSGA/GE 2004, 2007).

Migration [Geographical Spread]
There have been no studies investigating migration of post-breeding hawksbill turtles from their nesting locations as they return to their foraging areas in the Red Sea. Given the habitat available in the fringing shelf of the Red Sea and that hawksbill turtles reside on most of the coral-reef fringed islands and cays of the Red Sea, it is likely that a significant proportion of the nesting hawksbill turtles migrate from foraging areas within the region or from the Gulf of Aden.

Nesting [Geographical Spread]
Each country bordering the Red Sea, except Jordon, hosts some nesting. However, nesting is not uniformly distributed. Older data indicate that hawksbill turtles nested in low density on many of the offshore islands and at several near-shore and mainland locations scattered along the margin of the Red Sea (e.g., Saudi Arabia, Ormond et al. 1982; Egypt, Frazier and Salas 1984; other countries, Groombridge and Luxmore 1989). Higher density nesting aggregations are located in the northern (i.e., Egypt) and southern (i.e., Eritrea, Djibouti) portions, with low density nesting elsewhere (Mancini et al. 2015, Groombridge and Luxmore 1989).

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

Trends in Nesting Data: Systematic long term data sets concerning hawksbill turtle nesting do not exist for any country bordering the Red Sea. All nesting locations need confirmation of species, numbers, and nesting season. Determining long term trends requires monitoring the number of turtles nesting at specific locations on a regular basis. The use of standardized methods (PERSGA 2019) would facilitate comparison among reports. Some counts of nesting turtles are based on counting individual turtles, some report the number of tagged turtles, and others report the number of body pits found at the site. Most studies record data during only part of the nesting season. Although there are good reasons (often time and logistical constraints) for using each approach, the mixture of methods impacts the estimation of nesting numbers of turtles. For example, counting body pits is likely to over-estimate the actual number of turtles nesting, even when adjusted by the mean number of nests produced because (a) pits may be destroyed by other nesting turtles, (b) turtles may dig several body pits before oviposition or abandoning the effort, and (c) pits from previous seasons do not necessarily degrade (Miller 1989).

Egypt

The majority of the nesting along the Egyptian coast, including the Sinai Peninsula, is low density (1-10 individuals per season). However, medium density nesting (11-100) occurs on Gaftun (Jiftun) Kabir (Big Geftun) Island and Gaftun (Jiftun) eI Sagir (Little Geftun) Island. Low density nesting at multiple sites in Wadi al-Gamal National Park, including Baruda Island and coastal nesting sites aggregate to indicate this area hosts medium density nesting (11-100). Additional medium density nesting occurs in the Hamata Islands (50 females per year in the 1980s, Groombridge and Luxmoore 1986). There are no published data updates.

Hala'ib Triangle

Medium density nesting (11-100) occurs at three locations in the Hala'ib Triangle between Egypt and Sudan (Frazier and Salas 1984).

Sudan

Low density (1-10) Hawksbill turtle nesting occurs on most of the islands of the Suakin Archipelago (Hirth and Abdel Latif, 1980), 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.

Eritrea

Eriteria hosts the highest number of nesting sites for hawksbill turtles in the Red Sea. Nesting has been recorded at 110 islands and a few coastal locations, mostly low density (1-10), except in the southern part of the Dahlac Archipelago (Teclemariam et al. 2009). Aucan and Mojeudu (Mojeudi) Islands host between 101 and 500 nesting turtles as indicated by tagging (46 and 96 in 2006 and 2007, respectively), clutches, and counting nest pits (Teclemariam et al. 2009). During 2005 and 2006, more than 2000 Hawksbill nests (pits) were recorded on Mojeidi Island, with peak nesting occurring during February and March. During the same period, 1500 Hawksbill nests were recorded on Aucan Island (de Grissac & Negussie 2007). Other important nesting sites hosting more than 11 nesting hawksbill turtles per annum, include Dissei, Dahret Sigala, Dhul-kuff, Dehil, Entaentor, Entaasnu, Fatuma Island, Urukia

(Urubia) Islands. In addition, low density nesting occurs along the mainland coast at several sites including Berasole, Ras Tarma, Gahro and Deleme (de Grissac & Negussie 2007, Teclemariam et al. 2009).

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

Yemen
In the Red Sea portion of Yemeni territory, hawksbill turtle nesting primarily occurs on Perim Island (in the 101-500 level of nesting; Ross and Barwani 1982, Hirth 1968, Hirth and Carr 1970) and nesting has been reported on Kamaran and Makran Islands (Mancini et al. 2015). Along the Yemeni Gulf of Aden coast, Khor Umaira, on Jabal Aziz Island (= Jazirat Aziz), at Ras Imran and on Azizi Island in numbers at the lower end of the 11 to 100 level (PERSGA/GE 2004). Low density nesting (1-10) may occur infrequently along the Sharma-Jethmoun-Dhargham coast, Hadhramout Province, eastward toward Oman (Nasher and Jumaily 2015).

Saudi Arabia (Red Sea)
Older data indicate that hawksbill turtles nest in low density (1-10) on many of the offshore islands that are scattered along the full length of the Saudi Arabian coast (Ormond et al. 1982; Groombridge and Luxmoore 1989; Miller 1989). The Farasan Islands in the south-eastern Red Sea host 50 to 100 nesting individuals in the February through May nesting season (PERSGA 2004). At least 22 of the off-shore islands of the Umm al-Qamari islands and 4 near-/on-shore locations between the Farasan island and Jeddah host an additional 1-10 nesting hawksbill turtles each season. There is a gap in the distribution of nesting from just south of Jeddah northward to near the Weji Banks. The densest nesting occurs in the northern portion on Tiran, *Sanafir, and* Shusha *Islands (near the Sinai Peninsula), where 11-100 turtles nest* (Ormond et al. 1982; Groombridge and Luxmoore 1989; Miller 1989).

ADD FIGURE IN HERE

Figure XX. Distribution of hawksbill turtles nesting sites in the Red Sea and Gulf of Aden**.** Unquantified and Very low-density sites are not shown.

The majority (145 of 156) of nesting sites used by hawksbill turtles in the Red Sea host fewer than 100 turtles per annum **(Table XX).** However, because of differences in methods used to count nesting turtles and because the majority of nesting sites have not been assessed in recent years, all sites should be resurveyed using standard methodology to more accurately estimate the number of nesting turtles.

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

Estimated Annual	Country	Number of Beaches	Nesting beaches

Nesting Population			
501-1000 females/year	Djibouti	0	
	Egypt	0	
	Eritrea	1	Aucan Island
	Saudi Arabia	0	
	Sudan	0	
	Yemen	0	
101-500 females/year	Djibouti	0	
	Egypt	0	
	Eritrea	1	Mojeidi Is.
	Saudi Arabia	0	
	Sudan	2	SD-01-07, Suakin Archipelago
	Yemen	2	Perim Is (Barim), Ras Imran and Azizi Is., Aden.
11-100 females/year	Djibouti	2	Horod le 'Ale (Il de l'Est), Kadda Dabali (Grand Isle)
	Egypt	13	Abu Ghoson North (Wadi Al-Gimal NP), Baruda Is. (Wadi Gimal NP Is.), Gaflun (Jiftun) eI Sagir (Little Geftun) Is., Gaflun (Jiftun) Kabir (Big Geftun) Is., Gobal Kobra, Gobal Soghra' Hamata Is.s, Ras Banas, Ras Hankorab, Seiul Kobra, Shedwan Is., Umm Al-Karsh, Umm El-Abas, EI Hasa, Marsa Soma, Robala Is., Siyal Is.s (Jebel Elba).
	Eritrea	13	Dahret Bulke Is., Dahret Is., Dahret Segala Is., Delemi (Dilemmi), Dhul-kuff Is., Dissei Is., Entaasnu Is., Entaentor Is., Gahro,Ras Fatuma, Ras Terma,Selafi (Berasole),Urubia (Urukia) Is.,.
	Saudi Arabia	29	Al Hala Is., Al Umm Is., Barqan Is. E., Barqan Is. S., Barton lsland, Birema Is. (Mashabih), Dahert Simer Is., Danak Is., Dhahrat Simer Is., Disan Is., Dohrab Is., Dorish Is., Hadara Is., Mafsubber/Sabiya Is., Maghabiya Is., Malathu Is., Marrak Is., Qadd Humais Is. (S), Qalib Is. chain, Qutu Is., Sharbain Is. (Sharbayn), Shusha Is. E., Sinafir Is. W., Sirrain (Sirrayn) Is., Tidhkar Is., Tiran Is., Towasela Is., Waqada Is., Wasaliyat Is. (S), Zuqaq Is. (Zukak).
	Sudan	2	Mukawwar Is. (Megarsam) (SD-04-11), Seil Ada Kebir
	Yemen	2	Kamaran Is., Makran [part of Kamaran Is],
	Djibouti	0	

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

Biological data

Much needed Biological data for hawksbill turtles in the Red Sea is still unavailable for the breeding portion of the population **(Table XX).** The current use of known nesting sites needs to be assessed throughout the Red Sea region. At present, the curved carved carapace length of hawksbill turtles in the Red Sea appears to be somewhat shorter than those occurring elsewhere (Witzell 1983, Chatting et al. 2018), but larger sample sizes and better representation of nesting aggregations in the data are needed. The reasons for the size difference remain undefined. Long term monitoring at multiple sites is needed to better define the nesting turtles and to fill in the missing data.

Table XX. Biological data – Breeding for hawksbill turtles in the Red Sea region.

Parameter	**Value**	**Reference(s)**
Pivotal temperature	Unknown	
Remigration interval	Unknown	
Clutches per season	Unknown	
Mean size of nesting adult	59.5	PERSGA 2006 (Egypt)
	72	Frazier & Salas 1980 (Egypt)
	66-71.9	PERSGA 2006 (Sudan)
	69.2 ± 5.36 (25)	Hirth & Abdel Latif 1980 (Sudan)
Age at maturity	Unknown	
Clutch size	74±17.73, 34-95 (13)	Hanafy 2012 (Egypt)
	112.7, 96-134 (3)	Frazier & Salas 1980 (Egypt)
	100.8, 34-148 (26)	Hirth & Abdel Latif 1980 (Somalia)
Hatching Success	66.5±13.13, 53.4-96.3 (13) (11)	Hanafy 2012 (Egypt)

Characteristics of the foraging population (e.g., growth rate and survivorship) are more difficult to obtain but are necessary for conservation management of the turtles in the region (**Table XX**). In addition, determining the distribution of foraging habitat, as well as threatening processes will aid the development of management in areas important to hawksbill turtles. Data from monitoring habitat and the turtles at multiple sites are required to fill in the missing data.

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

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

*Presumed to be similar to data reported from the Arabian (Persian) Gulf

<u>Threats</u>

Threats to hawksbill turtles in the Red Sea were reviewed by Mancini et al. (2015), Gasperetti et al. (1993) and Miller (1989). The key threats include (1) Artisanal fishing (2)

Commercial Fisheries, (3) Habitat Destruction, (4) Oil Industry and (5) Dredging / Land-filling, (in rank order, PERSGA 2006). There are no quantified data on these threats and their impact on the population(s) is likely to vary among countries and locations. For example, the major threat to turtles in Yemen was identified as artisanal fishing (including egg collection) (PERSGA/GE 2004) in contrast to Saudi Arabia where the major threat is the impact of development on nesting beaches, including oil spills (PERSGA 2006). Coastal and island development, including tourism, pose clear threats to nesting and foraging areas. Older anecdotal information suggests that the threats to hawksbill turtles inhabiting the Red Sea are low to locally moderate (Miller 1989) but this may have changed.

Countries surrounding the Red Sea report no commercial use of adults and eggs (IOSEA 2019a, b, c, d, e, f) but some may occur. Most use of hawksbill is artisanal. However, the use of adults varies among areas because some local groups consider the meat to be poisonous and others do not.

The impact of fisheries (trawling, longline, gillnets) is wide spread, but bycatch of turtles is unquantified throughout the region. The complexity of the habitat used by hawksbills may afford some protection to the species but bycatch and damage to foraging habitat may be impacting the regional population, at least in local areas.

The projected impacts of climate change threaten most island and many coastal nesting sites but the potential impacts have not been assessed. Hawksbill turtles depend on coral reefs for foraging on sponges and other soft bodied organisms living in association with coral reefs and rocky outcroppings. Recently there has been extensive coral mortality on many reefs, including the southern Red Sea, the Socotra archipelago, and north east Gulf of Aden (PERSGA/GE. 2004). Reduction in coral density and diversity will potentially have a marked impact on hawksbill foraging; however, there has been no assessment of the impact.

Table XX. Threats to hawksbill turtles in the Red Sea region. KEY: Known or likely location of impact: A=Nesting beach, B=Oceanic/high seas, C=Coastal foraging areas. Quantified: 1=comprehensive documentation across population, 2= comprehensive documentation for some of the population, 3=non-published evidence only, 4=not quantified. **Sources:** Frazier & Salas 1984, IOSEA Country Report 2019, Miller 1989, PERSGA 2001, 2004, 2007,

Country **Length of Coast (km)**	**Egypt** 1805	**Sudan** 750	**Eritrea** 2,234	**Djibouti** 370	**Yemen** 800, 1400*	**Saudi Arabia** 1840	**Jordan** 27
Consumption – nesting beach							
Egg collection	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A,4
Commercial use of turtles	4	4	4	A, C, 4	4	4	4
Non-commercial use of turtles	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A, C, 4	A,4
Predation eggs by non-native fauna	4	4	4	4	4	4	4
Predation eggs by native fauna	4	4	4	4	4	4	4

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

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

Management and Protection

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

Table XX. Designated and proposed protected areas that include hawksbill turtle nesting areas in the Red Sea region. Based on PERSGA 2004, 2007; Mancini 2015; Phillott & Rees 2019; MCI 2020.

Country	NAME	DESIGNATION	TYPE	STATUS	Comment
Djibouti	Iles Musha et Maskhali	Marine protected landscape	National	Proposed	Nesting occurs at Iles Musha et Maskhali
Djibouti	Iles des Sept Freres ainsi que Ras Syan, Khor Angar et la foret de Godoria	Marine protected landscape	National	Proposed	Nesting occurs at Ras Siyyan
Egypt	Ras Mohammed	National Park	National	Designated	Only minor nesting occurs within Park; Major nesting occurs on Tiran Island [co-claimed by KSA]
Egypt	Abu Gallum	Multiple Use Management Area	National	Designated	Only minor nesting occurs within Park
Egypt	Wadi El-Gemal - Hamata	National Park	National	Designated	Park hosts important nesting on coast and islands; adjacent mainland to the north hosts minor to moderate nesting (Hamata area)
Egypt	Elba	Multiple Use Management Area	National	Designated	Minor coastal nesting
Egypt	Red Sea Islands	Developing Resources Protected Area	National	Designated	Only minor nesting occurs within Park; Major nesting occurs on Islands to the south of the Park
Saudi Arabia	Farasan Islands	Resource Use Reserve	National	Designated	Nesting on Disan Is., Dhi Dhayaha Is., and is probable on other islands in low numbers as well as on islands (Marrak Is., Dohrab Is., Towasela Is., Simer Is. to the south and on islands to the west of the Park
Saudi Arabia	Ra's Suwayhil / Ra's al-Qasbah	Resource Use Reserve	National	Proposed	These Islands are co-claimed by Egypt and host major nesting at Tiran Island and Barqan Island
Saudi Arabia	Al-Wajh Bank	Resource Use Reserve	National	Proposed	Major nesting occurs on Waqada Island and the Qalib Island chain. Several minor nesting

					sites also occur within the designated area
Saudi Arabia	Ra's Kishran / Jazirat Sharifah	Reserve	National	Proposed	Qishran Islats host minor nesting. Near by Qadd Humais Island host moderate nesting but is not with the designated area
Sudan	Suakin Archipelago	National Park	National	Proposed	
Sudan	Sanganeb Marine National Park and Dungonab Bay - Mukkawar Island Marine National Park	World Heritage Site (natural or mixed)	International	Inscribed	Nesting occurs on Mukawwar Island

The countries that border the Red Sea are members of many international agreements that directly or indirectly protect hawksbill turtles and/or their habitat (**Table XX**). Compliance is likely to vary among countries based on their resources and the information on which their conservation and management actions are based.

In addition, the countries of the Red Sea region have national laws that prohibit or regulate the use of eggs and turtles found on beaches as well as those captured in foraging areas either directly or by accident (Mancini 2015, Phillott and Rees 2019) but enforcement is an on-going issue because of the lack of resources (IOSEA 2019a, b, c, d, e, f).

Table XX. Accession of PERSGA States to International Legal Instruments Relevant to Turtle Conservation. PERSGA 2007 Regional Action Plan for the Conservation of Marine Turtles, and International Environmental Agreements (IEA) Database Project, 2002-2019.

	Djibouti	**Egypt**	**Eritrea**	**Jordan**	**Saudi Arabia**	**Somalia**	**Sudan**	**Yemen**
Convention on International Trade in Endangered Species of Wild Fauna and Flora (1973) [CITES]	X	X	X	X	X	X	X	X
Convention on Biological Diversity (1992) [CBD]	X	X	X	X	X	X	X	X
Convention on the Conservation of Migratory Species of Wild Animals (1979) [CMS]	X	X	X	X	X	X	O	X
Convention on Wetlands of International Importance Especially as Waterfowl Habitat (1971) [RAMSAR]	X	X	O	X	O	O	X	X
Memorandum of Understanding on the Conservation and Management of Marine Turtles and their Habitats of the Indian Ocean and South-East Asia [IOSEA]	O	X	X	X	X	O	X	X
Regional Organisation for the Conservation of the Red Sea and Gulf of Aden Environment (1982) [PERSGA]	X	X	O	X	X	X	X	X

International Convention for the Prevention of Pollution from Ships (1973/78) [MARPOL]	X	X	X	X	X	X	X	X
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972)	X	X	X	X	X	X	X	X
United Nations Convention on the Law of the Sea (1982) [UNCLOS]	X	X	O	X	X	X	X	X
Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency (1982)	X	X	X	X	X	X	X	X

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

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Known nesting areas currently unassigned to a management unit

Indonesia

Indonesia, straddling the equator, and within the Coral Triangle region is well known for its importance to global sea turtle populations. Hawksbill turtles have been reported nesting across the breadth of the nation, mostly in the Java sea region (Shultz 1987, Groombridge and Luxmoore 1989); Figure 19) and much of the Indonesian coral reef areas would provide habitat for foraging turtles. However, Indonesia was one of the main countries supplying hawksbill turtle shell to Japan in the late 20th century and this combined with the customary use of eggs led in many locations to wide spread declines and concern for the species. Thus, is it likely that current population sizes are a fraction of their 17th century size and some rookeries could be extirpated, or at least severely reduced. Indeed, in the 2008 assessment, there were approximately only 3,126 hawksbill nests per year in Indonesia (Mortimer and Donnelly, 2008). There have been no genetic-based studies on hawksbill turtles from Indonesian rookeries so the genetic-stock partitioning is not possible. It is likely there is more than one genetic-based stock within the country. Similarly, there are few foraging ground projects collecting data on population dynamics from which we can use as a proxy for stability of the stock (e.g. Ali Imron et al. no date). In this assessment we summarise what is known about hawksbill turtles on a regional basis, following a similar approach to Groombridge and Luxmoore (1989) and Mortimer and Donnelly (2008).

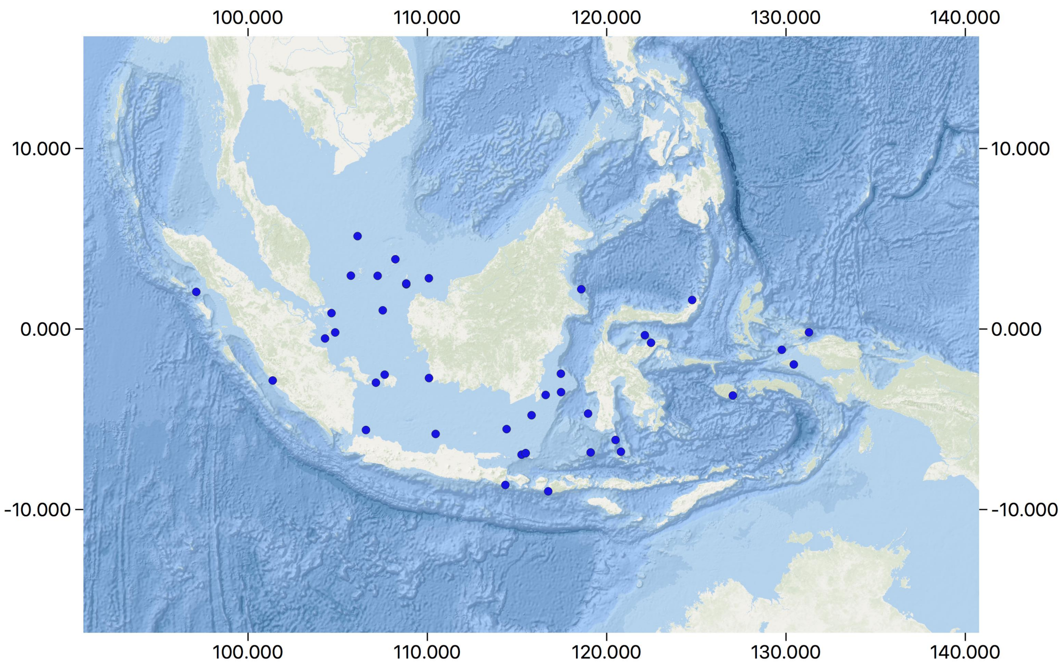

Figure 19. Distribution of nesting sites for hawksbill turtles in Indonesia

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, Suganuma 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 * are sites listed as index sites in Mortimer and Donnelly (2008)

Location	Clutches laid per year		
	1980 estimates (Table 88 of Groombridge and Luxmoore 1989)	2008/2009 estímate (Tanaka et al. 2010; Suganuma et al. 1999; Akil et al. 2004; Mortimer and Donnelly 2008)	Most recent estimate (year) ELNA personal communication
Riau and Riau Island Provinces			
Senayang	400		na
Natuna Besar	200	50	na
Natuna Selatan	620	285 (2009)*	na
Anambas	800	300	na
Tambelan	1000	300 (2004)	na
Riau and Lingga	150	94 (2009) (Lingga)*	na
Bintang	na	192 (2009)*	na
Singkep	na	27 (2009)*	na
South Sumatra and Bangka Belitung Provinces			
Momperang/Peserat*	400	357 (2009)	915 (2016-18)
Gresik	650	219 (1996)	203 (2008)
Kimar	na	290 (2009)	666 (2016-18)
Momperak and Pesambung	1250	na	
Tengah and Sembilan	800	na	
Other islands (P. Manggar, P. Plemah, P.Seliu, P Lima, P.Panjang, P. Lengkuas, Belitung	1100	na	
Lampung and Jakarta Provinces			
Seribu Islands NP	500	50 (1994)*	
Segama	na	191 (1996 to 2000) and 463 (2009)	1347 (2016-18)
South Kalimantan Province			
Sambergelap area	na	672 (2009)	na
West Kalimantan Province			
Paloh region	300	na	na
Kendawangan region	na	165 (2009)*	112 (2015-18) (Penambun)

South Sulawesi Province			
Islands in Makassar and P. Kayadi, Islands south of South Suluwesi	3000 to 4000	na	na

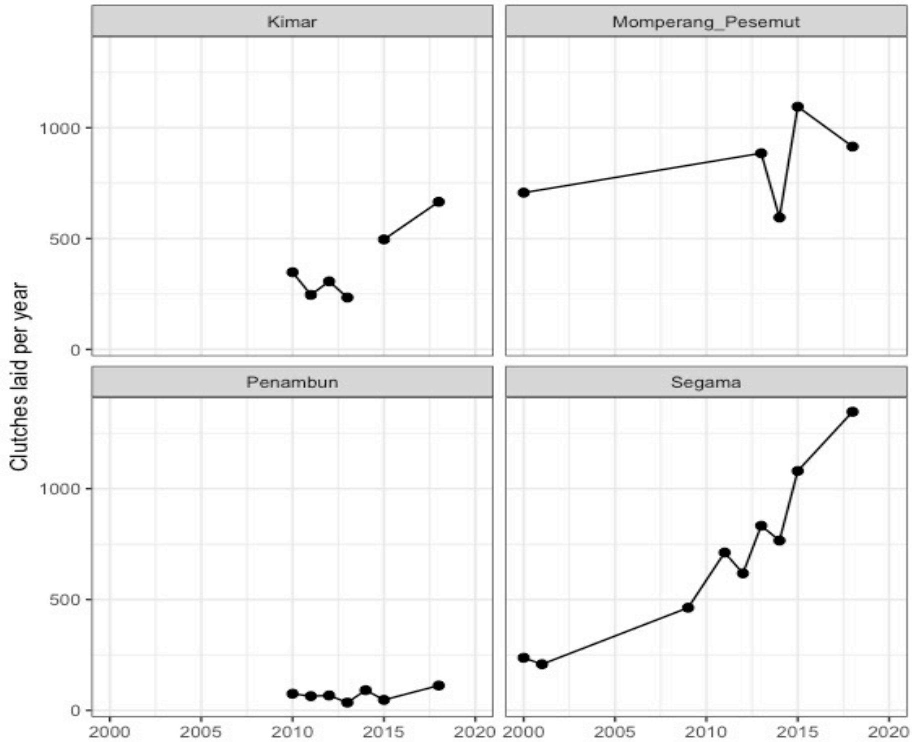

Figure 20. Results of monitoring in four locations in the Indonesian, Java Sea by the the NGO Everlasting Nature of Asia. Data up until 2010 (Tanaka et al. 2010) and data between 2010 and 2018 are unpublished and supplied by ELNA. The value for 2018 represents an average of 2016 to 2018.

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 anecdotal surveys indicate considerable declines are likely to have occurred, or continue to occur.

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 – 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) and in 2019 a local NGO began to locate and protect hawksbill turtle clutches on Palau Belambangan http://yayasanpenyu.org

Foraging
Maulida et al. (2017) conducted a survey of hawksbill turtle foraging and health in Maratua (2°08'N, 118°32'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 – 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). Local NGO Manengkel Solidaritas, has begun a project to locate and protect marine turtle nests in the Minahasa District.

Foraging

There are no data on foraging turtles in the region. However, there are 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 Sulawesi, Maluku, North Maluku, West Papua, Papua Provinces

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

Bird's Head Peninsula, 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 Batu Rumah and Warmamedi beaches between May and October 1999, these beaches are primarily used by leatherback turtles. A survey in this region by Setyadi (1997; cited in Putrawidjaja (2000)) found hawksbill turtle clutches on 6 of 8 beaches surveyed (Iwari, Matas, Rorebo, Tridacna Atoll, Kabaui, Nutabari). Hitipeuw (2003) report nesting on three islands in Raja Ampat, Waigeo (around 4 clutches per year), Kofiau (two beaches and around 2 clutches per year), and in particular Misool (six beaches and around 40 clutches per year).

Maluku, North Maluku and Southeast Sulawesi
There are no updates on the nesting sites, or the numbers using this region to breed. In 2018 the Marine and Fisheries Agency (DKP) of Sula Islands, North Maluku Province began a project to understand and protect hawksbill turtles on Sulabesi Island (Fatkauyon Village) https://www.sea-indonesia.org/initiating-sea-turtle-protection-in-fatkauyon/

Foraging
Cendrawasih Bay has around 80,000 hectares of coral reef systems and it is 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 (see van Dijk and Shepherd 2004, Mortimer and Donnelly 2008). 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), in 2004 it was considered to be substantial in the context of local and regional population sizes (van Dijk and Shepherd 2004). There is a growing number of species and habitat (e.g. MPA) conservation and protection being provided by Government, Community and NGO partnerships in many locations in Indonesia. However, there are still sound reasons for accepting in the short-term there will continue to 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, *E. imbricata* in ghost nets
3	The presumed substantial but unquantified mortality of foraging *E. imbricata* 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 *E. imbricate* (CITES, Vuto et al. 2019)
6	The illegal trade in *E. imbricata* particularly via China and Vietnam provides an incentive for continuing the illegal trade of *E. imbricata* or their scutes from countries in southeast Asia (e.g. CITES, Riskas et al. 2018)

Publications/weblinks for Indonesia

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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 Calamaine 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 many 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 turtles (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 Viet Nam (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.
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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.

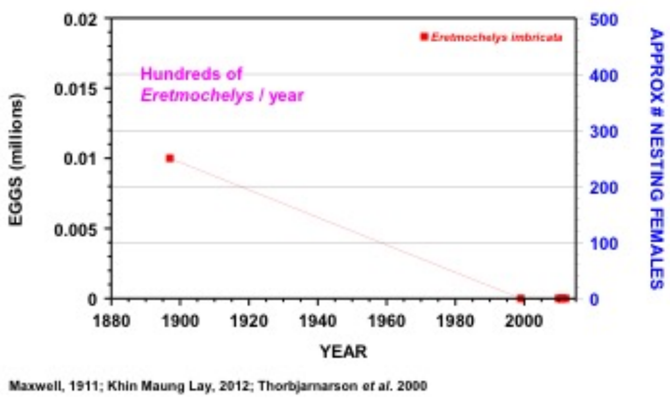

Figure 21. Long term changes in hawksbill turtle nesting at Thameehla Island, Myanmar, after Limpus (2012). UPDATE SAME FORMAT

Foraging

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

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

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Bangladesh

Nesting
Rare accounts of nesting by hawksbill turtles has been recorded from 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 of 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 and western Thailand

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

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

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

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

Overall, based on the collection of available information Andrews et al. (2006) estimated 205 females nesting annually on the Andaman Islands and 45 on islands in the Nicobar group. A summary of data collected from the monitoring camps conducted by Satish Bhaskar in 1992 and 1995 indicate that hawksbill turtles on South Reef Island averaged 77 cm in CCL and 69 cm in CCW, laid around 3 clutches per season of 114 eggs at approximately 14-day intervals (Bhaskar 1996; Namboothri et al. 2012). The Andaman and Nicobar Islands have been recorded as having the best nesting locations for hawksbills in India, as they favour small isolated island beaches (Bhaskar 1993a)

Foraging

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

Threats

Although not comprehensively quantified, hawksbill turtles have been reported as bycatch in coastal fisheries in mainland India (WWF 2003; Sulochanan et al. 2016). Within the Andaman and Nicobar Islands, many of the marine turtle nesting sites are remote and far from areas of human settlement and listed as Wildlife Sanctuaries. The main threats recorded within the Islands include hunting for meat and eggs, incident capture in coastal fisheries, such as shark fisheries, and the predation of eggs by native and introduced species such as feral dogs (Andrews 2000; Namboothri et al. 2012).

Thailand:

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

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).

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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 Lavania and Koggala in Southwest Sri Lanka (Mount Lavania (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).

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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 occurred 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). It is likely that the abundance of nesting hawksbill turtles in the Maldives is depleted.

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). In the last five to 10 years several resort operations have begun citizen science projects to encourage divers and dive companies to record sightings of marine megafauna, such as hawksbill turtles that occur around dive sites, and to rehabilitate sick and injured turtles. The growth of these citizen science initiatives across the nation could benefit species and habitat protection.

Migration

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

Threats

The 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). Most of the turtles were caught for the trade were from nesting beaches and the use almost certainly depleted the local populations. Opportunistic retention of hawksbill turtles caught in fishing gear also occurs and contributes to domestic use (Riskas et al. 2018). Egg collection was wide-spread and only managed in the mid 2000s.

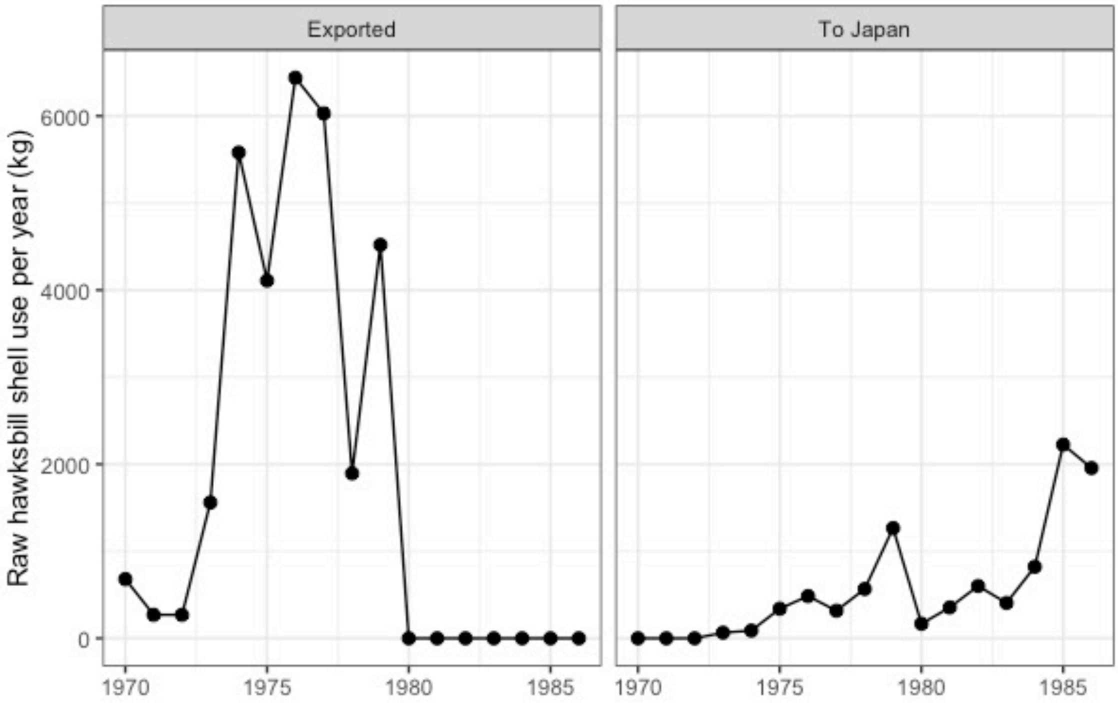

Figure 22. Raw hawksbill turtle shell exported from the Maldives and imported into Japan.

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South-west Indian Ocean – Kenya, French Indian Ocean Territories, Madagascar, Mauritius, Mozambique, Tanzania

The south-west Indian Ocean has been recognised as an important region for hawksbill turtles (Mortimer and Donnelly 2008). Genetic-based research has identified at least one genetically-distinct popoulation comprising rookeries in the Seychelle and the Chagos Archipelago (Vargas et al. 2016) and this population accounts for around 97% of hawksbill turtle nesting in the south-west Indian Ocean. Turtle monitoring surveys over the past four decades have also identified hawksbill turtle nesting within Madagascar, Mozambique, Tanzania, Kenya Mauritius, and French Indian Ocean Territories. There has been limited genetic research on hawksbills from these sites to know whether they form a separate genetic unit or whether they are aligned to the Seychelles/Chagos management unit (Vargas et al. 2016, Mortimer et al. 2020). One study, (Anastácio and Pereira 2017) sampled 57 turtles from the Vamizi nesting rookery in Mozambique and reported 14 different mDNA 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 information about genetic population structure.

<u>Nesting</u>
Nesting sites in the region include (and see Figure XX):

Mozambique: Vamizi Island in the Quirimbas Archipelago supports around 1 to 10 nesting females per year, key beaches are Comissette and Farol (Anastácio et al. 2017). On Vamizi, both Comissette 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 Comissette 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).

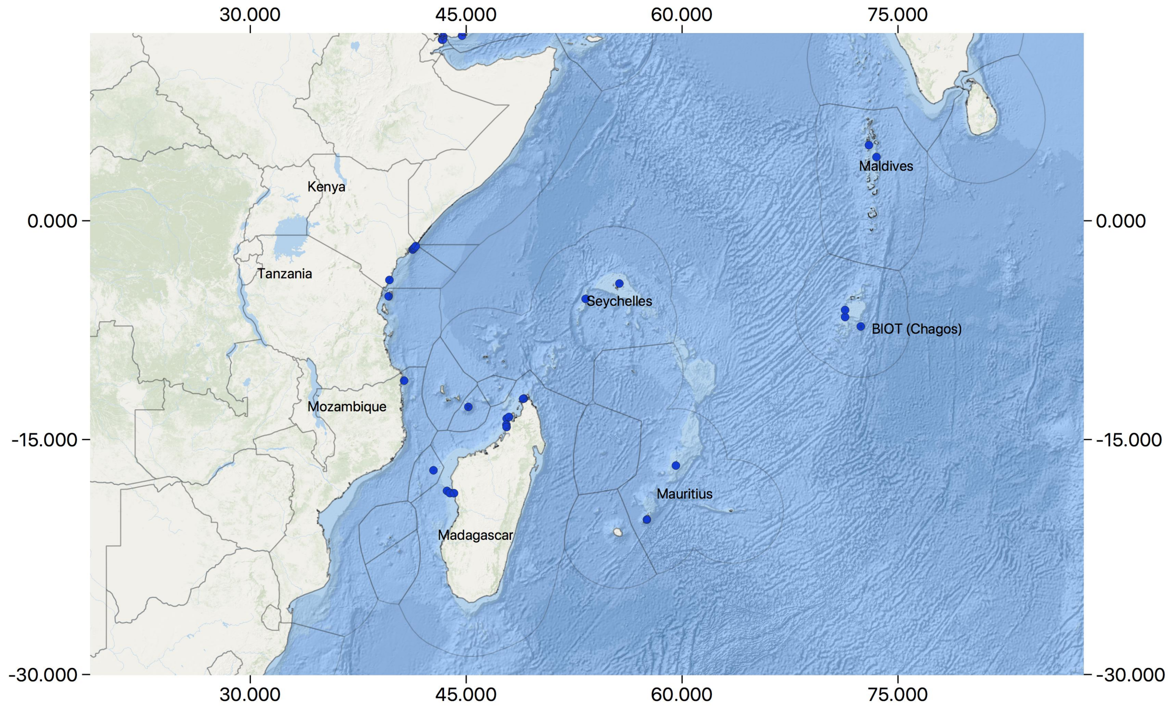

Figure X

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

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

Mauritius: Hawksbill turtles were heavily exploited in Mauritius until they were legally protected in 1998. St Brandon's Island is likely to support 101 to 500 clutches per year for hawksbill turtles (Mortimer et al. 2020). It is not known whether hawksbill turtles still nest on Agalega Island (Webster et al. 2016).

Madagascar: The number of hawksbill turtles nesting in Madagascar is likely to have declined due to consistent commercial exploitation of turtles and eggs, Indeed Hughes (1973) estimated mortality at around 600 adult turtles per year in the early 1970s. 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 1000 to 5000 hawksbill turtle clutches are laid per year breed on the beaches of Madagascar (Mortimer et al. 2020).

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, aperiodic and possibly declining (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).

Table X. Summary of size of annual hawksbill turtle nesting populations at XX recorded nesting beaches in the south west Indian Ocean (excluding Seychelles and Chagos – see Table X).

Estimated size of annual nesting population	Number of beaches	Nesting beaches
501-1000 females/year		
101-500 females /year		
11-100 females /year		
1-10 females / year		
Unquantified nesting		

Foraging

Each of the countries and many of the islands in the southwest Indian ocean have a considerable area of coral-reef or rock-reef habitats which offer the type of habitat used by hawksbill turtles, hence they probably occur in most of the coastal waters and coral-reef fringed habitats throughout the region (Chassagneux et al. 2013, Bourjea et al. 2008, Williams et al. 2015). There have been no dedicated studies on foraging hawksbill turtles in the region, however there are several dive-industry based citizen science projects which collect sightings data on marine mega fauna such as hawksbills (e.g. Mozambique Williams et al. 2015) and there is a growth in the use of photo-identification to assign identity to individual turtles foraging at dive sites.

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. It is likely that hawksbill turtles in this region of the Indian ocean are from the larger nesting aggregations in the Seychelles and Chagos.

Threats

At Vamizi Island in Mozambique, 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). In Madagascar, Kenya, Mozambique and Tanzania coastal development is impacting existing and possible future nesting habitats and accidental capture in gill nets from commercial and artisanal fisheries is a significant threat to hawksbill turtles of the region.

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Viet Nam

The status of hawskbill 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 recent 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.

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Singapore

Singapore National Parks have recently commenced the monitoring of turtle nesting. For example, 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 (ADD FIGURE TO SHOW LOCATIONS). Data to date indicates that tens of hawksbill turtles breed annually in Singapore. The nesting locations of Singapore are located between rookeries in Malaka and Johor states of 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. INSERT MAP OF turtle nesting events recorded in Singapore

The nesting in Singapore predominantly occurs on artificial beaches which have been created from dredging spoil (C. Limpus, pers. comm.). Hawksbill turtle nesting is influenced by beach type, vegetation, light pollution (Wen 2019) and adjacent development and future security of the nesting site will need to actively manage development, light pollution and use of the adjacent waters. There have not been any other studies on hawksbill turtles in Singapore, however, Parks Singapore have begun a monitoring program to collect data on nesting parameters, sand temperatures and genetics as well as place clutches into protective hatcheries to ensure hatchling production (https://www.nparks.gov.sg/gardens-parks-and-nature/dos-and-donts/animal-advisories/hawksbill-turtles).

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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.